A Study and Investigation of Just-in-time with Artificial Intelligence to Minimize Costs and Time in the Construction Industry

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Abstract – *The construction industry has long been plagued by inefficiencies leading to extended project durations and excessive expenditures on materials. In response to these challenges, this study proposes an investigation into the integration of Just-in-Time (JIT) principles with Artificial Intelligence (AI) technologies to streamline operations and enhance resource management. The primary objective of this research is to assess the potential impact of implementing JIT methodologies supported by AI in construction projects. By adopting JIT principles, construction firms aim to minimize waste, reduce lead times, and optimize material flows. Coupling JIT with AI capabilities offers opportunities for predictive analysis, enabling proactive decision-making based on market trends, demand fluctuations, and supply chain dynamics. This study will employ a mixed-methods approach, incorporating both quantitative and qualitative analyses. Quantitative data will be collected to measure the effects of JIT implementation on project timelines and material costs, while qualitative insights will be obtained through interviews and surveys with industry professionals. Key areas of investigation include the identification of critical success factors for JIT implementation in construction, the evaluation of AI-driven predictive models for material procurement and inventory management, and the assessment of potential barriers and challenges to adoption. The findings of this research are expected to contribute to the body of knowledge on lean construction practices and AI utilization in the construction industry. Ultimately, the insights gained will inform decision-makers on the feasibility and effectiveness of integrating JIT with AI to minimize costs and time in construction projects, thereby enhancing overall project efficiency and competitiveness in the marketplace.*

INTRODUCTION

The construction business is crucial to the global economy but encounters ongoing issues such as project delays, cost overruns, and ineffective resource management. Traditionally, construction projects have been known for their extended durations and high costs due to excessive spending on materials, resulting in considerable waste and inefficiency. Recognizing the issues, there is an increasing acknowledgment of the necessity for new methods to improve productivity, save costs, and streamline operations in the construction industry. The Just-in-Time (JIT) concept, originally developed by the manufacturing industry, is now being used in building projects to enhance efficiency and reduce waste. JIT principles focus on delivering items and resources exactly when and where they are required, which helps in eliminating surplus inventory and decreasing lead times. JIT strives to maximize resource use and enhance overall project performance by aligning output with demand. Implementing JIT in construction successfully necessitates thorough consideration of project-specific elements such as project intricacy, supply chain dynamics, and stakeholder coordination. Additionally, the conventional difficulties related to predicting demand, handling inventory, and reducing risks in construction make it more challenging to implement JIT approaches. Artificial Intelligence (AI) technology have the ability to enhance Just-In-Time (JIT) processes and tackle the challenges of construction projects in this scenario. AI-driven predictive analytics can help construction companies predict market trends, anticipate changes in demand, and optimize material procurement plans instantly. Construction businesses may use AI-driven insights to make educated decisions, reduce uncertainty, and improve operational efficiency during the project lifecycle. This study aims to explore the synergistic impact of integrating Just-In-Time (JIT) with Artificial Intelligence (AI) in the construction sector to reduce expenses and duration. This research seeks to offer significant insights to industry practitioners, policymakers, and researchers by analysing the feasibility, efficacy, and potential problems of combining these approaches. The construction business is acknowledged as a major sector worldwide, making a substantial contribution to economic growth and infrastructural development. Nevertheless, the industry has faced inefficiencies and obstacles that have impeded its potential for sustainable expansion. Major obstacles in building projects include extended project timelines and high costs due to issues including inadequate resource allocation, volatile market conditions, and ineffective processes. Recently, there has been an increasing focus on implementing lean principles in construction to reduce waste, improve processes, and boost project performance. The Just-in-Time (JIT) methodology, a key aspect of lean thinking, is increasingly being recognized as a promising strategy to tackle the inefficiencies commonly found in building projects. JIT promotes the timely supply of products and resources to minimize inventory costs, decrease lead times, and enhance productivity. Implementing Just-In-Time (JIT) in construction has hurdles due to the intricate

nature of building projects, fluctuating demand, and the complexities of supply chain management. Traditional methods of material procurement and inventory control may not possess the flexibility and responsiveness needed to adjust to changing project demands and market conditions.

Integrating Artificial Intelligence (AI) technologies can significantly improve Just-In-Time (JIT) processes in construction. Advanced technologies like AI-driven predictive analytics, machine learning algorithms, and data-driven decision-making tools may accurately predict demand, optimize inventory levels, and reduce risks more effectively than conventional methods.

OBJECTIVES

1. To examine the current practices and challenges in the construction industry related to project scheduling, resource management, and material procurement.
2. To explore the theoretical foundations of JIT and AI and their potential applications in addressing the identified challenges in construction projects.
3. To visit multiple construction sites and engage with stakeholders at different levels, including project managers, contractors, suppliers, and workers, to gather first-hand insights into their experiences, perceptions, and attitudes towards JIT with AI.
4. To collect quantitative data, such as project timelines, material costs, and productivity metrics, from the visited construction sites to assess the impact of JIT with AI on project performance.
5. To conduct qualitative interviews and surveys with stakeholders to understand their perspectives on the benefits, challenges, and feasibility of implementing JIT with AI in construction projects.
6. To analyse the collected data using appropriate statistical methods and qualitative analysis techniques to identify patterns, trends, and correlations related to the integration of JIT with AI in construction.
7. To synthesize the findings from the data analysis and draw conclusions regarding the importance and effectiveness of JIT with AI in minimizing costs and time in construction projects.
8. To provide recommendations and practical implications based on the study findings to guide industry stakeholders in adopting and implementing JIT with AI practices effectively

LITERATUREREVIEW

Mohd Arif Marhani(Sustainability through Lean Construction Approach: A literature review-2013)

Through the elimination of waste, lean construction (LC) is an efficient method for controlling the construction process and accomplishing the specific objectives of the project. The primary goals of this paper are to equip readers with essential knowledge of LC and to bring attention to the obstacles that stand in the way of successful implementation. The reviews of the relevant literature have been carried out using their respective databases. After conducting research, it was discovered that there is a requirement for the implementation of LC to incorporate more comprehensive approaches, such as health and safety, as well as six sigmas.

D.T.Matt (Adaptation of the value stream optimization approach to collaborative company networks in the construction industry)

In contrast to the automotive and aerospace industries, which are currently making extensive use of automation technologies and processes, as well as the implementation of lean manufacturing methods, the construction industry is falling behind in these advances. With the assistance of value stream design, which is primarily recognized in mass production but has recently also been utilized in variation intensive manufacturing, this context is being discuss

N.B.Kasim (Improving materials management practices on fast track construction projects-2005)

One of the most important factors that has a negative impact on the execution of the project is the incorrect handling and management of materials on site. Within the context of fast-track projects, where choices about design and procurement are made concurrently with construction activities, materials management presents a particularly challenging situation. In this study, the early stages of research establishing a novel way to managing materials on fast-track projects are discussed. The research is focused on information and communication technology (ICT).

Usama Hamed Issa (Implementation of lean construction techniques for minimizing the risks effect on project construction time-2013)

There are many different risk factors involved in building projects, each of which can have a different impact on the time objective, which can result in time overruns to occur. Through the use of lean construction concepts, this study proposes and implements a novel method for reducing the impact of risk variables on the duration of the project. As part of this investigation, the lean construction methodology is put into practice by utilizing the most recent planner system to carry out an industrial project in Egypt. Percent Expected Time-overrun (PET) and Percent Plan Completed (PPC) are the two measurements that are used to describe the process of evaluating the impact of utilizing the new technology

GlennBallard (TowardConstructionjit-2014)

Since the late 1980s, when manufacturing was attempting to tackle competitive difficulties by embracing newly emerging management theories and techniques, which some people refer to as Lean Production (1), the abbreviation JIT has been receiving a lot of attention. When is JIT used? What is the significance of this occurrence with regard to the development and implementation of Lean Construction theory and practice Just-in-time manufacturing (JIT) is a technique that involves moving work from one process to the next "just-in-time," or at the precise moment that the process that comes

after it requires it, with the ultimate goal of increasing throughput.

M.Muya(Construction Materials Supply Logistics Loughborough University Institutional Repository)

A considerable contribution to the achievement of the project delivery goals of cost, quality, and time is made by the logistics of the materials supply. As a result of the fact that customer service is the essential component that binds all supply logistics operations together, the process of selecting suppliers ought to start with an evaluation of the characteristics that are considered essential for a supplier to be able to give a pre-requisite level of customer service. The presence of such elements, also known as enablers, acts as an indicator of whether or not a certain supplier will be able to fulfil the essential materials supply targets

Ricardo Antunes (A Production Model for Construction: A Theoretical Framework)

There are a number of issues that the building construction business must contend with, including the increased complexity and scope needs of projects, as well as shorter deadlines. In addition, the construction sector is facing a drop-in profit margins, which consequently necessitates the creation of new approaches to construction management. This is an industry that is experiencing economic uncertainty and increased commercial competitiveness. The building construction industry, on the other hand, does not take into account the dynamics of its production system because it relies on techniques that are based on intuition and experience. Researchers also contend that there is no history of the building industry using mathematical methodologies to model and manage production. This is a claim that they make.

JIT

Just-in-Time (JIT) is a management philosophy and strategy aimed at optimizing processes by delivering goods or services precisely when they are needed, thereby minimizing waste and improving efficiency. Originally developed and popularized by the Japanese automotive industry, particularly Toyota, JIT has since been adopted and adapted by organizations across various industries worldwide.

KEY PRINCIPLES

Elimination of Waste: JIT seeks to eliminate waste in all forms, including excess inventory, overproduction, waiting time, unnecessary transportation, defects, and unused employee skills. By identifying and eliminating waste, organizations can streamline processes and reduce costs.

Pull System: JIT operates on a pull-based system, where production is driven by customer demand rather than forecasted estimates. This means that materials and resources are replenished only when needed, based on actual customer orders or consumption.

Just-in-Time Production: JIT emphasizes producing goods or delivering services just in time to meet customer demand. This minimizes the need for large inventories and reduces the risk of overproduction or stockouts.

Continuous Improvement: JIT promotes a culture of continuous improvement, known as kaizen in Japanese. This involves regularly reviewing processes, identifying areas for improvement, and implementing incremental changes to enhance efficiency and quality.

Supplier Partnerships: JIT requires close collaboration and partnerships with suppliers to ensure timely delivery of high-quality materials and components. Suppliers are often integrated into the production process, providing inputs directly to the assembly line as needed.

Flexible Workforce: JIT encourages a flexible workforce capable of performing multiple tasks and adapting to changing production demands. Cross-training employees and empowering them to make decisions facilitates agility and responsiveness in the production process.

METHODOLOGY

This study aims to explore the synergistic impact of integrating Just-In-Time (JIT) with Artificial Intelligence (AI) in the construction sector to reduce expenses and project duration. This research intends to give significant insights for industry stakeholders looking to enhance project results and competitiveness by analysing the feasibility, efficacy, and potential hurdles of combining these approaches. This project seeks to enhance lean building techniques and promote the integration of AI technologies in the construction sector to improve efficiency, sustainability, and innovation in the built environment. The construction sector is intrinsically sophisticated, encompassing several players, complex supply networks, and varying project specifications. Despite technological and management breakthroughs, construction projects frequently face delays, cost overruns, and quality concerns, causing unhappiness among clients and stakeholders. To tackle these difficulties, we need creative methods that improve efficiency, minimize waste, and optimize resource usage during the project's lifespan. The Just-in-Time (JIT) concept, originating from the manufacturing industry, focuses on delivering supplies and resources exactly when required to reduce inventory holding expenses and optimize production procedures. JIT has been successful in manufacturing but faces hurdles in the construction industry due to the dynamic nature of projects, demand variability, and uncertainties in planning and execution. AI technologies provide promising solutions to address these difficulties and improve the efficiency of Just-In-Time (JIT) methods in construction. Construction companies can use AI-driven predictive analytics, machine learning algorithms, and data-driven decision-making tools to forecast demand, improve procurement processes, and reduce risks more precisely and efficiently. Construction organizations may enhance their operations, optimize project results, and get a competitive edge in the market by utilizing AI technology. The study intends to explore the possible synergies between Just-In-Time (JIT) and Artificial Intelligence (AI) in

the construction sector to reduce expenses and project duration. This project aims to offer significant insights for construction professionals, policymakers, and researchers by examining the feasibility, benefits, and problems of combining these approaches. The construction sector is essential for infrastructure development and economic progress. It is known for its complexity, which includes various players, numerous processes, and significant resource usage. The industry has faced ongoing issues including project delays, cost overruns, and inefficient resource management despite its importance. The problems affect project results and also lead to environmental harm and economic inefficiency. The Just-in-Time (JIT) methodology, which originated in the manufacturing sector, provides a strong foundation for addressing difficulties by focusing on delivering materials and resources exactly when and where they are required. JIT has transformed manufacturing operations by lowering inventory, cutting lead times, and streamlining production processes, resulting in substantial enhancements in efficiency and quality. Implementing JIT in the construction industry poses distinctive challenges. Construction projects are inherently dynamic due to fluctuating requirements, unknown

JIT IMPLIMENTATION IN CONSTRUCTION INDUSTRIES

The main goal of JIT materials management system in construction project is to optimize materials delivery timing and to minimize inventory quantities. Materials inventory or storage on site are exposed into certain deficiencies such as protecting it against theft, damage, and weather, and failing to provide space for materials. The implementation of JIT in construction requires commitment from staff and crew involved in the construction in terms that all parties from the planning and site should collaborate together and participate in the decision-making process. The successful implementation of JIT is dependent on the suppliers' flexibility, users' stability, total management and employee commitment as well as teamwork.

1 ELIMINATION OF WASTE

JIT aims to improve product quality and productivity, through the elimination of waste. Waste is considered as non-value adding to an activity. 'Excess inventory is regarded as waste since no value is added by accumulating inventory. Furthermore, inventory takes up space, ties down capital, incurs storage costs, as well as security and insurance costs; not to mention the risk of damage during storage as well as the risk of obsolescence'. Hence, motion is regarded as a form of waste. Wastes include over-production of components and products, delays in materials and information, material transportation, unnecessary processing, excess stocks, unnecessary human activities and defects in material and information. Thus, the JIT concept calls for zero inventory or buffer stocks. Waiting time, inspection time, and time spent at rectifying defect is believed wasteful. JIT can also be applied in demolition projects where waste materials can be shipped directly to demanders through means of transportation generated from the project. Therefore, getting things done 'first time right' is another doctrine of the JIT concept.

2.CONTRACTORS AND SUPPLIERS COMMUNICATION

To ensure the right materials come at the right times and the exact right amounts are not an easy task for suppliers. Of course, assessing the supplier will be based on meeting such constraints: Delivery Cost, Material Cost, Reliability time, Quality of the material, availability of material. 'The suppliers must know and monitor each stage of work-in-process'. This can be achieved with ease by contractors giving authority to their site management to communicate directly with their suppliers on site materials requirements. Agapiou defined that the relationship between suppliers and contractors falls below "the need to secure the lowest price for materials. This is done without even taking into consideration the methodology of materials handling. The decisions of choosing suppliers by contractors are often based on fractional information. Suppliers should be involved in the planning stage of the contract as well as post-contract stage.

Suppliers should become fully aware of the bill of quantities along with final approved schedule of the construction project in order to prepare the required material that needed to be ordered and purchased and make sure to deliver the exact time with the precise quantities that they required on site. Radio Frequency Information (RFID) technology can be used to store material information whenever Just-in Time (JIT) method is adopted in specific project. Another point of view, a relationship should reform as "partnership" between contractors and materials suppliers and subcontractors to achieve performance improvement Construction Materials Quantities The daily requirements of materials during the construction project life-cycle need to be determined before assessing delivery methods and schedules. Underestimating or overestimating daily requirements can be counterproductive. There are two major drawbacks results from estimating at the extreme end of the spectrum: First, if there were a shortage in delivered materials that would possibly result in delaying the project. On the other hand, an excess of material on-site would count as waste since it does not add value to the final product. As a result, additional cost will be incurred to the budget for the excess delivery charges and the cost for storage, security as well as insurance. The quantity of material which is delivered on the daily or periodic basis is identified by the requirement of work-in-process. In order to ensure zero-inventory or near zero-inventory, the quantities have to be exact and accurate of construction materials and synchronized with the production plan and schedule.

3.CHALLENGES IN IMPLEMENTING JIT IN CONSTRUCTION

In reality the application of JIT on construction differs from manufacturing industry due to its characteristic. The different characteristics exist for the both industries are in context of different types of production, and because of the greater complexity and uncertainty of construction

There are several reasons why the construction industry

becomes uncertain and complex. The construction industry involves a lot of people with different of body knowledge, skills and experiences. Furthermore, the parties involved in the construction industry have their own objectives and target to be achieved in certain period of time. The situation becomes harder because a single actor's action, ideas and ego sat every stages of construction development may bring different effects to the whole project. Beside of multiple participants in construction development, the number of parts, relative lack of standardization and constraining factors easily make the construction of an automobile factory more difficult than the production of an automobile in that factory. When this complexity is joined with economic pressures to minimize time and cost that uncertainty arises in construction is not surprising

external events, and complex supplier systems. These variables create difficulties in using classic JIT principles efficiently, requiring unique strategies designed specifically for the construction industry. AI technologies have great potential to enhance Just-In-Time (JIT) processes in construction. Construction companies can use AI-driven predictive analytics, machine learning algorithms, and data-based decision-making tools to forecast demand, improve resource distribution, and better project planning and implementation. Construction organizations can leverage AI skills to discover new options for enhancing productivity, reducing costs, and managing risks. This study aims to investigate the possible synergies between Just-In-Time (JIT) and Artificial Intelligence (AI) in the construction sector, with an emphasis on integrating both approaches to reduce costs and time. This research intends to offer helpful information for industry practitioners, policymakers, and researchers looking to improve construction project performance through a thorough investigation that includes literature evaluation, empirical analysis, and qualitative insights. This paper is structured as follows: Section 2 presents a literature analysis of Just-In-Time (JIT), Artificial Intelligence (AI), and its utilization in construction. Section 3 details the research methodology, encompassing data gathering methods and analysis procedures. Section 4 discusses the practical results and in-depth observations obtained from the research. Section 5 concludes by examining the consequences of the results, outlining constraints, and proposing directions for future research. This project intends to enhance lean building techniques and promote the use of AI technology in the construction industry to improve efficiency, sustainability, and innovation.

BENEFITS

1. *Cost Reduction: By minimizing inventory holding costs, reducing waste, and improving process efficiency, JIT can lead to significant cost savings for organizations.*
2. *Improved Quality: JIT focuses on preventing defects and errors through rigorous quality control measures and continuous improvement initiatives, resulting in higher-quality products and services.*
3. *Enhanced Efficiency: JIT streamlines workflows, reduces lead times, and eliminates bottlenecks, leading to improved productivity and resource utilization.*
4. *Greater Flexibility: JIT enables organizations to respond quickly to changes in customer demand or market conditions, enhancing their ability to adapt and compete effectively.*
5. *Customer Satisfaction: By delivering products or services on time and to the expected quality standards, JIT enhances customer satisfaction and loyalty, fostering long-term relationships.*

CONCLUSIONS

From the literature study may papers proposed different strategies for implementing JIT in Construction Industry. The above literature survey one can conclude that even if manufacturing industries and construction firms are different kinds of production systems but a JIT technique can also be applicable to construction. Hence it can be concluded that, in various construction projects, use of just-in-time technique will improve project's productivity, improve work flow, and project durations will shorten. In this phase studied about JIT and preparing questionnaires from various construction companies. Further study continues in next phase to analysis the collected question and suggest the importance of implementing JIT on construction industries.

Integrating Just-In-Time (JIT) with Artificial Intelligence (AI) in the construction sector is crucial due to its ability to transform project management, optimize resources, and enhance overall efficiency. JIT with AI has potential for tackling major difficulties and fostering innovation in the construction industry by reducing costs, boosting productivity, and optimizing project scheduling.

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There are several methods to carry out underwater concreting such as termie method, pumping methods, toggle bag method and bag work method. At present, the Tremie placement method is the standard way of placing high-quality concrete underwater. The other placement method are not able to reliably place high-quality underwater concrete for major structures, although they may find application in special cases. For massive underwater concrete construction of navigation structures, the pump method should be prohibited. There are many challenges that affect the underwater construction. Its remedies are also explained in this article.

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