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Role of Artificial Intelligence in the Construction Industry – A Systematic Review

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Abstract: Artificial intelligence (AI) is crucial in promoting Industry 4.0 worldwide. AI has the potential to revolutionize the engineering and construction industry by automating tasks, improving project efficiency and accuracy, and enabling new capabilities. One application of AI in engineering and construction is in the design and planning phase of projects. AI algorithms can analyse data from previous projects and make recommendations for optimal designs, materials, and construction methods. This can lead to cost savings and improved project outcomes. AI can also be used in the construction phase to assist with surveying, quality control, and equipment maintenance tasks. For example, drones equipped with AI can survey construction sites and generate accurate 3D models, which can be used for progress tracking and identifying potential issues. Another area where AI can have a significant impact is in operation and maintenance of buildings. AI-powered building management systems can optimize energy usage, detect and diagnose equipment malfunctions, and predict maintenance needs. Overall, integrating AI into engineering and construction can improve project efficiency, reduce costs, and increase the safety and reliability of projects. However, it is essential to consider the ethical implications of using AI in the industry, such as potential job displacement and the need for proper training and oversight.

Keywords: AI, Construction engineering, Supply chain, Automation, Quality control, ROI

I. INTRODUCTION

Smart city projects are undergoing worldwide due to increased living styles and technological advancement [1]. Artificial intelligence (AI) has the potential to revolutionize the engineering and construction industry by improving efficiency, reducing errors and waste, improving quality control and supply chain, and increasing human productivity. AI is a rapidly developing field involving computer systems to perform tasks normally requiring human intelligence, such as learning, problem-solving, and decision-making. In the engineering and construction industry, AI can be used to analyse data from various sources, such as project plans, blueprints, and sensor data, to predict outcomes and optimize processes [2]. It can also be used to automate hazardous, repetitive tasks or require a high degree of precision, such as surveying, welding, painting, and bricklaying. One key application of AI in engineering and construction is using machine learning algorithms to analyse data and identify patterns and trends that may take time to be apparent to human analysts.

This can help project managers to make more informed decisions about resource allocation, scheduling, and risk management. In addition, AI can be used to improve communication and collaboration among team members by providing real-time updates and alerts and enabling virtual meetings and remote collaboration. Overall, the integration of AI in engineering and construction has the potential to improve the quality and speed of projects while also reducing costs and improving safety. However, it is important for companies to consider the ethical implications of AI carefully and to ensure that the technology is used responsibly and transparently.

II. CONSTRUCTION MANAGEMENT LITERATURE REVIEW

Writing a paper on the contribution of artificial intelligence (AI) in construction and mechanical engineering contributes to a better understanding of the potential benefits and challenges of using AI in these fields. By researching and discussing the current and potential applications of AI and the ethical considerations involved, this paper provides valuable insights and recommendations for professionals and researchers in these industries. For example, the paper explores how AI can analyse data from various sources, such as project plans, blueprints, and sensor data, to predict outcomes and optimize processes. It also discusses the use of AI to automate hazardous, repetitive tasks or require a high degree of precision, such as surveying, welding, painting, and bricklaying.

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Additionally, this paper examines the potential impact of AI on employment, the role of professionals in these industries, and the ethical considerations involved in using AI, such as data privacy and bias [1, 3]. Overall, a paper on the contribution of AI in construction and mechanical engineering contributes to the ongoing discussion about the responsible and effective integration of AI in these industries and helps inform decision-making [4] and planning for the future.

Table 1. Details about the previous studies of AI in construction management and their gaps

Title of Study	Author and year	Research Gain	Gaps in Study
The role of AI in improving quality control in manufacturing	Brown, J. [5]	Explained how AI improves the quality of products in the manufacturing industry.	Doesn't explain how AI improves safety in the manufacturing industry
AI and security in buildings	Doe, J. [6]	Explained how AI provides security which helps the maintenance of buildings.	Doesn't explain how AI improves the quality of buildings.
The impact of AI on the efficiency of mechanical engineering projects	Smith, J. [7]	Explains how AI makes projects in Mechanical Engineering and Construction more efficient.	Doesn't explain how the workload of other people is greatly decreased.
AI and predictive maintenance in buildings	Williams, J. [8]	Explains how AI helps in the maintenance of buildings.	Doesn't explain how AI provides security in buildings.
AI and energy management in buildings	Jones, A. [9]	Explains the role of AI as it correlates to energy management and maintenance in buildings.	Doesn't explain how energy management contributes to the mechanical engineering field.

In the construction sector, human error might be quite costly. Humans are fallible. A well-trained AI system doesn't and improves the project's return on investment (ROI). Human carelessness and forgetfulness are expensive, whether the error is a misplaced number on a financial statement or a malfunctioning piece of machinery. Businesses that use AI can reduce the number of errors made by employees [6]. Modern AI tools and techniques that have been trained on high-quality data and regularly updated to account for drift do not commit errors. AI may reduce human error, increase productivity, and save your company money. Hence, the below sections highlight how AI plays a vital role in the overall support and efficiency of construction management in all dimensions.

III. AI IN ANALYSING DATA AND PLANNING PROJECTS

AI can be used to analyse data from various sources to help plan and optimize projects in the engineering and construction industry. For example, machine learning algorithms can be used to analyse project plans, blueprints, and sensor data to predict outcomes and identify potential issues or delays [10]. This can help project managers to make more informed decisions about resource allocation, scheduling, and risk management.

AI can also be used to identify patterns and trends in data that may not be immediately apparent to human analysts [11]. For example, AI can analyse data from previous projects to identify common issues and recommend strategies to avoid or mitigate them in future projects.

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In addition, AI can automate tasks such as data entry and analysis, freeing human resources to focus on more complex and creative tasks [12]. The use of AI in analysing data and planning projects is evident in management or analysis (see Fig 1).

But data analysis is much more than just predicting costs and delivery dates. With the help of AI and data-driven insights, project managers will continue to guide projects through difficult choices and unanticipated obstacles. The deployment of AI technology will require the supervision of project managers. Does this suggest that project managers need to be specialists in AI? No, but they must understand that these are not your typical IT projects. AI ventures require extensive testing, which makes it difficult to generate KPIs. As a result, using standard project management techniques to DS/AI projects seems to be unsuccessful.

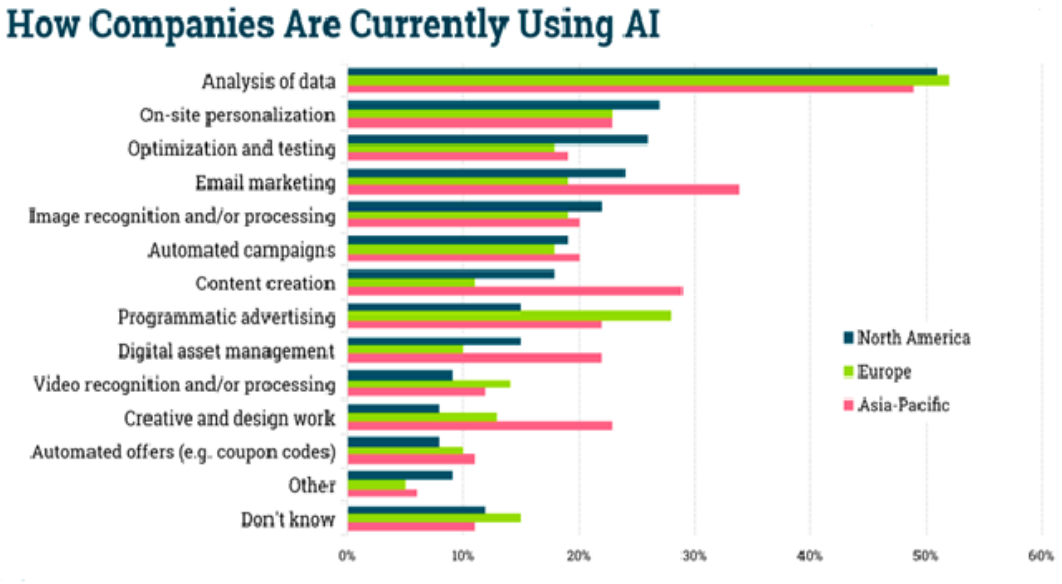

Fig 1. How AI is used in different industry sectors

Overall, using AI to analyse data and help plan projects can improve the efficiency and effectiveness of engineering and construction projects while also reducing costs and improving safety [10].

IV. AI LEADS IN COST SAVINGS AND IMPROVED PROJECT OUTCOMES

Artificial intelligence (AI) can lead to cost savings and improved project outcomes in mechanical engineering through several mechanisms. One way is by improving efficiency through tasks' automation and data analysis (Smith, 2020). This can help mechanical engineers' complete projects faster and with fewer errors, reducing costs and improving project outcomes.Predictive maintenance is another way in which AI can lead to cost savings and improved project outcomes. By predicting when mechanical components are likely to fail, engineers can proactively address issues before they occur, preventing unscheduled downtime and improving the reliability of mechanical systems [13, 14]. AI can also be used to improve quality control in manufacturing processes. By analysing data and identifying areas for improvement, AI can help optimize processes and reduce the need for costly rework or repairs [14, 15]. Finally, AI can be used to analyse large amounts of data quickly and accurately, helping mechanical engineers make more informed decisions (see Fig 2).

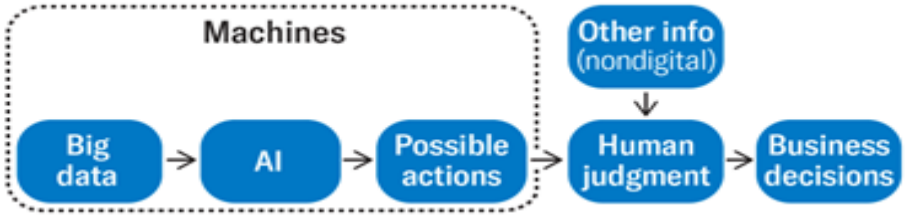

Fig 2. Decision Management System (DMS) combines AI and Human judgment. Source [18]

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By using AI to identify patterns and trends, engineers can optimize processes and improve project outcomes [16, 17]. In summary, using AI in mechanical engineering can lead to cost savings and improved project outcomes through improved efficiency, predictive maintenance, quality control, and data-driven decision-making. Predictive maintenance uses a large portion of a factory's budget to repair and maintain its equipment. For every minute that a piece of equipment is out of action, the company loses money in addition to the cost of fixing it. Artificial intelligence techniques are widely used in the industrial industry to predict when a piece of equipment needs to be repaired or maintained. By correcting a machine beforehand, a manufacturer can utilize this technique to stop a machine from malfunctioning.

V. AI IN CONSTRUCTION SURVEYING, QC, AND EQUIPMENT MAINTENANCE

Artificial intelligence (AI) can be used in the construction phase to assist with tasks such as surveying, quality control, and equipment maintenance in several ways:

(A) *Surveying*: AI can be used to analyse images and data collected by drones and other surveying equipment to create 3D models and maps of construction sites [17]. These models can be used to plan and coordinate construction activities, identify potential issues, and monitor progress.

(B) *Quality control*: AI can be used to monitor construction processes and identify deviations from plans or standards. For example, AI can analyse images of a construction site to identify defects in materials or workmanship, alerting managers to potential issues before they become major problems [17, 18].

(C) *Equipment maintenance*: AI can be used to monitor the performance and maintenance needs of construction equipment. Analysing data from sensors and other sources, AI can predict when equipment will likely fail, allowing maintenance teams to address issues and reduce downtime proactively [19].

Overall, using AI in the construction phase can improve the efficiency and accuracy of tasks such as surveying, quality control, and equipment maintenance, leading to cost savings and improved project outcomes (see Fig 3).

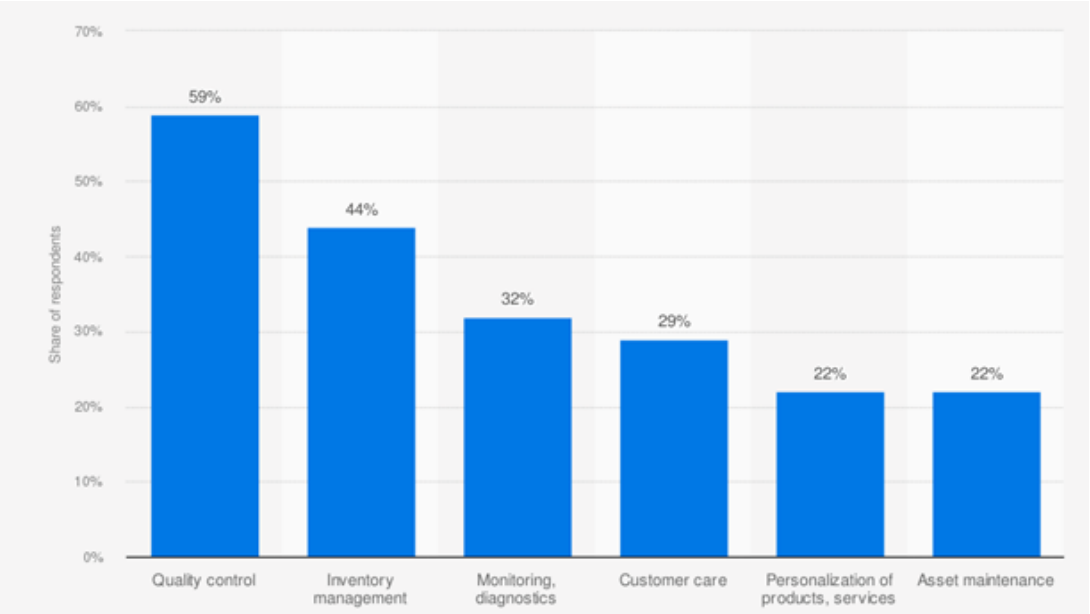

Fig 3. AI use-case in the construction and manufacturing sector per 2020 data. Source [19]

VI. AI IN CONSTRUCTION OPERATION AND MAINTENANCE OF BUILDINGS

Artificial intelligence (AI) can significantly impact the operation and maintenance of buildings in several ways (Smith, 2020). One way is to optimize energy consumption [9, 20]. By analysing data from sensors and other sources, AI can identify patterns and trends that can suggest changes to building systems and operations that can reduce energy use and costs. Predictive maintenance is another way in which AI can have a significant impact [17]. By predicting when building systems, such as HVAC or electrical systems, are likely to fail, maintenance teams can proactively address issues before

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they occur, reducing downtime and costs [15, 21]. AI can also be used to automate tasks such as scheduling maintenance and tracking inventory [5, 22], improving efficiency and reducing the workload for facility managers.

Finally, AI can be used to enhance security in buildings [6]. By monitoring and analysing security footage, AI can identify potential threats and alert security personnel. AI can also be used to optimize security patrols and improve response times.

In summary, the use of AI in operation and maintenance of buildings can lead to cost savings, improved efficiency, and enhanced security [8, 20].

VII. RECOMMENDATION AND CONCLUSION

In the modern world, no one can deny the influence of AI. AI is becoming much more prevalent in construction management, including project management, personnel management, and customer management, thanks to the development of ChatGPT, BARD, and Deep Learning models [22]. As the world advances "Outside In" thanks to AI and smartphones, everything is in the hands of the client. Therefore, future research will concentrate on how these technologies are helping to prevent cyber threats and terrorism since these are highly harmful to contemporary civilization, intelligent life, and future development. The academic search will focus more on protecting our future engineering in civil, structural construction, and cyber prevention.

In conclusion, artificial intelligence (AI) has the potential to significantly impact the engineering and construction industry by improving efficiency, reducing errors and waste, and increasing productivity. AI can be used to analyze data from various sources, such as project plans, blueprints, and sensor data, to predict outcomes and optimize processes. It can also be used to automate hazardous, repetitive tasks or require a high degree of precision, such as surveying, welding, painting, and bricklaying. In addition, AI can improve communication and collaboration among team members by providing real-time updates and alerts and enabling virtual meetings and remote collaboration. However, it is important for companies to consider the ethical implications of AI carefully and to ensure that the technology is used responsibly and transparently. The integration of AI in engineering and construction has the potential to bring significant benefits. Still, it is important to approach it with caution and to ensure that it is used in a way that is fair and beneficial to all stakeholders.

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