

Artificial Intelligence in Building Construction — A Review

Dr. Manoj Hedao¹, Arpita Bhadre², and Harshada Parkhi³

¹, *Adjunct Faculty, Department of Civil Engineering, Government College of Engineering, Amravati, [M.S] India*

^{2,3} *UG Scholar Department of Civil Engineering, Government College of Engineering, Amravati, [M.S] India*

Abstract—The construction industry plays a vital role in driving economic growth by providing infrastructure, creating employment opportunities, and supporting overall societal and economic development. Despite its significance, much construction work continues to rely on manual labor and traditional methods, often leading to delays, inefficiencies, increased costs, and lower productivity. Compared to other sectors, construction has been slow in adopting digital technologies, making it one of the least digitalized industries. In recent years, the integration of Artificial Intelligence (AI) has emerged as a promising approach to overcome these challenges. AI applications in construction can enhance planning, scheduling, design optimization, risk management, and quality control, resulting in improved decision-making, higher operational efficiency. By processing and analyzing large volumes of project data, AI enables accurate forecasting, better resource allocation, early identification of risks, and real-time monitoring of activities. However, implementing AI faces challenges, including high initial costs, shortage of skilled professionals, and difficulties in integrating AI tools with existing systems and workflows. This paper examines various AI tools, techniques, and emerging trends transforming construction processes, management practices, and project outcomes. Special attention is given to AI's role in enhancing construction site safety through advanced surveillance systems, hazard detection algorithms, and predictive risk management, which is particularly important given the higher rate of accidents and fatalities in construction compared to other industries. Overall, adopting AI in construction has the potential to make operations more precise, efficient, sustainable, and safer, representing a major step toward the digital transformation and modernization of this critical sector [1].

Index Terms—Artificial Intelligence, Construction industry, Construction management, Machine Learning, Building Information Modelling.

I. INTRODUCTION

The construction sector is essential for developing national infrastructure and stimulating economic progress. From residential housing to large-scale industrial projects, construction activities contribute significantly to employment, trade, and technological progress. Although it plays a major role in the economy, construction has lagged behind in adopting digital technologies. Many construction processes still depend on manual labor, paper-based documentation, and conventional project management practices. This reliance often results in inefficiencies, delays, cost overruns, and communication gaps among stakeholders, making project delivery more challenging.

In recent years, the global push for digital transformation has created opportunities for innovation in construction. One of the most promising developments is the integration of Artificial Intelligence (AI) into construction processes. AI extends beyond robotics and automation to include data-driven decision-making, predictive analytics, computer vision, and intelligent resource management. By processing large volumes of data with speed and accuracy, AI can optimize nearly every stage of a project—from planning and design to execution, monitoring, and post-construction evaluation.

In construction management, AI can transform project planning, scheduling, and control. Machine learning algorithms can predict risks, recommend preventive measures, and adjust schedules in real time based on site conditions. Computer vision systems can automatically monitor progress, detect safety violations, and ensure quality standards without continuous manual supervision. AI-powered tools also assist in resource allocation, promoting efficient use of labor, materials, and equipment, thereby reducing waste and enhancing on-site safety. Additionally, AI can facilitate predictive maintenance of machinery, ensuring minimal downtime and extending equipment lifespan.

Moreover, AI improves collaboration among architects, engineers, contractors, and clients by providing accurate, up-to-date project information. When integrated with Building Information Modelling (BIM), AI can forecast material requirements, estimate costs more precisely, and identify design conflicts before they affect construction. AI can also support sustainability goals by optimizing energy use, minimizing carbon emissions, and promoting eco-friendly construction methods. As the industry faces growing pressure to deliver sustainable and cost-effective solutions, adopting AI-driven strategies has become essential.

Modern construction projects are becoming increasingly complex, requiring coordination among multiple teams, advanced materials, and sophisticated technologies. Traditional methods alone are often insufficient to meet the growing demands for faster project delivery, higher quality, and cost efficiency. By leveraging innovative tools like Artificial Intelligence, the industry can analyze large amounts of data, predict potential risks, optimize resource allocation, and streamline workflows. This integration not only improves operational efficiency but also enhances safety, reduces waste, and supports sustainable construction practices, making projects more reliable and environmentally responsible. Figure 1 highlights key challenges in modern construction.

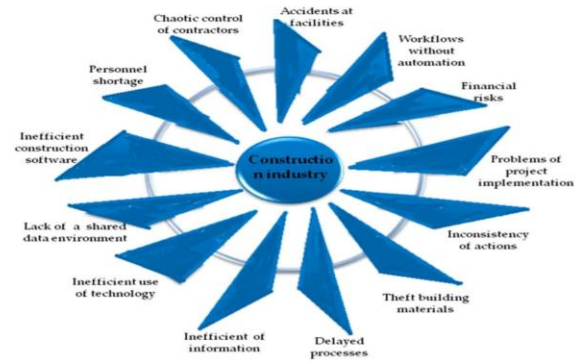


FIGURE 1: KEY PROBLEMS OF MODERN CONSTRUCTION INDUSTRY [2].

This paper explores the tools, trends, and applications of AI in construction processes, with a particular focus on its role in construction management. By analyzing current practices, potential benefits, and future directions, it aims to highlight how AI can address existing industry challenges and pave the way for a more efficient, safe, and sustainable construction future.

II. CONSTRUCTION INDUSTRY

The construction industry is highly interdisciplinary [3], which makes it difficult for newcomers to enter, and the productivity of existing professionals is often relatively low [4]. Even with the recent introduction of BIM and other 3D modeling software, some personnel have struggled to adapt to these new methods, and many users have reported that they remain inefficient. These challenges affect not only architectural design but also on-site construction processes. The emergence of Artificial Intelligence (AI) has helped address a significant portion of these issues. Additionally, the world is currently experiencing demographic aging, which is expected to substantially impact the future workforce [3], particularly in labor-intensive sectors such as construction.

III. ARTIFICIAL INTELLIGENCE (AI)

refers to the capacity of machines and computer programs to carry out tasks that normally demand human reasoning, such as data analysis, decision-making, and problem-solving. Unlike conventional software, AI has the ability to learn from historical data, detect patterns in extensive datasets, and make

informed predictions. In construction, AI is increasingly used to simplify operations, improve safety, coordinate complex processes, support sustainable practices, and enhance overall project efficiency [5]. Following are some subfields of AI.

A. Natural Language Processing (NLP)

NLP enables systems to interpret and process human language. Within construction projects, AI can help analyze contracts, inspection reports, and verbal instructions, reducing mistakes and saving time. It can also pull key insights from large volumes of documentation, enabling managers to make faster and more informed decisions [6]

B. Computer Vision

Computer vision enables AI systems to understand and analyze visual data, such as images and video footage. On building sites, it can monitor progress, evaluate material quality, identify structural flaws, and recognize safety risks. By identifying such issues early, computer vision reduces the likelihood of accidents and ensures better quality outcomes [6].

C. Expert Systems

Expert systems apply stored expert knowledge to recommend appropriate construction practices. These systems support engineers in selecting appropriate materials, choosing the right equipment, and deciding on construction methods, enabling decisions that are both effective and dependable [6]

D. Robotics

Robots are used on construction sites to handle tasks that are repetitive, dangerous, or physically demanding. By handling these tasks, they help increase productivity and reduce the likelihood of accidents for human workers [6]

E. Planning and Scheduling

AI-powered tools help plan project timelines, allocate resources efficiently, and adjust schedules dynamically when unexpected delays occur. This ensures that projects remain within budget, on time, and adaptable to unexpected changes [6].

F. Knowledge-Based Systems (KBS)

Knowledge-Based Systems (KBS) use accumulated expert knowledge to provide reasoned guidance on

construction activities. They assist in estimating costs, assessing safety risks, and checking design accuracy, ensuring reliable and consistent support throughout different projects [6].

G. Machine Learning (ML)

Machine learning uses historical project data to continuously enhance its predictions and decision-making capabilities. In construction, ML can predict delays, identify quality issues, estimate costs, and improve resource allocation [6]. Machine learning has following types:

H. Supervised Learning (SL)

Supervised Learning (SL) involves training AI models on labeled data so they can make predictions, such as identifying high-risk zones or estimating project completion timelines [7].

I. Deep Learning (DL)

Detects complex patterns and supports decision-making, such as identifying hidden structural defects or anticipating site hazards [6].

By combining these AI technologies, construction projects can be planned more effectively, risks can be managed better, and overall performance is improved [7].

IV. ARTIFICIAL INTELLIGENCE IN CONSTRUCTION INDUSTRY

Artificial intelligence is increasingly supporting and transforming the construction sector. AI is driving significant changes in construction by enabling higher levels of automation, improving efficiency, and enhancing accuracy throughout project workflows. Some key ways in which AI is reshaping the construction industry are highlighted below [8].

A. Construction Planning

Artificial Intelligence significantly contributes to the design and planning of construction project plans. Autonomous machinery, considered a form of AI, can sense its environment and navigate without direct human input. During the planning phase, such equipment can survey construction sites and gather detailed information to generate 3D maps, blueprints, and comprehensive construction plans. Tasks that once required weeks can now be completed in a single

day, resulting in substantial time and cost savings for construction firms [9].

B. Administrative Roles

Once construction begins, AI assists in managing projects and coordinating tasks. It also supports office functions; for instance, employees' sick days, sudden vacancies, or absences can be entered into a data system, and AI automatically reassigns tasks to maintain workflow continuity [10].

C. Construction Execution

AI keeps engineers informed about optimal methods and strategies for projects by leveraging extensive historical data. For example, while designing a new bridge, AI systems can suggest construction approaches based on decades of past projects and verify existing blueprints for the design and implementation stages. This allows engineers to make informed, evidence-based decisions. Additionally, autonomous machinery improves safety on-site, allowing operators to remain outside vehicles while they perform tasks at dangerous heights using GPS and sensors to select the safest paths [11].

D. Autonomous Vehicles

Self-operating bulldozers, cranes, and other construction vehicles can ensure consistent productivity. Beyond self-driving freight and personnel transport, these systems offer further efficiency and reliability benefits [12].

E. Robots on Site Powered by AI and Machine Learning

AI is revolutionizing conventional construction methods. Robotic bricklayers are already being deployed, and in the future, such robots could construct buildings in extreme or hazardous environments, reducing human exposure to dangerous tasks [13].

F. Safety Sensors

The Internet of Things (IoT) is not only making homes smarter but also enhancing jobsite safety. Wearable sensors, such as Spot-r, monitor worker locations and send alerts in case of slips, falls, or accidents [14].

G. Drones Deploying

The use of drones and mapping software, such as Drone Deploy, significantly reduces the time needed for accurate site surveys, maps, and aerial images. This technology allows project managers to monitor progress remotely and gain additional perspectives to detect issues or conflicts that might not be visible from the ground [14].

V. ARTIFICIAL INTELLIGENCE IN CONSTRUCTION MANAGEMENT

Recent developments in construction technology have greatly enhanced the quality of buildings and helped complete projects more quickly. Managing a construction project involves a variety of responsibilities, including planning, coordinating resources, budgeting, and supervising on-site activities. Traditionally, these tasks have relied heavily on engineers using standard software tools. Progress tracking often involves manual activities such as taking photographs, recording updates, and preparing detailed reports. Similarly, safety on construction sites has usually been maintained through direct supervision and hands-on monitoring [15]. Future developments may include:

A. Predictive Project Planning

Artificial Intelligence (AI) is now transforming these processes by enabling predictive planning. By analyzing historical project data—such as schedules, costs, resource use, and past risk events—AI can identify patterns and potential challenges before they occur. Armed with this information, project managers can modify schedules, reassign resources, or implement specific strategies to manage potential risks. By taking a proactive approach, project managers can reduce uncertainty, improve overall supervision, and enhance the chances of completing projects according to timeline and budget constraints [16,17].

B. Automation in Safety Monitoring

Safety management also benefits from AI through systems equipped with cameras and sensors that continuously monitor worker behavior, equipment use, and site conditions. AI systems continuously monitor for unsafe behaviors, such as neglecting to wear protective equipment, entering dangerous zones,

or using tools incorrectly. When such risks are detected, supervisors receive immediate alerts, allowing them to take swift action to prevent accidents. These systems also keep comprehensive logs of all safety-related events, which support audits, ongoing risk assessments, and the continual improvement of safety practices on construction sites [18].

C. Optimized Resource Allocation

Efficient use of materials, labor, and equipment is essential for smooth project execution. AI can accurately predict the quantities of materials required at different stages and assign personnel based on their skills and availability. These improvements contribute to reducing material waste, cutting expenses, streamlining project workflows, and promoting environmentally sustainable construction practices [17,19].

D. Robotics Integration

Integrating AI with robotics takes this further by automating labor-intensive or hazardous tasks, such as bricklaying, welding, concrete pouring, and site inspections. AI-powered robots can adjust to evolving site conditions, improve their performance through learning, and minimize mistakes that might result from human fatigue or variability. Incorporating these robotic systems into construction enhances efficiency, accelerates project timelines, increases safety, and helps address labor shortages [18,20].

E. Intelligent Building Maintenance

Intelligent maintenance is another area where AI has a major impact. Buildings equipped with IoT sensors generate real-time data on structural strain, vibrations, temperature, humidity, and cracks. AI examines building data to detect potential structural issues at an early stage. By enabling predictive maintenance, it allows timely interventions that can prevent serious damage. By adopting this strategy, costly emergency repairs are reduced, the building's lifespan is extended, and safety is enhanced. In addition, this approach helps control maintenance expenses more effectively and strengthens the building's ability to withstand both operational demands and environmental pressures [16,17]

F. Enhanced BIM Capabilities

When AI is combined with Building Information Modeling (BIM), digital models become dynamic, interactive tools that actively assist in managing construction projects. AI can identify conflicts among architectural, structural, and mechanical, electrical, and plumbing aspects in the design phase, helping avoid high-cost on-site fixes. AI can also integrate live data from sensors and drones, providing managers with up-to-the-minute information on construction progress, quality standards, and regulatory compliance. In addition, it can forecast future maintenance and operational expenses, supporting better long-term planning and management of construction assets [16,20].

VI. AI FOR COST ESTIMATION, CONTRACTS AND MANAGEMENT

Artificial Intelligence plays a significant role in building facilities management by assisting with strategic planning, supporting bidding decisions, predicting construction timelines, and estimating the costs involved in construction projects [21]. Digital tools for cost estimation and contract management are extensively implemented to enhance the efficiency of project workflows during the planning phase [22]. Obtaining precise cost estimates during the early stages of a construction project is essential for making well-informed planning and budgeting decisions [2].

VII. CHALLENGES AND LIMITATIONS OF AI IN CONSTRUCTION

While Artificial Intelligence provides numerous benefits to the construction industry, its implementation is accompanied by several significant challenges. Construction projects are inherently complex, subject to constant change, and often lack consistent and high-quality data needed for AI applications. Furthermore, technical, financial, social, and ethical factors influence the successful adoption of AI. The following outlines some of the main obstacles faced when integrating AI in construction.

A. Data Scarcity and Quality Concerns

The application of AI in data analysis and site monitoring raises ethical issues, including concerns over worker privacy and the protection of confidential data. In construction, however, data often comes from a variety of fragmented sources, including site sensors,

BIM models, and manual records, which can be incomplete, inconsistent, or contain errors. The presence of low-quality data directly impacts the accuracy of AI predictions and decision-making, limiting its practical effectiveness in real-world construction scenarios [16,17].

B. Complexity of Construction Environments

Construction sites are dynamic and unstructured, with frequent changes in layout, weather conditions, human activities, and unexpected events. AI systems may find it challenging to adjust quickly and make accurate decisions in these fast-changing, complex environments. This unpredictability presents major obstacles for AI-driven automation and real-time decision-making [20].

C. Integration Challenges with Existing Systems

Most construction firms operate multiple legacy software platforms and tools. Incorporating AI technologies into these heterogeneous and sometimes outdated systems is technically challenging and expensive. The lack of standardization and interoperability among different platforms can hinder seamless AI integration, reducing the practical benefits of deployment [20].

D. High Costs and Resource Demands

Adopting AI in construction demands significant spending on hardware (like IoT devices and computing systems), software, and professionals experienced in both AI and construction management. For smaller firms, the high costs and need for specialized expertise can make adoption difficult, potentially slowing the wider implementation of AI in the industry [18].

E. Resistance to Change and Workforce Concerns

The construction industry often maintains a traditional approach, which can result in resistance to adopting new technologies. Workers and managers may be hesitant to trust AI due to concerns over job displacement, lack of confidence in automated decision-making, or disruption of established workflows. This social and cultural resistance impedes the integration of AI and diminishes its potential advantages [16].

F. Ethical, Legal, and Privacy Considerations

The use of AI for monitoring and analyzing construction operations introduces critical ethical, legal, and privacy issues, including safeguarding employee rights, regulating surveillance practices, and protecting confidential data. Moreover, ongoing legal ambiguities, such as determining accountability when AI systems make errors in safety supervision or project management, present ethical and legal obstacles that may slow the broader adoption of AI in construction [17,18]. Dependence on Continuous Data and System Maintenance AI systems require continuous real-time input from devices such as sensors, cameras, and monitoring equipment. Any disruptions—like device failures, connectivity problems, or inadequate upkeep—can compromise their performance. Ensuring stable infrastructure and maintaining system operations adds operational challenges and raises overall costs [17].

VIII. FUTURE OF AI IN CONSTRUCTION INDUSTRY

The future of AI in the construction industry holds tremendous promise, with the potential to fundamentally transform workflows, enhance project outcomes, and improve overall efficiency. As AI continues to evolve, the construction sector is likely to witness the emergence of more practical and innovative applications across its operations in the coming years.

A. Advanced Predictive Analytics for Project Management

AI will continue to evolve, offering highly accurate and detailed predictions for project timelines, budget requirements, and risk factors. By utilizing larger datasets—including real-time IoT sensor inputs and external influences such as weather patterns or market trends—AI will enable highly responsive and adaptive project planning. Such predictive insights enable managers to apply effective risk management strategies and make well-informed, data-driven decisions with higher confidence [16,17].

B. Fully Autonomous Construction Robotics

The integration of AI with robotics is advancing toward the development of fully autonomous machines able to perform complex construction

activities—such as structural assembly, finishing tasks, and quality checks—with little human involvement. This evolution is expected to greatly enhance productivity, accuracy, and safety on construction sites, while lowering dependence on manual labor [18,20].

C.AI-Enhanced Building Information Modelling (BIM)

AI is expected to enhance BIM by enabling real-time simulation and optimization of construction processes, automating material procurement, and supporting lifecycle planning. A deeper AI-BIM integration will pave the way for smart buildings capable of tracking their own performance, optimizing energy consumption, and managing maintenance needs throughout their lifespan [16,20].

D.Personalized and Adaptive Workforce Management

AI-driven platforms will tailor workforce scheduling and training programs based on the analysis of individual skills, health data, and performance metrics. This personalized approach will optimize labor efficiency and workplace safety while fostering continuous skill development and professional growth among construction personnel [17].

E. Sustainability and Green Construction

AI will take a key role in advancing sustainable construction by improving material efficiency, cutting down waste, and lowering environmental impact. Future AI systems will assess real-time environmental footprints and recommend eco-friendly alternatives in construction materials and methods, supporting the development of greener building projects [19].

F. Integration with Emerging Technologies

AI will increasingly collaborate with emerging technologies such as augmented reality (AR), virtual reality (VR), drones, and 5G networks. This integration will facilitate immersive site monitoring, remote inspections, and real-time collaboration among stakeholders, thereby improving construction efficiency, reducing errors, and enhancing decision-making processes [17].

G. Enhanced Safety and Risk Management

Next-generation AI systems will utilize deep learning and multi-sensor data fusion to anticipate potential

hazards before they occur. By analyzing behavioral patterns and site activities, these systems will recommend personalized interventions, enabling preemptive safety measures and reducing the likelihood of accidents [18].

VII. CONCLUSION

Artificial Intelligence is reshaping the construction industry by improving key areas such as project planning, safety management, resource allocation, robotics integration, facility maintenance, and Building Information Modeling (BIM). Through the use of predictive analytics and automation, AI enables construction projects to achieve higher efficiency, stronger safety standards, and greater sustainability.

Nevertheless, the adoption of AI faces several challenges, such as limitations in data quality, integration with existing systems, high deployment costs, resistance from the workforce, and ethical concerns. Addressing these challenges will require not only advancements in technology but also shifts in organizational culture, management approaches, and policy frameworks.

Looking forward, AI's role in construction is poised to expand further, with developments including fully autonomous construction robots, improved human–AI collaboration, more intelligent BIM tools, and stronger support for sustainable and green construction practices. With ongoing innovation and careful implementation, AI has the potential to substantially improve construction management, making the industry more adaptive, efficient, and environmentally responsible.

REFERENCES

- [1] Z. Zhou, J. Irizarry, and Q. Li, "Applying advanced technology to improve safety management in the construction industry: A literature review," *Construction Management and Economics*, vol. 31, no. 6, pp. 606–622, 2013.
- [2] S. Ivanova, A. Kuznetsov, R. Zverev, and A. Rada, "Artificial Intelligence Methods for the Construction and Management of Buildings," *Sensors*, vol. 23, no. 21, Art. no. 8740, 2023.
- [3] M. Zhao and J. Hu, "Application of artificial intelligence technology in housing construction,"

- Residential & Real Estate, no. 22, pp. 243–244, 2021.
- [4] J. Qi, J. Wang, and B. Zhang, “BIM design of residential buildings combined with AI,” *Building Structure*, no. S2, pp. 1263–1266, 2021.
- [5] R. Parveen, “Artificial Intelligence in Construction Industry: Legal Issues and Regulatory Challenges,” *International Journal of Civil Engineering and Technology (IJCET)*, vol. 9, no. 13, pp. 957–962, 2018.
- [6] C. N. Egwim, H. Alaka, E. Demir, H. Balogun, R. Olu-Ajayi, I. Sulaimon, G. Wusu, W. Yusuf, and A. A. Muideen, “Artificial Intelligence in the Construction Industry: A Systematic Review of the Entire Construction Value Chain Lifecycle,” *Energies*, vol. 17, no. 1, Art. no. 182, 2024.
- [7] M. S. Kuttimarks, K. A. Sarosh, R. M. Swamy, et al., “Artificial intelligence in construction industry – a review,” *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, vol. 11, no. 5, pp. 612–618, 2023.
- [8] D. Khan, “Artificial Intelligence in Building Construction,” *International Journal of Research in Engineering and Science (IJRES)*, vol. 11, no. 5, pp. 612–618, 2023.
- [9] K. Booth, “The Impact of Artificial Intelligence in the Construction Industry,” *BDC Magazine*, 2018.
- [10] Y. R. Reddy, “Applications of artificial intelligence and machine learning in geotechnical engineering,” *International Journal of Emerging Technologies and Innovative Research*, vol. 4, no. 2, pp. 425–428, 2017.
- [11] T. Wadlow, “Feature: How Artificial Intelligence Supports Construction Industry,” *Construction Global Weekly*, 2018.
- [12] P. Debney, “How Artificial Intelligence is Changing the Construction Industry,” *Artificial Intelligence News*, 2018.
- [13] Y. R. Reddy, “Applications of artificial intelligence and machine learning in geotechnical engineering,” *International Journal of Emerging Technologies and Innovative Research*, vol. 4, no. 2, pp. 425–428, 2017.
- [14] R. Bharadwaz, “AI Applications in Construction and Building – Current Use-Cases,” *Emerj*, 2018.
- [15] S. K. Baduge, S. Thilakarathna, and J. S. Perera, “Artificial intelligence and smart vision for building and construction 4.0: Machine and deep learning methods and applications,” *Automation in Construction*, vol. 141, Art. no. 104440, 2022.
- [16] H. Li, Y. Pan, and M. Skitmore, “Artificial intelligence applications in construction engineering and management: A review,” *Automation in Construction*, vol. 89, pp. 110–121, 2018.
- [17] Y. Pan and S. Zhang, “Artificial intelligence in construction management: Current status and future outlook,” *Journal of Construction Engineering and Management*, vol. 147, no. 5, Art. no. 04021037, 2021.
- [18] A. Darko, A. P. C. Chan, and E. E. Ameyaw, “Artificial intelligence in safety management: Applications and challenges,” *Safety Science*, vol. 130, Art. no. 104891, 2020.
- [19] J. K. W. Wong and J. Zhou, “Enhancing environmental sustainability over building life cycles through green BIM: A review,” *Automation in Construction*, vol. 57, pp. 156–165, 2015.
- [20] T. Bock, “The future of construction automation: Technological disruption and the upcoming ubiquity of robotics,” *Automation in Construction*, vol. 59, pp. 113–121, 2015.
- [21] H. Anysz, A. Foremny, and J. Kulejewski, “Comparison of ANN classifier to the neuro-fuzzy system for collusion detection in the tender procedures of road construction sector,” *IOP Conference Series: Materials Science and Engineering*, vol. 471, Art. no. 112064, 2020.
- [22] L. Dimitriou, M. Marinelli, and N. Fragakakis, “Early bill-of-quantities estimation of concrete road bridges: An artificial intelligence-based application,” *Public Works Management & Policy*, vol. 23, pp. 127–149, 2018.