



Building the Future: Robotic and Automation in Construction Industry

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ABSTRACT: The construction industry, traditionally reliant on manual labor and conventional processes, is undergoing a transformative shift with the integration of robotics and automation. This technological evolution aims to enhance productivity, safety, and precision while addressing challenges such as labor shortages, project delays, and rising costs. Robotics applications in construction include automated bricklaying, 3D printing of structures, drone-based site monitoring, and robotic machinery for heavy lifting and repetitive tasks. Automation streamlines project management through smart systems, real-time data analysis, and predictive maintenance, enabling efficient resource allocation and reducing human error. This paper explores the current advancements, practical implementations, and potential impacts of robotic and automated systems on construction workflows. By adopting these innovations, the construction sector is positioned to achieve faster project delivery, improved quality, and sustainable practices, ultimately building the future of infrastructure development.

KEYWORDS: 3D printing, Underwater waste detection, deep learning, object detection, Robotics.

I. INTRODUCTION

Historically, the construction industry has lagged behind other sectors, such as manufacturing and automotive, in adopting automation technologies. The reliance on manual labour and conventional tools often results in inefficiencies, cost overruns, and inconsistent quality. Furthermore, global challenges such as skilled labour shortages, tight project timelines, and safety risks have intensified the demand for innovative solutions.

Robotics and automation provide promising answers to these challenges. Technologies like robotic bricklayers, concrete-printing machines, and autonomous site inspection drones are already being implemented in some advanced construction projects worldwide. Automation systems such as Building Information Modelling (BIM), AI-driven scheduling tools, and prefabrication robots further optimize project management and execution.

By leveraging these technologies, the construction industry can achieve higher productivity, enhanced precision, and safer working environments. This project aims to explore the evolution, current applications, and future potential of robotics and automation in the construction sector, focusing on their transformative impact on efficiency and sustainability.

II. LITERATURE REVIEW

Khoshnevis (2004) introduced the concept of Contour Crafting, an automated 3D printing technology capable of constructing large-scale concrete structures layer by layer. This innovation demonstrated that automation could drastically reduce construction time and labor requirements.

Similarly, Balaguer and Abderrahim (2008) discussed the evolution of various robotic systems designed for tasks such as bricklaying, material handling, and inspection. They highlighted that the main barriers to implementation included high costs, complex site conditions, and lack of standardization.

Automation in construction extends beyond physical robots to include digital systems for design, scheduling, and project management.



According to Bock and Linner (2016), the concept of robotic industrialization emerged to address inefficiencies in traditional construction. Their work emphasized modularization, prefabrication, and robotic assembly as the foundation for automation in construction

Mehmet Sakin (2017) had recommended 3D Printing of Buildings: Construction of the Sustainable Houses of the Future by BIM . Building Information Modelling is an integrated process designed to create and manage building data from design through construction. It can also be used in building maintenance, life cycle, cost analysis and operations. Integration of BIM method with 3D printing modelling will be effective for better design, cost reduction, energy efficiency and isolation of a structure.

Akshath (2017) compared the traditional and human operated systems with autonomous robotics technology. mention various robotic technology used in construction industry i.e. Semiautonomous Robot. Concrete Crusher, Fireproofing spray robot, Steel-beam positioning manipulator, Ceiling-panel positioning robot, Wall-finishing robot, Spray-coating robot etc. and concluded that robots can be completed work at faster rate as compared to traditional method .

Pathan.Md Rafi (2019) an integration of REVIT and PRIMAVERA was carried out for preparation of 5D applications of BIM in construction scheduling and cost estimation. Cost estimation can be done using REVIT and PRIMAVERA software by interlinking both construction schedule and cost estimation. The scheduling of the project can be done using REVIT architecture scheduling, PRIMAVERA P6, and micro soft Excel sheet. From this integration of REVIT and A Review of Automation & Robotics for Semantic Construction (IJSRD/Vol. 10/Issue 3/2022/028) All rights reserved by www.ijrsrd.com 97 PRIMAVERA it concluded that the integration of BIM used for evaluating activities, resources allocation and for visualizing the project using 5D applications of BIM in construction management.

Pan and Zhang (2020) emphasized that the combination of Artificial Intelligence (AI), Machine Learning (ML), and Internet of Things (IoT) technologies supports predictive maintenance, automated decision-making, and real-time monitoring of construction activities.

Recent developments in autonomous machinery—such as self-driving excavators, robotic welders, and drones—have demonstrated that automation can significantly improve safety and reduce dependence on human labor for hazardous or repetitive tasks.

Xiaojuan Li (2021) carried a case study of highrise building project in China to develop the process of integrating VE and BIM. VE can used to identify highcost elements, appropriate construction materials and for developing a construction site management plan and BIM was used to develop cost information and to proposed changes. The integration of BIM in VE approach showed a saving of 10% in project cost and duration.

S. B. Umesh¹ and U. Sindhu Vaardini (2023)An in-depth examination of the difficulties in the field of construction robots is required to completely deliver the promise of technological breakthroughs in the construction business. Robotics integration has the potential to improve productivity, safety, and efficiency, but the technology's slow adoption suggests that significant barriers remain. The goal of this research is to thoroughly identify and investigate these limitations, providing insight into specific challenges limiting the widespread deployment of robotics in construction projects. Robotics in building projects shows huge potential for altering traditional construction techniques. In the construction business, the scope of robotics is complex, that extend different applications to improve efficiency, safety, and overall project outcomes. Despite the considerable promise, problems such as economic concerns, integration issues, and legal frameworks must be overcome before robotics in construction can be widely adopted. Robotic bricklaying, masonry, and welding improve precision and uniformity while lowering labor costs and shortening project schedules. Continued research and development in this subject is critical to realizing robotics' full potential, assuring its seamless integration into construction projects, and driving an industry model change.

III. RESEARCH METHODOLOGY

SURVEY FINDINGS

3.1.1 ADOPTION AND INTENT

- In a global survey of about 1,900 construction firms (Europe, US, China) commissioned by ABB Robotics:
 - o 91% of respondents expect a skills crisis in the next 10 years; 44% currently struggle to recruit for construction jobs.
 - o Only 55% of construction companies reported that they currently use robots, compared with 84% in automotive and 79% in manufacturing.

- o Yet — 81% indicated they will introduce or increase robotics/automation in the next decade.
- Survey by Built Worlds shows that although positive sentiment toward construction robotics has risen sharply (good or better evaluations rose from ~74% to ~95%), the actual reported deployment dropped from 65% to 46% of respondents.

3.1.2 IMPACT AND METRICS

- A study titled “Safety, quality, schedule, and cost impacts of ten construction robots” found:
 - o Robots reduced repetitive site work by 25-90%, hazardous task time by ~72% on average.
 - o Accuracy improved by ~55%; rework was reduced by >50%.
 - o Cost reduction averaged 13% (but some cases increased costs).
- From the “Robotics in the Construction Industry: A Bibliometric Review of Recent Trends and Technological Evolution” article: research output grew ~320% from 2015 to 2022, showing increasing academic and industry interest.

3.1.3 TECHNOLOGY READINESS AND CHALLENGES

- From the bibliometric review: dominant clusters include autonomous navigation, human–robot collaboration, sustainability driven automation. However: gaps remain in cost/benefit analyses, real world implementation, interoperability, and human robot integration.
- From other survey/literature: barriers include high initial investment, low technology literacy, maintenance & upgrade costs, adaptation to dynamic sites.
- A survey of sensing & robotics technologies for civil infrastructure mentions that many robotic systems are still in inspection rather than full automation/deployment phases.

IV. RESULTS AND DISCUSSION

4.1.1 ROBOTIC BRICK LAYING SYSTEM

- **Function:** Automate repetitive bricklaying tasks, ensuring speed and precision.
- **Examples:** SAM100 (Construction Robotics), Hadrian X (Fastbrick Robotics).
- **Benefits:**
 - o Reduces labor requirements for repetitive tasks
 - o Improves alignment and structural quality
 - o Speeds up construction by 3–5x compared to manual methods
- **Limitations:**
 - o High initial cost



Fig 4.1 Robotic brick layer

4.1.2. 3D CONCRETE PRINTING/ ADDITIVE MANUFACTURING

- **Function:** Robotically extrudes concrete layer by layer to create walls or entire structures.
- **Examples:** Apis Cor, Contour Crafting.
- **Benefits:**
 - o Allows complex designs without molds
 - o Reduces construction waste
 - o Potentially lowers labor costs
- **Limitations:**
 - o Limited to certain materials (mainly concrete-based)
 - o Requires skilled operators and post-processing for structural integrity



Fig 4.2 concrete printing

4.1.3 AUTONOMOUS CONSTRUCTION INDUSTRY

- **Function:** Self-driving vehicles for material transport, excavation, or site surveying.
- **Examples:** Autonomous bulldozers (Built Robotics), drone-guided excavation machines.
- **Benefits:**
 - Reduces labour-intensive hauling tasks
 - Can operate in hazardous conditions
 - Improves site productivity
- **Limitations:**
 - Requires GPS and sensors for accurate navigation
 - High maintenance costs and technology dependence

4.1.4 DRONE FOR SITE MONITORING & SURVEYED

- **Function:** Aerial inspection, surveying, mapping, and monitoring of construction sites.
- **Examples:** DJI Phantom, sense Fly drones.
- **Benefits:**
 - Real-time site monitoring and progress tracking
 - Reduced inspection time and risk for workers
 - Accurate data for planning and documentation
- **Limitations:**
 - Limited flight time and payload
 - Regulatory restrictions in some regions

4.1.5 ROBOTIC INSPECTION & QUALITY CONTROL

- **Function:** Automated detection of structural defects, cracks, or misalignments using AI-powered sensors and robots.
- **Examples:** Wall-climbing inspection robots, AI-enabled cameras.
- **Benefits:**
 - Enhances safety by reducing manual inspection in dangerous areas
 - Ensures quality and compliance with standards
- **Limitations:**
 - Requires advanced AI algorithms and sensor calibration
 - May not fully replace human judgment in complex situations



Fig 5.3 robotic inspection



4.1.6 HUMAN ROBOT COLLABORATION (Cobots)

- **Function:** Robots designed to work alongside humans to assist with lifting, precision tasks, or repetitive movements.
- **Benefits:**
 - Reduces worker fatigue
 - Enhances efficiency without fully replacing human labor
 - Flexible and adaptable to different tasks
- **Limitations:**
 - Limited payload and speed compared to full automation
 - Requires training for safe human-robot interaction

V. CONCLUSION

In this paper lays the foundation for integrating robotics and automation into the construction industry. By identifying suitable tasks, studying existing technologies, and creating conceptual designs, this phase ensures that Phase 2 (prototype development and testing) will be guided by well-researched and feasible ideas. Robotics has the potential to transform the construction industry, making it safer, faster, and more sustainable. Phase 1 demonstrates that robotics and automation in construction are both promising and practical for modern construction projects. While some challenges exist—primarily cost, training, and regulatory compliance—careful planning, phased implementation, and targeted deployment can make this technology highly effective.

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