International Journal of Management and Humanities (IJMH)
ISSN: 2394-0913 (Online), Volume-11 Issue-2, October 2024

Comprehensive Analysis of Implementing Robotics in the Indian Construction Industry

Devi Priyanka Y, Kranti Kumar M.

Abstract: ***Implementing robotics in the Indian construction industry presents a significant opportunity to address longstanding challenges such as labour shortages, project delays, safety concerns, and quality inconsistencies. As India's urbanization accelerates, the demand for faster, safer, and more efficient construction processes is growing. This comprehensive analysis explores the potential benefits, obstacles, and strategies associated with adopting robotics in India's construction sector. Key drivers include increasing automation trends, government initiatives like "Make in India," and the global shift toward smart infrastructure. However, challenges such as high initial investment, a fragmented industry structure, and the need for skilled operators and technicians could hinder widespread adoption. The analysis also highlights the role of robotics in enhancing productivity, reducing construction costs, and improving worker safety through a cost-benefit analysis, ultimately paving the way for more sustainable and advanced construction methodologies in India.***

Keywords: ***Cost-Benefit Analysis, Labour Shortage, Productivity, Robotics***

I. INTRODUCTION

India's construction sector has grown at an annual rate of around 9% since 2000, contributing nearly 10% to the nation's GDP. With a government projection of $1000 billion investment in infrastructure, the industry faces challenges such as managing multiple projects, meeting deadlines, ensuring quality, and dealing with fluctuating material costs [1]. Studies have emphasised the need to reduce non-value-adding activities, such as delays and interruptions, to improve worker productivity [2]. Despite the growth, labour productivity in construction has remained flat for the last two decades compared to other sectors, resulting in a global productivity gap of around $1.6 trillion [3]. The future of construction is likely to be shaped by rapid urbanisation, the integration of AI and automation, and the need to address climate change [4]. Robotics is seen as a key solution for addressing skilled labour shortages, enhancing safety, and improving productivity [5].

Manuscript received on 19 September 2024 | Revised Manuscript received on 25 September 2024 | Manuscript Accepted on 15 October 2024 | Manuscript published on 30 October 2024.
*Correspondence Author(s)
Devi Priyanka Y, Department Masters of Building and Engineering Management, School of Planning and Architecture, Vijayawada (Andhra Pradesh), India. E-mail ID: devipriyankayerra@gmail.com
Dr. Kranti Kumar M.*, Department Masters of Building and Engineering Management, School of Planning and Architecture, Vijayawada (Andhra Pradesh), India. E-mail ID: kranti.myneni@spav.ac.in, ORCID ID: 0000-0002-0753-5636

Countries like China and Japan have already embraced automation to mitigate the challenges posed by shrinking working-age populations [6]. The adoption of robotics is expected to streamline construction operations by delivering tasks with greater precision and efficiency than human labour, offering substantial long-term benefits.

A. Statistics on the Labour Shortage in the Indian Construction Industry

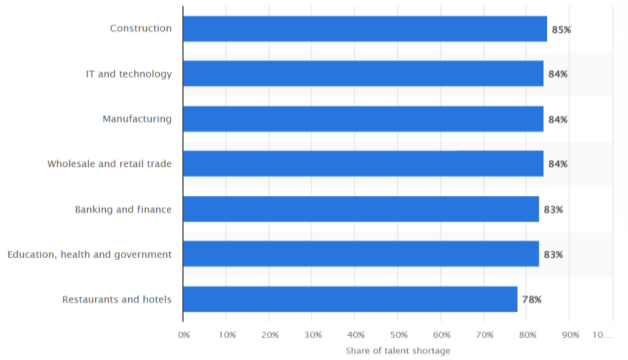

Figure 1: "Share of Talent Shortage Across India in 2022, by Industry" by Statista

The construction industry had the highest shortage of skilled labour about 85 percent in the year 2022 [7]. While unskilled labour is abundant in India, skilled labour is in short supply. This scarcity of skilled workers can hamper the progress of construction projects, leading to delays and increased costs.

B. Role of Robotics

Robotics has transformed various industries by enhancing efficiency, precision, and safety. In manufacturing, robots dominate tasks like welding and quality control, especially in the automotive and electronics sectors [8]. Healthcare benefits from surgical robots for minimally invasive procedures, while logistics and warehousing use robotics for inventory management and order fulfilment [8]. Even agriculture is adopting robots to address labour shortages and improve productivity [8]. In construction, robotics is emerging as a solution to labour shortages and increasing project complexity, with robots used for tasks like bricklaying, material handling, and demolition, driving greater efficiency, safety, and cost reduction across projects [9].

C. Statistics on the Adoption of Robotics in Construction

The incorporation of robotics technology in the construction sector is growing rapidly. Some key statistics are:

- According to industry statistics, the market for construction robots is expected to grow at a Compound Annual Growth Rate (CAGR) of over 20% between 2021 and 2026 [6].
- According to Statista, the global market for construction robots is projected to reach $470 million by 2027, showing an increasing demand for this technology [10].
- A study by the International Federation of Robotics revealed that the global annual supply of construction robots is expected to reach over 37,000 units by 2022 [10].
- Research suggests that construction robots could potentially replace 20% of the human workforce in the industry by 2030, leading to cost savings and increased efficiency [10].

While motivations like safety, speed, precision, sustainability, and coping with the decreasing number of skilled construction workers drive the adoption of robotics, several drawbacks impede their widespread implementation. The objective of this paper is to conduct a comprehensive analysis of the feasibility and impact of implementing robotics in the Indian construction industry. The study aims to evaluate the potential benefits in terms of operational efficiency, cost savings, and safety improvements, while also identifying the challenges including high initial investment, maintenance costs, and skill gaps.

II. OVERVIEW OF ROBOTICS IN CONSTRUCTION

A. Global Trends in Robotic Construction

The global construction robot market is poised for significant growth, projected to rise from US$ 173 billion in 2022 to US$ 936 billion by 2033, with a CAGR of 16.6% [11]. This expansion is driven by automation advancements, workforce shortages, and safety concerns. Asia Pacific leads the market, with China and Japan at the forefront—China through government-backed investments and Japan through company-driven efforts. Robots like the SAM100 and Hadrian X are revolutionizing bricklaying, while demolition robots, with advanced safety features, are expected to grow at a CAGR of 13.1% [12]. Rising urbanization and the need for precision and efficiency continue to fuel this demand globally.

Table 1: Showing the Construction Robot Market Outlook in Different Countries

Country	Market Value & CAGR
Construction Robot Market Size (2022A)	US$ 173 Billion
Estimated Market Value (2023E)	US$ 201.3 Billion
Forecasted Market Value (2033F)	US$ 936 Billion
Global Market growth rate (2023 to 2033)	**16.6%** CAGR
US Market growth rate (2023 to 2033)	**11.6%** CAGR
Japan Market growth rate (2023 to 2033)	**14.6%** CAGR
China Market growth rate (2023 to 2033)	**16%** CAGR
Germany Market growth rate (2023 to 2033)	**12.2%** CAGR

B. Existing Robotic Technologies in Indian Construction Industry

The existing robotic technologies in the Indian construction industry are gradually evolving, driven by the need for increased efficiency, safety, and productivity. Here's an overview of the different types of Robotic Technologies in India:

i. Autonomous Drones

Drones are increasingly used for site surveys, inspections, and monitoring progress. They provide real-time data, enhancing decision-making and reducing the need for manual labour on-site [13].

ii. Robotic Arm Systems

These systems are employed for tasks such as cutting, stacking, and packaging materials. They help automate repetitive tasks, increasing precision and reducing labour costs [13].

iii. 3D Printing Robots

3D printing technology is being explored for constructing buildings and components, allowing for rapid construction and customization of designs [14].

iv. Painting Robots

For instance, WALT, developed by Endless Robotics, can paint walls significantly faster than human workers, showcasing the potential for robots to handle specific tasks efficiently [15].

v. Logistics Robots

These robots streamline the movement of materials on construction sites, improving workflow and productivity by automating the transportation of supplies [15].

To expand automated construction methods, improvements in hardware engineering, standardized control software, and algorithmic structures for multi-robot autonomous construction planning are deemed essential [14].

C. Current Integration Practices

i. Government Initiatives

The Indian government has recognized the potential of robotics in construction, with plans to invest significantly to enhance construction efficiency and promote automation [16].

ii. Industry Adoption

Major construction firms and startups are increasingly exploring robotic technologies to improve their operations. Initiatives like 'Make in India' and 'Digital India' are fostering an environment conducive to technological advancements.

iii. Research and Development

There is a growing focus on R&D to develop new robotic solutions tailored to the unique challenges of the Indian construction landscape.

D. Challenges in Indian Construction

While the integration of robotic technologies in the Indian construction industry is promising, challenges such as high initial costs, the need for skilled operators, and regulatory hurdles remain [17]. However, with continued investment and innovation, the use of robotics in construction is expected to grow, leading to a more efficient and safer industry [17]. In summary, the Indian construction industry is beginning to embrace robotic technologies, with various applications and capabilities being explored. As the sector continues to evolve, the integration of robotics is likely to play a crucial role in enhancing productivity, safety, and overall project outcomes.

Retrieval Number: 100.1/ijmh.B175811021024
DOI: 10.35940/ijmh.B1758.11021024
Journal Website: www.ijmh.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

III. METHODOLOGY

A. Research Design

This study employed a survey-based research design to gather insights into the current integration of robotics in the construction industry, including its benefits, challenges, and prospects. A questionnaire was distributed to building professionals in India to collect data. The survey approach was chosen for its effectiveness in capturing information from a large number of respondents within a short timeframe.

B. Sampling Technique

This study utilized a non-probability convenience sampling method for selecting participants. Respondents will be chosen based on their availability and willingness to participate. The sample will include professionals from various sectors of the Indian construction industry, such as project managers, architects, engineers, contractors, and subcontractors. This diverse representation aims to provide a comprehensive perspective on the integration of robotics in the construction industry.

C. Data Collection Method

A structured questionnaire was employed to gather data for the study. Its objective was to capture information on the current practices of robotics integration, its benefits, challenges, and prospects in the construction industry. The questionnaire was distributed online to selected participants, who were provided with a link and invited to complete it.

D. Data Analysis Method

The data analysis method for this study will involve examining the responses gathered from the questionnaire to identify the key concerns and perceptions related to the adoption of robotics in construction, particularly focusing on technologies with significant future potential. After analysing the data, the study will address one of the most significant barriers to adoption: the high initial investment required for robotic systems. By conducting a cost-benefit analysis, the research will evaluate the financial viability of robotic technology, comparing the upfront costs with the long-term benefits such as improved productivity, reduced labour costs, enhanced safety, and minimized material wastage.

Cost-benefit analysis is a systematic approach to estimating the strengths and weaknesses of different investment options by quantifying both the costs and expected benefits, providing a clear picture of the overall return on investment (ROI). This analysis will help to identify the most cost-effective robotic technology with future growth potential for addressing construction challenges in India, enabling stakeholders to make informed decisions about future investments in automation.

E. Questionnaire Structure

By structuring the questionnaire in this manner, researchers can gather comprehensive data on participants' perceptions, experiences, and attitudes towards the integration of robotics in the construction industry, aiding in the development of informed strategies and policies in this field. Provided a brief overview of the purpose of the questionnaire and its importance in gathering insights on the integration of robotics in the construction industry. The questionnaire has been divided into 5 sections:

i. *Section 1 – Participant information*

Collected basic demographic data such as name, age, location, the organization they belong to and years of experience in the construction industry. This helps in categorizing and analyzing responses.

ii. *Section 2 – Understanding Current Practices in the Construction Industry*

Inquired about current methods and technologies used in the construction industry, the level of mechanization in the construction projects the participants' companies' are involved in, to what extent they are currently using robotic technologies in their construction projects and what specific types of robotic applications are being used in the present scenario.

iii. *Section 3 – Present Scenario*

Collected data about how the participants perceive the potential benefits of using robotics in construction projects, the primary barriers or challenges hindering the widespread adoption of robotics in construction, how effective the government strategies, policies, and incentives for the integration of robotics in India and what additional measures can the government take to effectively integrate robotics into the construction industry in India.

iv. *Section 4 –Future Projections*

Inquired about what areas of construction hold the most promise for future robotic applications, how do they see the role of human workers evolving alongside the integration of robotics, what are the expectations for the growth of the robotics market in the Indian construction industry over the next 5-10 years.

v. *Section 5- Recommendation and Conclusions*

Concluded the questionnaire by inquiring about Which sector or stakeholder within the construction industry is demonstrating the most interest in integrating robotics into the construction industry in India and asked for other additional insight into this area of research.

IV. RESULTS AND ANALYSIS

Out of 30 respondents to the survey on "Integration of Robotics in the Construction Industry," 36.67% were architects, 30% civil engineers, and 33.33% from Project Management Consultancy (PMC), with representation from firms like Cushman & Wakefield and L&T. Most participants (66.67%) had less than 5 years of experience, while 23.33% had over 10 years. A majority (60%) worked on residential projects, with the remainder involved in commercial, industrial, infrastructure, and mixed-use projects. Regarding current technologies, 63.3% use semi-automated processes, 30% rely on traditional methods, and only 6.6% report using advanced robotic integration. The survey also revealed that 40% of respondents reported a low level of mechanization in their projects, while 46.7% experienced moderate levels, and only 13.3% saw high levels of mechanization.

Retrieval Number: 100.1/ijmh.B175811021024
DOI: 10.35940/ijmh.B1758.11021024
Journal Website: www.ijmh.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

Notably, 63.3% of participants stated that robotic technologies are not yet being used in their projects, and 20% reported limited usage, primarily in pilot projects. Current robotics applications in the construction industry include demolition, prefabrication, material handling, and inspection robots, with some adoption of bricklaying, masonry, welding, and finishing robots.

A. Key Construction Tasks for Robotic Integration

The construction industry, particularly in developing countries like India, relies heavily on manual labour for tasks such as digging, carrying materials, bricklaying, and other physically demanding activities. The tasks within the construction process that could benefit from robotic implementation are Excavation and earthmoving, Bricklaying and masonry, Plastering, Painting and Finishes, Concrete pouring and finishing, Material Handling and Transport, Demolition, Formwork erection, Welding and Steel Fabrication. While manual labour is essential, it can also pose productivity challenges compared to mechanized or automated methods. Factors such as fatigue, skill levels, and weather conditions can affect the efficiency and output of labour-intensive work.

B. Benefits and Challenges in the Implementation of Robotics in Construction

Potential benefits of integrating robotics in construction in the order of ranking are Safety Improvement, Increased Productivity, Enhanced Quality and Consistency, Government Incentives, Cost Reduction, and Labour Shortage. Hence, this paper analyses the implementation of Robotics for Safety and Productivity.

Primary barriers or challenges hindering the widespread adoption of robotics in construction in the order of ranking are High initial cost, Technological limitations, Limited availability of robots suitable for specific construction tasks, Lack of Skilled labour, Regulatory hurdles, Resistance to change, Adoption and Integration of Robotic Technology. Hence, this paper addresses the challenge of High initial cost for the implementation of Robotics through Return on Investment (ROI) analysis.

C. Areas of Construction Hold the Most Promise for Future Robotic Applications

In order of ranking are: Bricklaying, Interior Finishing and Painting, Prefabrication and Modular Construction, Material handling and logistics, Demolition and hazardous material removal, building inspection and data collection, Welding and fabrication. Although bricklaying holds significant potential for the future, it was not considered in this study as it has proven to be financially unviable in the Indian context. The cost savings associated with bricklaying robots are not substantial, and some numerous complexities and challenges need to be addressed before they can be widely adopted. So, the next in the order, Robotics related to Interior Finishing and Painting is considered for the study.

V. COST ANALYSIS OF IMPLEMENTING ROBOTICS

Wall-finishing robots are automated systems designed to perform various tasks related to interior wall finishing in construction projects [18]. These robots can handle a wide range of tasks, including plastering, putty application, painting, and even tiling. They are equipped with advanced features like robotic arms, precision sensors, and intelligent software algorithms to ensure accurate and efficient wall-finishing operations. There are several types of wall-finishing robots:

Modular Wall Finishing Robots: These robots are designed to automate tasks like plastering, putty application, and painting. They offer significant advantages in terms of speed, cost savings, and consistent quality compared to traditional manual methods [19]. Drywall Finishing Robots: Robots like the Canvas Finishing System can semi-autonomously finish large sections of drywall, changing the way drywall teams perform their work. These robots use on-board visual sensors to identify the work area and perform tasks assigned by the operator [20].

(i) *(ii)*

Figure 2: (i) Wall Finishing Robot Manufactured by CANVAS, (ii) Wall Finishing Robot Manufactured by PACE Robotics

Retrieval Number: 100.1/ijmh.B175811021024
DOI: 10.35940/ijmh.B1758.11021024
Journal Website: www.ijmh.org

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication (BEIESP)

Multipurpose Interior Finishing Robots: Robots like "TAMIR" (Technion Autonomous Multipurpose Interior Robot) are designed to perform various interior finishing tasks, including wall building, plastering/painting, and tile setting. These robots require mutual adaptation between manual methods and available robotic technology to ensure successful execution [21].

A. Long-Term Benefits and Strategic Advantages

i. *Increased Productivity*

A Wall Finishing Robot can work continuously, reducing downtime. Traditional methods rely on manual labour, which is subject to fatigue and inconsistency. Robots can work up to 3-4 times faster, achieving greater efficiency [22][26][27][28][29][30].

ii. *Consistency and Quality*

Robotic systems ensure uniformity in plastering, putty application, and painting, reducing errors and rework, unlike human labour which can lead to uneven finishes [18].

iii. *Cost Savings in Labour*

As labour shortages become more prevalent and labour costs rise, the investment in a robotic solution would help reduce long-term reliance on manual labour [4].

iv. *Safety and Risk Mitigation*

Robots minimize human involvement in hazardous environments, leading to fewer workplace injuries and associated costs [4].

v. *Scalability and Project Timeline*

Large-scale projects can be completed faster, which results in strategic advantages for companies looking to meet tight deadlines and reduce overall project costs [15].

B. Comparison with Traditional Methods

The comparison between robotic technology and traditional methods is based on four key parameters: labour cost, productivity, safety, and material wastage.

vi. *Labour Market Cost and Productivity in India*

Activity	Assumed Daily Labour Cost (Cost per gang)	Productivity Rate	Cost per m²
Plastering	Rs 1461.17	10.39 m²/day	Rs 141.2 per m²
Putty Application	Rs 1179.36	8 to 10 m²/day	Rs 117.9 to Rs 147.42 per m²
Painting	Rs 1000	12 to 15 m²/day	Rs 66.67 to Rs 83.33 per m²

Wall Finishing Robot:

The productivity of the Wall Finishing Robot is approximately 100 m²/ day, which is 10 times more than the traditional method [22]. The tentative cost of the making of the wall finishing Robot is in the range of Rs20 lakhs to Rs25 Lakhs.

i. *Safety*

Traditional method: Higher risk of accidents due to manual handling on ladders or scaffolding. Injury rates may add costs related to medical expenses or insurance claims. Risks associated with repetitive motion injuries and working at heights. Painters are exposed to chemical fumes and physical strain, increasing risks of health issues and workplace accidents [15].

Wall Finishing Robot: Robots reduce human exposure to hazardous chemicals, eliminate direct human involvement, and reduce risks of falls and repetitive strain injuries improving safety by **95% [23]**.

ii. *Material Wastage*

Traditional method: Manual plastering can lead to up to **15% material wastage** due to inconsistent application [24]. Manual painting and putty application can lead to **5-10% wastage** due to overspray and uneven coverage [25].

Wall Finishing Robot: Robots ensure precise application, reducing wastage to around **2-3%**, and enhancing material efficiency by **80%**.

C. Return on Investment (ROI) Analysis

The ROI analysis is based on a case study of a residential gated community project covering 3 acres in Rajahmundry, Andhra Pradesh. The project consists of five blocks, each with six floors, and a clubhouse with a shared basement. For this analysis, only Block C has been considered, which has a total built-up area of 6,384 square meters. The plastering area for Block C amounts to 10,193 square meters, while the putty and painting areas cover 11,409.2 square meters. The total estimated budget of the project is ₹168 Crores and the estimated project duration is 3.5 years

i. *Cost Assumptions and Calculations*

- **Two** wall-finishing robots will be deployed for the project, covering plastering, putty, and painting tasks. Each robot is priced at approximately ₹20,00,000. So the total investment for the two robots amounts to ₹40,00,000.
- The costs are calculated annually to determine the payback period.
- The total number of working days is assumed to be 310 per year, with 120 days allocated for plastering, 100 days for putty application, and 90 days for painting.
- The assumed Operational Cost of Robot is ₹500/day (for maintenance and electricity)

ii. *ROI Calculation*

The total annual cost incurred on Labour: for Plastering, Putty and Painting = ₹34,75,808.2

The cost incurred on Robots (Including Purchase Spread Over 3.5 Years) = ₹40,00,000/3.5 = ₹11,42,857.14

Operational Cost: ₹500 × 310 = ₹1,55,000

Total annual cost of Robots = ₹11,42,857.14+₹1,55,000 = ₹12,97,857.14

Annual Cost Savings from Labour: ₹34,75,808.2 (traditional) – ₹12,97,857 (robot) = ₹21,77,951.2

Annual Material Wastage (Traditional): ₹3,79,970.

Annual Material Wastage (Robot): ₹3,79,970 x 80% = ₹75,994

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

Annual Material Savings: ₹3,03,976
Total Annual Savings: ₹21,77,951.2 (labour savings) + ₹3,03,976 (material savings) = ₹24,81,927.2
Payback Period:
Payback period = Initial Investment / Annual cash flow
Payback period = ₹40,00,000 / ₹24,81,927.2 ≈ 1.61 years
The Wall Finishing Robot offers substantial cost savings through increased productivity, reduced labour costs, and minimized material wastage. The payback period is **1.6 years i.e. 1 year and 7 months**, making it a financially viable investment with significant long-term benefits.

VI. RECOMMENDATIONS

A. Adoption Strategy

- *Pilot Projects:* Begin with a pilot project to assess the real-world performance of the Wall Finishing Robot in various construction environments. This allows for practical evaluation of productivity gains and cost savings before full-scale implementation.
- *Gradual Integration:* Gradually integrate the robotics technology into existing workflows to minimize disruption and allow time for staff training and adjustment to new processes.

B. Training and Skill Development

- *Employee Training:* Invest in comprehensive training programs for operators and maintenance personnel to ensure the effective use and upkeep of the robotics system. This includes both initial training and ongoing education as technology evolves.
- *Skill Enhancement:* Partner with educational institutions or industry organizations to develop specialized courses focused on robotics in construction, enhancing the overall skill set of the workforce.

C. Maintenance and Support

- *Regular Maintenance:* Establish a routine maintenance schedule to ensure the robot remains in optimal condition and performs consistently. This includes scheduled inspections, software updates, and prompt repair of any issues.
- *Technical Support:* Secure a reliable technical support agreement with the robotics manufacturer to address any operational problems quickly and minimize downtime.

D. Cost Management

- *Budgeting for Additional Costs:* Factor in potential additional costs, such as unexpected repairs or technological upgrades, into the overall budget. This will help manage financial risks and ensure smoother financial planning.
- *Financial Planning:* Explore financing options or leasing arrangements to manage the initial capital outlay more effectively, allowing for smoother cash flow management.

E. Evaluate Long-Term Benefits

- *Ongoing Performance Assessment:* Continuously monitor and evaluate the performance of the Wall Finishing Robot to ensure it meets productivity and cost-saving expectations. Adjust operational strategies based on performance data.
- *Strategic Expansion:* Once the initial implementation proves successful, consider expanding the use of robotics to other tasks or projects within the organization to maximize the benefits of automation.

VII. CONCLUSION

The Wall Finishing Robot from Pace Robotics represents a significant advancement over traditional wall finishing methods. With a productivity rate of 100 m²/day, the robot dramatically outperforms manual methods, which range from 10 to 15 m²/day depending on the task. The financial analysis indicates that the robot's initial investment, ₹40,00,000, can be offset by substantial annual savings. Specifically, the robot leads to cost savings of approximately ₹21,77,951.2 in labour and ₹3,03,976 in material wastage, totalling annual savings of around **₹24,81,927.2**. Consequently, the payback period for the robot is estimated between **1.6 years**. In addition to economic benefits, the robot enhances safety by reducing human exposure to hazardous conditions and repetitive strain injuries, improving overall safety by up to **95%**. It also ensures precision in application, reducing material wastage from up to **15%** to around **2-3%**, thereby enhancing efficiency. However, one limitation of the Wall Finishing Robot is that its financial viability is more suited for large-scale projects, where its high productivity and cost savings can be fully realized. For smaller-scale projects, the return on investment may not be as significant, potentially making the robot less practical in those scenarios. Overall, the Wall Finishing Robot offers a compelling return on investment through improved efficiency, cost savings, and enhanced safety, making it a valuable addition to the construction industry.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been sponsored or funded by any organization or agency. The independence of this research is a crucial factor in affirming its impartiality, as it has been conducted without any external sway.
- **Ethical Approval and Consent to Participate:** The data provided in this article is exempt from the requirement for ethical approval or participant consent.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Authors Contributions:** The authorship of this article is contributed equally to all participating individuals.

REFERENCES

1. Deshmukh, "A review on need of implementation of modern construction tecniques and equipment in Indian Construction Sector," *International Journal of Applied Research*, pp. 379-386, 2017.

2. E. V. J. Müller S, "Physical and psychological workload of construction workers in the mechanical and electrical trades," in *Proceedings of the XVth Triennial Congress of the International Ergonomics Association*, Seoul, Korea, 2003.
3. C.-R. Y. L. ,. R. Y. Z. ,. H. L. Marwan Gharbia, "Robotic technologies for on-site building construction: A systematic review," *Journal of Building Engineering*, 2020.
4. K. a. R. K. Sharma, "Robotics in Construction: Opportunities and Challenges," *International Journal of Recent Technology and Engineering*, 2019.
5. M. L. ZUZANA STRUKOVÁ, "Application of automation and robotics in construction work execution," *JOURNAL OF INTERDISC IPLINARY RESEARCH*, 2023.
6. M. S. a. I. Insights, "LinkedIn," 08 September 2023. [Online]. Available: https://www.linkedin.com/pulse/construction-robotics-market-future.
7. S. Keelery, 10 July 2023. [Online]. Available: https://www.statista.com/statistics/1320128/india-share-of-talent-shortage-by-industry/.
8. R. P. Yamini Dwivedi, "AI Robots in Various Sector," *International Journal of Innovative Science and Research Technology*, vol. Volume 9 , no. Issue 6 - June, 2024. https://doi.org/10.38124/ijisrt/IJISRT24JUN1345
9. M. Shareef, "A Review on Automation and Robotic Technology," *International Journal of Science and Research*, vol. 12, no. 1, 2023. https://doi.org/10.21275/SR23123123333
10. Utilities One, "Robotic Bricklayers Increasing Construction Speed and Precision," 02 November 2023. [Online]. Available: https://utilitiesone.com/robotic-bricklayers-increasing-construction-speed-and-precision.
11. Grand View Research, "Construction Robots Market Size, Share & Growth Report 2030," Grand View Research, [Online]. Available: https://www.grandviewresearch.com/industry-analysis/construction-robots-market-report.
12. Fact.MR, "Construction Robot Market," Fact.MR, [Online]. Available: https://www.factmr.com/report/construction-robot-market/toc.
13. S. E. Nuno Pereira da Silva, "Robotic Construction: Robotic Fabrication Experiments for the Building Construction Industry," *Sustainability and Automation in Smart Constructions*, 2020. https://doi.org/10.1007/978-3-030-35533-3_14
14. Abbasi, "The future of Construction: Exploring Robotics and Automation," 15 June 2023. [Online]. Available: https://www.azobuild.com/article.aspx?ArticleID=8614.
15. H. D. A. Jayaraj, "Robotics in Construction Industry," in *IOP Conference Series: Materials Science and Engineering*, 2018. https://doi.org/10.1088/1757-899X/376/1/012114
16. B. F. d. C. D. V. D. B. A. N. H. M. K. N. Abdullah Al Masri, "Roles of Robotics in Architectural and Engineering Construction Industries: Review and Future Trends," *Jounarl of Building Design and Environment*, 2024.
17. E. H. Daniel Trujillo, "Barriers to Automation and Robotics in Construction," *Daniel Trujillo, E. Holt*, 2020.
18. S. E. A. Bulgakov, "Robotic system for plaster and finishing works on the construction site," in *Future Technologies Conference*, 2016. https://doi.org/10.1109/FTC.2016.7821707
19. NBM&CW, "Equipment and Machinery," August 2023. [Online].
20. J. Rubenstone, "More Contractors See Benefits of Drywall Finishing Robot," 13 January 2022. [Online].
21. A. W. U. Z. Y. Rosenfeld, "Interior Finishing Building Robot "TAMIR"," *Engineering*, 1991. https://doi.org/10.22260/ISARC1991/0035
22. Pace Robotics, "Product Specifications," Pace Robotics, [Online]. Available: https://www.pacerobotics.net/.
23. S. K. R. K. P. Shreeram Patil, "WALL PAINTING ROBOT," *Engineering, Environmental Science*, 2023.
24. E. I. Ameh Oko John, "Professionals' views of material wastage on construction sites and cost overruns," *Organization, technology and management in construction: An international journal*, 2013.
25. V. B. Prakash Mallappa Naik, "Case Study-Deviations between standard allowances considered against actual generation of materials wastage on construction projects," *Engineering, Environmental Sciences*, 2020.
26. N., N., D. V., S., & K., P. (2020). NSE Stock Monitoring using Robotic Process Automation. In International Journal of Innovative Technology and Exploring Engineering (Vol. 4, Issue 9, pp. 1590–1596). https://doi.org/10.35940/ijitee.i8926.029420
27. Chitroda, M., & Patle, Dr. B. K. (2023). A Review on Technologies in Robotic Gripper. In International Journal of Advanced Engineering and Nano Technology (Vol. 10, Issue 5, pp. 1–5). https://doi.org/10.35940/ijaent.c7232.0511523
28. Satkar, A. A., Patil, A. R., Bhoware, R., & Shinde, K. (2020). Impact of Robotics on Education. In International Journal of Recent Technology and Engineering (IJRTE) (Vol. 9, Issue 1, pp. 1542–1543). https://doi.org/10.35940/ijrte.a1582.059120
29. Vasumathi, G., Dhanasekar, J., & Priya, V. (2019). A New Method of Farming Robot. In International Journal of Engineering and Advanced Technology (Vol. 8, Issue 6s2, pp. 502–503). https://doi.org/10.35940/ijeat.f1145.0886s219
30. Mwangi, P. N., Muriithi, C. M., & Agufana. (2022). Development of Educational Robotics Activities for Secondary School Students to Promote Interest in Engineering Career Path. In International Journal of Soft Computing and Engineering (Vol. 12, Issue 3, pp. 12–19). https://doi.org/10.35940/ijsce.c3580.0712322

AUTHOR PROFILE

Devi Priyanka As an architect, she is dedicated to bridging the gap between design vision and practical implementation. My work focuses on ensuring that projects not only align with client expectations but also adhere to industry standards. With a solid foundation in construction management, I am committed to maintaining a proactive and collaborative approach. I aim to contribute meaningfully to innovative construction teams by fostering synergy between design intent and practical execution, optimizing project outcomes, and enhancing efficiency within the construction process.

Dr. Kranti Kumar Myneni received B.Arch degree from JNTU, Hyderabad, Telangana, India in 2001, pursed Masters (M.Sc. - Construction Management) from South Bank University, London in 2003 and received doctorate from School of Planning Architecture Vijayawada. Currently working as Assistant Professor in School of Planning Architecture Vijayawada. Member of Council of Architecture and Fellow member of Indian Institute of Architects. Published nearly 25 articles and presented papers in 5 international conferences.3 chapters.