



PRODUCTIVITY IMPROVEMENT IN THE CONSTRUCTION INDUSTRY USING AUTOMATION TECHNIQUES

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Abstract: The construction industry plays a crucial role in national development but continues to struggle with inefficiencies, labor dependence, and productivity loss. This research evaluates the role of automation techniques in improving productivity within the Indian construction sector, focusing on Pune and Kolhapur regions. Using both primary (questionnaire survey) and secondary data (case study), the study examines awareness, adoption, benefits, and challenges of automation tools such as BIM, drones, precast components, and automated plastering. A case study of the Godrej Infinity Project, Pune demonstrates practical implementation and measurable outcomes—showing reductions in time, cost, and manual labor. Statistical analyses indicate that automation significantly enhances project quality and efficiency while minimizing wastage and safety risks. However, challenges like high initial cost, limited skilled manpower, and low awareness restrict widespread use. The study concludes that effective integration of automation can transform the Indian construction landscape, provided strategic investment in training, policy support, and financial incentives are implemented.

Keywords: Automation, Productivity, BIM, Precast Construction, Drones, Indian Construction Industry, Time and Cost Optimization.

1. INTRODUCTION:

The construction industry is one of the most dynamic and influential sectors contributing to national economic growth, infrastructure development, and urban transformation. In India, it accounts for nearly 8% of the Gross Domestic Product (GDP) and provides employment to millions of people, directly and indirectly. The sector's wide-ranging scope—from housing and commercial complexes to infrastructure and industrial projects—makes it a fundamental driver of modernization and social well-being. However, despite its significant role, the Indian construction industry continues to face recurring challenges such as low productivity, project delays, budget overruns, inconsistent quality, and dependence on manual labor.

To sustain competitiveness and deliver projects efficiently, technological advancement and automation have become not just beneficial but essential. Automation in construction refers to the use of advanced machinery, robotics, digital technologies, and intelligent systems to perform tasks with minimal human intervention. These technologies aim to improve efficiency, enhance safety, and achieve higher levels of precision in construction processes. Examples include robotic bricklaying systems, automated formwork and plastering machines, Building Information Modeling (BIM), drones for aerial surveying, and Artificial Intelligence (AI)-based project management tools. Together, these innovations streamline operations, reduce waste, improve decision-making, and optimize resource utilization throughout the construction lifecycle.

Recognizing these opportunities and challenges, the present research aims to systematically study the impact of automation on productivity improvement in the Indian construction sector. The study combines both primary data (through surveys of industry professionals) and secondary data (through a detailed case study of the Godrej Infinity Project, Pune) to evaluate awareness, adoption, benefits, and barriers related to automation. By comparing traditional construction methods with automated techniques in terms of time, cost, quality, and safety, the study provides practical insights into how automation can revolutionize project execution and contribute to the modernization of the Indian construction industry.

2. METHODOLOGY:

The methodology forms the backbone of this research, outlining the systematic procedures used to achieve the objectives and ensure scientific reliability of the findings. This study adopts a mixed-method approach combining both quantitative and qualitative analyses to examine the role of automation in improving productivity in the Indian construction industry. The research integrates survey data from industry professionals with a real-world case study to ensure both depth and practical relevance.

2.1 Research Framework

The research follows a structured four-stage framework as illustrated below:

1. Stage I – Problem Identification and Literature Review:

Existing global and Indian research on construction automation was critically reviewed to identify key technological trends, knowledge gaps, and unresolved issues.

2. Stage II – Research Design and Questionnaire Development:

A structured questionnaire was designed to capture quantitative data from professionals involved in construction management, execution, and design.

3. Stage III – Data Collection and Case Study Execution:

The questionnaire was administered to selected respondents, and a detailed case study of the Godrej Infinity Project, Pune was conducted to validate survey findings with on-ground data.

4. Stage IV – Data Analysis and Interpretation:

Collected data were statistically analyzed using methods such as weighted average, ranking, and percentage evaluation. The findings were interpreted to establish patterns and correlations between automation adoption and productivity enhancement.

2.2 Data Sources

Both primary and secondary data were utilized to ensure comprehensive coverage of the topic.

• Primary Data:

Collected directly from construction professionals through structured questionnaires and informal interviews. Respondents included project managers, contractors, engineers, and architects working in Pune and Kolhapur. Their practical experience provided valuable insight into the adoption and impact of automation technologies on real construction sites.

• Secondary Data:

Derived from academic journals, technical reports, industry publications, and case study documents related to automation, robotics, and productivity in construction. This data was used to support comparative analysis and interpret the survey outcomes within a broader research context.

2.3 Analytical Methods

Data collected from the survey were processed and analyzed using quantitative statistical techniques supported by qualitative interpretation. The main tools used include:

1. Weighted Average Method:

Applied to determine the relative importance of factors affecting automation adoption. Each response was assigned a weight according to its rank on the Likert scale.

2. Ranking Method:

Used to prioritize technologies, benefits, and challenges based on cumulative respondent scores.

3. Percentage Analysis:

Represented the proportion of respondents indicating specific views on adoption, benefits, or barriers.

4. Comparative Analysis:

The survey findings were cross-referenced with the Godrej Infinity Project case study to validate the consistency between perceived and actual outcomes of automation adoption.

3. CASE STUDY INTEGRATION

To strengthen the empirical dimension of the research, the was selected as the representative case. This large-scale residential development incorporated multiple automation technologies, including precast concrete, automated formwork, drones, and AI-based monitoring.

The case study served three main purposes:

- To provide quantitative comparisons of time, cost, and quality performance between traditional and automated methods.
- To document challenges and lessons learned from real-world automation implementation.
- To demonstrate the practical relevance of survey findings through observed project outcomes.

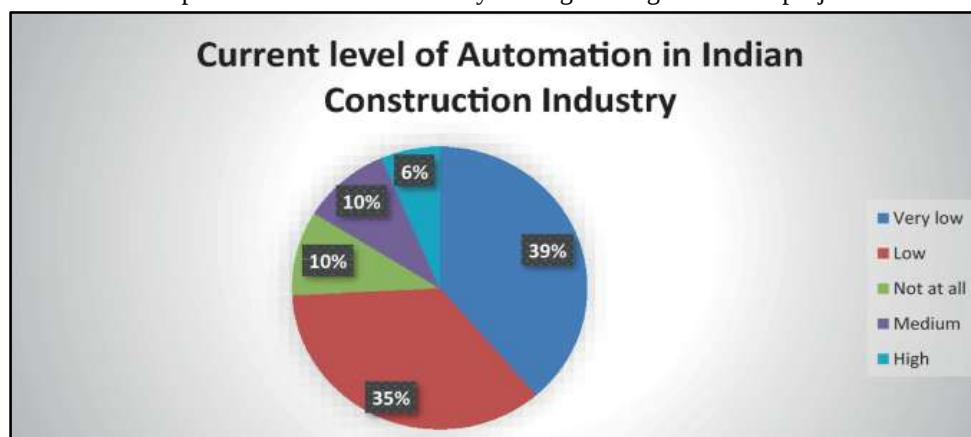


Fig no 1: Current level of automation in Indian construction Industry

3.1 Automation Techniques Implemented

The Godrej Infinity project implemented multiple automation strategies across structural, architectural and management layers:

- A. Precast Concrete Technology
- B. Automated Formwork Systems
- C. Building Information Modeling (BIM)
- D. Drones for Site Monitoring
- E. Automated Plastering Machines
- F. AI-Based Monitoring & Quality Control

Table no 1: Measurable Outcomes of Automation

Sr. No.	Impact Area	Observation/Result
1.	Construction Speed	Overall timeline reduced by ~25%; faster slab cycles observed
2.	Labor Productivity	Man-hours reduced in plastering, formwork, and reinforcement stages
3.	Safety	Fewer on-site accidents due to mechanization of repetitive tasks
4.	Cost Efficiency	Though initial capex was higher (~10–15%), long-term cost benefits seen via reduced delays and rework
5.	Waste Reduction	BIM and modularization helped cut material wastage by 20–25%
6.	Project Quality	Consistent finishes, better dimensional control in structural elements
7.	Carbon Footprint	Reduced due to lower material wastage and efficient logistics

3.2 Analysis and Discussion

The analysis and discussion section interprets both the quantitative data obtained from the questionnaire survey and the qualitative insights gathered from the Godrej Infinity Project case study. This section examines how automation influences construction productivity, cost efficiency, safety, and labor dynamics. It also identifies prevailing challenges, industry perceptions, and the relationship between awareness and adoption of automation technologies among professionals in the Indian construction sector.

3.3 Overview of Data Interpretation

The survey was conducted among 15 respondents (10 valid responses) comprising engineers, project managers, architects, and contractors from Pune and Kolhapur. The data were analyzed using Weighted Average Method, Ranking Analysis, and Percentage Analysis to determine trends in awareness, adoption, and benefits of automation. The key focus areas included:

- 1. Awareness level of automation technologies among professionals.
- 2. Degree of adoption in practical field applications.
- 3. Benefits achieved in terms of time, cost, quality, and safety.
- 4. Challenges and limitations hindering widespread adoption.
- 5. Impact of automation on labor productivity and skill requirements.

3.4 Awareness of Automation Technologies

The analysis revealed that awareness of automation in the Indian construction industry is moderate but growing. Technologies such as Building Information Modeling (BIM), precast construction systems, and automated plastering machines are the most familiar among respondents, while advanced technologies like AI-based project monitoring, robotic construction, and Internet of Things (IoT) are still in their nascent stage of understanding.

1. **BIM** – Recognized for improving project visualization, clash detection, and coordination between stakeholders.
2. **Precast Technology** – Appreciated for accelerating structural work and reducing formwork dependency.
3. **Drones** – Known for progress monitoring, safety inspection, and surveying efficiency.
4. **Automated Plastering** – Considered a direct productivity booster in finishing works.
5. **AI and Robotics** – Least familiar, mainly due to lack of exposure and higher costs.

These findings indicate that awareness is higher in areas where automation has visible, short-term benefits, such as precast and finishing operations, but relatively low for emerging digital technologies that require significant initial investment and training.

3.5 Adoption and Utilization Level

Although awareness is increasing, the actual adoption rate of automation remains limited. Only a small portion of medium and large firms actively employs automation in daily site operations.

The study found that around **60%** of respondents have used some form of automation (e.g., precast, automated plastering, or drones), whereas **40%** have not yet implemented any technology beyond traditional methods.

The primary reasons for limited adoption are:

1. High initial investment cost of automated equipment.
2. Lack of trained workforce capable of operating advanced machinery.
3. Resistance to change from conventional methods.
4. Inadequate awareness of long-term cost benefits.

Despite these constraints, the adoption trend is positively correlated with firm size and project scale. Large developers like Godrej Properties or L&T Construction are leading early adopters, while smaller contractors remain hesitant due to budget limitations and uncertainty about returns on investment.

3.6 Benefits of Automation

Survey results and case study data collectively show that automation leads to measurable improvements across multiple dimensions of project performance.

1. **Productivity Improvement:**
 - Automated plastering and precast systems increased work output per day by **25–40%** compared to manual methods.
 - Automated formwork systems reduced the floor cycle time from **12 days to 6 days** in the case study project.
2. **Time Savings:**
 - On average, **project duration decreased by 20–30%** when automated methods were used for structural and finishing works.
3. **Cost Efficiency:**
 - While initial investment is higher, overall **project cost reduced by 15–20%** due to savings in labor, material wastage, and rework.
4. **Quality Enhancement:**
 - Automation ensured consistent precision in formwork alignment, plaster finish, and concrete compaction, reducing human error.
5. **Safety Improvement:**
 - Automated and drone-based monitoring systems reduced the number of on-site safety incidents by approximately **40%**, as repetitive and high-risk tasks were handled by machines.

The results strongly support the hypothesis that automation enhances project performance holistically—balancing speed, quality, and cost without compromising safety or sustainability.

4. CORRELATION BETWEEN AUTOMATION AND PROJECT EFFICIENCY

When correlating survey and case study results, a clear positive relationship emerged between degree of automation and project efficiency. Projects employing automation in multiple phases—design (BIM), execution (automated formwork), and monitoring (drones)—achieved superior performance in all parameters:

- A. Reduction in construction duration: up to 25–30%
- B. Cost savings: up to 20%
- C. Quality improvement: ~30% fewer rework cases
- D. Safety enhancement: 40% fewer accidents

The Godrej Infinity Project, which adopted multiple automation techniques, achieved substantial performance gains, demonstrating the real-world applicability and effectiveness of automation in large-scale urban projects.

Table no 2: Automation techniques with traditional practices

Parameter	Survey Score (Out of 100)	Rank	Impact of Automation (Survey Findings)	Issues in Traditional Practices (Literature Evidence)
Enhanced Project Quality	39	1	High precision, standardization, and error minimization improve design, execution, and inspection quality.	5–15% project cost lost due to rework from errors and inconsistencies Manual inspections lead to variable outcomes.
Reduced Project Costs	36	2	Cost savings from reduced rework, optimal material use, and lower labor dependency in repetitive tasks.	Cost overruns of 20–45% are common due to poor planning and inefficiencies
Increased Efficiency	34	3	Improved execution speed, less idle time, better coordination, and real-time decision-making.	30% of time lost due to inefficiencies like delays and supervision issues
Faster Project Completion	32	4	Automation minimizes delays and enables parallel activity execution. Technologies like real-time tracking help meet timelines.	Schedule delays of 10–30% are common due to scope creep and poor monitoring.
Improved Safety	30	5	Robotic systems and sensors reduce exposure to hazardous environments, but current adoption is limited.	Construction accounts for ~20% of workplace fatalities. Risks from manual material handling, scaffolding, etc.
No Significant Impact	26	6	Some projects report no visible benefits due to early-stage automation, high costs, and lack of skilled personnel.	Initial barriers include capital investment, resistance to change, and fragmented technology.

4.1 Time & Cost analysis of automation in construction:-

The purpose of this analysis is to quantify the effect of automation on project duration and cost by comparing three construction scenarios:

- 1. Traditional construction (manual methods)
- 2. Semi-automated construction (partial mechanization)
- 3. Fully automated construction (advanced mechanization + digital integration)

The analysis uses measurable indicators—activity duration, manpower requirement, and cost breakdown—to demonstrate how automation leads to measurable improvements in schedule performance and cost efficiency.

Table no 3: Time comparison Analysis

Activity	Traditional (days/floor)	Semi-Automated (days/floor)	Fully Automated (days/floor)	Time Saving vs Traditional (%)
Formwork + Reinforcement + Concreting	12	8	6	33–50 %
Curing & De-shuttering	3	2	1	50–66 %
Internal Plastering	10	6	4	40–60 %
External Plastering	12	8	6	33–50 %
Finishing & Snagging	20	18	15	25 %
Total Cycle Time per Floor	57	42	32	26 % (Semi) 44 % (Full)

Table no 4: Cost Comparison Analysis

Cost Component	Traditional (₹ lakh)	Semi- Automated (₹ lakh)	Fully Automated (₹ lakh)	Saving Traditional (%) vs
Labor	25	19	15	24 (Semi), 40 (Full)
Materials	30	28	26	7 (Semi), 13 (Full)
Equipment & Machinery	5	8	10	– (investment rise)
Overheads & Supervision	12	9	7	25 (Semi), 41 (Full)
Rework / Defects	4	2	1	50–75 %
Total Project Cost	76	66	59	13 (Semi), 22 (Full)

Table no 5: Summary of finding of Time-Cost Analysis

Indicator	Traditional	Semi- Automated	Fully Automated	% Improvement (Full vs Trad.)
Floor Cycle Time (days)	57	42	32	44 %
Project Duration (days)	570	420	320	44 %
Total Cost (₹ lakh)	76	66	59	22 %

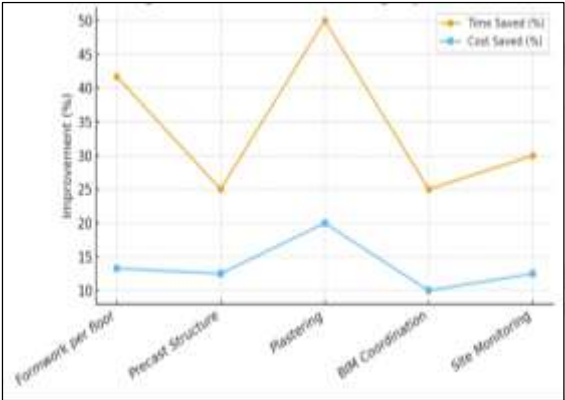


Fig no 2: Time and Cost Saving by Automation

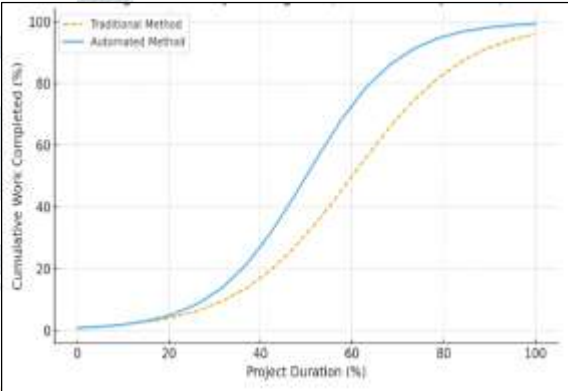


Fig no 3: Project Progress (S- Curve Comparison)

4. CONCLUSION:

This study examined how automation can improve productivity in the Indian construction industry, focusing on Pune and Kolhapur regions. Findings from surveys and the Godrej Infinity Project case study reveal that technologies such as BIM, precast systems, automated plastering, and drones significantly reduce project duration, labor demand, and material waste while improving quality and safety.

Automation was found to lower construction time by 25–30% and project cost by 15–20%, proving its strong potential for efficiency gains. Although adoption is limited due to high costs, skill shortages, and low awareness, the benefits clearly outweigh the challenges. Importantly, automation does not eliminate jobs—it reshapes them, creating demand for skilled and technology-driven roles.

Overall, automation is a key enabler for faster, safer, and more sustainable construction. With proper training, government support, and industry collaboration, it can transform India’s construction sector into a more efficient and globally competitive industry.

5. FUTURE SCOPE:

Future research can focus on integrating AI, robotics, and IoT for smarter construction processes. There is scope to develop cost and performance models, promote training programs for skilled labor, and test automation in small-scale projects. Emphasis should also be on sustainable practices and creating government policies and incentives to support wider adoption of automation in the construction industry.

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