

Analysis of Contradictions in Construction Innovation and Equipment for Improved Productivity

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Abstract - This research explores the challenges and opportunities related to the adoption of innovative technologies and effective equipment management practices within the construction industry. A survey conducted among 97 construction professionals aimed to evaluate management training tools, identify key issues in managing construction equipment, assess the effectiveness of management practices, and determine the success rate of current equipment management processes. The findings reveal a significant gap between awareness and actual adoption of advanced technologies, such as Building Information Modeling (BIM) and 3D printing, with barriers including high costs and a lack of skilled labor. Additionally, critical issues in equipment management, such as inadequate maintenance practices and reliance on outdated machinery, were identified as factors negatively impacting overall project productivity. The study demonstrates a strong positive correlation between structured project management methodologies and enhanced productivity levels. Furthermore, the assessment of current equipment management processes highlights both strengths and weaknesses, with many firms facing challenges related to maintenance scheduling and operator training. The research emphasizes the necessity for construction firms to invest in comprehensive training programs, implement systematic maintenance practices, and foster a culture of innovation to overcome barriers to technology adoption. Overall, this study contributes valuable insights into how effective management and innovative technologies can enhance productivity in the construction industry, providing actionable recommendations for practitioners to improve project outcomes and competitiveness.

Key Words: Construction Industry, Equipment Management, Survey, Data collection, Barriers to Adoption, Productivity construction

1. INTRODUCTION

The construction industry is a vital sector that significantly contributes to economic development and infrastructure growth worldwide. However, it faces numerous challenges, including low productivity, high operational costs, and a pressing need for innovation. As the industry evolves, the integration of advanced technologies such as Building Information Modeling (BIM), 3D printing, drones, and robotics has emerged as a potential solution to enhance

efficiency and productivity. Despite the recognized benefits of these technologies, their adoption remains limited, primarily due to barriers such as high costs, a lack of skilled labor, and resistance to change.

Effective management practices play a crucial role in navigating these challenges and facilitating the successful implementation of innovative technologies. Management training tools are essential for equipping construction professionals with the necessary skills to adapt to new methodologies and technologies. However, the effectiveness of these training programs and their impact on productivity and equipment management practices have not been thoroughly examined.

1.1 Background of study

Effective equipment management methods not merely boost production time and equipment accessibility, but additionally capitalize on the business benefit by decreasing many expenses like all those from pricey downtime. Nevertheless, investigations in the area of equipment control practice, especially in the building context, are already unusual.

The building equipment applied to an enterprise has a life cycle. It starts off with the recognition of a possibility, then simply advances to approval and feasibility. If the concept is found beneficial a complete selection, equipment is bought, set up and placed into operation. The vast bulk of the life cycle is its operation which carries on until the place & equipment are inevitably decommissioned and disposed. Source, audit report of Indian construction equipment life cycle.

1.2 Aim of the Study

1. Future studies should explore other influencing factors affecting construction productivity at all stages of the procurement process.

2. Contracting companies have to conduct productivity study at the activity/operation level such as studying factors affecting labour productivity.

3. The productivity and materials waste data can be used to prepare estimates for future projects.

1.3 Objective of the study

1. To evaluate the primary tools management training and managing experience within the target business in the building sector.
2. To recognize the main issues of managing construction equipment.
3. In order to look at the effectiveness and productivity regard to management.
4. In order to assess the success rate of the latest building equipment management process of the enterprise understudy and also in order to determine the weakness.

1.4 Problem statement

The construction industry is vital to India, making workforce efficiency crucial for productivity. Effective resource management ensures timely, cost-effective, and quality project delivery, key to success. Labor productivity directly impacts project outcomes, emphasizing the need for performance improvement. Enhancing workforce efficiency is essential for achieving construction goals.

2. LITERATURE REVIEW

The performance of excavating equipment in construction depends on factors like utilization, maintenance, operator skill, site conditions, and project management. Efficient scheduling, regular maintenance, and skilled operators enhance productivity and minimize downtime. Advanced technologies, optimize equipment management, improving efficiency and safety while reducing costs.

[1] "Integrated agent- based construction equipment management: conceptual design"

Effective equipment management is crucial for construction firms to minimize financial losses and improve efficiency. Existing systems often lack integration and rely on subjective decisions, leading to errors. The proposed agent-based equipment management system (ABEMS) leverages real-time data, ERP integration, and autonomous decision-making to optimize operations, reduce human interference, and enhance overall performance.

[2] "Management of Equipment & Machinery in Construction"

The paper emphasizes the importance of effective equipment management in construction to enhance productivity, efficiency, and project success. It highlights key aspects such as equipment selection, maintenance, and skilled operation while addressing challenges like high costs and downtime. The authors advocate leveraging advanced technologies and systematic practices to optimize resource utilization and improve decision-making.

[3] "Systematic Review of The Literature on Construction & Productivity"

The authors review research on construction productivity, identifying key themes like project management, workforce skills, technology, and economic factors. They emphasize the need for both quantitative and qualitative approaches to understand productivity challenges. Future research areas include digital technologies, collaboration, and sustainability. The paper aims to guide improvements for efficient project delivery.

[4] "Implementation of technologies in the construction industry: a systematic review"

This paper reviews technologies like BIM, automation, robotics, and digital tools in construction, highlighting their potential to boost efficiency, safety, and productivity. It examines challenges such as resistance to change, high costs, and the need for skilled labor. The authors stress the importance of management support and call for research on best practices for technology integration.

[5] "Control Charts as a Productivity Improvement Tool in Construction"

The author discusses using control charts to enhance construction productivity by monitoring process variations and enabling early corrective actions. Ault highlights their value in identifying trends, stabilizing processes, and optimizing resources. Case studies demonstrate their success, and the paper calls for broader adoption, research, and training to integrate control charts into construction management.

[6] "Factors Affecting Performance of Excavating Equipment: An Overview"

The authors analyze factors affecting excavator performance, including design, operations, maintenance, and environmental conditions. They stress the importance of training, maintenance, and best practices to optimize efficiency. Addressing these factors minimizes downtime, reduces costs, and enhances project outcomes in construction.

[7] "Innovation in construction equipment and its flow into the construction industry"

The authors examine drivers of innovation like technology, market demands, and competition, emphasizing collaboration between manufacturers and construction firms. They address challenges such as resistance to change and the need for training. The paper underscores the importance of fostering innovation to boost productivity, safety, and project outcomes.

3. RESEARCH METHODOLOGY

This research used survey methods, favoring web-based questionnaires for cost-effectiveness and respondent convenience despite lower response rates than interviews. Data sources included literature reviews and focus interviews, followed by a structured plan for field data

collection. Clear communication was emphasized to ensure respondents understood definitions and procedures.

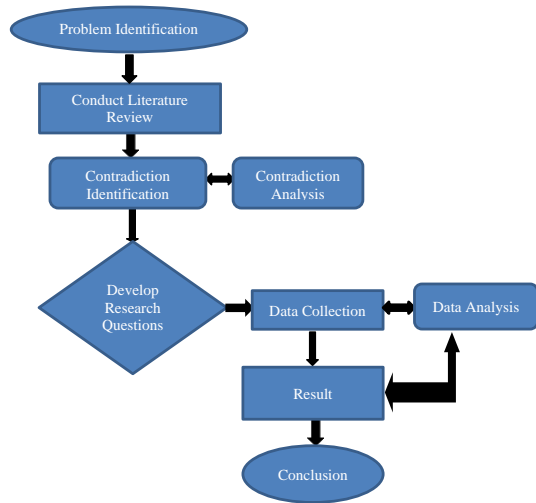


Fig. No. 1 Flow Chart for Methodology

4. DISCUSSIONS & FINDINGS

The questionnaire was distributed to 97 participants with construction experience, and their feedback was analyzed. It included Yes/No, scaled, and contingency questions to gather detailed insights.

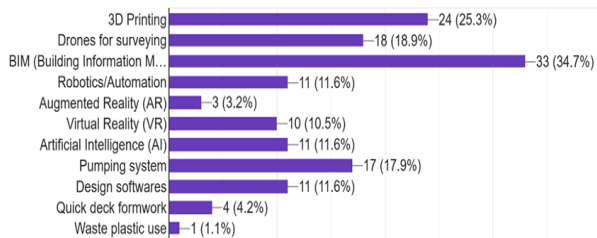


Fig. No. 02 Innovative technologies have you used or seen in construction projects

BIM (34.7%) and 3D printing (25.3%) are the most commonly used technologies reported by respondents.

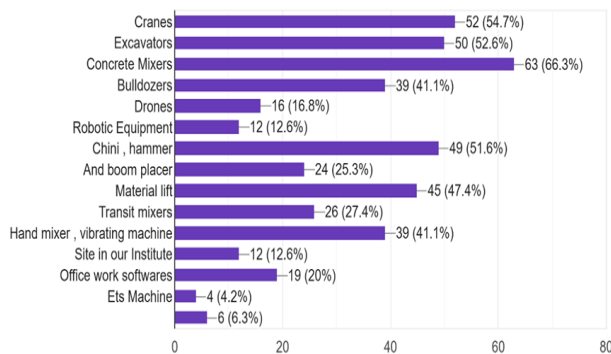


Fig. No. 03 Construction Equipment Regularly Use in Projects

Concrete Mixers (66.3%) are the most widely used, followed by Cranes (54.7%) and Excavators (52.6%), with advanced technologies like Drones (16.8%) and Robotics (12.6%) being less adopted. Traditional equipment like Chini and Hammers (51.6%) and Material Lifts (47.4%) are more common than newer tools like Office Work Software (12.6%) and ETS Machines (4.2%).

Table -01: Innovative technologies in construction

Technology/Method	Count	Percentage
3D Printing	24	25.3%
Drones for Surveying	18	18.9%
BIM (Building Information Modeling)	40	42.1%
Robotics/Automation	11	11.6%
Augmented Reality (AR)	3	3.2%
Virtual Reality (VR)	10	10.5%
Artificial Intelligence (AI)	11	11.6%
Pumping System	17	17.9%
Design Softwares	11	11.6%
Quick Deck Formwork	4	4.2%
Waste Plastic Use	1	1.1%
IMS	29	30.6%

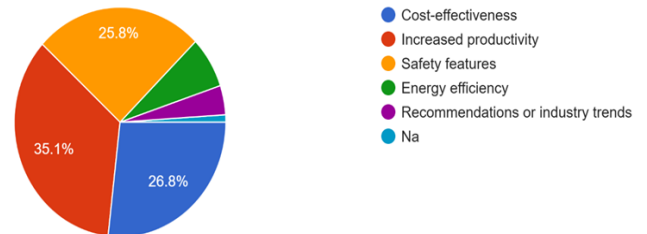


Fig. No. 04 Factors influence to adopt new construction equipment

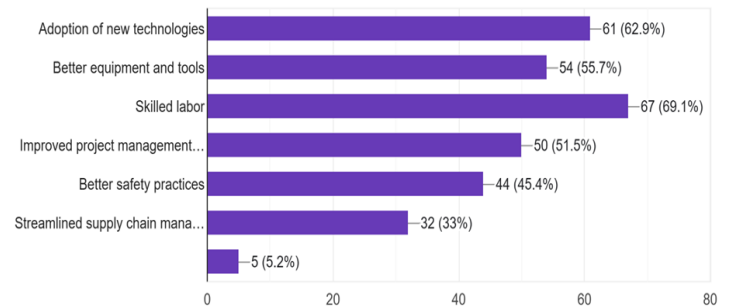


Fig. No. 05 Factors do you believe are most critical in improving productivity on construction projects

5. RESULT ANALYSIS

The evaluation emphasizes adopting advanced technologies like BIM, AI, and automation to improve construction efficiency, with data-driven strategies enhancing equipment management and decision-making.

Survey Question	Key Findings
Innovative Technologies Used in Construction	BIM (34.7%), 3D Printing (25.3%)
Barrier to Adopting Innovative Technologies	High Costs (40.2%), Lack of Skilled Labor (30.9%), Insufficient Training (11.3%)
Construction Equipment Regularly Used	Concrete Mixers (66.3%), Cranes (54.7%), Excavators (52.6%)
Frequency of Equipment Upgrade	2-3 Years (30.9%), 4-5 Years (27.8%), Annually (18.6%)
Factors Influencing Equipment Adoption	Increased Productivity (35.1%), Cost-Effectiveness (26.8%), Safety Features (25.8%)
Challenges in Adopting New Technologies	High Costs (58.3%), Lack of Skilled Workers (59.4%), Maintenance Issues (33.3%), Limited Technology Availability (34.4%)
Critical Factors for Improving Productivity	Skilled Labor (69.1%), New Technologies (62.9%), Better Equipment (55.7%), Improved Project Management (51.5%)

6. CONCLUSION

The survey results provide valuable insights into construction technology adoption and its impact on productivity. Traditional equipment like cranes, excavators, and concrete mixers remains dominant, yet innovative technologies such as BIM and 3D printing are gaining interest. However, their adoption remains limited, with only 34.7% using BIM and 25.3% using 3D printing, mainly due to financial constraints and the need for specialized skills. This indicates that while innovation holds potential, overcoming these barriers is essential for broader adoption.

Financial costs (40.2%) and the lack of skilled labor (30.9%) are significant challenges hindering the adoption of advanced technologies. Despite a relatively low percentage of respondents citing resistance to change (5.2%), the data shows that the construction industry must address workforce readiness and the financial feasibility of new technologies. The need for a balance between technological advancement and cost-effective, skilled labor solutions is crucial.

Additionally, equipment upgrading practices vary, with some firms hesitant to invest in newer machinery, potentially affecting productivity and safety in the long term.

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