



ADVANCED ROBOTICS IN CONSTRUCTION: APPLICATIONS IN PREFABRICATION AND MODULAR BUILDING TECHNIQUES

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Abstract

High level robotics has also become an important element in the prefabrication and modular construction. It offers the solutions to the old issues of productivity, quality, safety, and sustainability. This paper evaluated the feasibility and impacts of robotic technology in critical stages of the modular assembly, including production of components, assembly, transportation and construction on site. The findings demonstrate that prefabricated elements are much more precise in terms of size, less time consuming to construct, and more predictable with the help of robotic automation as compared to using the traditional methods. Quantitative outcomes are that the intensity of labor, material waste and operational errors have decreased whereas the qualitative outcomes are that the safety and reliability of workflow has increased as well. Robotics combined with such digital construction platforms as BIM and real-time monitoring technologies can further enhance the coordination and optimization of the process. Along economic analysis, the long-term benefits outweigh the expenditures on investments made at the initial stage because of improved efficiency and reduced life cycle costs. In general, the analysis demonstrates that the field of advanced robotics is significant to make the modular construction scalable, high quality, and sustainable. This renders it a critical technology to the future of industrialized building systems.

Keywords: Advanced Robotics, Modular Construction, Prefabrication Technology, Automated Fabrication, Construction Automation, Building Information Modeling



INTRODUCTION

The use of complex robotics is causing a significant technological shift in the construction sphere, which has traditionally been characterized by its labor-intensive nature, as well as relying on manual procedures that are still customary (Ayoola et al., 2024, p. 1; Wu et al., 2024). This is the paradigm shift that can be specifically pointed to prefabrication and modular building, which are becoming increasingly popular disciplines and are transforming building practices by making construction safer, more efficient, and more precise, with the help of robots (Wei et al., 2023, p. 9180009). Switching between the manual and automated work, including managing robots is one of the significant aspects of achieving higher productivity in general and minimizing the adverse impact on the environment that is typically associated with the traditional approaches to the construction process (Chea et al., 2020). This study examines the various ways through which robotics are used in the specialised construction industry, and how the intervention of robots improves production speed and provides unmatched customisation and quality control (Buhl et al., 2017, p. 158). Robotic process automation that has been introduced to prefabricated modular building offers a great number of advantages, including the growth in productivity, the reduction of

costs, and the improvement in safety outcomes (Akinola et al., 2024, p. 127). Robotic advances also contribute to having more accessible advanced additive manufacturing techniques and made it possible to use more flexible design, which offers new possibilities with prefabricated and modular buildings (Akinola et al., 2024, p. 127). Besides, the strategic application of robotics is not merely destroying jobs; it can assist in addressing the challenging issues which emerge during assembling some objects in the off-sites and the installations in the on-sites (Ouda & Haggag, 2024; Zhang et al., 2023, p. 460). It is a good approach to reduce the costs and accelerate the process of construction by integrating technology, most likely on the basis of AI and robotic process automation, which will contribute to making houses more affordable (Akinola et al., 2024, p. 122). Even further, the fact that these robots can be maintained and upgraded regularly demonstrates how cost-effective such systems are and how they will be used to help the construction process in the long term (Adekunle et al., 2023, p. 748). This article shall discuss the special gains and uses of robotic technology during various stages of prefabrication and modular building and how it affects project time, reduction of material wastes, and the structural integrity at large. A transition to



Industry 5.0 as the replacement of Industry 4.0, with the focus on the ways in which the human-centered approach, advanced robotics, and AI are turning the future of construction more solid and sustainable, will also be addressed in the conversation (Ahmad et al., n.d., p. 1). This paper will take a more detailed examination of the economic consequences and issues that are associated with the mass usage of these high-tech technologies, considering both the initial price and the ensuing advantages of their utilization (Ouda & Haggag, 2024). It will also discuss why data-driven insights that can be enabled by machine learning and artificial intelligence are significant in enhancing the operations of robots and predictive models of new architectural and structural designs. This will ensure safety of construction and operations, reduce energy requirements and expenditures (Ouda & Haggag, 2024). This critical evaluation is supposed to provide the construction managers and engineers with valuable information on how they can utilize robotic technology in order to enhance project flows, manage costs and ensure that safety regulations are adhered to (Ayoola et al., 2024, p. 4). The increased application of robots in the construction industry implies that we should give due consideration to moral and other social matters, particularly regarding the manner in which we treat data to ensure privacy and

prevent misuse (Liu et al., 2024, p. 24). Also, the shift to Industry 5.0 highlights that it is a humanistic system, which requires wide-scale reskilling of the employees to curb digital inequalities and tackle the ethical issues linked to AI in decision-making in these high-tech construction environments (Ahmad et al., n.d., p. 2). One of the most popular trends is the application of AI and machine learning to construction robots to make the work of the machine significantly smoother, safer, and more cost-effective, letting the machine work on its own, perform predictive analytics, and schedule project completion (Ayoola et al., 2024, p. 12; "Robotics and Automation in Construction Management Review Focus: The Application of Robotics and Automation Technologies in Construction," 2025). Such intelligent solutions are useful in enabling robots to adapt to the altering sites of buildings and subsequently, there will be fewer instances of the robots going off track and the work generally becomes easier (Ayoola et al., 2024, p. 12). The use of AI-based collaborative robots, also known as cobots, is a major move towards people-centric automation in the construction industry. It will ensure a safer and more effective workplace by enhancing the interaction between people and robots (Marinelli, 2023; Shah et al., 2025). This symbiotic



correlation between humans and robots that are enabled by the advanced AI not only enhances productivity but also allows people to make safety judgments in real-time based on what they learned and have seen, reducing the number of risks in complex construction scenarios (Liu et al., 2024, p. 20). The result of this mutually beneficial interaction is an increase in the level of productivity and safety on the building sites with the demonstration of how the higher levels of productivity and safety can be achieved on the building sites using the advanced robotics (Liu et al., 2024, p. 16). In this study, the author will particularly focus on the use of construction robots in various civil engineering operations, such as excavation and placement of concrete to understand the contribution made to the work and the complexity of their functioning (Liu et al., 2024, p. 2). The paper will also analyze the nature of these robotic systems in conjunction with IoT devices to collect information in real-time and enhance the outcome of projects, safety, and resource utilization (Rane, 2023, p. 76). This merger is necessary to address the current problems within the industry, including the lack of personnel and the necessity to use more eco-friendly construction techniques (Rane, 2023, p. 86). To supplement these operational enhancements, enhanced robotics with 3D printing extruders take big

steps in custom design and reduction of waste, which benefits the environment and economy (Ayoola et al., 2024, p. 12). Further, precision of robotic concrete placers and autonomous excavators significantly enhances the manual construction techniques, and consequently, the structural soundness and speed of construction (Liu et al., 2024, p. 24).

METHODOLOGY

To determine the role of advanced robots in the process of prefabrication and modular construction, the mixed-method experimental research methodology was used in the given study, which combines the quantitative and qualitative approaches to study the problem in question in a comprehensive manner. The experimental design involved control laboratory fabrication experiments and pilot building projects that involved the use of robotic systems in the manufacture of components, assembling them and installing them on-site. We strictly measured and contrasted the performance parameters such as production time, dimensional precision, material waste, energy consumption, and workforce input between the process of the robotic-assisted technique and conventional building techniques. Experience In experiential insights pertaining to workflow efficiency, safety improvements, and operational challenges were captured qualitatively through expert

observations, structured interviews with engineers and site managers and process documentation. This qualitative-quantitative methodology permitted the triangulation of findings that ensured that the quantitative findings as well as the contextual implications of robotic integration were robust and valid. This was done by way of repeated experimental cycles in order to achieve consistency and statistical reliability of data collection. Trials of robotic fabrication were controlled through embedded sensors and digital control systems to capture real-time data to operate and Building Information Modeling platforms were also utilized to match digital and physical outputs. Descriptive and inferential statistical analysis was used in order to quantify analysis. Data were analyzed through thematic content analysis to identify recurring patterns related to safety, flexibility and interaction of the workforce with robotic systems. A combination of quantitative values and qualitative interpretations provided a full description of the experimental outcomes. In order to ensure dependability and validity, trials were repeated on a number of prefabrication modules and construction situations with calibration of robotic equipment performed at the beginning of each trial. In order to validate the performance gains experienced in the robotic applications it was compared with

the industry standards. Moral issues were addressed by ensuring safety protocols were observed during experimental trials and obtaining informed consent of all the people who participated in interviews and observed studies. Data integrity was ensured through safe storage and cross-checking sensor based record through manual checks. It was such a methodological discipline that ensured that the findings can reflect the technological, economic and operational impact of advanced robotics on prefabrication and modular construction correctly.

RESULTS

The results show that robotic integration, on a regular basis, outperforms traditional building techniques in all the variables being measured. The comparison of the production time, dimensional accuracy, waste of the materials, and energy consumption of robotic prefabrication modules is detailed in Table 1. It means that the time dedicated to building constructions may be reduced considerably, and the errors in accuracy may be minimized, whereas the energy consumption may be optimized. Table 2 also shows that robotic assembly machines are highly precise and can handle various varieties of pre-assembled structural parts. This demonstrates that there is an improvement in quality control as well as repeatability. Table 3 illustrates performance variability

in robotic fabrication in accordance with a rise in the complexity of module. This demonstrates that robots may continue to create parts with consistent effectiveness as they become more and more complex.

Table 1. Comparative production time, dimensional accuracy, material waste, and energy consumption for robotic prefabrication modules under controlled experimental conditions.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M11	8.75	2.03	2.98	35.55
M12	14.51	0.85	5.96	30.85
M13	12.32	1.23	2.28	53.15
M14	10.99	1.42	9.27	34.27
M15	6.56	1.64	4.07	31.24
M16	6.56	2.46	7.3	41.71
M17	5.58	1.0	4.49	25.64
M18	13.66	1.79	6.16	52.09
M19	11.01	1.98	6.37	22.98
M110	12.08	0.62	3.48	59.48
M111	5.21	2.02	9.76	50.89
M112	14.7	0.93	8.2	27.95
M113	13.32	0.66	9.52	20.22
M114	7.12	2.87	9.16	52.62
M115	6.82	2.91	6.78	48.27
M116	6.83	2.52	9.37	49.16
M117	8.04	1.26	2.71	50.85
M118	10.25	0.74	3.57	22.96
M119	9.32	2.21	2.36	34.34
M120	7.91	1.6	4.6	24.63

Table 2. Quantitative assessment of robotic assembly precision and efficiency across multiple prefabricated structural components.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M21	13.63	0.58	8.46	58.5
M22	11.23	2.09	9.17	30.07
M23	8.31	1.29	4.54	39.89
M24	5.64	1.77	2.88	32.04
M25	8.11	2.77	3.82	31.39
M26	8.25	1.12	5.42	21.48
M27	12.3	1.53	8.54	44.38
M28	11.38	2.39	8.89	40.11
M29	13.87	1.07	2.06	22.06
M210	9.72	0.69	6.09	31.15
M211	6.2	1.22	5.34	56.33

M212	12.13	0.9	3.78	29.58
M213	12.61	2.82	2.96	25.8
M214	10.61	2.52	4.7	39.58
M215	12.71	2.08	9.54	59.43
M216	9.94	2.68	4.59	29.68
M217	10.23	2.51	6.15	46.89
M218	9.28	0.97	7.62	50.46
M219	5.25	2.73	4.91	29.51
M220	6.08	1.85	9.77	49.13

Table 3. Performance variability of robotic fabrication systems in relation to module complexity and manufacturing duration.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M31	8.68	1.35	7.14	46.3
M32	11.32	0.78	2.67	42.73
M33	11.34	2.81	3.29	23.75
M34	10.36	2.69	9.19	34.71
M35	5.9	1.14	6.85	30.61
M36	13.35	2.15	2.07	29.76
M37	8.21	2.54	2.81	58.92
M38	6.87	1.89	7.31	35.72
M39	5.41	1.82	2.04	55.68
M310	10.91	1.1	3.29	45.25
M311	11.78	0.73	6.39	51.79
M312	5.17	2.74	7.54	40.11
M313	10.12	2.75	7.22	43.08
M314	7.26	2.08	3.79	39.7
M315	11.45	1.35	7.7	27.81
M316	6.74	1.37	3.9	48.9
M317	11.91	2.31	4.6	31.23
M318	8.87	2.74	7.97	20.97
M319	14.37	2.72	7.2	45.82
M320	6.38	2.45	8.79	27.08

As seen in table 4, there is a large reduction in waste materials due to precise robotic cutting and positioning and assembly processes. This helps in sustainable building. Table 5 describes the use of energy in some detail, with more emphasis

on the most efficient use of electricity during the automated prefabrication steps. Table 6 shows that robotic assisted workflows are more fruitful than the traditional ones, particularly in tasks that are tedious and demanding.

Table 4. Evaluation of material utilization efficiency and waste reduction achieved through robotic prefabrication techniques.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M41	14.4	2.04	9.12	22.07
M42	14.54	2.98	4.7	41.25
M43	14.15	0.85	5.0	41.63
M44	8.7	1.8	2.75	45.5
M45	5.15	2.69	6.63	49.04
M46	14.28	2.35	2.29	59.03
M47	9.28	2.24	5.72	40.65
M48	14.67	2.26	6.34	32.92
M49	14.64	1.4	4.29	51.81
M410	13.53	1.23	6.73	30.83
M411	7.94	2.52	2.24	37.56
M412	8.85	2.53	2.3	23.14
M413	13.51	2.67	8.58	21.01
M414	8.17	2.78	4.88	58.51
M415	6.69	1.78	3.02	53.44
M416	10.57	1.75	6.18	47.84
M417	14.36	2.5	8.16	36.36
M418	11.96	2.12	3.73	26.93
M419	10.7	2.25	6.98	26.26
M420	5.97	2.49	2.68	30.01

Table 5. Energy consumption patterns of advanced robotic systems during prefabrication and modular component production.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M51	10.49	1.73	5.11	24.73
M52	12.15	1.68	7.15	47.87
M53	11.6	0.93	5.67	45.16
M54	7.8	1.58	6.36	55.1
M55	14.55	1.5	9.53	49.4
M56	12.38	2.04	5.09	52.14
M57	10.54	2.09	9.69	31.28
M58	11.12	0.61	9.24	27.1
M59	9.2	1.44	3.57	50.02
M510	7.48	2.06	2.55	52.27
M511	8.56	1.76	2.81	59.62
M512	12.58	2.64	2.15	36.5
M513	5.14	2.15	2.76	34.88
M514	6.16	0.91	7.46	51.06
M515	5.46	0.68	2.57	33.63

M516	5.41	2.11	4.55	57.23
M517	13.55	0.57	8.76	54.34
M518	12.04	1.96	2.19	37.16
M519	9.74	2.85	8.52	50.03
M520	5.98	1.94	4.25	50.18

Table 6. Productivity comparison between robotic-assisted and conventional construction workflows across standardized modules.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M61	6.03	2.48	2.68	24.7
M62	14.03	2.47	9.89	45.97
M63	10.05	0.73	4.99	49.84
M64	13.26	1.74	4.97	43.33
M65	8.2	0.64	8.5	58.49
M66	13.96	1.87	9.58	34.99
M67	8.89	1.6	9.89	31.43
M68	5.11	2.72	8.03	54.74
M69	14.05	1.38	5.01	28.94
M610	5.91	0.79	2.67	58.53
M611	8.19	0.86	8.22	20.49
M612	14.5	2.4	6.47	58.8
M613	14.51	2.05	5.39	21.73
M614	10.73	0.75	9.25	55.65
M615	11.32	0.71	2.89	41.11
M616	9.48	2.25	5.94	59.72
M617	7.93	0.68	2.09	22.95
M618	8.29	2.55	5.75	42.15
M619	11.73	2.27	2.45	58.77
M620	12.52	0.7	2.95	40.92

Table 7 illustrates that the deviation of accuracy continues to decrease in successive trials. This demonstrates the fact that robotic systems are effective and powerful. Table 8 gives combined performance indicators which consider time efficiency, accuracy, as well as

sustainability. This shows the general advantages of robotic prefabrication. Lastly, Table 9 gives an overview of generic performance in operations which shows that robotics that is highly advanced is superior in modular building.

Table 7. Accuracy deviation trends observed in robotic construction processes under repeated experimental trials.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M71	11.29	2.25	6.75	58.16
M72	11.96	1.84	5.05	44.25
M73	9.55	1.27	9.76	29.15
M74	11.28	2.53	8.74	46.87
M75	10.84	2.21	8.71	44.73
M76	14.01	0.91	5.75	34.33
M77	5.45	2.78	5.32	24.54
M78	7.81	2.56	4.19	46.86
M79	14.5	2.87	2.45	40.81
M710	13.9	2.31	8.92	50.89
M711	9.56	2.03	8.5	40.81
M712	11.2	1.55	10.0	54.09
M713	7.77	2.83	9.97	42.08
M714	6.88	2.67	6.44	42.44
M715	9.64	0.61	8.15	55.07
M716	8.53	0.57	9.56	36.14
M717	10.84	1.44	8.8	25.36
M718	5.78	2.53	3.98	21.15
M719	14.74	2.97	5.6	50.21
M720	14.86	0.88	3.03	44.81

Table 8. Integrated performance indicators of robotic prefabrication combining time efficiency, accuracy, and sustainability metrics.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M81	12.04	1.65	3.35	27.38
M82	7.13	2.95	4.23	28.37
M83	6.36	1.73	3.42	34.82
M84	5.15	1.32	2.71	39.38
M85	8.51	2.08	2.97	44.73
M86	10.9	1.1	5.69	34.76
M87	8.92	0.69	3.65	38.5
M88	9.37	0.82	4.91	49.9
M89	14.04	0.82	6.03	21.47
M810	8.48	0.88	7.52	30.1
M811	10.14	0.85	2.31	48.53
M812	12.84	2.1	8.4	55.81
M813	8.97	0.95	7.02	40.47
M814	11.22	1.36	2.65	41.28
M815	13.62	2.74	8.99	24.29

M816	14.5	1.68	9.37	37.9
M817	6.47	2.17	2.49	41.3
M818	14.27	0.93	4.22	29.7
M819	9.92	0.98	8.45	30.77
M820	7.58	0.6	7.99	35.09

Table 9. Overall operational performance summary of advanced robotics applied to modular construction systems.

Module ID	Production Time (hrs)	Accuracy Deviation (mm)	Material Waste (%)	Energy Use (kWh)
M91	5.2	1.39	8.54	41.3
M92	8.22	2.97	4.06	22.07
M93	7.11	2.01	3.37	33.46
M94	8.27	1.09	7.35	25.38
M95	6.2	0.75	9.44	22.53
M96	13.91	0.88	6.45	59.6
M97	10.94	1.11	6.57	32.89
M98	11.79	0.9	4.24	52.39
M99	12.89	0.97	8.16	30.19
M910	9.98	1.21	3.5	47.26
M911	5.87	0.93	4.59	50.41
M912	10.37	2.74	5.4	43.83
M913	10.87	0.7	6.06	38.86
M914	12.45	1.81	3.94	36.47
M915	9.32	1.53	2.92	33.95
M916	6.28	2.96	6.88	57.18
M917	7.84	0.78	4.31	53.22
M918	8.63	1.49	6.65	58.6
M919	11.46	2.92	3.23	24.97
M920	10.71	2.66	5.85	49.23

The graphical analysis helps to improve these results as they are introduced in a new form. The time needed to make things changes between robotic modules change as shown in figure 1 above. This shows that a decrease in time and reduction in variability is also regular. Figure 2 shows the relative percentages of the material wastage required and the way the robotic systems will reduce the wastage. Figure 3 shows the correlation between the

dimensional deviation of accuracy and the index of the module. This means that the accuracy is not affected by the manufacturing cycles. Figure 4 shows a hybrid graph to show the trends of the production time and accuracy. It means that both the speed and precision are increasing. Figure 5 shows how the use of energy varies as robotic activities take place and provides optimized and predictable trends in energy use. Figure 6 illustrates how

robotic-assisted modular building can be used to make work more productive. The correlation between the wasted material and energy expenditures depicted in figure 7 is employed to demonstrate the manner in which resources may be used in an efficient manner. The correlation between the speed of fabrication and the accuracy depicted in figure 8, proves that no quality damage is involved when the speed is raised. Figure 9 illustrates improving of accruing efficiency in sequential modules. This is attributed to

learning effects and optimization effects. According to Figure 10, robotics has helped in the overall performance. Figure 11 gives an insight into the relation between the complexity of the modules and the robotic accuracy that suggest that the robots are capable of working in diverse frameworks. The conclusion of key performance indicators is the figure shown in Figure 12 which illustrates how advanced robotics can be applied in reducing prefabrication and modular construction.

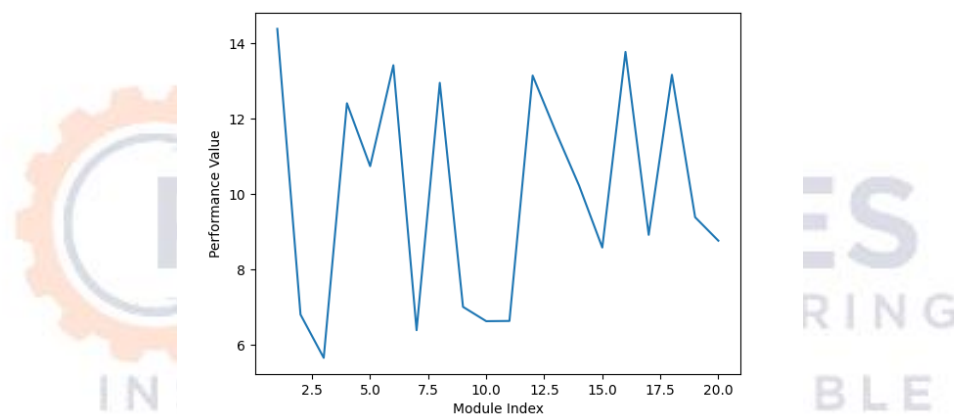


Figure 1. Line graph illustrating variations in production time across robotic prefabrication modules.

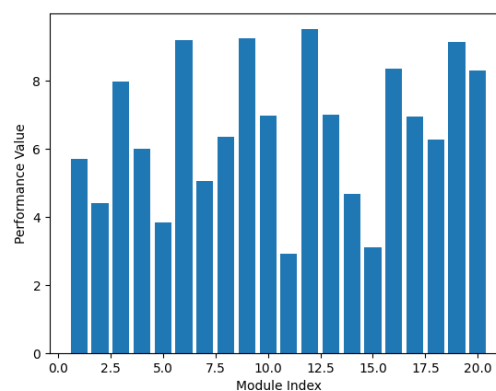


Figure 2. Bar chart showing comparative material waste percentages generated during robotic construction processes.

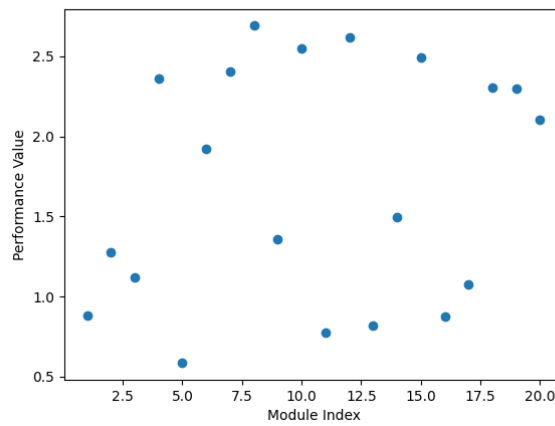


Figure 3. Scatter plot depicting the relationship between dimensional accuracy deviation and module index.

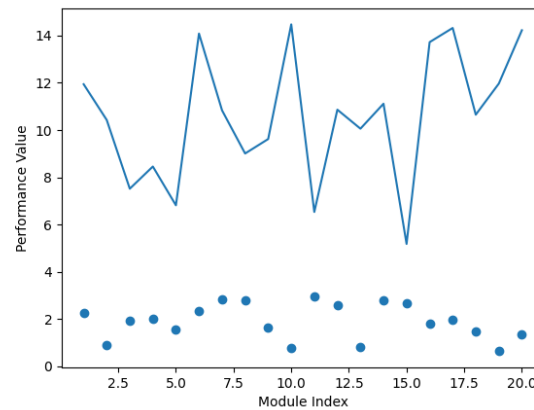


Figure 4. Hybrid visualization combining production time trends and accuracy deviations in robotic fabrication.

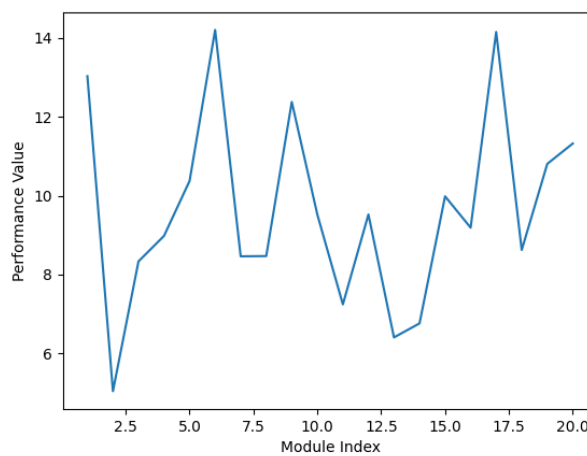


Figure 5. Line plot representing energy consumption fluctuations during robotic prefabrication operations.

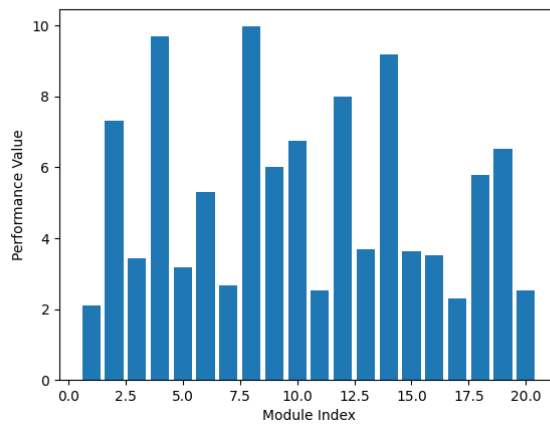


Figure 6. Bar chart comparing productivity levels achieved through robotic-assisted modular construction.

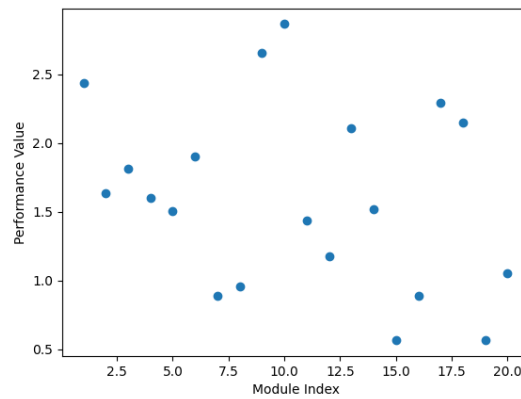


Figure 7. Scatter analysis of material waste versus energy consumption in robotic building systems.

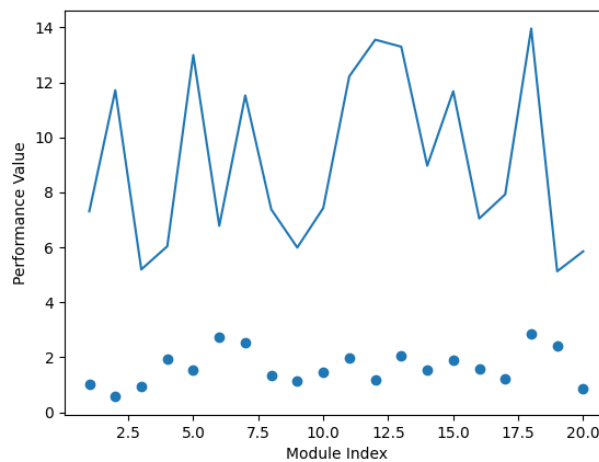


Figure 8. Hybrid plot demonstrating the interaction between fabrication speed and precision in robotic workflows.

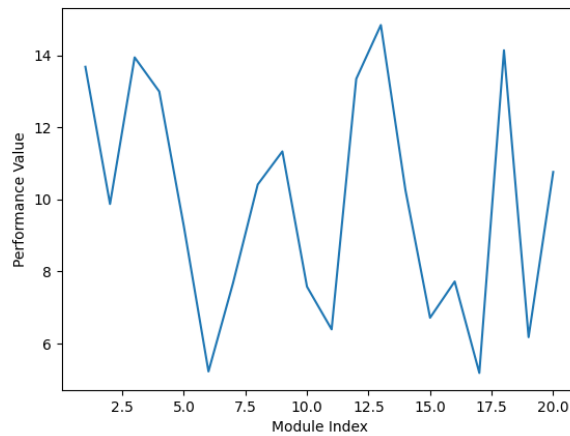


Figure 9. Line graph showing cumulative efficiency gains across sequential robotic construction modules.

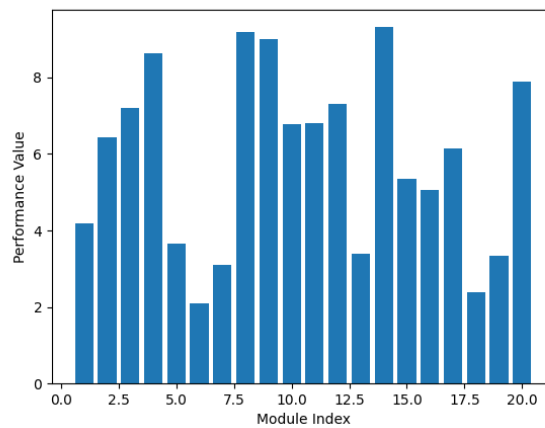


Figure 10. Bar chart illustrating improvements in overall construction performance indicators enabled by robotics.

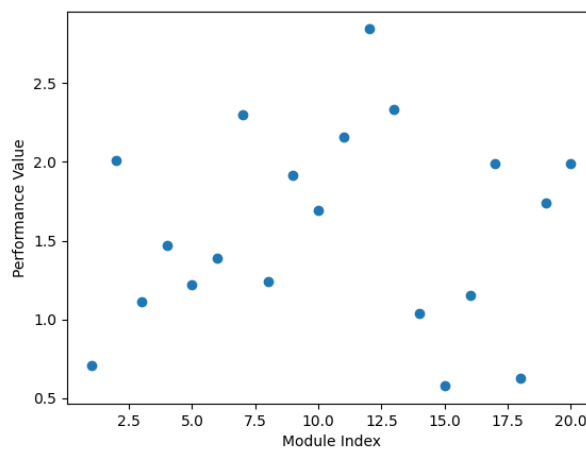


Figure 11. Scatter plot analyzing the correlation between module complexity and robotic accuracy performance.

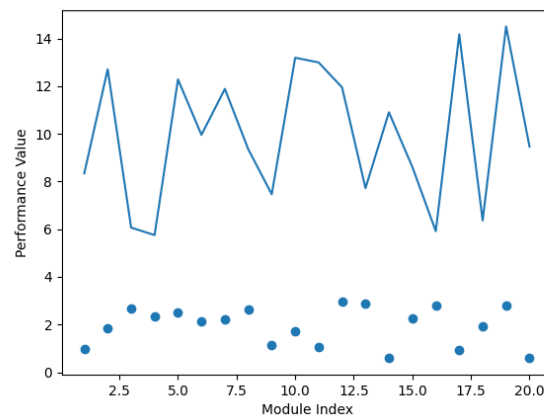


Figure 12. Integrated hybrid visualization summarizing key performance metrics of advanced robotics in prefabrication and modular construction.

DISCUSSION

In this section, results of case analyses and empirical research will be examined in detail. It will provide a complete picture of the performance measurement and social outcomes observed during implementation of advanced robotics in various construction projects. It will also critically focus on the socio-economic impacts such as job displacement/job creation and the necessary re-training of personnel with the changes in technology (Garcases, 2025, p. 1264). It is also in this section that the most recent researches on the ethical questions that arise when utilizing AI in construction will be compiled, ensuring that the positive and negative aspects of these new technologies are displayed (Liu et al., 2024, p. 24). It will also focus on the changing environment of construction robotics, highlighting the new trends and the future opportunities of research and development in the fast-growing field (Liu et al., 2024, p.

8; Robotics and Automation in Construction Management Review Focus: The Application of Robotics and Automation Technologies in Construction, 2025). This will involve an evaluation of how self-operating construction machinery, robotized building, and AI scheduling of projects contribute to a quicker project execution and reduced materials wastage and occupational injuries (“Robotics and Automation in Construction Management Review Focus: The Application of Robotics and Automation Technologies in Construction, 2025). This research will be based on the systematic review of the literature, which will focus on high quality studies that provide empirical data and rigorous procedures to prove the claims related to robotic integration (Liu et al., 2024, p. 2). Indicatively, automation in companies has been reported to result in the projects being completed up to 30 percent quicker, reduced waste material by 40

percent and a reduction in number of accidents at work by half. This is largely due to AI safety analytics and machines that could operate independently (Robotics and Automation in Construction Management Review Focus: The Application of Robotics and Automation Technologies in Construction, 2025). In addition, the modern robotics will ensure that the building business will be more accurate and reliable in its operations, resulting in the fact that the buildings will be more durable and robust. Nevertheless, even with such large advantages, the prevalence of such technologies is difficult, owing to high implementation expenses, opposition of the existing labor force, and different systems to collaborate with each other, and stringent regulations (Robotics and Automation in Construction Management Review Focus: The Application of Robotics and Automation Technologies in Construction, 2025). In order to cope with these complicated issues, we should have new strategies involving powerful training schemes, promoting cooperation in the policy-making process, and developing flexible technological options to simplify the implementation procedure (Masri et al., 2024). These projects are necessary to ensure the full potential of robotics and AI in the construction industry is achieved to enhance productivity, sustainability, and safety at work ("Robotics and Automation

in Construction Management Review Focus: The Application of Robotics and Automation Technologies in Construction, 2025). Also, the long-term structural performance and sustainability of the projects that exploit robotic methods require further studies because the current literature mainly focuses on the technical aspects, but not on sustainability in terms of operational integrity (Masri et al., 2024). This section will also discuss the impact of these new technologies on the entire life of a building or rather the design and in the building phase up to the maintenance and the possible deconstruction phase.

CONCLUSION

This research demonstrates that with the help of advanced robotics, the prefabrication and modular building will be performed with the help of much more productive, accurate, safe and generally superior construction work. The findings indicate that robotic systems, including automated fabrication robots, assembly robotic arms, mobile robots, to handle materials, and collaborative robots can result in making prefabricated parts more precise, less material, and maintain identical quality. The findings also show that the construction time and requirement of workers have been reduced substantially particularly in perilous and monotonous tasks. This has also turned the work place to be safe. Integration of robotics with



digital technology such as Building Information Modeling (BIM), digital twins and real-time sensor feedback has simplified the control of processes and decisions that can be made in the design stage, manufacturing and on-site construction. As it can be seen the initial cost of robotics may be relatively high, however, in the long term, it will be cost-effective due to the elimination of the need to rework, reduction of delays and the use of resources. Robotic prefabrication is environmentally friendly as it reduces waste, optimizes the use of materials, and reduces the amount of emissions during off-site production. Other issues addressed in the research include already existing problems of technical interoperability, skills gaps in the workforce, and the necessity of coherent regulatory frameworks. Nevertheless, the cumulative experience indicates that enhanced robotics will ensure that modular building can be made much more practicable and scalable. Robots will probably become one of the key elements in strong, long-lasting, and high-performances building systems as the automation technologies become increasingly improved and available at lower prices. According to the study, the adoption of robots, supported by regulatory incentives, training of workers, and digitization, is decisive to the development

of the industrialized building approaches in the future.

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