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BENEFITS OF ROBOTIC UTILIZATION IN THE PREFABRICATED CONSTRUCTION INDUSTRY

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ABSTRACT

Electronically automated machines with a longer lifespan than human work make up robotic technology. The aging workforce in the prefabricated building business may be addressed by robots, which explains why there are less young people employed there than in other sectors of the economy. Robotic technology is cost-effective since it reduces the time required to complete building projects and the expense of manpower, which also lessens the possibility of accidents. Therefore, it is crucial to consider the benefits of robotic technology adoption in the context of the South African prefabricated building industry. The study adopted a quantitative survey method to obtain data from architects, civil engineers, quantity surveyors, mechanical and electrical engineers, construction managers, and project managers. The data were examined using SPSS, and the suitable dispersion measure and inferential statistics were used. According to the report, the key benefits of adopting robotic technology in the prefabricated building business in South Africa include faster construction timeframes, improved work quality, and increased productivity, efficiency, and profitability. The results also showed that improving worker health and safety would result from introducing robotic technology to the prefabricated building industry. The study's conclusions suggest that because of the advantages discovered, the prefabricated building industry in South Africa should adopt robots more swiftly.

KEYWORDS

Robotics, Prefabrication, Accuracy, Construction Duration

INTRODUCTION

Mhlanga & Moloi, (2020) claim that South Africa is one of the world's emerging nations. Because building processes have changed and improved through time, the industry is currently experiencing a productivity issue due to a lack of investment in technical development. The South African construction industry must adapt to technological advancements on a worldwide scale since technology is essential to increasing effectiveness. According to Akinradewo et al., (2021) the use of robotic technology in the prefabricated building sector would improve worker health and safety since robots will do laborious activities on the construction site. Also, Maurice et al., (2018) opined that there will be lesser health problems associated with physically demanding construction labor. Its adoption is primarily for employee welfare. Less accidents and unplanned events will occur because of the use of robot technology in the

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prefabricated construction sector. Prefabricated materials might endanger the health and safety of manual employees since they are bulky and heavy. In modern businesses like the chemical and educational industries, robots have helped lift the heavy goods (Grau et al., 2020). According to Adekunle et al., (2022), robotic technology will also handle the repetitive jobs, cutting down on task length. Consequently, projects will be finished on time and within the allotted time framse without experiencing any more delays. It is crucial to consider the advantages of robotic technology in the context of the prefabricated building sector.

Robotic technology is the automation of machines using electronics to improve their accuracy (Toma et al., 2022). They outlive human effort in terms of lifespan. Robots are the answer to the labor shortfall caused by the construction industry's needs and an aging labor force (Flandorfer, 2012). Since these robots are trained to carry out certain jobs in detail, their precision minimizes errors brought on by improper handling and underestimation of building processes. Therefore, using robot’s technology improves the quality of the job produced. Robotic technology can save money since it cuts down on labor expenses and building time. There seems to be a lack of information in the literature about the advantages of using robotics within the prefabricated construction industry practices being carried out in developing and sub-Saharan countries like South Africa, aside from the issue of the prefabricated construction industry's poor adoption of digitization. It is crucial to keep in mind that South Africa is only now beginning to adapt and use prefabricated construction. This study evaluated the benefits of adopting robotic technology for prefabricated construction processes within the South African construction industry based on this information, with the goal of suggesting potential actions that would lead to an increase in utilization.

LITERATURE REVIEW

Due to a number of well-known obstacles, the adoption of robotic technology within the construction sector has historically been met with great opposition (Carra et al., 2018). Thanks to several recently discovered forces that are driving innovation processes within the construction sector, the situation is now changing quickly. Additionally, these factors gave rise to several easily visible trends that are altering how buildings are designed, constructed, and maintained. Because there is less human labor present when robotic technology is deployed, there are less opportunities for mishaps and strike breakouts (Delgado et al., 2019). As a result, robotic technology is a more dependable alternative to manual labor in terms of efficiency, production, and profitability. It is crucial to understand that prefabricated components are made in a factory with rigorous regulations, in a regulated, and under constant observation environment. This suggests that enhanced work supervision and factory inspections are carried out to guarantee that the components adhere to specification, according to Zhu et al., (2021). Additionally, components are produced in factories and merely transported to the construction site to be built into the required structure, requiring less handling and storage of resources. As building projects are delivered in modules to be built on site, less material storage and handling leads in lower site waste (Mahbub, 2012). The factories are constructed so they may repurpose building materials that were utilized in a prior manufacturing or production process. Due to this phenomena, more recycled materials are being used (Bademosi & Issa, 2022). Prefabricated construction is an ecologically beneficial method of building that will aid the sector in attaining its aims for sustainable growth. Robotic technology can help with material logistics and on-site assembly for reasons of health and safety.

Since the construction sector is dangerous to work in, businesses aim to adopt safer practices. And as a result of human’s construct subassemblies in climate-controlled factories, there is a reduced likelihood of issues with dirt, dampness, and other environmental dangers when employing robotics for prefabrication (Malomane & Musonda, 2022). Prefabricated building structures and assemblies are now as sturdy as conventional structures because to advances in engineering and prefabricated material technology. A factory-controlled environment offers greater safety compared to a project job site since employees and potential tenants are more vulnerable to weather-related health concerns on construction sites. Additionally, stricter production protocols and practices shield employees from workplace accidents. Despite the importance placed on worker safety at construction sites, shifting ground conditions, weather-related circumstances, and wind all increase the risk of accident. Another advantage is that the building business will become more productive, efficient, and profitable as a consequence of the implementation of robotic technology in the prefabricated construction sector (Tankova & Da Silva, 2020). Given how few construction companies now use automation, robots hold enormous potential for revolutionizing the sector.

Robotic technology's use in the lifting of large objects will reduce the demand for physical labor because workers won't need to engage in arduous activities there (Kyjanek et al., 2019). For the safety of human workers as well as the financial health of heavy industrial and construction enterprises, a robot is an attractive alternative to a human employee. The world population is aging, and the construction sector will have a difficult time attracting new employees in the future. The use of robotics technology appears to be the industry's panacea. Companies will recruit younger, more technologically knowledgeable employees if they are regarded to be implementing cutting-edge techniques and technology (Oke et al., 2019). Additionally, this will guarantee that businesses can retain productivity when the number of people in the globe who are working-age declines. Prefabricated materials are produced in facilities with extensive quality assurance and control procedures (Yahya et al., 2019). Realizing the harmony and unity of all parts is essential to building quality management. Considering construction quality management in its whole will help to advance the development of construction quality. Robotics adoption not only enhances quality management through the creation of economic advantages, but also fosters the growth of businesses (Adekunle et al., 2022). Less accidents and unplanned events on the job site will come from the application of robotic technology in the building procedures. Since robots are machines and are programmed to do certain tasks, there are fewer opportunities for error than there are with manual labor.

Robotic technology is appropriate for heavy lifting in a construction setting where flexibility and range are crucial (Pan et al., 2018). Robotic technology lowers building expenses and ultimately generates enormous profits for construction companies because it removes the possibility of human mistake and waste while producing results that are extremely exact. The robots have a long-life span because they are machines they merely need to be maintained and updated as frequently as necessary (Pan & Pan, 2019). Literature demonstrates that employees may easily disassemble and move sub-assemblies to other locations (Huang et al., 2022). But since prefabricated building technologies offer flexibility without stifling innovation, general contractors and clients are increasingly turning to alternatives. The use of robots in prefabricated and modular building opens up a world of possibilities by allowing for flexible structural design.

METHODOLOGY

This study used a structured questionnaire that was given to quantity surveyors, architects, engineers, construction managers, and project managers as part of a quantitative methodology. These experts were chosen from the public and private (contractor and consulting) sectors. These experts were chosen from the public and corporate sectors of Gauteng, the country's largest province. The province was chosen due to its strategic position and capacity to handle administrative duties. The province is also the core of high-end service delivery for industries including manufacturing, technical and industrial services, and construction. Those registered with the different professional organisations in South Africa and other countries in the Southern

African area were the construction industry's target professions. This precaution was deemed essential for the poll to guarantee that the findings accurately reflected the public's perception of the advantages of adopting robotic technology. 110 professionals were chosen as the sample size using a non-random sampling approach. As in the study conducted by Adekunle et al., (2022), a closed-end questionnaire was created and split into two portions. The purpose of the first portion was to gather demographic data from the respondents, such as their level of education, occupation, and experience. The purpose of the second section was to evaluate the benefits of using robots. In order to evaluate the advantages of robotic use, a 5-point Likert scale was used. 88 of the 110 questionnaires that were distributed received a response, which is an 80% response rate. When analyzing the collected data, percentages were used to evaluate the advantages of using robotic technology in pre-fabricated homes, and Mean Item Score (MIS) was used to rate the data on the respondents' backgrounds. Kruskal-Wallis was also used to compare respondents' perspectives based on their years of experience. The Cronbach's alpha reliability test, which was used to evaluate the data sets' dependability, yielded a result of 0.905, which denotes a high degree of consistency.

FINDINGS AND DISCUSSION

In terms of gender, the statistics showed that men, who made up 73.2% of respondents, received more responses than women, who made up 26.8% of respondents. In terms of profession, 14.2% of respondents were civil engineers, 13.3% were mechanical and electrical engineers, 24.5% were quantity surveyors, 4.5% were project managers for construction, 15% were managers of construction, and 13.2% were project managers. Moreover, 49.4% of respondents worked for contracting firms, while 29.9% were consultants. Also, 20.8% of them worked for the government. In addition, more than 87% of the respondents claimed that they had worked on seven or more projects, while the remaining 13% had only worked on six or less. The responses were trustworthy and credible as, on average, more than 90% of respondents had over five years of working experience in the South African construction business, which is a significantly high proportion.

Table 1 shows the respondents ranking of the benefits of the application of robotic technology in the South African prefabricated construction industry in Gauteng. The results reveal that 'shortens construction duration' was ranked first with a mean score of 4.25 and standard deviation of 0.821, 'Improved quality of work' ranked second with a mean score of 4.24 and standard deviation of 0.951, 'productivity, efficiency and profitability' ranked third with a mean score of 4.22 and standard deviation of 0.856, 'less material storage and handling' ranked fourth with the mean score of 4.16 and standard deviation of 0.857, 'less accidents and unforeseen circumstances' ranked fifth with the mean score of 4.14 and standard deviation of 0.939. Furthermore 'suitable for lifting heavy materials' ranked sixth with the mean score of 4.10 and standard deviation of 0.900, 'improved work supervision' ranked seventh with the mean score of 4.04 and standard deviation of 1.095, 'improved health and safety culture' ranked eighth with the mean score of 4.02 and a standard deviation of 1.104, 'Reduced mishandling and miscalculation' ranked ninth with the mean score of 4.00 and standard deviation of 0.980, 'reduce health issues for strenuous activities' ranked tenth with the mean score of 4.00 and a standard deviation of 1.077, 'reduced site waste' ranked fourteenth with the mean score of 3.88 and standard deviation of 0.931, 'long-life span' ranked eleventh with both having the mean score of 3.88 and standard deviation of 0.952, 'increased use of recycled materials' ranked thirteenth with the mean score of 3.86 and standard deviation of 1.020, 'solves ageing population crisis' ranked fourteenth with the mean score of 3.71 and standard deviation of 1.119 and 'cost effective' ranked fifteenth with the mean score of 3.45 and the standard deviation of 1.006 as the least benefit of the application of robotic technology in the South African prefabricated construction industry.

Table 1: Benefits of Adopting Robotic Technology

Benefits	Rank	Mean	Std. Deviation
Shortens construction duration	1	4.25	0.821
Improved quality of work	2	4.24	0.951
Productivity, efficiency and profitability	3	4.22	0.856
Less material storage and handling	4	4.16	0.857
Less accidents and unforeseen circumstances	5	4.14	0.939
Suitable for lifting heavy materials	6	4.10	0.900
Improved work supervision	7	4.04	1.095
Improved health and safety culture	8	4.02	1.104
Reduced mishandling and miscalculation	9	4.00	0.980
Reduction of strenuous activities	10	4.00	1.077
Reduces site waste	11	3.88	0.931
Long-life span	12	3.88	0.952
Increase use of recycled materials	13	3.86	1.020
Solves ageing population crisis	14	3.71	1.119
Cost effective	15	3.45	1.006

Table 2: Kruskal-Wallis Test Showing P-Values for Measures

Benefits	P-Values
Shortens construction duration	0.003
Improved quality of work	0.000
Productivity, efficiency and profitability	0.000
Less material storage and handling	0.064
Less accidents and unforeseen circumstances	0.827
Suitable for lifting heavy materials	0.000
Improved work supervision	0.000
Improved health and safety culture	0.004
Reduced mishandling and miscalculation	0.013
Reduction of strenuous activities	0.000
Reduces site waste	0.002
Long-life span	0.000
Increase use of recycled materials	0.044
Solves ageing population crisis	0.031
Cost effective	0.022

The results of this study back up Delgado et al., (2019) claim that the South African prefabricated building sector may reduce construction time by using robotic technology. As a consequence, projects will be finished on time and within the allotted time frame without experiencing any more delays. This advantage received the highest ranking, indicating that respondents believe it to be the most significant benefit that will hasten the adoption of robotic technology in the prefabricated building sector. Additionally, the study supported Chea et al., (2020) who claimed that using technology improves the caliber of work produced. Robotic technology is a more dependable alternative to manual labor since it will increase efficiency, production, and profitability in the prefabricated building business. Application of robotic technology leads in less material storage and handling since materials are created at the plant and only delivered to the site to be built to the appropriate structure because they are prefabricated components. This is in line with the findings of a research by (Bademosi & Issa, 2022), which predicted that the use of robot technology will lead to fewer mishaps and unanticipated events. The results of this study further confirm Oke et al., (2019) assertion that robots will be useful for carrying large goods on site, especially prefabricated pieces. Prefabricated parts are created at a plant that adheres to stringent regulations and is closely watched. This will lead to better job supervision because factory checks are done to guarantee that the components meet specifications. According to Akinradewo et al., (2021), the use of robotic technology in the prefabricated building sector would improve worker health and safety since the robots will handle activities that are riskier.

Robots are machines whose accuracy prevents errors caused by carelessness and error in calculation, depending on their capacity and what they are programmed to do (Pan et al., 2018). However, the respondents to this study gave a low rating to this benefit, believing that it does little to encourage the use of robotic technology. Robotic technology will thereby lessen the health problems caused by physically demanding construction labor since its adoption will improve employee wellness. In line with Kumar et al., (2016) study, the outcome also showed that less material handling and storage leads to less waste generated on the site. Prefabricated buildings require no adjustments, so materials are delivered on site and put together to create the desired structure. Despite the fact that robotic technology has a longer lifespan than human labor (Pradhananga et al., 2021), the results of this study do not appear to view this advantage as a key driver for the use of robotic technology in the prefabricated construction sector. According to the study's findings, the fact that factories are built so they may reuse materials from earlier production processes does not significantly influence whether or not robotic technology will be applied there. This also increases the usage of recyclable materials. The findings of this study do not support Aghimien et al., (2020), who claimed that robots are the answer to the construction industry's ageing population, which results in fewer young people than in other industries. Even though this is a benefit, it does little to influence the construction industry's adoption of robotic technology in the prefabricated construction sector.

The cost effectiveness of robotic technology was the benefit that received the lowest ranking in this study for its use in the prefabricated building sector of South Africa. Robotic technology, according to Chen et al., (2022), is cost-effective since it lowers labor expenses and construction time, which has a cost associated with it because construction equipment must be hired; the less time spent on a project, the more money is saved. Because they are not considering the fact that robotic technology shortens the period of building, which would save money, the respondents to this survey do not see the benefit as being crucial to encourage its implementation.

A Kruskal-Walli test was also run, as seen in Fig. 2, to compare the respondents' perspectives depending on their years of experience. Except for "Less accidents and unforeseen circumstances," which revealed that there is a statistically significant difference in the mean values of the respondent category, it was determined that there really is no significant difference in the mean values for any of the benefits.

CONCLUSION

Among the major institutions in the global market is construction. Construction has been slower than other industries to adopt robotics because, as was already mentioned, it is one of the sectors that takes the longest to start down the path of automation and digitalization. A number of things, including the price of labor or the processes' lack of preparation, causes this. Robotics has several benefits, and it is already used in a number of industries, including architecture, masonry, demolition, and infrastructure. Safety and inspection activities, which employ technology to examine and detect any problems in real time and convey the information to the system so that it can be fixed as soon as possible, are some of the duties that call for succinct use of robots. Robotics will improve the construction sector in a variety of ways, including greater production, decreased mistakes, meeting deadlines, reducing accidents, and lowering prices.

The study suggests that the government step in to fund and provide incentives for construction companies to apply robotic technology in order to make the construction industry appear innovative and efficient rather than outdated and reticent to adopt new technologies. This is because the application of robotic technology is thought to be expensive to implement.

If the construction industry is to quickly adopt robotic technology in the South African prefabricated construction industry, big private construction companies must also consider this collaboration and collaborate with the government to educate and train small construction companies, clients, and end-users in this area.

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