Benefits of Construction Automation and Robotics in the South African Construction Industry

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Abstract. Construction is known for playing important role to the country’s economy and construction research is being conducted across the whole world on improving construction industry from the traditional method of construction to a more suitable advanced construction approach. Automation in construction industry are tools for ensuring production in a business without compromising quality of the construction products, which may result from tiredness of workers. The study aimed at assessing the benefits of construction automation and robotics in the South African Construction Industry. Related literatures were reviewed and the study adopted quantitative analysis in which a well-structured questionnaire was developed to retrieve information from respondents within Gauteng province of South Africa. Respondents for the study were Construction Managers, Quantity Surveyors, Architects and Project Managers. Data retrieved was analysed using Mean Item Score and Standard Deviation. The study revealed and concluded that robotics and construction automation results in increasing quality of the construction project by increasing accuracy of components of the construction project, promote design specifications, reduction in the delivery time of a construction project and also make room for achieving standards.

1. Introduction

Construction is known for playing important role to the country’s economy and construction research is being conducted across the whole world on improving construction industry from the traditional method of construction to a more suitable advanced construction approach. Construction automation has been implemented in other parts of the world such Malaysia, Japan, and America due to the positive effects that this advanced technology brings to the society in improving construction. These new methods of construction technology had been found to resolve problems associated with conventional method of construction referred to as manual method construction, such as construction waste, lower productivity, and construction accident to the workers that are caused by falling from heights and negligence by the management [1]. This approach of construction automation is very advantageous in construction management because it simplifies the work of consultants or professionals involved in the construction industry by assisting in planning, designing and assuming the life span of the project to be delivered to the client. This approach can also be suitable to countries with high labour cost, with the use of construction automation which can help to eliminate demand that may lead to strikes because they may affect the delivery of the construction project [2].
Automation in construction industry are tools for ensuring production in a business without compromising quality of the construction products, which may result from tiredness of workers. It becomes easy to estimate quantity of materials or products that can be manufactured daily. High production in construction industry means the construction product may be delivered on time. Construction products manufactured under automation process can be produced at higher speeds [2]. Construction automation and robotics is usually applied in the manufacturing of components such as concrete beams, columns and bricks. Technology involved in the production of construction components are lasers (for ensuring quality and for checking dimensions) concrete mixer, cutting and drilling automated equipment etc. The reasons for using prefabricated components is because they are produced under high supervision and controlled environment to maintain temperatures that may affect the quality of the products. Final work is then carried onsite where minimal amount of work is required [3].

2. Literature Review

The motivation for construction automation and robotics came as a result of successes recorded in civil engineering via bridge, tunnel, earthworks and road construction with robotic applications [4]. Outputs of the construction industry has grown very fast in developed countries due to the shift from construction using traditional procedures to Industrialised Building System (IBS) in which prefabrication is carried out in workshops before assemblage is done on the construction site [5]. The construction industry remains conservative when compared to the manufacturing industry in adoption of automation and robotics. This as reported by [6] was as a result of new automatic products not being complementary to the old ones which therefore, doesn’t allow their implementation in the construction industry unlike the manufacturing industry. Robotics and automation can be applied to the construction industry in the following ways.

2.1. Construction Monitoring

Construction requires supervision by the construction manager at all times to ensure quality construction delivery to the client. Automation can be applied to improve safety on site and improved quality. Construction automation used for supervision can monitor during the times when managers and safety officer are not available on site or attending meetings to record information about situation on site. Managers can view information at any time because it can be stored and analyzed at a later stage [7].

2.2. Planning and Estimating

Planning and estimation can be complicated which requires an expert project manager. Application software can be applied during this phase of construction. Information technology brings applications that are able to plan and make accurate estimates of cost. With this software, the project manager has less chance of making wrong estimate because breakdown of activities can be automatically produced from the design which makes estimation simpler since each activity can be focused on [8, 7].

2.3. Construction Manufacturing

Construction involves the use of pre-fabricated components, which are manufactured in controlled environment where 100% work is executed using machinery and computer programs to automate the robotics. Automation in the pre-fabrication phase involves cutting, welding, batching, lifting and pre-fabrication of formwork. Automatic cutting grinders and welding robots are required to improve working condition and ensuring high level of safety because less work will be completed by the workers. Cranes are required to carry section of component which requires more labour to lift because they are heavy. Robotics are required for lifting and loading components for storage or transportation so that they can be delivered to site [3].

2.4. Designing

Over the years, construction involves manual designing using 2-dimesional plan. Advanced software can be implemented in the construction industry especially for the architect and engineer to ease
designing. This software allows the designer to have a view of the design in 3-dimension and are quicker means of designing while the designer can analyse all the sides of the structure in three-dimensional view. More sophisticated software is used to design and allow the 4-dimension view of structures. These applications can work as a simulator which assists designers in checking if components do not overlap one another [8].

2.5. Quality Control
Construction is concerned with delivering quality products. Automation is used to improve quality of the construction product using highly advanced inspection sensors and lasers. This technology is used to verify work inspected by worker and are mostly used in the pre-fabrication. Testing can be performed on components to monitor the strength of the product in construction using hydraulics, this hydraulics can be connected to a monitor to display information about the components which allows the operator view information on a screen. Lasers and sensors can be linked with computer system to accept and reject if the product fails the test hence automation is applied at higher levels to avoid the failure of structure and unnecessary cost [6, 8].

3. Research Methodology
Due to the nature of this research work, quantitative research method was adopted. A well-structured questionnaire was designed based on literatures reviewed. First section of the questionnaire retrieved the demographic information of the respondents while the second section was designed to assess the opinion of the respondents on the benefits of construction automation and robotics in the South African Construction Industry. Respondents chosen for this research work are construction industry professionals within Gauteng province of South African construction Industry. These respondents include Construction Managers, Quantity Surveyors, Architects and Project Managers. Purposive sampling technique was adopted for the sampling of professionals in order to ensure that they have adequate knowledge of construction automation and robotics. Mean Item Score (MIS) and Standard Deviation (SD) were employed in analysing retrieved data in order to rank the benefits of construction automation and robotics on the South African construction industry.

4. Findings and Discussions
Findings relating to respondents’ working experience as shown in figure 1 revealed that 43% have between 1-5 years of working experience, 32% were between 6-10 years of experience, 20% were 11-15 years of experience, 5% were 16-20 years of working experience and 0% have 20 year and above working experience in the construction industry.

![Figure 1. Respondents’ years of working experience](image-url)
Professional qualification of the respondents as shown in figure 2 indicated that 14% were Architect, 30% were quantity surveyor, 20% were construction engineers, 20% were project managers and 16% were construction manager.

The findings on the benefits of construction Automation and Robotics on the South African construction industry in table 1 indicated that Increases accuracy of components was rank first with a mean score item of 4.11 and a standard deviation of 0.920. Promotes design specifications was rank second with a mean score item of 4.07 and standard deviation (SD)= 0.873. Increases quality of construction products was rank third with a means score item of 3.98 and standard deviation (SD)=1.045, Reduces the duration of project delivery was rank fourth with a mean score item of 3.89 and standard deviation (SD)= 1.061, Better finished product performance was rank fifth with a mean score item of 3.84 and standard deviation (SD)= 0.914, Standard achieved was rank sixth with a mean score item of 3.84 and standard deviation (SD)=1.010, Cost effectiveness was rank seventh with a mean score item of 3.80 and standard deviation (SD)= 0.978, Eliminates material wastage was rank eighth with a mean score item of 3.77 and standard deviation (SD)= 0.937, Saves Material was rank ninth with a mean score item of 3.77 and standard deviation (SD)= 0.912, Reduces construction accidents was rank tenth with a mean score item of 3.77 and standard deviation (SD)= 1.008, Improves working condition was rank eleventh with a mean score item of 3.77 and standard deviation (SD)= 0.803, Reduces labour cost was rank twelfth with a mean score item of 3.73 and standard deviation (SD)= 0.973, Eliminates injuries was rank thirteenth with mean score item of 3.59 and standard deviation (SD)= 0.996.

| Benefits                                | MIS  | SD   | Rank |
|-----------------------------------------|------|------|------|
| Increases accuracy of components        | 4.11 | 0.920| 1    |
| Promotes design specifications          | 4.07 | 0.873| 2    |
| Increases quality of construction products| 3.98 | 1.045| 3    |
| Reduces the duration of project delivery| 3.89 | 1.061| 4    |
| Better finished product performance    | 3.84 | 0.914| 5    |
| Standard achieved                       | 3.84 | 1.010| 6    |
| Cost effectiveness                     | 3.80 | 0.978| 7    |
| Eliminates material wastage             | 3.77 | 0.937| 8    |
| Saves Material                          | 3.77 | 0.912| 9    |
| Reduces construction accidents          | 3.77 | 1.008| 10   |
| Improves working condition              | 3.77 | 0.803| 11   |
| Reduces labour cost                     | 3.73 | 0.973| 12   |
| Eliminates injuries                     | 3.59 | 0.996| 13   |
Using a 5-point Likert scale, the identified benefits were ranked based on their MIS and SD values. All the benefits have a MIS value above 3.00 which is the average score, this shows that respondents are of the opinion that construction automation and robotics has high benefits on the South African construction industry. Most of the benefits have SD value below 1.00 which shows that there is little deviation in the opinion of the respondents concerning each of the benefits ranked. The results were in supports of the research work carried out by [2] whose findings were that Automation helps in labour cost saving, increase productivity, Reduced accidents, cost effective, material saving, and improve working condition, increased accuracy. It is also in agreement with [9] who revealed that automation improve design of the construction product and accurate. The findings were also in tandem with [6] and [8] who asserted that construction automation and robotics helps in quality and reliability, productivity improvement, enhancement of working conditions, safety, savings in labour costs, life cycle cost savings, standardization of components, and simplification of the workforce.

5. Conclusion and Recommendation
The study has succeeded in indicating that robotics and construction automation results in increasing quality of the construction project by increasing accuracy of components of the construction project, promote design specifications, reduction in the delivery time of a construction project and also make room for achieving standards. This study therefore recommends that construction stakeholders and participants should be ready to take financial risks in adopting the use of construction automation and robotics in order for the construction industry to be beneficial of the advantages. For further studies, research can be carried out on the implementation of construction automation and robotics in the South African construction industry.

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