# Willingness to Adopt Robotics and Construction Automation in the South African Construction Industry

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## Abstract

Automation in construction has shown a great advantage in the construction industry for execution of different types of work in construction in terms of increasing production, cost reduction, resolving labour issue and delivering project on time. Problem faced in construction had been studied and inventors designed new robotics and construction automation to mitigate those problems. This study focused on assessing the level of willingness to adopt robotics and construction automation in South Africa. Literatures were reviewed and with the findings obtained from the administered questionnaire, the objective of the study was achieved. Respondents were chosen from the population of construction professional and retrieved data was analysed. The study indicated that construction professionals are willing to adopt robotics and construction automation. Although reviewed literatures showed there are barriers to the adoption of Robotics and Construction Automation. The study concluded that construction automation and robotics would have positive effects on the delivery of the construction project by increasing quality of the construction product, enhancing supervision, improving working conditions, cost effectiveness and it will also reduce construction accidents if adopted. It was recommended that government provide subsidies to encourage construction professionals in getting necessary technology for the adoption of robotics and construction automation.

## Keywords
Robotics and Automation; Computer Aided Manufacturing; Computer Aided Design; Building Information Modelling

## 1. Introduction

Productivity is slow without the use of construction technology (Bock, 2008). Construction is an industry that is identified to have more accidents and workers dying at work. Collapsing of the building is the main factor of fatalities in construction and falling from heights. Till today construction had proved that implementation of construction automation is required for the purpose of lifting heavy materials because cranes are faster than workers in moving materials from one point to where it is required and it is a safer way to avoid accidents. To avoid material from falling, cranes are automated with computers that calculate the weight of the material to ensure that it is not beyond the lifting capacity of the crane. The use of robots is proven to be safer, prototypes are developed to improve the quality of machines and to be user-friendly in order to reduce fatalities in the construction industry (Chonnaparamutt & Birk, 2006). Quality can be achieved using construction automation because machines are more precise than worker and advanced software in the factory are used to automate the machines so that it can reject the product that does not meet required standards. Factory specializing in the precast concrete use concrete cubes to check the quality of the components by using robotic hydraulic, records of readings are then examined to see if they meet the required standards and rejected if they fail the test. Precast components are manufactured in a controlled environment so that temperature that causes cracks to a concrete can be avoided, they are allowed to pass through laser sensor to check for quality, information is captured on the computer as report of component, save time to check the product manually (Kwen & Cheong, 2005).

Kamaruddin, Mohammad, Mahbub & Ahmad, (2013) mentioned that the solution to the shortage of labour, occupational health and safety, decrease in quality and productivity is by fully adopting the use of technology such as robots and construction automation. Modern method of construction (MMC) encouraged improvement in the economy of the country. There is high level of inspection for components that are manufactured in the industry and they are tested using hydraulics test to ensure required strength of the component (Kamaruddin, Mohammad, Mahbub &Ahmad, 2013). Malaysia implemented Industrialized Building System (IBS) sometimes referred to as modern method of construction (MMC). This a technique in which components manufactured off-site, transported and less work is completed on-site. Industrialized building system is adopted for the purpose of reducing wastage which has a negative impact to the environment because it is always a case that wastage of concrete, dust, air pollution and noise pollution is a serious problem during operation of construction equipment (Yee, 2001). In the pre-fabrication there is 100% of robotics and construction automation which are more accurate in measuring batching, meaning on necessary concrete can be produced to avoid wastage. Industrial Building System (IBS) was implemented by the government after research was conducted, the parliament implemented regulation that emphasized the use of components manufactured in factory to promote high-quality products and to ensure that the environment is not affected by construction activities. Implantation of Industrial Building System (IBS) was to encourage contractors to fully adopt modern methods construction to achieve a safe work environment, improve the quality of construction work and because there is high involvement of automation and Robotics in the factory (Yee, 2001).

Automation is mostly adopted by Malaysian country, because of the demands for simplifying work, work can be repeated over and over again moreover due to the large amount of work in construction. Construction automation is a replacement for labour and reduces the demand for skilled labour in the construction field. This technology can increase productivity at a lower cost because it substitute high labour, robotics and construction automation are being widely used in the pre-fabrication of components such as pre-cast concrete, prefabrication of masonry and prefabrication of steel due to higher degree of machinery in the industry which can bring about good quality of products, high level of monitoring in manufacturing plant and supervision by worker is simplified because of inspecting automation in the factory, moreover the workplace is highly controlled to suit the situation of component hence quality can be achieved to optimum level (Kamaruddin, Mohammad, Mahbub &Ahmad, 2013). This research study seeks to assess the level of willingness to adopt Robotics and Construction Automation in the South African Construction Industry while taking a look at the barriers to the adoption of the Robotics and Construction Automation.

## 2. Literature Review

Kumar, Prasanthi, Leena, (2008) mentioned that Construction is an industry requiring strategies and new approaches to achieve a successful construction with time, cost, safety, and quality. The use of automation is slowly increasing in the construction industry. Automation in construction has shown a great advantage in the construction industry for execution of different types of work in terms of increasing production, cost reduction, resolving labour issue and delivering the project on time. Problem faced in construction has been studied and inventors designed new robotics and construction automation to mitigate those problems. Robotics offers great advantages to the society and also has negative impact on labour. Nawi, (2007) mentioned that the construction industry plays a major role in the Malaysian Gross price index (GDP). Robotics reduce the demand for skilled labour in the construction industry. Malaysia government encourages the use of construction automation due to unskilled labour in the construction industry and Shaari and Ismail (2003) further explained that construction robots and automation was a factor that encourages the use of machinery in Malaysia because automation is more productive compared with labour, had a tendency of work reparative and quality products are achieved. Robotics require operators to control or guide hence so knowledge about robots will be required to operate the robots. This means that operator will require proper training to operate the machines every time a new machinery is brought to site to operate the equipment properly. Automation is all about computerising machinery to perform certain functions, academic background will be required for the operator to understand the operation of equipment (Kumar, Prasanthi, Leena, 2008).

Automation showed a rapid increase in the manufacturing industry of mechanical and industrial products because of the quality results of robotics, hence construction industry embrace the use of pre-fabricated component such as precast concrete due to high usage of robotics in pre-fabrication of component, Full implementation of robots in the construction industry is affected by human factor because people are willing to adopt the use of construction technology, as Warzawki (1991) mentioned that for full adaptation of construction automation and robotics is dependent on the human barriers. Automation implementation is not affected by the human factors alone, social and economic factor plays a role in the adaptation of advanced construction technology.

Workers whose lives depend on the construction industry are not willing to adopt because people fear for losing jobs as automation substitute the level of labour in the construction industry. As robotics and construction automation is able to perform many functions from estimating, designing and manufacturing. The deliverance of automation are also the sources for slow adaptation of technology in construction since it requires academic background to understanding how equipment operates, many workers employed as labour force are mostly people with no qualification (Navon, Kelley & Fellow, 1993).

## 2.1 Barriers to Implementation of Automation

### 2.1.1 Workers concerns about their employment

James, Wong, & Chan, (2006) stated that Construction industry plays a significant role in the employment of workers in the country. Researches are conducted across the world in Malaysia and Hong Kong in improving construction related problems, robotics and automation are the solution to problems related to labour issues such as labour cost saving and increasing quality and productivity at the same time, automation and robotics as technology of the future and mentioned technology in construction will substitute labour. (Majchrzak, 1988) mentioned that workers fear unemployment with the implementation of robots and automation in the construction industry, hence it becomes the barriers for automation because if robots are the future construction technology it means there will be job loss. Full adaptation of robotics in construction will change most of the employment structure since there will be decrease in the amount of work that will be available. Only jobs of those that robots are able to perform will be reduced because machines can execute specific task with benefits of increased production and better-quality products. The usage of robotics will replace skilled labour, and those workers that are affected by usage of robots and automation will be required to change trade in which they specialize in, for example bricklayers will change to specialize in carpentry because robots that can lay brick are introduced, so substitution for bricklayer will be expected. Unskilled labour will be left with shortage of work (Navon, Kelley & Fellow, 1993:805).

### 2.1.2 New Work Methods

Most labours in construction do not have higher education, workers were trained on the job in construction to become expert in certain trade as the managers see potential in their workers. Most construction workers are trained in single trade and happen to specialize in that trade for number of years, which makes it difficult for the workers to consider training because it involves a little bit of academic background. Managers may therefore doubt workers ability to be able to operate new robots and construction automation (Navon, Kelley & Fellow, 1993),

### 2.1.3 Cost of Robotics and Automation

Barriers to construction automation are controlled by the cost factors. The willingness of contractor to adopt use of construction automation is dependent on the specific size of the project. According to Mahbub (2012) the resistance in the implementation of robotics and construction automation involves high cost, maintaining machinery is also expensive. Construction demand such as increased quality of the project requires the use of heavy equipment or high duty machinery depending on the task to be executed, these equipment can be extremely expensive. Rahman and Omar (2006) mentioned that there is lack of investment for industrial machinery and heavy equipment due to high capital investment required to automate construction sites. It becomes difficult for contractors or companies to adopt the use of construction automation because small companies are not recognized by the market, which means stronger companies have higher chance to purchase or hire heavy equipment (Kamar & Hamid, 2009). Robotics and automation are faced with high maintenance cost; hence the contractors still prefer the use of traditional method of constructing. The most difficult part in adopting robots and construction automation is finance to purchase the equipment. Robotics can be complex which makes it difficult to be understood by people because it involves integration of information technology, the lower level of knowledge about computer and to operate future construction automation will have to undergo training to be familiar with the new technology and to avoid being eliminated in the construction industry (Kamaruddin, Mohammad, & Mahbub, 2016). Sadique & Mahesh (2016) further elaborates the barriers to implementation of robots and automation as expensive to update as technology release new automation and adopting new technology to suit the task because not all the construction processes are the same (Mahbub, 2008)

### 2.2 Willingness to Adopt Automation

#### 2.2.1 Managers and Owners Demand

It is the desire of the client and contractor to achieve project on time agreed in the contract so the client can make use of the structure as planned. The use of construction automation and robotics will definitely increase productivity of the construction project. Everett and Saito, (1994) mentioned that the client and construction managers are concerned with the profit and acceptable construction performance hence the demand for the use of mechanization is expected than using manual labour, good corporate image and competition to increase market share are also one of the key factors driving the demand for construction automation. The demands for construction automation are improved quality, improved safety which will mean project completed with less accidents and no death and increased speed of construction and lower quality specifically in labour cost countries, means that the manager will be able to deliver the project on time, this means improved cost benefits of return on investments (Bock, 2008).

#### 2.2.2 Government Incentives

Robotic and construction automation are faced with high cost to implement, government should be involved in assisting the construction users with incentives to promote the use of technology in construction. The government needs to assist the contractors to improve the quality of construction, productivity, and reduce construction accidents by paying incentives to reduce cost of machinery to have economical buildings and contractors being able to complete the projects in a short period (Samari, Ghodrati, and Shafiei, 2012). The other factor that is affecting the purchasing of equipment is the bank interest rate. Construction robotics and automation user should be able to obtain loan at a lower interest rate to have a high increase in the usage of automation in the industries and construction sites. Lower interest rate will encourage the construction users to take loan and be able to face-out problems of maintenance (Tambi, Kolhe & Saharkar, 2014).

#### 2.2.3 Training

Robotics may be complex depending on the size of the equipment. Workers in the construction industry will require academic background to understand robots. The problem is that workers employed under construction most times do not have qualifications (Navon Kelly & fellow, 1999). For workers to be able to operate robots and automation, training will be required every time a new machinery is brought to site to operate the equipment properly. Automation is all about computerizing machinery to perform certain functions, academic background will be required for the operator to understand the operation of equipment (Kumar, Prasanthi, Leena, 2008). Workers will need to be retrained to upgrade their skills to avoid replacement by automation and infact to be the operators of the machineries. Training and education may be required for the construction professional that are threatened by the implementation of automation to become familiar with the use of new technology (Tambi, Kolhe & Saharkar, 2014).

## 3. Research Methodology

This research survey was conducted employing quantitative method by using questionnaire to collect data from the respondent. The questionnaires were distributed to the construction professionals such as Architects, Quantity Surveyors, Project Managers, Construction Managers and Contractors as well as Civil Engineers within the Gauteng province of South Africa. The research questionnaire was designed to have close-ended questions and it used the 5-point Likert scale (1- very low, 2- low, 3- Average, 4-high, 5-very high) for the respondents to rank their opinions. Factors for the objective were extracted from the literature review which were obtained from the primary source of information including journal, internet source, text books and articles. Data for this research were analysed using the descriptive statistics to help describe, summarize data and organize data in a sequence. The data retrieved was analysed with the use of the software called SPSS.

## 4. Result and Findings

From the retrieved questionnaires, the following results were retrieved. 64% of the respondents were male and 37% were females. Age group of the respondents indicated that 18% were ranging between 20- 25 years old, 32% were between 26-30 years old, 32% were between 31-35 years old, 14% were between 36-40 years old, 5% were between 41- 45 years old and 0% were for respondent that were 46 and above older. This is an indication that the respondents are relatively young professionals who grew up knowing about technology and its use. Professional qualification of the respondents indicated that 14% were Architect, 30% were quantity surveyor, 20% were construction engineers,

20% were project managers and 16% were construction manager. None of the respondents is with no qualification, 5% are those with secondary qualification, 34% are with Diploma, 18% are with Degrees, 32% are with Honours and 11% are with Masters Degree. 43% of the respondents ranged 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% were 20 year and above of working experience. 11% of the respondents have been involved in 1-2 projects, 55% were involved in 3-4 projects, 23% were involved in 5-6 projects and 11% were involved 7-8 projects. 20% of the respondent works for private client, 9% works for consultant, 32% works for contractor, 39% works for public client/government. From the information gathered, it was discovered that the respondents have good number of years of experience as well has quite number of projects embarked upon to give them the necessary capacity to give professional opinion on adoption of robotics and construction automation in the South African Construction Industry.

Findings on the willingness to adopt robotics and construction automation factors in South Africa, indicated that Computer Aided Design (CAD) ranked first with a mean score item of 4.41 and standard deviation (SD) = 0.757, Computer Aided Manufacturing (CAM), Building Information Modelling (BIM) ranked second and third respectively. Concrete steam curing system, Non-tactile sensor and Concrete electric and infrared curing system were ranked joint lowest with Mean Score Item of 3.86 and standard deviation (SD)= 1.047, 1.068 and 0.905 respectively.

Table 1: Willingness to Adopt Robotics and Construction Automation tools

| **ROBOTICS AND CONSTRUCTION AUTOMATION TOOLS** | **Mean Item Score** | **Standard Deviation** | **Rank** |
|---|---|---|---|
| Computer Aided design (CAD) | 4.41 | .757 | 1 |
| Computer Aided Manufacturing (CAM) | 4.39 | .813 | 2 |
| Building information modelling (BIM) | 4.27 | .845 | 3 |
| Global Positioning system (GPS) | 4.23 | .711 | 4 |
| Construction equipment reversing camera | 4.07 | .789 | 5 |
| Equipment blind sport sensor | 4.05 | .834 | 6 |
| Site Monitoring Camera vision | 4.00 | .964 | 7 |
| Vision sensors | 3.98 | 1.023 | 8 |
| Inspection laser sensor | 3.95 | .806 | 9 |
| Automated welding machine | 3.95 | .939 | 9 |
| Automated cutting grinder | 3.93 | .974 | 11 |
| Proximity sensors | 3.91 | .884 | 12 |
| Concrete steam curing system | 3.86 | 1.047 | 13 |
| Non-tactile sensor | 3.86 | 1.069 | 13 |
| Concrete electric and infrared curing system | 3.86 | .905 | 13 |

The study indicated high level of willingness to adopt automation with the lowest tool having a MIS above the average of 3.00. It indicated that construction professionals in the South African Construction Industry are willing to start using Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Building Information and Modelling (BIM), and all other tools of Construction Automation and Robotics. These findings were not in support of the findings of Warzawki (1991), that construction workers are not willing to adopt robotics and construction automation on bases that it becomes a threat to the construction workers employment. This might be because the findings of Warzawki were carried out in 1991 when exposure to the benefits of Robotics and Construction Automation were not known to Construction industry practitioners. This research finding thus gives a background to the submissions of Kamar, Prasanthi and Leena (2008) that willingness to adopt Robotics and construction automation can be encouraged by implementing training for the workers because results shows high level of willingness to adopt, this implies that workers are willing to reskill or undergo training to avoid being replaced by machines in construction.

## 5. Conclusion and Recommendation

The study indicated that there is willingness to adopt robotics and construction automation in South Africa construction industry. This shows that the professionals are ready to adopt Robotic and Construction automation so as to improve working conditions, increase the level of productivity of workers, improve health and safety, improve scheduling and upgrade the overall performance of construction projects. Literatures revealed that robotics and construction automation have barriers in gaining ground in the society. Automation has been considered expensive and professionals are not willing to adopt because of threats robotics has on workers, society, and construction professional. This study concludes by revealing that construction professionals are ready for the adoption of automation and robotics which will have positive effect on the delivery of the construction project by increasing quality of the construction product, enhancing supervision, improving working conditions, cost effectiveness and it will also reduce construction accidents. It is therefore recommended that there is the need for government to subsidies and lower interest rate so as to encourage construction professionals take loans which will give them opportunity to acquire the necessary technology for the adoption of robotics and construction automation.

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## Biographies

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