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A Study on Automation and Robotics in Construction Industry

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Abstract: *In this paper an attempt is made to do an in-depth study about the factors influencing automation and robotics in construction industry and what best strategy can be developed to overcome it So, in this research work the progress is going to be Identify the factors influencing automation and robotics in construction industry by literature review study so the different type of factors has been identified for automation and robotics & identify reason for the effective usage of automation and robotics in construction field and conceptual framework will be developed. The conceptual framework can be developed after analysing the survey responses. Automation and robotics technology is expected to improve the productivity of the construction industry as well as to solve problems such as labour shortage and safety risks.*

Keywords: Automation and Robotics, Safety Management, Survey Response

I. INTRODUCTION

1.1 Background of the Study

Automation in construction refer to the application of any technology or machines capable of doing human tasks in a faster and smarter way. automation in building construction is the integration of machines, system equipment, and components with artificial intelligence that leads the industry to a new level of efficiency and productivity. automation refers to the process of automating repetitive and time-consuming tasks to enhance efficiency, save time, and improve the safety of workers on construction sites

One of the uses of robotics is to allow for greater automation in various processes. In many aspects of construction, specifically manufacturing, packing and building, automating these processes is becoming the goal. With greater development in robotics and machinery, construction companies are becoming more open to utilizing technology. With robotic technology, you can expect traditional construction activities like welding, material handling, packing, dispensing, cutting and packing to be fully automated. This will not only allow for precision and accuracy throughout all construction processes, it represents a significant time and financial savings as well.

1.2 Areas of Automation in Construction

- Roads and runway construction
- Structures
- Building's construction
- Ports
- Tunnels
- Factories and industries

1.3 Roles of Automation and Robotics

The Role of Automation and Robotics With traditional issues surrounding the construction industry, there is always opportunity for improvement and robotics engineering plays an important role in it. "Robotics is the science of designing, building, and applying robots. Robotics is a solid discipline of study that incorporates the background, knowledge, and creativity of mechanical, electrical, computer, industrial, and manufacturing engineering" (Jackson, 2015). Robots, in general, have many advantages and benefits. Some of these benefits are an improved production quality, and an improved quality of life for workers in any industry. For example, robots can have microscopic precision and produce quality in

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products otherwise not possible to achieve with traditional labor skills. Robots can also be used in areas that are hazardous to humans. Many of the emerging robotic technologies today that can be applied to construction applications are demolition robots, 3D printing robots, robotic drones, bricklaying robots, welding robots, exoskeletons, forklift robots, and roadwork robots

1.4 Application of Automation and Robotics

- Demolition
- Making of steel components
- Precast concrete industry
- On site masonry construction
- Welding
- Brick laying
- Assembly of building elements
- Prefabricated
- Interior painting
- Autonomous machines

A. Demolition

Demolition robots are primarily used for tearing down building walls and other various structures. Demolition is an important part of construction, specifically in the renovation field. In a case where a floor of a building needs to be redesigned, demolition occurs to topple existing walls in order to give room to create a new layout. The primary benefits of demolition robots are that they are much more effective than handheld equipment. They also allow the operator to stand away from the debris and contaminants, making them safer than handheld devices. A key note here is that current versions of demolition robots are primarily designed for small scale demolition, not largescale applications. Some demolition robots use hydropower to bring down materials such as weak concrete and can prevent the air from being polluted with material dust. Some of the negative aspects of demolition robots from the social point of view is that it could require less workers for the typical demolition job, leading to job loss

B. Making of Steel Components

Automation and robotics have been significantly used by steel companies that prefabricate building components according to contractor demand, and then the steel components will be transferred to the project site for erection, automation and robotics are not used in the erection process to a great extent. The utilization of steel in house construction is very low, but some factories prefabricate components of houses using automation and robotics.

C. Precast Concrete Industry

Regarding concrete precast component production, large degree of automation is utilized and necessary number of precast components can be produced as per buyer's demand. The automation of precast components is very beneficial because it provides products which its quality is not changing and waste of the factory is declined. This decrease of factory waste is made possible because of using required amount of materials which is arranged with the help of computer planning and programming.

D. On-Site Masonry Construction

Automation and robotics in masonry prefabrication play a significant role and have considerable advantages because it substantially raises the production of masonry blocks and decreases workforce and labor cost. Plants that produce masonry elements may be completely automatic or partially automated, and individually designed masonry blocks can be prefabricated. Prefabricating masonry blocks and bricks are not free from obstacles and difficulty.

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E. Welding

Robotic welding automates the welding process to increase accuracy, enhance safety and reduce the time needed to complete each project. These benefits make the robotic welding process a popular alternative to manual metal joining. Several industries take advantage of this automated process to get the results they need as quickly as possible. This automated welding process increases the speed, precision, quality and also minimizes the chance of errors or inconsistent welds compared to manual welding. Welding robots are very precise, move smoothly and at considerable speed through a programmed path Robot welding is commonly used for resistance spot welding and arc welding in high production applications, such as the automotive industry.

F. Brick Laying

A robotic bricklayer can lay up to 3000 bricks per day, reducing the overall project duration. A robotic bricklayer is relentless; it doesn't need any breaks. A robotic bricklayer keeps operating as long as it has enough fuel, mortar, and brick, dramatically increasing productivity and efficiency. It reduces labour costs by up to 50%. A robotic bricklayer reduces the amount of physical labour, enabling them to work safer with less fatigue and a lower risk of injury. the overall quality of wall alignment can be improved using a robotic bricklayer. A robotic bricklayer is exceptionally good at lining bricks up vertically. a robotic bricklayer can help reduce labour shortage problems.

G. Assembly of Building Elements

The most exciting experience is the Automation and robotization of the complete building erection and applied to many high-rise buildings in Japan. The important is the "SMAT" system developed by Shimizu used for the construction of 30 stories office building. This system reduces labour requirements by around 30%. Future projects are expected to achieve a labor-saving of about 50%. A hybrid high-rise construction site is understood as the semi-automated storage, transport and assembly equipment and robots used to erect a building almost entirely automatically. It attempts to improve the sequencing of construction processes and construction site management by using real-time computerized control systems.

H. Prefabrication

A Productivity Issue Embracing the technologies that revolutionized manufacturing industry, prefab builders may radically improve the efficiency with which it produces end products - buildings. The future builders will evaluate ways to improve productivity through the application of **lean production, information and automation technologies**. It will include efficient methods for warehousing, develop strategies to reduce construction waste, and adopt techniques for recycling. It will develop and deploy technologies for defect-free transportation of the prefab components. It will develop and test transportation system features that are high performance, low cost and more fully integrated into the building's structural system.

I. Interior Painting

The improvement of autonomous robots for painting the interior walls of buildings is one of the breakthroughs in applying robotics in the construction sector. The painting fluids can cause risks to the human painters, such as eye and respiratory system problems. Also, the nature of the painting procedure, which requires repeated work where lots of effort is needed, is a tedious and time-consuming job. The above factors motivate the development of an automated robotic painting system. Using the roller painter instead of spray reduces the cost efficiently since the spray gun and its accessories are inexpensive. Lightweight is achieved here by using a lightweight two-link robotic arm with a new joint actuation mechanism.

J. Autonomus Machines to Handle Tasks and Process

When it comes to construction industry automation, the adoption of autonomous machines and equipment is perhaps the most common example. Essentially, these are self-driving machines used for various tasks and processes. For example, projects use automated vehicles for transporting material across the site without posing safety hazards for the

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workers. Trucks, diggers, forklifts, and other similar equipment are some examples of autonomous machines used for different purposes on the project sites.

Site workers can remotely operate such machinery and equipment with the help of technologies such as GPS and machine learning. Apart from reducing safety risks for the workers, these machines double up the efficiency and cut down the dependency on human drivers and operators even for the most complex equipment. These are a one-time investment for any construction company as they provide extensive benefits year after year.

1.5 Advantage of Automation and Robotics

- Automation and robotics in construction provides more precise and uniform quality product compare with products produced by experienced worker.
- It replaces labours in those tasks which involve difficult physical work.
- Automation and robotics carry out jobs much easier which is hardly done by labors.
- It simultaneously declines costs and increases efficiency and productivity. Added to that, it is claimed that counties such as Japan and Germany have improved living standard and gross income substantially in twentieth century as a result of employing automation and robotics in the construction.
- It conducts labour tasks at dangerous locations for example at substantial height places.
- Finally, it is worth mentioning that automated construction and robotics enhance work environment because workers will be distanced from uncomfortable work position.

1.6 Social Issues

There are many social issues to take into account when discussing robotic applications in construction. One of these concerns comes in the form of privacy, both worker and public privacy. Any surveillance technologies are examples of potential invasions of privacy when using robotic technologies. Another main issue is the fear of job loss. One big fear for the rise of robotics is that workers may lose their jobs to a machine. They do not want an automated robot to do the job they, as a human, are paid to do. The robots make the job easier and potentially lower costs of production since they are not necessarily subject to negotiation of hourly wages. A robot is a one-time investment that will pay for itself over time. With a robot there are no unions to worry about, no healthcare costs, just maintenance costs. This job substitution could also be seen as a good thing. Instead of humans being in charge of the simpler jobs that robots can do, they could potentially be hired to perform maintenance checks on the robots instead. With the rise of robotics comes the rise of those with knowledge in robotics to work on them. Another societal issue is the concern of safety

1.7 Automation and Robotics in Construction Industry Need for Robots

Fast changing, field-based, project-oriented industries like construction are severely handicapped by their lack of accurate, timely and systematic technical, cost and production data from ongoing operations. Meanwhile, technologies have evolved that can not only monitor the ongoing operation of manufacturing facilities and collect operational and passenger volume data from transit systems, but can monitor vehicle operations characteristics, transit high resolution video images.

Factors Affecting Production Efficiency The computation of the production efficiency factors depends upon numerous variables which affect workers productivity in actual job conditions at the project site. These variables vary from project to project, and over place and time. Some of the typical factors affecting the workers production efficiency are given in following

- Repetition of Work
- Equipment-Intensive Tasks
- Climatic and Weather Conditions
- Labor Availability
- Scheduling Direct Workers Adjustment for Daily Manpower Requirement
- Selecting Construction Equipment
- Equipment Output Capability
- Work Complexity

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II. LITERATURE REVIEW

Ayodeji Oke, 2007, The growth of infrastructure and development in an emerging country may requires the construction industry to shift from traditional methods of construction to modern ones in order to improve productivity and enhance performance. most of the existing studies have been tailored towards the awareness, willingness, drivers, barriers and benefits of such modern methods, including automation and robotics. Like other technological advancement, there are some negative impacts that should be assessed and understood by stakeholders with a view to managing and minimizing them. In view of this, the purpose of this study is to investigate the extent to which the usage of automation can influence negatively on the delivery of construction projects if fully implemented in the construction industry

VSS Kumar, I Prasanthi, AEI 2008: Construction phase is one of the important aspects of civil engineering structures. The success of a project depends on how well the construction phase is carried out. Efficient and economical construction is particularly important because of the increasing complexity of structures being built, the availability of improved materials and construction equipment. Typically, in manufacturing field, robots are stationary and product moves along the assembly line. Automation is easier to incorporate because each product is identical with respective tasks done over and over. However, construction robots face with different demands than conventional industrial robots. They must move about the site, because buildings are stationary and of a large size. They require engines, batteries or motors and drive themselves. Construction robots also faced with changing site conditions and must be reprogrammed with each new condition. They must be able to function under adverse weather conditions including variations in humidity and temperature. Additionally, they are constantly exposed to dust and dirt on the site. Thus, there is a need to develop a robotic system for full-scale experimentation for realistic assessment of automation in the construction industry. This paper presents some aspects of robotization and automation and a case study is presented to demonstrate the applicability of robotics in construction industry.

Rohana Mahbub 2016: The major concern to the construction industry in general, would be the decreasing quality and productivity of end products; labour shortages; occupational health and safety; and allowing work to be performed where people cannot do. This paper discusses how the quality of life may be achieved by tackling the barriers and their impact to this initiative which could improve the industry in terms of productivity, safety and quality. This will also ensure the harmony between the environment and energy management with productivity enhancement for better quality products that could lead to better quality of life for the end users.

Qian Chen, Borja García de Soto 2018 : Construction automation has shown the potential to increase construction productivity after years of technical development and experimenting in its field. Exactly how, and the possible benefits and challenges of construction automation, though is unclear and missing from current research efforts. In order to better understand the comprehensive potential of construction automation for increasing construction productivity and the associated possible ramifications, an objective and data-driven review of the use of automation technologies in construction was done. The review was accomplished by using text mining methods on publically available written documents, covering a wide range of relevant data including scientific publications and social media. The text mining software VOS Viewer and RapidMiner Studio were used to determine the most promising areas of research through the analysis of scientific publications, and the main areas of concern of industry through the analysis of text on social media, respectively. These research areas and concerns are summarized in this paper, and based on them suggestions for industry are made to help advance the uptake of automation in construction.

Joseph Neelamkavil, 2009: The construction industry at-large is dominated by numerous small and specialized subcontractors who typically are not technologically advanced enough to embrace automation. The sector that represents factory built housing (the modular, prefab, panelized, precast, etc.) is an exception. Since the products are built in factories, the principles of mass production and mass customization that are the norm in manufacturing, apply. It will also make it easy to adapt to automation, integration and optimization. In this scenario, the constructability aspects

Michael Chui, Jan Mischke, 2019: A substantial shift to modular construction off-site could have a significant impact on the construction workforce, but the transition will take decades. Producing individual components, or modules, in factories lends itself to much more machine use than what can be done on-site. Some companies, such as Katerra, are already building such modules. A lot of the construction in these factories is still done manually, but over time, as scale increases, the process will become more automated. We estimate that about 15 to 20 percent of new building construction will be modular in the United States and Europe by 2030. So, while it's an increasing share and a big market, it's slow

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process, and a lot of activities will remain on-site and relatively unpredictable for some time to come. For those activities that do remain on-site, it's unlikely that a company will fire a carpenter and bring in the latest robot to do everything the carpenter did. Rather, machines will take over individual activities within a role. What that means is workers will need to learn to work side by side—or in a hybrid role—with machines. For example, even the average construction worker will be expected to use a tablet to access building plans or operate a drone in place of doing a physical site walkthrough.

Hyojoo Son, Changwan Kim, 2010: Attention to development of automation and robotics technology in the construction industry seems to have been growing and there has been an increased awareness of the potential benefits of automation and robotics technology development. Although research and development (R&D) facilitates progress in the state of technology and-in the long run-yields significant savings in time and money for companies that take advantage of it, the costs of R&D in the short term are high and resources are limited. Analysis of trends in existing research is helpful in identifying where further R&D is needed and in suggesting directions for future research. In addition, it can be used to help predict the return on investment in individual technologies. This study was to identify global trends and issues in automation and robotics technology in the construction industry by analyzing papers published in the proceedings of the International Symposium on Automation and Robotics in Construction (ISARC). The results of that analysis show that various research topics are actively researched from the viewpoint of automation in construction and contributed by different countries and regions as well as different types of research institutions.

Carlos Balaguer, 2004: The actual research trends in robotics and automation in construction industry (RAC) are much different in comparison with the last decade. While during the 90s the R&D activities were focused in the development of new robotic systems (most of them teleoperated) and in existing machinery automation, the actual efforts are concentrated more in the software integration, sensory data acquisition and processing, safety and secure systems, sensor-based process control and construction industrialization. This paper deals with the short state-of-the-art in the actual and features RAC research areas, including representative examples.

Divyesh Joshi, 2015: In India, the construction industry is one of the largest industrial sectors. The construction industry plays to enhance the overall national economy of the India, the complaints of poor construction quality is major problem in the India construction industry. For successful quality work, such as lack of skilled workers, poorly installed equipment, poor platns, etc among this in an increase in the real cost of construction & labour. The construction industry is labour intensive and construction work is conducted in risky and dangerous situations. The importance of construction automation has grown rapidly in developed countries. In developing countries like India, the construction industries need automation technologies such as new machineries, electronic devices etc. The infrastructure project requires more numbers of skilled labour, good quality of work, increases productivity etc. Studying recent application and projects for using robots and automation in the construction industry. The qualitative study has been carried out. From this qualitative study some obstacles in implementing automation are discussed in this paper.

Marcus Sandberg, Robert Gerth, 2016: As the construction industry continues its digital journey the applications within design automation is growing, making development processes less time-demanding and more organized. Design automation applications can show design impact on eg cost, equipment availability, staff capabilities and buildability. It can also facilitate reuse of successful solutions instead of reinventing the wheel for every project. Thanks to automation it becomes easier to generate several solutions and trying different what-if-conditions. The field has many different approaches but an overview for construction where the connections between the different approaches are indicated is needed. The purpose of this paper is to describe our view of how the design automation fields of building information modelling, master models, knowledge-based engineering, configuration, modularization, platforms and simulation are connected and to provide input to the design automation discussion in construction. Each of these areas are introduced and then they are analyzed in relation to each other and presented as an overview. These results will serve as a base for future studies.

SMS Elattar 2008: Building and construction is one of the major industries around the world. Construction industry is labor-intensive and is conducted in dangerous situations; therefore, the importance of construction robotics has grown rapidly. Applications and activities of robotics and automation in this industry started in the early 90s aiming to optimize equipment operations, improve safety, enhance perception of workspace and furthermore, ensure quality environment for building occupants. The main goal of this paper is to convince building designers and managers to incorporate robotic systems when managing modern buildings. This paper studies recent applications for robots and automation in the

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construction industry and sets opportunities and challenges through a new framework for better planning and control of construction equipment operation.

Vahid Faghihi, Ali Nejat, 2015: Automating the development of construction schedules has been an interesting topic for researchers around the world for almost three decades. Researchers have approached solving scheduling problems with different tools and techniques. Whenever a new artificial intelligence or optimization tool has been introduced, researchers in the construction field have tried to use it to find the answer to one of their key problems—the "better" construction schedule. Each researcher defines this "better" slightly different. This article reviews the research on automation in construction scheduling from 1985 to 2014. It also covers the topic using different approaches, including case-based reasoning, knowledge-based approaches, model-based approaches, genetic algorithms, expert systems, neural networks, and other methods. The synthesis of the results highlights the share of the aforementioned methods in tackling the scheduling challenge, with genetic algorithms shown to be the most dominant approach. Although the synthesis reveals the high applicability of genetic algorithms to the different aspects of managing a project, including schedule, cost, and quality, it exposed a more limited project management application for the other methods.

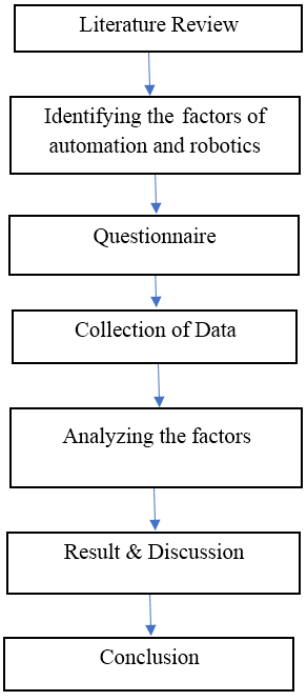
Borja Garcia de Soto, Miroslaw J Skibniewski, 2020: The idea of using robots and automating construction sites is not new–the first research and publications on construction robotics date back to the 1970s in the former Soviet Union. By the mid-1980s, robotic systems were developed and introduced for inspection tasks on a radioactively contaminated building site. By 1991, the first full-scale application of construction automation was materialized in Japan. Fast-forward almost four decades, and when you look around on construction sites, you will see that still, the use of robots and construction automation is very limited or non-existent.

III. RESEARCH METHODOLOGY

3.1 General

By referring the literatures various Factors affecting automation and robotics are identified. Based on the Factors and the responsible stakeholder questionnaire have been developed and circulated and based on the response an analysis through SPSS software is done and a conceptual Framework is developed to mitigate the overcome of automation and robotics in construction industry

3.2 Methodology



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IV. CONCLUSION

From survey, Automation and Robotization of construction sites is very important to replace men for hazardous operations in foul weather, darkness, deep waters, high radiation zones, dangerous areas, and high elevations. It is also helpful from the point of view of avoidance of disruptive effects of strikes, problems of motivation and administration, safety and health regulations, shortage of skilled labours and to carry out repetitive, dirty and dangerous works and completion of projects or tasks with quality control, within the specified time and economy. Based on the questionnaires the further scope is to analyses the responses received and to mitigate by developing a conceptual Framework.

4.1 Future Works for Phase II Project

- Collecting questionnaire forms from various construction industry
- Using SPSS software for statistical analysis for questionnaire
- With AMOS software, creating a framework model for automation and robotics for construction industry

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ANNEXURE 1

STUDY ON AUTOMATION AND ROBOTICS IN CONSTRUCTION INDUSTRY

The purpose of this questionnaire is to look at the numerous factors that influence automation and robotics in construction industry. The results of this survey are used to determine the project's success.

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Instructions for filling up the form:

1. Please choose the relevant options or provide the necessary information for the questions.
2. Please describe any alternative option not listed in the questionnaire that is relevant to the study and would add to its output in the area provided at the conclusion of the questions.
3. The questionnaire must be filled out as completely as possible with relevant information. All information provided in this questionnaire will be used solely for academic research purposes and will remain totally secret, with the name of the organization not being mentioned.

Give your opinion on the following criteria using the scale provided:
1-Strongly Disagree
2-Disagree
3-Neutral
4-Agree
5-Strongly agree

1. Will Application of Automation and Robotics solve such issues like poor productivity and risky working conditions in construction
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

2. Do you believe that automation can reduce labors dependability and reduced human error in construction
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

3. Have you ever used automation for a specific work to reduce cost of the work in a construction
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

4. Will you accept that large investment has to be involved in owning and using automation and robotics product in a company
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

5. Do you think Automation and Robot can be used in all the phases of construction
Strongly disagree
Disagree
Neutral

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Agree
Strongly agree

6. Do you accept the fact Automation and Robot cause continuous unemployment for skilled labors
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

7. Do you think that automation saves a lot of construction time in a project
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

8. Due to Limited resources available in small and medium size firm automation is not adopted by all construction industry
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

9. Will Automation Technology are expensive to adapt and maintain
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

10. Will Employees need a training program for implementation of automation in construction work
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

11. Will you accept that Implementation of automation help in Safety improvement and Improving working conditions
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

12. Will automation process help in Less material wastage
Strongly disagree
Disagree
Neutral

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Agree
Strongly agree

13. Does unique construction product are required in initiation stage of assimilation of automation products
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

14. Do you think that automation system is more easily locally available in the market nowadays
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

15. Does automation technology are expensive to update and services
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

16. Does Automation and robotics are not used in the erection process in making of steel components
Strongly disagree
Disagree
Neutral
Agree
strongly agree

17. Have you ever demolished a building with automation process and without use of an employee
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

18. Do you think that implementing automation method in your site will improve the market value of your company
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

19. Will Automation process can be used depending upon the size of project
Strongly disagree
Disagree
Neutral

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Agree
Strongly Agree

20. Do you think that current engineers have an awareness about automation in construction industry
Strongly disagree
Disagree
Neutral
Agree
Strongly agree