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A Review Paper on Automation Robotics in Construction Industry

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ABSTRACT: Robotic systems are increasingly being used in the construction industry to reduce construction time and increase safety by replacing human workers in dangerous operations. These systems are designed to operate in dynamic environments where structures, operators, and equipment constantly change. They have proven to be more robust, safe, efficient, accurate, and productive. Traditionally, the construction industry relied on traditional methods and equipment, but the rapid growth of the industry has led to a growing interest in robots for various tasks during execution. However, developing efficient robotic systems alone is not enough to ensure successful implementation. The subject has recently emerged as a coherent, multidisciplinary activity. Robots can benefit specific areas of the construction industry, such as building design and construction planning. This dissertation describes concrete-floor finishing robots, partition masonry construction robots, plastering robots, and painting, which assist human operators in performing their tasks on construction sites. The feasibility of using robots in building construction is determined by comparing robotic versus manual performance of relevant tasks. The study presents a quantitative assessment of robotic feasibility, focusing on saving human labor and its impact on costs. The objective is to study the feasibility of robots in the construction industry and provide guidelines for developing future equipment more economically.

KEYWORDS: Automation, Robotics, Construction Industry, Building Automation, Industrial Automation, Digitalization in Construction, Construction Technology, Automated Assembly

I. INTRODUCTION

Construction is an ancient profession that might be traced back to the evolution of man from a primitive to a higher quality of living. The building business is the second largest employer after agriculture. Until the nineteenth century, our country's construction industry, like other industries, developed slowly and unevenly. Large-scale mechanization has resulted in changes in building techniques and construction work management in this century. This is dependent on the most efficient use of resources such as labor, machinery, and materials. Despite significant mechanization in India, the building industry relies heavily on manual labor. Since the start of civilization, man has engaged in some type of construction activity. The word "construction project" refers to a high-value, time-sensitive, and unique construction mission with predetermined performance objectives. Today, the building industry serves as a key indicator of the nation's social and economic progress. The majority of overall expenditure in any five-year plan is used for construction activities. Since independence in 1947, India's construction sector has undergone significant mechanization, with quick changes and developments in construction methods as well as construction project management.

Some of the most important construction activities include dams, power plants, underground works, subways, marine projects, airports, thermal stations, transmission lines, industrial buildings, high-rise buildings, housing projects, hospitals, educational institutions, post offices, and commercial recreation facilities. High risk and pit falls in the sector place a high demand on the safety of construction workers at all levels. The construction industry employs an average of 5% of the local labor force and accounts for around 11% of all occupational injuries and 20% of all fatalities caused by workplace accidents. With safety, a dearth of qualified personnel, time to complete construction, and working space all around the building in mind, it's time to consider alternate solutions. Shimizu Corporation of Japan began robotics research and development in 1975 to enhance construction industry innovation. Properly designed robots produce higher-quality products than people, and building owners are more delighted with the end result. As a result, contractors should enjoy improved relationships with their clients and expect to be welcomed back for future jobs. Furthermore, by deploying robots, builders are less likely to receive calls back to replace bad handiwork. Thus, using

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robots instead of humans can lessen the number of accidents that occur. Although robotic technology can aid the construction industry in numerous ways, it is not inexpensive, particularly for use in harsh outside environments. Robotics research is multidisciplinary, involving advanced technology and machinery that require specialized expertise to operate and maintain.

For the past two decades, the construction sector has shown a strong interest in construction automation and robotics. Over fifteen years ago, early development of onsite robotized concepts began, and they were even tested. Atomization and robotics in the sector began in Japan in the 1980s. The inaugural ISARC (International Symposium on Automation and Robotics in Construction) was established in the United States in 1984. The symposia were thereafter organized annually in a number of different nations. The International Association of Robotics in Construction (IAARC) was founded in 1990, and the organization has substantially aided construction automation and robotization efforts. A building robot was defined as an automated equipment used to do a building task on a construction site. The definition is the same as the one in Encyclopedia Britannica: "automatically operated machines that replace human effort". Automation in the broad meaning of preprogrammed autonomous tasks. A robot can be defined broadly as a reprogrammable, versatile manipulator capable of performing a wide range of activities. In other words, a robot is a system that operates under automatic control.

II. REVIEW OF LITERATURE

Thompson (1994) The development of robotic technologies for building has improved substantially in recent years. Robotic systems were initially designed to reduce labor requirements, shorten building time, and lower prices and quality. The high expectations for building robotics stemmed from the industry's very serious problems, such as continuously declining productivity or, as stated by Whittaker (1986), labor efficiency is alarmingly low in construction "a high accident rate; low quality; insufficient control of the construction site; and the vanishing of a skilled work force."

Paulson (1985) A study citing incidents in which robots were already performing economically beneficial activities in the field for Japanese construction contractors ("Japan" 1913) created the impression that construction robotics had become a reality. In a review and analysis of developing technologies, Paulson (1985) concluded that if no large research effort develops in the United States, American contractors will be able to address their difficulties by importing robots and process control technology from outside.

Whittaker and Bandari (1986) were already considering the next step of construction robotics, in which a group of robots would collaborate. According to their findings, "robots were emerging in construction as a way to increase productivity, improve quality and decrease hazard to human workers" .

Skibniewski and Russell (1989) According to them, "with less optimistic estimates for construction robotics due to their operational environments, it can be anticipated that this application can result in approximately 10-15% increase in the overall construction productivity rate" . (1992) reported on early application in the United States, stating that "the process of disseminating the early results of research and development of construction automation and robotics into industry practice is now slowly taking place." Several robotic prototypes have been conceived and built in the United States, and some of them are almost ready for commercial use.

Winston (2000) Shortages have become so acute that construction companies are turning to temporary labor agencies to fill gaps wherever possible. Furthermore, the current workforce is aging at a rapid pace. Many young individuals see construction labor as unclean and unattractive. A poll of 10,000 high school students indicated that construction ranked 251 out of 252 conceivable career paths (Donohue, 2000).

Warszawski (1994) described the use of robotics in constructing. A global survey of construction businesses, universities, and other research institutions was done to assess the state of the art in the development and deployment of building robots. The examination of the results paints a bleak picture of the current level of on-site robot employment. The causes for this predicament are highlighted as follows: existing robots are not well suited to building construction, there are issues with conventionally planned buildings, it is difficult to justify robot employment automatically, and there are managerial impediments. As a result, recommendations are made for more efficient implementations.

Boyer (1990) stated that the work of construction engineers and management researchers in automation and robotics can be best summarized using the four overlapping parts of scholarship: discovery, integration, application, and teaching. One is tempted to consider the steps of discovery, integration, and application in the order stated.

Thompson (1994) Robotics systems were originally designed to reduce labor requirements, shorten building time, lower costs, and increase quality. Benefits such as the elimination of hazardous work places for employees and compliance with requirements set by the Environmental Protection Agency, the Toxic Substance Control Act, and the Occupational Society and Health Administration have enhanced the working environment and morale.

Obayashi (1992) Another point of view in Japan is that "only a few construction robots have been made commercially available for the execution state of construction because many of them are stalled at the demonstration stage" . added that "most of the commercialized techniques replace hand work by machines, which mean that they do not have the desired effect that could be achieved from high-tech systems" .

Tucker (1986) Need drives robotization of construction processes. If the need is significant enough, the economic benefits will outweigh the development costs required to overcome technological limitations. For example, has noticed that pipe is a major cost center in industrial building. The economic benefits of automating pipe production and erection can be calculated.

III. AUTOMATION AND ROBOTICS IN CONSTRUCTION INDUSTRY

Intense rivalry, skilled labor shortages, and technological advancements are driving rapid change in the construction business, resulting in increased focus on construction robots. The use of robots for some skilled and unskilled jobs may boost productivity and save construction time by increasing the rate of labor. Robotics in the construction sector is a rapidly emerging interdisciplinary field. Robot applications in construction can be divided into two categories. The first category is the replacement of extremely labor-intensive, repetitive, and basic tasks, while the second is the performance of operations that endanger human workers' health. Work in the ocean, on chemically or radioactively contaminated areas, or in harsh climate regions can all pose such risks. A construction robot can be used to increase productivity, reduce costs, improve work pace and quality, prevent job-related injuries, and lower medical costs. Construction robots are based on the same premise as manufacturing robots. The majority of them use an effector (a gripper or work tool) mounted on a multiaxial arm, and their tasks are defined and controlled by a computer. However, unlike most manufacturing robots, which perform preprogrammed tasks from static workstations, construction robots must be mobile and, once fully developed, must interact with the changing environment via sensors, adapting their tasks in response to feedback.

Need for Robots

Construction and other rapidly changing, field-based, project-oriented sectors suffer greatly from a lack of reliable, timely, and systematic technical, cost, and production data from ongoing operations. Meanwhile, technologies have evolved that can not only monitor the continuous operation of industrial facilities and gather operational and passenger volume data from transit systems, but also monitor vehicle operation characteristics and transit high quality video images. To achieve adequate and consistent quality, the traditional method of carrying out construction work necessitates the use of highly skilled workers. This labor-intensive construction technique carries a significant expense. Various strategies have been attempted to improve rationalization and humanization. For example, one of the tactics utilized by the sand-lime brick and cellular concrete industries is to increase the size of the construction blocks. However, the larger dimensions of these blocks correspond to a higher physical weight of up to 300 kg. Because of their greater dimensions and heavier weights, these building blocks are not ergonomically desirable, hence various mechanical help devices such as hydraulic balancers or tiny cranes with counterweights are utilized during assembly. Another trend that is gaining popularity is the use of accurate, plane parallel bricks put on a thin mortar, glue bed, and concrete. Because of the lack of mortar connections, these technologies provide improved physical features like as heat insulation and increased load bearing capability. Because of the reduced number of walling processes, they allow for faster work and easier use. A initial layer of smaller blocks in a more or less thick mortar bed typically compensates for the various errors of the floor. Using this strategy, the challenging alignment required to modify the position of each block can be decreased. Though an increase in working speed can be accomplished by using less skilled people on the construction site, the current and future share of labor costs will continue to rise.

Other present approaches require some level of automation. Certain activities, like as block cutting, can be moved from the construction site to the manufacturing facility. Precutting blocks streamlines the task by avoiding transporting larger cutting equipment. However, this method involves labeling the blocks and providing them together with an assembly plan that depicts the positions of the individual blocks in the wall. Thus, information technology is required to create assembly plans and manage cutting equipment. Further optimization can only be achieved by reducing labor and

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construction timeframes. Since the aforementioned mechanized masonry methods have reached their limits, they cannot contribute to further effectiveness, necessitating an innovative leap by a system approach that combines existing construction technologies with new information and robot technologies. Robot assembly system for computer integrated construction project is concerned with the creation and implementation of an integrated automation system. Thus, standard control measures are inadequate and entirely insufficient. New control approaches are identified in order to obtain great performance with a reasonable time-consuming algorithm that may be used in real-time control systems.

IV. FACTORS AFFECTING WORK SCHEDULE

Many aspects must be considered while scheduling a project plan, such as time, resources, and financial restrictions. It is impossible to enumerate the principles that control all of these aspects, which may differ from project to project.

1. Time
The availability of time is an important project constraint. More time typically indicates less investment.

2. Manpower
Manpower is an important aspect in the project's success. Idle labor time is compensated for, and management is aware of strikes and job disruptions. Task efficiency, labor wealth conditions, nature of work, supervisors, and leadership all have an impact on labor productivity. The lack of suitable workers is typically a limiting problem. The labor turnover, sickness and absenteeism further aggravate the problem.

3. Factors Affecting Production Efficiency
The computation of production efficiency factors is dependent on a number of variables that influence worker productivity in real-world job conditions at the project site. These variables vary with project, location, and time. Some of the typical elements affecting workers' output efficiency are listed below:

4. Work Complexity
A basic, known task is easier to do than an unusual, complex one. The additional effort required for the latter sort of task, particularly in the early phases, can range from 10 to 100% of the average expected output.

5. Repetition of Work
While the first time an unknown task is performed requires additional effort and resulting in a poor output, the expertise acquired during the process, when applied over time to comparable tasks, improves productivity rate when the crew of workers is the same. This increase in productivity continues until a specific limit is achieved.

6. Equipment-Intensive Tasks
The construction equipment completes work quickly, but it need operators. A variety of factors influence the productivity of man-machine combinations. However, equipment-intensive tasks are more resistant to productivity increases than labor-intensive tasks.

7. Climatic and Weather Conditions
Workers often continue to operate at the same productivity level in normal weather circumstances with temperatures ranging from 40 to 70 degrees Fahrenheit and a relative humidity of 60%. However, extreme conditions and seasonal variations, such as hot and cold weather, high humidity, and strong winds and rain, have an impact on both productivity and work performance.

8. Labor Availability
Labor productivity is also determined by the number of job possibilities available in the market. When jobs are plentiful and labor is scarce, labor productivity tends to decrease. During a downturn in the construction industry, labor is plentiful yet job opportunities are few. Employers can be picky in such conditions because recruiting and terminating employees is simple. In a scarce job environment, total productivity increases because employers may pick out labor with low output. Laborers also tend to gravitate toward high-value, large-scale projects since they provide longer service, better job possibilities, and greater stability.

9. Scheduling Direct Workers
The project's direct personnel accounts for a significant share of the labor strength. Because each activity has a specific length, work content, and manpower necessary for completion, the daily average manpower required for each scheduled activity can be calculated as:

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Manpower req. = Quality of work × labor productivity standard in man – days / duration in days.

ROBOTS USED IN CONSTRUCTION INDUSTRY

Robotics and automation are predicted to become increasingly essential in the construction industry during the next decade. Because of the construction industry's dynamic and unstructured nature, research and development (R&D) in the application of high technology is required. Recent advances in robotics in other industrial domains have demonstrated a significant opportunity to enhance the automation of complex construction operations. In 1975, Japan's Shimizu Corporation launched robotics research and development to enhance innovation in construction production. The company's rationale for research and development in construction is to boost production, improve quality, Reduce costs, boost efficiency, expand into new markets, and improve construction worker safety. The ultimate goal is to establish a flexible and integrated environment for construction projects. The organization has concentrated on both of these sectors, automating traditional building sites and new construction domains.

The following section summarizes the company's progress in R & D in various areas:

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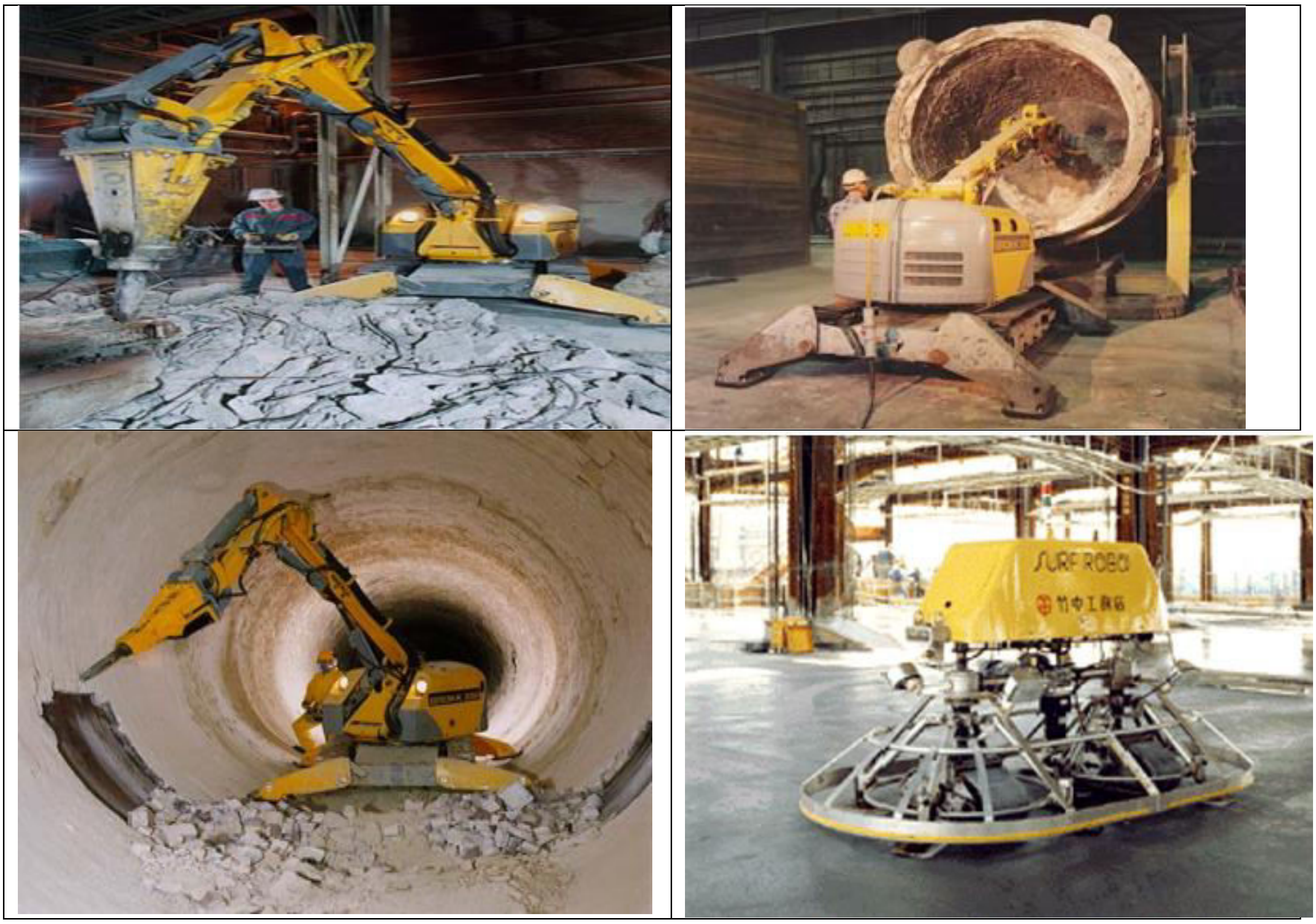

CHALLENGES FACING AUTOMATION AND ROBOTICS INCONSTRUCTION

Automation's key contribution in building is the development of a full, multidimensional cost-benefit analysis of a specific robotic application. It is critical to assess success through technical and economic feasibility. The technical feasibility is assessed by an ergonomic evaluation of the individual steps taken to complete a specific job task, as well as an examination of the needs for robot control and process monitoring. The economic feasibility, which is regarded as the most important factor in the market success of the proposed robotic systems, is established by an examination of the costs and advantages related with their development and field implementation.

In contrast, a robotic system that does not require thorough pre-planning is less technologically demanding and hence more easily built during the early phases of robotics integration into the construction business. The "Senseand-Act" technique may minimize the need for high accuracy while positioning the robot at its workplace, saving time and increasing the system's economic feasibility. Some researchers aimed to boost robot autonomy by allowing them to map and explore their environments independently. Although building sites are distinguished by erroneous geometry, various impediments, etc. The mapping and navigation algorithms may be modified to accommodate it. Such navigation systems are supposed to overcome these challenges and produce accurate results. Researchers and developers of autonomous robots have sought to overcome the difficulty of adjusting the robot to its surroundings by creating automatic mapping and self-positioning techniques. The robot then moves autonomously from one workstation to another.

EVALUATION FOR USING ROBOTS AND AUTOMATION

Initially, robots were designed for the manufacturing industry and were intended to do normal tasks in a familiar setting. Unlike such robots, those used on construction sites must be mobile, adapt to changing circumstances, and execute a different duty at practically every step. Construction engineering is being transformed by the use of greater industrial production, sustainable production, mass individualization, and intelligent construction to increase constructability. Recent study shows that robot technologies can considerably increase quality and equipment control in a variety of construction automation applications. The ability to automate construction would be especially valuable in

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situations where human presence is risky or troublesome; for example, robots may be dispatched to underwater or interplanetary environments to build habitats for future human explorers.

Building Management and Security Systems

Surveillance for security purposes is essential following the commissioning of buildings or big estates to guarantee residents have a quality environment. If robots can do surveillance, productivity can be increased, resulting in significant labor savings and greater management staff safety. Furthermore, if the robot can collect commands from the building management system via a local area network (LAN), human management workers can save even more time attending to first-line faults[19]. The creation of a unique security system in which the necessary safety helmet required for all construction workers serves as the foundation for small location and communication gadgets. Each worker's position and ID are periodically sampled and transmitted via radio to a monitoring station, where the data is compared to a database holding the jobs and procedures being performed on the site. According to this, the positions of workers and machinery are known at all times, and risk situations can be identified instantly, preventing damage.

V. SCOPE FOR FUTURE WORK

It is critical to understand the current state of building robots in order to determine the best course of action for the future. Is there a future for robotized building in view of the current gloomy situation? The answer is yes, but only if the matter is approached properly. Robots created with adequate consideration for these requirements will have a significantly greater chance of survival. The robot must be "site-friendly," that is, well-suited to the specific conditions of the construction site. This refers to the overall system performance. All aspects of operation, mobility, material feeding and transfer, and their adaptation to the specific requirements of a construction site must be considered in the design.

Ensure that the weight does not exceed the permissible level load.

Its mobility, or ability to work in limited locations.

Its flexibility, or capacity to execute a variety of jobs, expands its usefulness.

Its independence in terms of power and material supply.

Its durability allows for minimal upkeep on the construction site, even in harsh situations.

VI. CONCLUSION

Maintaining a proper link between processing speed and material delivery speed is critical for automation in the construction sector. The use of robots will directly or indirectly spare the builder/contractor/owner from facing legal problems, as well as allow the activities to be accomplished more quickly. Although robotic technology can aid the construction industry in a variety of ways, it is not inexpensive, particularly for use in tough outside environments. The economy of robot utilization necessitates a sufficient amount of acceptable labor to ensure their continued employment. The fundamental argument for such employment will most likely be a lack of local workers, as well as the explicit and implicit costs of importing foreign labor. Robots can currently be used efficiently in the construction of repetitive buildings constructed with robotic limits in mind, as well as in complicated and high precision activities and unclean and risky building duties.

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