Implementation of Automation Technologies in Construction Industries: A Review

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Abstract

The construction scenario is changed from an ancient working system to the current working system. There are several innovative techniques improved in the last decade. The structures are now light in weight, but load-carrying capacity more simultaneously constructions of building technique also improve. Nowadays, the automation technology used for constructing a building saves money and time along with labour safety. It would not be an overstatement that it is the "Ideal construction Technique". The term "Ideal Construction Technique" means to reduce wastage of material, labour safety, increases productivity, material management, labour management, improve quality of work and within estimated duration and cost. This research's framework is focused on developing preventive factors of implementation of automation technologies in construction industries. The research area covers four main aspects: level of using advanced technologies in various countries, knowledge about automation technologies, future opportunities, level of uses in the construction area, and impact of utilisation of automation technologies.

Keywords: *- Automation Technologies, Advancement, Construction Management, Labour safety, Productivity, Robotics Technologies.*

INTRODUCTION

As per population growth, India is the 2nd largest country in the world and 44th rank in infrastructure development [1]. The Construction industry is directly affected by country growth in terms of economic and infrastructure development. 3rd largest construction market globally. The construction sector is expected to contribute 15% of the Indian economy by 2030 [2]. The best growths of the construction industry will increase the country's gross domestic product (GDP) growth [3]. The main factor of success and failure of a project depends on the time and cost of the project, including the quality of construction. The construction industries require a considerable labour force, after agriculture. For speed-up construction production, automation technology plays a prominent role. In the current scenario,

various types of automation technologies are available for on-site and off-site construction practice. The main purpose of use automation is to better humans in tasks that are dangerous, dirty, or demanding [4]. Automation technologies in construction are the electro-mechanical device that operates using remote or by labour for saving human effort. Construction automation works on behalf of labour to some extent and benefits project cost, duration and quality.

Automation in construction is described as the use of mechanical and electronic means to achieve automatic operation or control to reduce potential exposer, time or effort while maintaining or improving quality. [5]

Construction is the process of creating or renovating a building or an infrastructure facility. This research is about studies on understanding effort pertaining to a worker in an automation technique and examines finances and timeline of a construction task. It is more important to investigate the current availability of innovative technologies, current working procedures on-site and future opportunities for make potential conclusions. The main purpose of this research is to find a preventive factor of automation techniques. The preventive factor shall be considering the area of labour oriented, cost-oriented, time-oriented and technology-oriented. This paper describes a ranking system for countries intending to use automation technologies to examine their readiness.

LITERATURE REVIEW

The following literature reviews on "Implementation of Automation in Construction Industries" from international journals are below.

Hiroshi M et al. [6] stated that comprehensive automated building construction system (ABCS) mainly use for high-rise steel structures which sub-divided in three parts one is climbing structure that encloses working space called “super construction factory (SCF)” which resist all type weather condition, second is automated parallel delivery systems for material lifting and third is centralised management systems for production management, equipment operation management and machine control which is based on “Big Canopy”.

Josephine Lale [7] described advantages are safety, increased productivity and sustainability. The disadvantages are the possibility that people may get jobless and have high capital costs. Wider adoption of automation and robotics will be beneficial for construction industries. The labour-oriented project might use a teleoperated or programmable construction machine to coordinate between machines and humans. The technique may be semi-automatic or fully automatic, but the working environment and labour safety are the main consideration. Bricklaying machines and contour crafting are possibly used to reduce urban infrastructure block logs. Stockholders should find the solution of reducing the cost of automation and robotics construction. Wider adoption of automation and robotics construction will still face challenges in South Africa.

Stain et al. [8] analysed that Construction robotics must be as per site because buildings are stationary and of a large size, and these robots require engines, batteries or motors and drive for mobility. The construction robotics programming changed as per new conditions, therefore, requires digital control with manipulator using coordination system to deal three-dimensional movements. The

construction robots performance encourage repetition, and the construction sites need to be re-configured facilities to provide a more structured and controlled operating environment. After careful investigation, Mark Dunlop et al. [9] summarised existing automated equipment and robotics use in construction in Japan and advises that construction environments should be more structured and controlled to apply construction robots.

Gar maas et al. [10] studied automation and robotics technology development are beneficial for all across during the utilisation phase. The direct impact on various construction aspects such as performance management, construction engineering and costing management.

Frans van Gassel et al. [11] noted that the proposed framework of self-supporting robotics curtain wall system is automatic mechanisms utilise for the assembly and dismantle as per input provided by the operator. The design of robotics is such that alignment, bolting, installation, and disassembly work by the machine itself. They design the mechanical and tracking workflow of a self-assembling curtain wall system.

SMS. Elattar (2008) [12] the main studies involve robotics and automation in construction operation for a high degree of accuracy, reduce hazardous risks and achieve improved control and safety. The area of automated construction covers design, engineering, maintenance of existing and planned structures. The building management combines automation and robotics to improve workmanship quality, which is called modern intelligent buildings. All idea behind developing automation and robotics technologies comes from condition and issue occurred during the execution of work, and solution of those issues with the help of continuous effort on research and development to design automation and robotics technologies. The automation with intelligence activity such as generalisation, analysis and decision-making for multi-objective to understand construction engineering problem.

C-Y Cho et al. [13] stated that by changing arrangement in existing one lift-car in such a way that developed a hoist-mountable intelligent toolkit installed and converts into automation. The upgraded automated lift-car has remote sensing and communication technologies to capture the material trip information and manage it intelligently without any collusion. The smart lift-car is the concept with the function of automatic loading/unloading operation and wireless communication.

Kyongmo Jung et al. [14] noted the proposed diagram of a teleoperation system for developing a safer and more convenient working environment for human operation while working with a robotic beam assembly system. A control station is built outside the operator's cabin, including joysticks of the monitoring system and controller for operation.

Pakka Kilpelainen et al. [15] noted that widely uses of automation survey techniques and sensors save time and cost with remarkable accuracy.

Sadiya Thazeen [16] stated that electronic magnetic distance is carried heavy equipment and time taking process along with increasing labour time. While land survey over acres then robotics survey are needful. The manufacturing of survey robots is made with the help of a micro-controller, ZigBee, DC motor, Program supportive driver, and battery. The buzzer works as a sensor to prevent an

accident. Survey robot requires low workforce as well as low equipment. The cost-effective survey technique reduces time consumption and eliminates rework due to a high degree of accuracy.

AkashTambi et al. [17] analysed that the implementation of automation and robotics technologies enhances productivity and excellent quality of work for small and medium-sized firms, which are helpful for different construction sectors such as designing, planning, and fabrication of on-site and off-site construction. Automation and robotics technology is beneficial with various aspects like reducing project cost, reducing project duration, inferior quality of work almost eliminated, highest labour safety, and increased productivity.

Thomas Bock [18] stated the vast difference between conventional construction techniques and technologies of construction automation. Construction automation is still in the innovation phase. The only way to enter growth phases is a continuous effort on research and development and adoption on a large scale. Automation and robotics technologies are becoming ubiquitous. There are various Thematic fields of automation and robotics are for infrastructure production, transportation systems, construction, environments, farming and food production, town planning and general manufacturing industry.

Mistri P.S. et al. [19] researched an essential factor for implementing automation and robotics technologies. Workers should understand the process of tasks doing by robotics technologies. Worker training and re-training are necessaryfor operators and helpers to enhance their knowledge of robotics.

Wan Pan et al. [20] improve the conventional tower crane-based installation method and give a conceptual framework for precast concrete panel installation system utilised during construction at high-rise buildings and an integrated approach for panel-loading, transportation, and assembly and management.

Rongo Hu et al. [21] the idea of SMARTBEE system would come over with challenges imposed on renovation industry for an ageing society. The SMARTBEE is still in the design stage and still require more research on the pilot project. Refer to next page figure-1 for various robotics purposes. The aspect behind future research such as standardised module, more modularised end-effectors with different functions as well as mobile-based translations joint need to develop and integrated into SMARTBEE, A feasible collaboration between various Single-task construction robot (STCRs) and SMARTBEE system will be a crucial factor of successful application of the proposed system, The system must be user-friendly, and process of installation and reconfiguration of the system must be easy to use, high degree of safety standard considered, especially when human-robot interaction is involved. The end product should be under laws and regulations in Germany and Europe.

Thomas Bock et al. [22] there are 24 categories according to their background: development, operational, capacity, control strategy and informational aspects, dimension and workplace, construction work process, and analysis of composition and structure. They include: (1) automated site measuring and construction progress

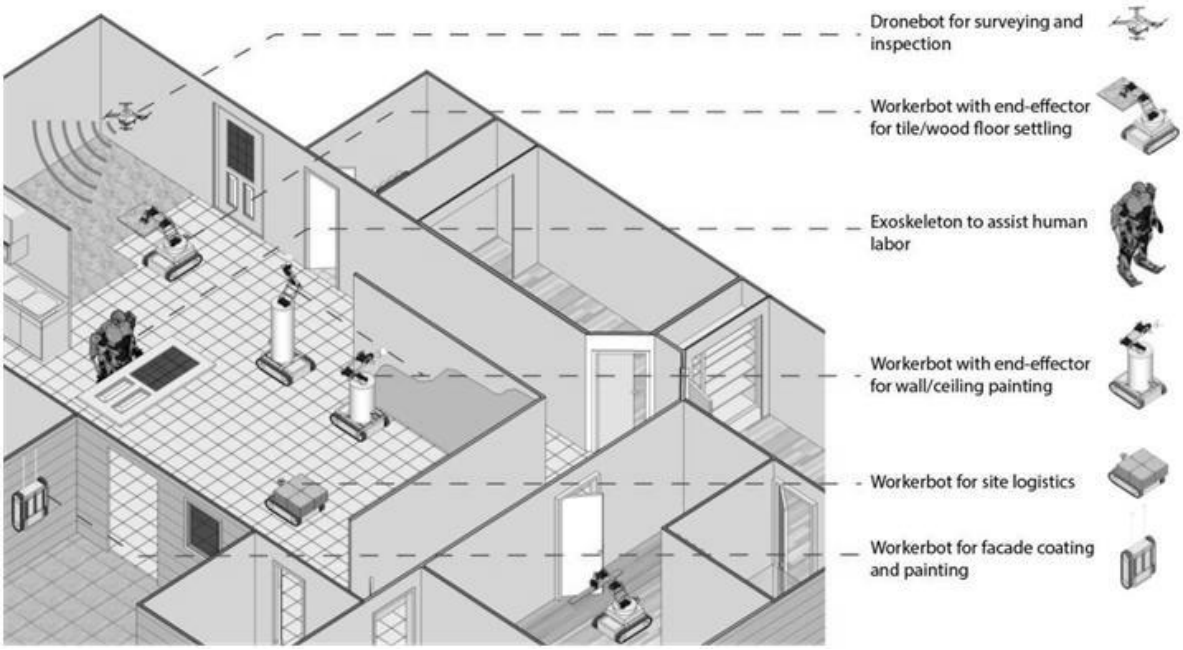

Figure - 1. In a typical renovation job site, various STCRs of SMARTBEE will coordinate to work correctly and simultaneously.

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mobile robots and aerial robots, (2) earth and foundation work robots, (3) robotised conventional construction machines, (4) reinforcement production/positioning, (5) automated 3D concrete structure on-site production, (6) automated 3D truss/steel structure on-site assembly, (7) bricklaying robots, (8) concrete distribution robots, (9) concrete levelling/compaction robots, (10) concrete finishing robots, (11) site logistic robots, (12) aerial robots for structure assembly, (13) swarm robotics and self-assembling building structures, (14) robots for positioning of components, (15) steel welding robots, (16) façade installation robots, (17) Tile setting and floor finishing robots, (18) façade coating/painting robots, (19) humanoid construction robots, (20) Exoskeletons / wearable assistive robots, (21) interior finishing robots, (22) fireproof coating robots, robots, (24) and renovation and recycling robots. And STCRs categories as (1) site measuring robots, (2) tile setting and floor finishing robots, (3) façade coating/painting robots, (4) interior finishing robots, (5) fireproof coating robots, (6) logistic robots, and (7) renovation/recycling robots.

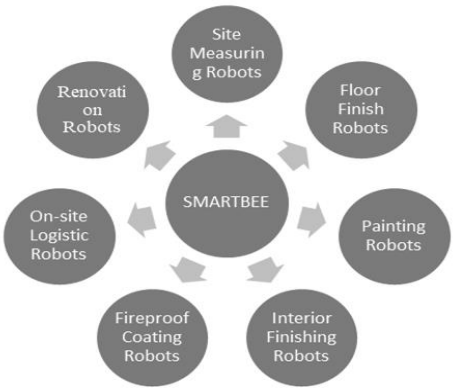

Figure - 2.Concept of SMARTBEE for a construction task

SMARTBEE will be applied especially to these scenarios: (1) Building surveying/inspection, (2) building façade coating/painting, (3) interior floor setting/Replacing, (4) interior wall/ceiling painting, (5) façade fireproof coating, (6) wearable assistive devices, (7) site logistics (8) and recycling, etc. see Figure-2 for more detail.

Thomas Bock and Thomas Linner [23] the application of robotics and automation helps directly connect different building life stages.

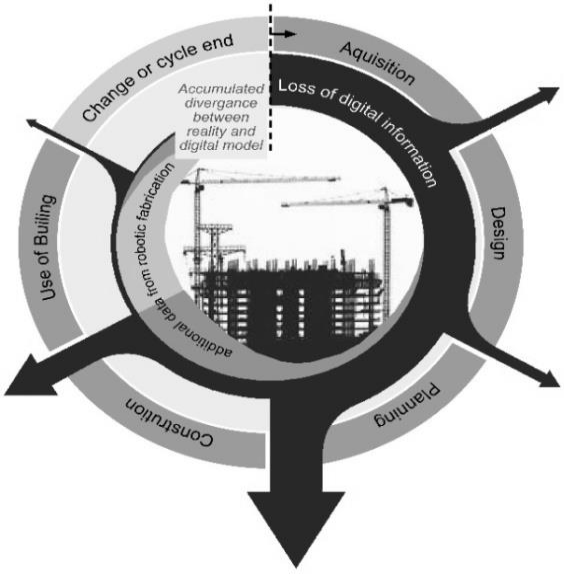

Figure - 3.Loss of information during building lifecycle and additional data through robot integration

The automated machinery should grab data and information to overcome issues for implementing advanced automation on building sites – the absence of a close digital process chain (figure-3) from planning than execution on site until the end of building life.

Using this automated machinery for building elements product, connecting various information such as material type and condition, handling and manipulation Planned execution and connecting them with geometric information of digital building model will be enabled.

Ci-Jyun Liang et al. [24] studied to develop a robotic assembly system for the erection of steel structure and assembly of all components together. A system consists of four methods such as rotation, alignment, bolting and unloading. This system works automatically without an operator in the high vertical distance as well.

E. Azar et al. [25] review of the technical advances in earthmoving automation in industrial and academic communities gives limitations and future directions. The earthmoving equipment is classified into four categories: equipment tracking, safety management, equipment pose estimation, machine control, and autonomous operation, which identified the most immature field.

Rajesh Singh et al. [26] RFID systems are a good solution with RSSI localisation working technique. The RFID is for safety management which is based on RTLS (real-time location system). It is a wireless system that deals with logistic management. The sensor is used to prevent crashes or disasters at work. The actual implementation of the proposed system is complex at the site because of loops in programming and the need for an embedded system based automation in the construction industry.

Akshatha D. et al. [27] Automation in construction industries relates to processing speed and material delivery. The automation equipment is economical while having a sufficient amount of work with continuous employment. The main benefits of use robotics are the building designs are unique, but the process of working with the material is the same. The purpose behind the employment of robots is to be a shortage of skilled labour and the direct and hidden cost of importing foreign labour. The robots are helpful for repetitive tasks to program themselves, in sophisticated and high accuracy for each job in the dirty and tedious building core.

ShiyaoCai et al. [28] the convention construction technique reached its limit, the future opportunities for automation such as robot-oriented design, robotic industrialisation, construction robots, site automation and ambient robotics.

A. Jayraj et al. [29]By research and development concept wall painting robot created with the help of CAD model and by fixing necessary elements and Bosch PPR 520 pump. The model was prepared from Pro-engineer-WF4. Development of automation and robotics is costly in the initial stages, but continuous utilisation of the developed automation systems increase productivity. When the number of projects accomplished increases, it becomes clear that using manual methods is costlier than robotics technologies.

M. Yahya et al. [30] research is based on finding preventive factors during challenges faced during implement automation and robotics technologies. The major finding factors such as research and development and maintenance cost high, depending on the nature of construction, worker-oriented issues and government policies. Strategic partnerships with G7 contractors will provide a solution for all challenges.

M. Gharbia et al. [31], With the help of detailed conventional methods, prove that construction industries are innovative stage towards health and safety and time and cost savings. The robotics scope for some tasks such as construction activities related to formwork, steel reinforcement and concrete placing are eliminated. The innovative robotics technologies utilised in all construction segment disciplines are architecture, engineering, on-site, and off-site construction, which would be essential for developing a co-related research area.

Table 1 Example of Robotics, Automated and Robotics System in Construction Industry.

Category	Description or Name of Automation	Reference
1. Drones type automation	For carrying loading and transfer one site to another site up to 0.5 to 1T	[32]
	For Land survey	[21], [75]
	For Inspection and Monitoring	[6], [75]
	Access in a hazardous condition	[34], [35]
2. Automated Vehicle	The building elements manufacturing/production at an off-site location	[36], [37]
	automated drilling, excavation and earthmoving	[38], [39]

3. Off-site Automation for Prefabrication System	Building elements manufacturing	[40]
	Large Scale Prefabrication	[16], [31]
	3D Printing	[41], [42] [43]
	Robotics on-site factories	[44], [45]
4. On-site Automated System	Single task Robo (STCrs) for doing a specific task such as bricklaying, plastering, steel-truss assembly, welding, façade installation, wall painting, concrete laying etc.	[15], [16], [46]
	Robot for building element assembly	[47]

The following table – 2 shows Factor findings that prevent the implementation of automation technologies.

TABLE 2

Major Finding Factors while implementing automation and robotics technology

Factor no.	Core Factors	Factors	RohanaMahbub [4]	M.Gharbia [6]	M.Yahya [7]	ShiyaoCai [8]	A Jayraj et al. [9]	Akshatha et al. [10]	E.Azar, et al. [12]	T. Bock, et al. [14]	T. Linner, et al. [15]	Wan Pan et al. [17]	AkashTambi et al. [20]	SMS. Elettra [25]	Hiroshi M, et al. [30]	Prasathkumar et al. [32]
F1	Cost	project completion cost reduces by implementing Automation	•				•			•	•		•			•
F2		high owning cost of Robotics technology	•			•			•			•	•		•	•
F3		High maintenance cost of Automation		•	•							•	•		•	
F4		High cost of training and re-training of worker	•				•		•			•	•			
F5	Time	need more workout for		•						•	•	•				

		economically Automation														
F6		easy to use						•			•			•		•
F7		difficult to use	•										•			
F8		readily available locally and quick maintenance													•	•
F9		Tight project duration preventing for implementation of automation.	•	•		•				•	•			•		
F10	Productivity	High productivity	•				•	•		•			•		•	•
F11		Project size matter for implementation			•	•		•	•			•				
F12		good quality construction	•			•	•				•	•	•	•		•
F13	Social issues	shortage of skilled labour	•		•			•	•		•					
F14		Government policy prevents adopting automation.	•	•	•						•		•		•	
F15		Technology suitable for a small and medium-size firm				•	•							•		•

CONCLUSION

Below are the conclusion based on the literature review:

The implementation of automation technologies isn't beneficial for small scale work/tasks. But by making joint ventures with a top contractor or some relief in government policy.

- The innovation of automation is still in the initial stage. By continual improvement in research and development, automation will be economical and more beneficial for the construction industry.
- There may chance of loss of labour job and increasing unemployment or possibilities to take opportunities or learn new technologies and enhance the increasing skill of labour.
- There may be chances of hacking/hijacking of automation as a result of loss of equipment

and wastage of time and may injuries to operator/labour nearby.

- Implementation of automation technologies makes it possible to complete the project within planned duration and cost because of the high rate of qualitative product and increasing productivity.
- It can continue working on-site under adverse atmospheric conditions on-site and day or night without stoppage.
- The automation technologies fulfil the issue of shortage of labour, inferior quality output, repetition of work, limitation of working hrs, labour safety, time and cost overrun, effort of inspection, elimination of unwanted labour expenses, and decreasing productivity under climate changes.

By continual improvement in research and development, automation technologies economic will be economical automation equipment with the help of collaboration with government, labour training, motivate people for research and development, allowances for government tax and other charges and make a strategic partnership with companies.

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