

BUILDING MECHANIZATION: ROBOTICS, 3D PRINTING AND AUTOMATED CONTROL OF CONSTRUCTION SITE STAGES

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ABSTRACT

The different phases of building construction can be broken down into four stages: design and planning, site preparation, construction, and post-construction. Design and planning cover the feasibility study, project development, and design with all building details (plans, technical specifications). Site preparation can be handled through earthworks, foundation work, and the installation of the basic infrastructure essential for construction. Construction is the phase in which the project is actually carried out. It covers the layout of the load-bearing structure, walls, and roofing, as well as the interior and exterior fitting-out of the building. Post-construction corresponds to the handover phase to the project owner once construction is complete, but also to the operation and maintenance phase. Concrete printing makes it possible to shape building elements (walls, slabs, etc.) while enabling complex shapes to be produced with high precision. Reinforcement (the set of steel bars embedded in concrete) plays an important role in the strength of concrete and contributes to its durability. Applying a layer of interior and exterior mortar makes it possible to cover the structure with a render. This cement render contributes to insulation, and sanding it produces a smooth surface before the paint finish. Painting drones are equipped with high-precision spraying systems and operate on the basis of artificial intelligence, connectivity, sensors, and embedded systems. This allows them to provide paint coverage over a much larger surface in record time compared with manual work.

KEYWORDS: Design, Construction, Post-Construction, Concrete Printing, Reinforcement, Cement Render, Painting Drone.

1. INTRODUCTION

The construction sector, which is highly labor-intensive and suffers from a lack of technological innovation and low productivity, is considered one of the world's leading providers of employment. Traditional construction methods have always been known and applied in the architecture, engineering, and construction (AEC) sector. However, this branch of engineering has been slow to adopt technological advances and innovations. Relying on manual construction processes, these construction methods limit expansion capacity, increase errors, and slow down schedules[1]. Compared with other sectors, the construction industry faces a labor shortage and insufficient investment in research and development. Thus, compared with the most digitized industrial sectors, such as manufacturing, its productivity and growth are lagging behind[2]. "Digital transformation is essential for these projects because of its many benefits, notably increased productivity and an improved collaborative environment[3]." The solution to the problem of labor shortages, particularly in nations with a high dependence on immigrant workers, is achieved through 3D printing, which reduces the number of workers required. On the other hand, it proves disadvantageous in areas where construction is one of the main economic activities, accompanied by cheaper labor[4]. To automate construction processes, 3D printing proves highly promising. It makes it possible to save money on projects, shorten construction timelines, and avoid material waste and hazardous operations for personnel. Unlike the traditional method, it makes it possible to create complex geometries; improve safety; minimize environmental pollution; and reduce the costs, materials, and timelines of construction. The use of materials such as recycled glass aggregates and fly ash in construction helps reduce environmental impacts. These materials also help improve the strength of building elements and their long-term durability. "3D printing technology has the potential to transform the construction sector by offering economical, efficient, and environmentally friendly solutions[5]." Computer vision should be favored to automate quality control and the automation of manufacturing

processes. Consequently, for the manufacturing and assembly of off-site modular systems, the integration of AI techniques and 3D printing of buildings facilitates automated design and improves production efficiency[6]. Improved productivity, labor shortages, safety risks, and pressure on construction costs are essential factors that robotics and automation should take into account, particularly for high-rise buildings[7].

The objective of the study is to identify the construction phases that can be automated in order to reduce errors, improve safety, reduce timelines and costs, and increase durability.

2. AUTOMATABLE CONSTRUCTION PHASES

Automation in construction has the distinctive feature of being applicable to several phases, notably design, manufacturing, on-site construction, and maintenance. It helps improve efficiency, precision, and safety, while reducing costs and timelines.

1. Design and modeling:

The creation of 3D building models is achieved through BIM (Building Information Modeling) software. This creation facilitates coordination between the different stakeholders and the detection of conflicts. This software is used for the automatic generation of technical construction plans based on the BIM model. The automation of design aims to test the different proposals quickly and efficiently in order to optimize the building's energy performance, structural integrity, and occupant comfort. It thus helps reduce design errors and improve the quality of the final product.

2. Manufacturing and prefabrication:

The components of a building can be prefabricated in a factory through prefabricated modules and automated factory assembly, then assembled on site. This approach is advantageous in terms of efficiency, as it reduces costs and timelines. Robots (automated arms) are used for the manufacturing and assembly of construction elements (pre-walls, beams, walls, roofs, etc.) for greater precision.

Prefabrication consists of manufacturing construction elements in advance in a factory, most often in series, to be assembled on site afterward[8]. It is therefore a construction technique involving the assembly of modular elements in controlled environments, intended to be transported and then assembled to form a building. It is highly advantageous in that it enables construction schedules to be met, reduces the need for on-site labor, improves comfort and quality, limits waste, strengthens safety, respects the environment, and reduces construction costs[9]. Since construction modules can be easily modified and customized as needs evolve, this method offers greater flexibility than the traditional approach. Figure 1 illustrates the assembly of prefabricated modules.



Figure 1: Assembly of prefabricated modules[9]

Figure 2 illustrates the gradual evolution of prefabricated components toward greater integration. It should be read from bottom to top; the first level consists of prefabricated materials (such as metal structures, precast concrete, etc.).

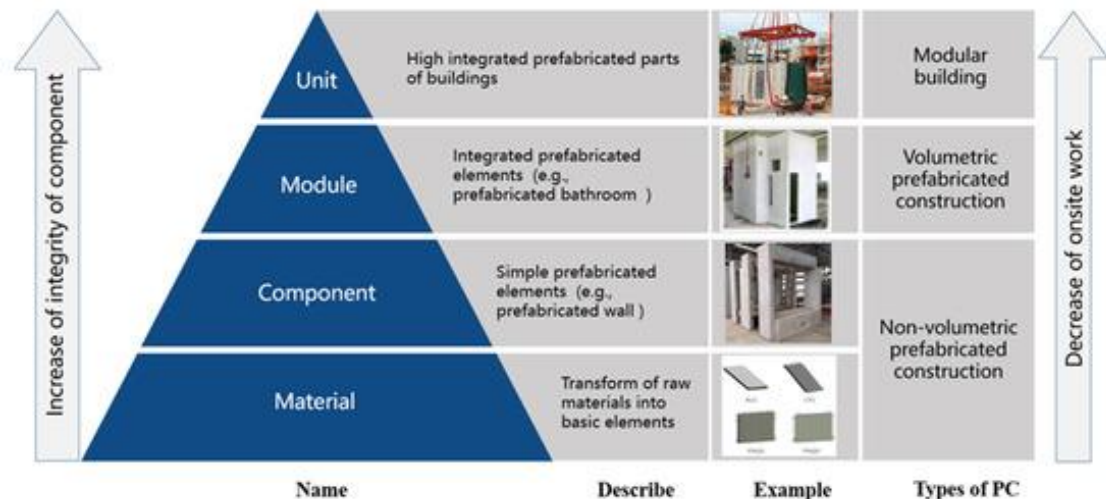


Figure 2: Evolution of prefabricated components[10]

3. On-site construction:

Building construction has undergone major changes thanks to the automation of the various stages and construction processes. There are several types of technology that can be used to automate construction.

1.3.1 Construction robots

Construction robots, such as bricklaying robots used in Australia and the USA, are semi- or fully automated machines capable of laying building blocks and bricks with great speed and precision. The principle relies on the use of an articulated arm that first picks up the bricks, then applies a layer of mortar to them before stacking them precisely according to laser guidance. They can be used to reduce labor costs and speed up construction projects. “Designed by the company Construction Robotics, Sam is a robot capable of laying up to 3,000 bricks a day, compared with an average of 500 for a bricklayer, according to the start-up, thereby doing the work of six laborers, it calculates[11].” It should be noted that the Sam robot does not have the ability to fully replace construction workers. Loading bricks and cleaning up mortar residue still need to be handled by these workers. Figure 3 is a representation of the construction of a wall by the Sam robot in four steps: picking up a brick, moving to the mortar, applying mortar, and stacking bricks.

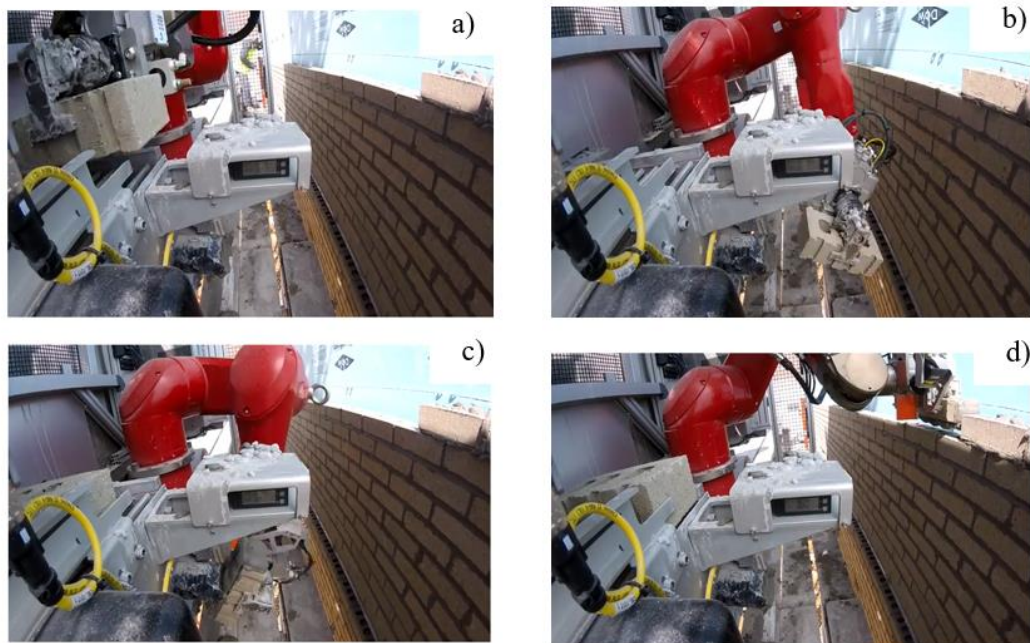


Figure 3: Construction of a wall by the Sam robot[11]

1.3.2 3D printing (3D construction)

3D printing, already used in the United States and China, is an emerging technology that makes it possible to manufacture construction elements or entire buildings using 3D printers. Thanks to giant printers, houses and buildings printed in concrete have been built. This approach is advantageous, especially since it allows for rapid execution and reduced waste. The 3D construction process is based first on creating a 3D digital model using computer-aided design (CAD) software. Next, the digital model is sliced into thin layers by specialized software such as Cura Ultimaker. Finally, the construction material is printed according to the model designed, in sliced layers deposited in the form of a polymer. The operating principle of a 3D printer, from the reception of electronic signals from a computer's control board, relies on interpreting these signals and transmitting them as instructions to the print head.

The process first involves digital design via BIM (Building Information Modeling) software. Next, the structure is 3D printed layer by layer in the form of a paste, automatically, by a machine that can work on-site or off-site. Depending on the design parameters, the build-up of the mixture (mortar, concrete, plastic, earth) is achieved by a robotic arm or a nozzle, thereby producing the main structure in the form of an extruded structure[12]. Often used for plastic or rubber materials, extrusion is a process in which a liquid or malleable material is forced through a die or nozzle in order to create a shape. Figure 4 is an example of 3D printing of a concrete house layer by layer.



Figure 4: 3D printing of a concrete house[12]

1.3.3 Caulking, render-sanding, and painting robots

A caulking robot is designed to apply caulk precisely and automatically. A sanding robot, with automatic navigation for walls and ceilings, is used to obtain a smooth surface before finishing with a coat of paint. A painting robot, which is automated, is intended to apply paint to interior walls and ceilings, from the first coat to the finish.

“Thanks to in-house-developed spraying technology, automatic trajectory planning, indoor navigation via laser SLAM, and four-axis robotic control, it moves and sprays autonomously, thereby reducing the risks associated with paint spray exposure for workers. It offers a high quality of application, uniform spraying, and a flawless visual result. Its output is high, 1.5 times greater than manual spraying and 3 times greater than manual roller application[13].”

Figure 5 clearly illustrates the different types of robots used for finishing work.



Figure 5: Caulking, sanding, and painting robots[13]

4. Drones

Drones are used to inspect, monitor, and transport lightweight materials along pathways. They have the distinctive feature of being able to operate autonomously without direct human intervention. Equipped with cameras and sensors, their role is to monitor work progress, inspect hard-to-reach areas, and detect potential problems.

With a view to achieving optimal professional painting results, it is through their speed and efficiency that aerial drones will revolutionize this sector. Thanks to technological progress, the construction sector can now rely on work at height being carried out safely and precisely, particularly in hard-to-reach locations. This technique also helps improve productivity. It meets the strong demand for economical and environmentally friendly solutions[14]. Figure 6 illustrates aerial painting by drone.



Figure 6: Aerial painting by drone[14]

Traditionally, painting at height requires heavy equipment such as elevated platforms or scaffolding. This can lead to longer timelines and higher costs. On the other hand, using painting drones reduces both the cost and the execution time of construction projects. The table below clearly illustrates the differences in time and cost between traditional methods and the use of drones.

Table 1: Comparison of time and cost of paint application[14]

Method	Intervention time	Average cost
Scaffolding	4 to 8 hours	High
Aerial work platform	3 to 5 hours	Medium
Drones	1 to 2 hours	Low

Working at height sometimes carries risks with serious consequences. Aerial painting drones therefore make it possible to carry out work safely without endangering workers' lives. There are many advantages to using painting drones. However, we can cite:

- Reduced falls from height
- Remote interventions carried out safely
- Less need for specialized training for intervention teams

3. AUTOMATION OF BUILDING REINFORCEMENT

The automation of building reinforcement involves the use of software and technologies to simplify and optimize the design, calculation, and production of reinforcement plans, as well as the manufacturing of rebar. The goal is to save time, improve precision, and reduce costs. The manufacturing of rebar can be handled by automated machines, such as benders and cutters, used to manufacture the rebar according to the plans generated by the software. Automation considerably reduces the time needed for the design, calculation, and production of reinforcement plans. The software helps avoid human errors in calculations and plan production. Better material management and fewer errors can lead to significant savings. Accurate plans and precisely manufactured rebar contribute to construction quality. The use of BIM software facilitates communication and collaboration between the various project stakeholders. In short, reinforcement automation represents a major development in the construction sector, offering powerful tools to design, calculate, and produce rebar more efficiently and precisely.

1. Rebar

A reinforcing bar, or rebar, is a steel bar used to reinforce concrete (reinforced concrete) or masonry (reinforced stone). It is made of low-carbon steel and has a ribbed surface to improve its bond with concrete.

The steel used for reinforced concrete (RC) is recyclable, as it most often comes from the electric steelmaking route. Bars, wires, coils, and welded mesh are steel elements used to create reinforcement. Rebar is a framework or assembly of metal elements embedded in concrete to form reinforced concrete[15]. Figure 7 is a representation of rebar.



Figure 7: Rebar[15]

A welded wire mesh, also called a welded reinforcement mesh, is an assembly of steel bars welded together to form a mesh network. These meshes are used in reinforced concrete construction to strengthen the concrete and give it resistance to tension, compression, and cracking. Reinforced concrete is used in structures where concrete is subjected to compressive and tensile/bending stresses (forces), such as slabs, columns, beams, foundations, and walls. Concrete is strong, durable, easy to work with, and fire-resistant.

2. The rebar bending machine

Reinforcement cages, also called stirrups or hairpins, are essential elements of reinforcement in reinforced concrete. They are used to reinforce construction elements such as beams, columns, and walls, and contribute to the structure's strength, particularly against shear forces. A stirrup is an open frame with two parallel strands, often used for reinforcing beams and columns. A hairpin is an open frame with a single strand, sometimes used for reinforcing walls. A closed frame is a rectangular or square frame used in various applications, such as beams, columns, and foundations.

Embedded within the concrete mass, this rebar makes it possible to combine the strength properties of concrete (in compression) and steel (in tension) to obtain reinforced concrete[16].

In short, cages are crucial reinforcement elements that improve the strength, durability, and stability of reinforced concrete structures. Figure 8 clearly illustrates these reinforcement elements.



Figure 8: Reinforcement elements[16]

A rebar bending machine is a machine used to shape the steel bars (rebar) used in reinforced concrete. It bends and cuts these bars into specific shapes and dimensions so they can be incorporated into construction elements. There are manual bending machines suited to small-batch work, automatic bending machines suited to complex series work, and bending machines with control systems based on programming dimensions and shapes for high-precision work. Figure 9 is a representation of a rebar bending machine.



Figure 9: Rebar bending machine

Reinforcement steel cages come in several three-dimensional shapes and are produced by welding, machining, or weaving. Whether open or closed, they are obtained by bending on one or more sides and are used as spacers between slabs or walls. They are also used as connectors for lintels, beams, and footings, since they are important for the static properties of concrete structures under tension (prestressed concrete)[17]. Figure 10 clearly illustrates the shapes that can be produced on a rebar bending machine.

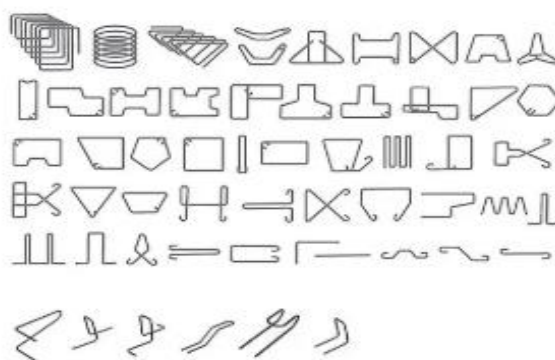


Figure 10: The different shapes that can be bent by a rebar bending machine[17]

2. Modeling of automated systems in construction

An automated system can be modeled in different ways. These include the algebraic form (logical equation), the tabulated form (truth table), and the symbolic form (logic diagram). In this study, the focus will be on representation using a GRAFCET-type logic diagram (Step/Transition Function Chart).

1. GRAFCET

GRAFCET (Step-Transition Function Chart) is a graphical tool used to describe the operation of an automated system in the form of sequential logic. The description of an automated system, after translation of a specification document, is expressed in a logic that can be understood by humans and translated into control signals by a programmable controller.

1. Controls:

- R1: Heating resistor for the nozzle (heating and maintaining the melting chamber at melting temperature)
- R2: Heating resistor for the build plate (heating and maintaining the plate at the heating temperature)
- KM1: Control of the stepper motor for filament feed
- KM2: Control of the motor moving the nozzle along the OX axis
- KM3: Control of the motor moving the nozzle along the OY axis
- KM4 and KM5: Controls of the motors moving the nozzle along the OZ axis

- T_1 : Timer for heating the nozzle and the build plate, and for the step-by-step advance of the filament to the nozzle chamber
- T_2 : Timer for one print cycle
- T_3 : Timer for cooling the nozzle and the build plate
- C_1 : Counter for the number of cycles (number of layers)

Receptivities:

- I : Printer power switch. Takes the value 1 if ON and 0 if OFF
- f : Filament presence sensor
- a_0 : Limit switch/home position sensor relative to the 0X axis
- b_0 : Limit switch/home position sensor relative to the 0Y axis
- c_0 : Limit switch/home position sensor relative to the 0Z axis
- r_1 : Nozzle temperature sensor calibrated to 250°C
- r_2 : Build-plate temperature sensor calibrated to 70°C

Figure 11: GRAFCET, control-side view of the 3D printer's operation

1. Activation and deactivation

The table below presents the activation and deactivation equations for the steps.

Table 2: Activation and deactivation of the steps

Step	Activation	Deactivation
KA_0 *K	A_5, a_0, b_0, t_3 *K	A_1 *
KA_1	KA_0, f, I	KA_2
KA_2	KA_1, r_1, r_2, t_1	KA_3
KA_3	$KA_2, a_0, b_0, c_0 + KA_4, c_1$	KA_4
KA_4	KA_3, t_2	$KA_3 + KA_5$
KA_5	$*KA_4, **C_1$ *KA	0 *

2. Step equations

The following equations represent the step equations.

$$KA_0 = (KA_5, a_0, b_0, t_3 + Ka_0 + Init). Ka_1$$

$$KA_1 = (Ka_0, f, I + Ka_1). Ka_2$$

$$KA_2 = (Ka_1, r_1, r_2, t_1 + Ka_2). Ka_3$$

$$KA_3 = (Ka_2, a_0, b_0, c_0 + Ka_4, c_1 + Ka_3). Ka_4$$

$$KA_4 = (Ka_3, t_2 + Ka_4). (Ka_3, Ka_5)$$

$$KA_5 = (Ka_4, c_1 + Ka_5). Ka_0$$

3. Output equations

The following equations represent the output equations of the steps.

$$T_1 = Ka_1$$

$$T_2 = Ka_3$$

$$T_3 = Ka_5$$

$$C_1 = Ka_4$$

$$RESET = Ka_5$$

$$R_1 = Ka_1 + Ka_2 + Ka_3 + Ka_4$$

$$R_2 = Ka_1 + Ka_2 + Ka_3 + Ka_4$$

$$KM_1 = Ka_1 + Ka_2 + Ka_3 + Ka_4$$

$$KM_2 = Ka_2 + Ka_3 + Ka_4 + Ka_5$$

$$KM_3 = Ka_2 + Ka_3 + Ka_4 + Ka_5$$

$$KM_4 = Ka_2 + Ka_3 + Ka_4 + Ka_5$$

$$KM_5 = Ka_2 + Ka_3 + Ka_4 + Ka_5$$

4. Address definitions

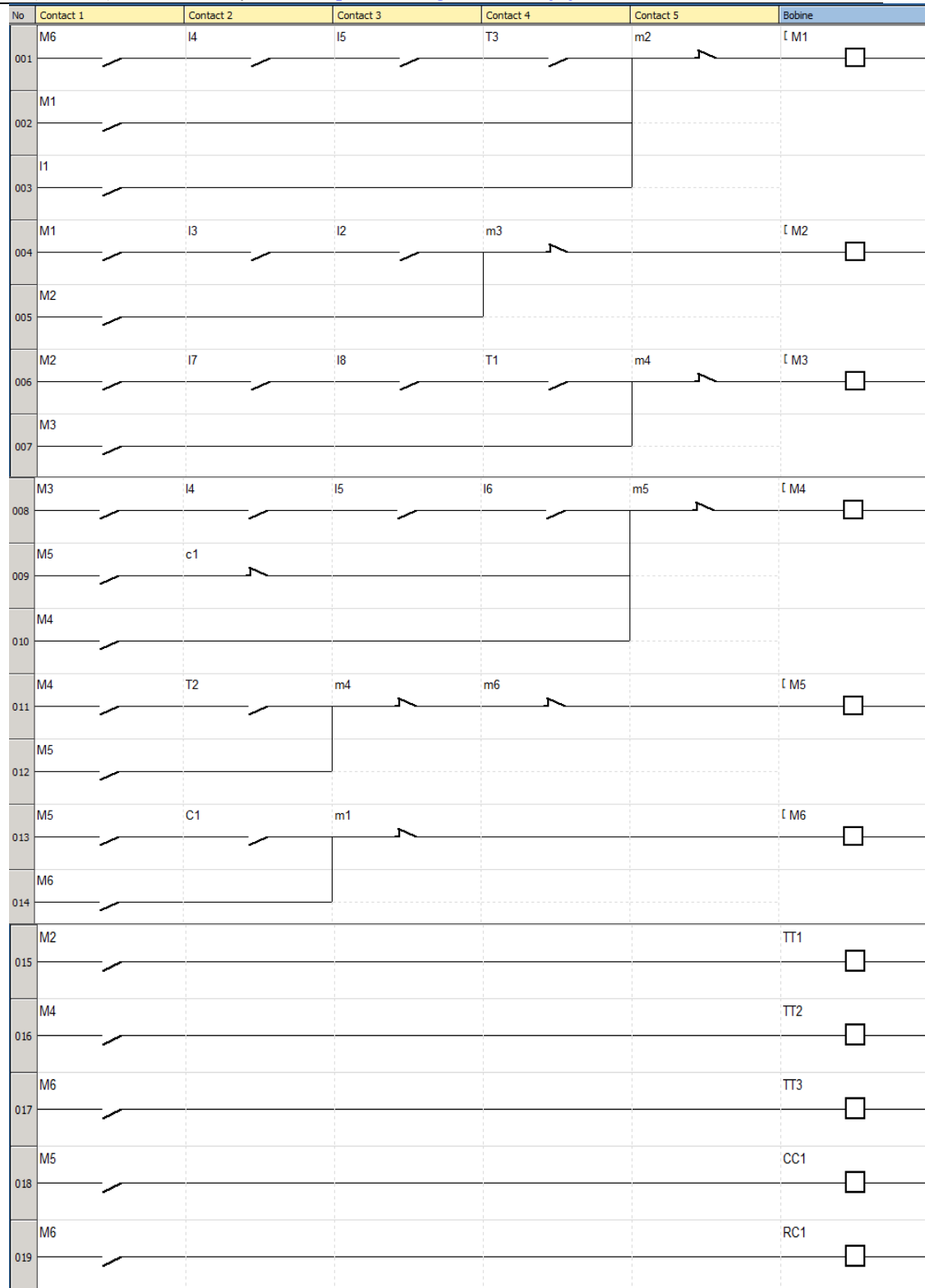
The following table represents the address definitions.

Table 3: Address definitions

Variable	Input s	Time r	Counter r	Auxiliary contactors	Coil s	Address ss
Initialization	Init					I_1
Switch	I				$*I$	2^*
Sensor-1	F					I_3
Sensor-2	a_0					I_4
Sensor-3	b_0					I_5
Sensor-4	c_0					I_6
Sensor-5	r_1					I_7
Sensor-6	r_2					I_8
Timer-1		T_1			$*T_1$	$*$
Timer-2		T_2			$*T_2$	$*$
Timer-3		T_3			$*T_3$	$*$
Counter-1			C_1		$*C_1$	$1 \sim *$
Auxiliary contactor-1			$*$	KA_0^*	M_1	
Auxiliary contactor-2			$*$	KA_1^*	M_2	
Auxiliary contactor-3			$*$	KA_2^*	M_3	
Auxiliary contactor-4			$*$	KA_3^*	M_4	
Auxiliary contactor-5			$*$	KA_4^*	M_5	
Auxiliary contactor-5			$*$	KA_5^*	M_6	
Resistor actuator-1				$*$	R_1^* Q_1	
Resistor actuator-2				$*$	R_2^* Q_2	
Motor actuator-1				$*$	KM_1 $* Q_3$	
Motor actuator-2				$*$	KM_2 $* Q_4$	
Motor actuator-3				$*$	KM_3 $* Q_5$	
Motor actuator-4				$*$	KM_4 $* Q_6$	
Motor actuator-5				$*$	KM_5 $* Q_7$	

5. Ladder diagram

The ladder diagram is a contact diagram, or a graphical representation in the form of an electrical schematic, used to control an automated system by means of a programmable logic controller. Figure 12 is a representation of the control circuit of the 3D printing system in the form of an electrical schematic.



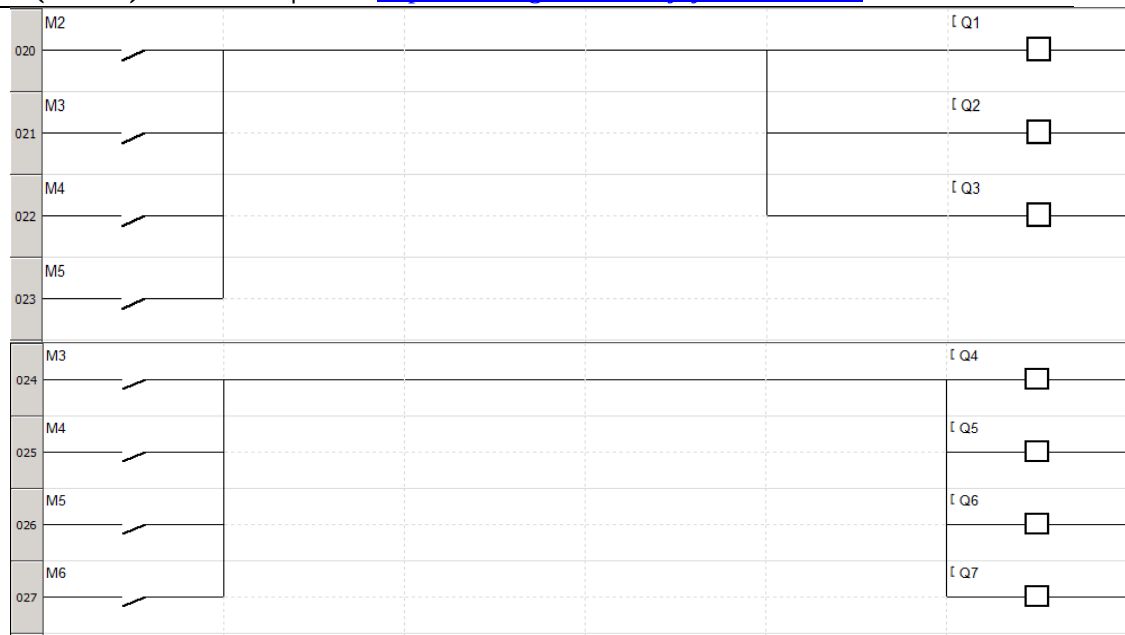


Figure 12: Control circuit of the 3D printing process

3. Time, cost, safety, health, energy efficiency, and sustainability

Building construction has an environmental impact. This impact can be reduced through sustainable construction, which also delivers long-term energy efficiency. The approach adopted by sustainable construction takes into account the design, materials, systems, and operations of the building in order to reduce energy consumption, greenhouse gas emissions, and waste. This, in turn, promotes the comfort and health of occupants. The increase in productivity and efficiency is explained by the fact that machines, compared with human labor, offer greater precision and speed of execution for certain tasks. Reducing the risk of accidents through automation helps improve safety on construction sites. It keeps workers from being exposed to hazards. It can lead to a reduction in labor and material costs. The advantage of using robots is that they can perform repetitive tasks with great precision, thereby improving construction quality. This automation offers significant potential to transform the construction sector. It contributes considerably to improving the efficiency, safety, and quality of buildings. It also helps reduce construction costs and timelines.

4. CONCLUSION

The use of robots in construction enables a reduction in repetitive on-site tasks, estimated at between 25 and 90%, a reduction in hazardous tasks of 72% on average, a 55% improvement in precision, a reduction of more than 50% in repeated actions, an average 2.3-fold reduction in execution time, and a 13% reduction in costs[18].

3D printing is an innovative and effective technology. It offers economic, environmental, and other benefits. Its use in this sector depends heavily on print precision, material availability, and print cost and time[19]. Compared with the traditional construction method, it offers several advantages, such as constructability and durability. Nevertheless, it comes with additional challenges and risks. These additional risks are classified into seven categories: 3D printing materials, 3D printing equipment, site and environment, management, stakeholders, regulatory and economic aspects, and cybersecurity[20].

“Industrial buildings should be safer and more productive for occupants, and more operationally efficient for owners. Thus, if indoor workspaces (IWS) can provide a healthy working environment, fostering increased productivity and employee well-being while reducing absenteeism, the public and private sectors would be increasingly encouraged to invest in this type of space “[21].

In sum, construction technology based on the use of mechanical systems such as 3D printers is environmentally friendly. This technology ensures better waste management, the use and flexibility of workspace, human health and well-being, safety and security measures, efficiency and productivity at work, meeting client expectations, as well as the overall quality and cost of construction.

REFERENCES

- [1] Comment l'automatisation dans la construction ouvre la voie au secteur de l'AEC ? <https://www.novatr.com/blog/future-of-automation-in-construction>
- [2] Johannes Brozovsky, Nathalie Labonnote, Olli Vigren, Technologies numériques dans l'architecture, l'ingénierie et la construction, Automatisation dans la construction, Volume 158, février 2024, 105212, <https://doi.org/10.1016/j.autcon.2023.105212>
- [3] Amila Gamage, Étude des défis liés à la mise en œuvre de la transformation numérique dans les projets de construction, Décembre 2021, DOI : 10.52155/ijpsat.v30.1.3912
- [4] M. Aslam Hossain, Altynay Joumabekova, Suvash Chandra Paul, Jong Ryeol Kim, un aperçu de l'impression 3D dans la construction et de son impact sur le marché du travail, Développement durable 2020, 12 (20), 8492 ; <https://doi.org/10.3390/su12208492>
- [5] Toiba Tabassum, Ajaz Ahmad Mir, Un aperçu de la technologie d'impression 3D - l'avenir de la construction durable, Volume 93, Partie 3, 2023, <https://doi.org/10.1016/j.matpr.2023.08.013>
- [6] Shanaka Kristombu Baduge, Sadeep Thilakarathna, Jude Shalitha Perera, Mehrdad Arashpour, Pejman Sharafi, Bertrand Teodosio, Ankit Shringi, Priyan Mendis, Intelligence artificielle et vision intelligente pour le bâtiment et la construction 4.0 : méthodes et applications d'apprentissage automatique et en profondeur, Automatisation dans la construction, Volume 141, septembre 2022, 104440, <https://doi.org/10.1016/j.autcon.2022.104440>
- [7] Shiyao Cai, Zhiliang Ma, Mirosław J. Skibniewski, Chanson Bao, Automatisation et robotisation de la construction pour les immeubles de grande hauteur au cours des dernières décennies : un aperçu complet, Octobre 2019, DOI : 10.1016/j.aei.2019.100989
- [8] La préfabrication en béton armé, <https://fr.scribd.com/presentation/408419492/La-prefabrication-pptx>
- [9] [9] La préfabrication, c'est quoi ? Ou comment construire plus vite et mieux ? <https://infos.trouver-un-logement-neuf.com/construire-maison-neuve/conseils/prefabrication-definition-construction-prefabriquee-10971.html>
- [10] Clyde Zhengdao Li, Shanyang Li, Xiao Li, Hengqin Wu, Bing Xiao, Vivian W.Y. Tam et Cornelia Asiedu-Kwakyewa, Une étude scientométrique de la gestion de la construction préfabriquée de 2011 à 2021, *Bâtiments* 2022, 12 (10), 1515 ; <https://doi.org/10.3390/buildings12101515>
- [11] Robots poseur de briques, <https://www.lemoniteur.fr/article/ce-robot-est-capable-de-poser-jusqu-a-3000-briques-par-jour-video.725594>
- [12] Maisons imprimées en 3D : Est-ce l'avenir de la construction résidentielle ? <https://www.ecohome.net/fr/guides/3846/maisons-imprimees-en-3d-est-ce-lavenir-de-la-construction-residentielle/>
- [13] BOZHILIN corporation, série de robots de construction, Bright Dream Robotics Corporation, 2022, <https://www.bzlrobot.com/channels/3.html>
- [14] Quelles sont les possibilités offertes par la peinture aérienne avec un drone ? <https://animation-digitale.com/quelles-sont-les-possibilites-offertes-par-la-peinture-aerienne-avec-un-drone/>
- [15] Le béton armé : armatures, ferrailage, treillis soudés, <https://www.concretedispatch.eu/blog/beton-arme-armatures-btp/>
- [16] Le béton armé, <https://tpdemain.com/module/le-beton-arme/>
- [17] Cadres d'armature, <https://www.progress-m.com/fr/produits/cadreuses>
- [18] Brosque, C., Fischer, M. : Impacts sur la sécurité, la qualité, le calendrier et les coûts de dix robots de construction. *Constr. Robot.* 6 (2), 163–186 (2022). <https://doi.org/10.1007/s41693-022-00072-5>
- [19] Peng Wu, Jun Wang, Xiangyu Wang, Une revue critique de l'utilisation de l'impression 3D dans l'industrie de la construction, *Automatisation dans la construction*, 2016/8/31, DOI: 10.1016/j.autcon.2016.04.005
- [20] El-Sayegh, S., Romdhane, L., Manjikian, S. : Une revue critique de l'impression 3D dans la construction : avantages, défis et risques. *Arch. Civ. Mécanique. Eng.* 20 (2), 34 (2020). <https://doi.org/10.1007/s43452-020-00038-w>
- [21] A. Ghaffarian Hoseini, Umberto Berardi, Husam Al-Waer, Seongju Chang, Edouard Halawa, Ali Ghaffarianhoseini et Derek Clements-Croome (2016), What is an intelligent building? Analysis of recent interpretations from an international perspective. *Architectural Science Review*, 59 (5). pp. 238-257. ISSN 0003-8628 doi: 10.1080/00038628.2015.1079164 Available at <https://centaur.reading.ac.uk/67745/>



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