# 博 士 論 文

RESEARCH ON CONSTRUCTION PERFORMANCE EVALUATION OF STATIONARY AND MOBILE ROBOTS IN WOODEN BLOCK STACKING METHOD

木ブロック積層工法における定置型ロボットと移動型ロボットの施工性評価に関する研究

2022 年 06 月

王　璐

WANG LU

# Research on Construction Performance Evaluation of Stationary and Mobile Robots in Wooden Block Stacking Method

## ABSTRACT

The involvement of robots in building construction is already a global trend. Compared with the current stage of construction in which a large number of people are involved, the stability of the robot construction process will greatly affect the construction efficiency and construction accuracy, thus 1) reducing the impact on the environment, saving natural resources and other obvious advantages of natural environmental benefits and 2) reducing construction costs, reducing the economic and environmental benefits of artificial use. In this thesis, a reconstruction of a completed wooden building, from the design process, construction process to the final evaluation of construction efficiency, is proposed for the construction of a wooden building with stationary robots and mobile robots. The construction method of two continuous building components for the robot static and beyond static workspace is discussed, and the construction experiment of the wooden building is completed using the construction method.

Based on the experiment, 1) an innovative way to build a wood-frame building that satisfies the robot's construction logic and 2) the mobile robot's ability to accurately assemble building components in space, including the ability to align them with existing components on site, were addressed. Ultimately, the completion of this experiment and its construction evaluation demonstrated: the superiority of mobile robot construction over manual construction in terms of reduced manual use and increased construction efficiency. The structures are explored as follows:

In Chapter 1, RESEARCH BACKGROUND AND PURPOSE OF THE STUDY. The research backgrounds of robotic construction are introduced in Chapter1, which is including the current status of robotic in architecture. And introduced several representative robot types in the construction robot industry. As well as the advantages of robotic construction, its obvious advantages over traditional construction manufacturing in terms of natural, economic, and social environments. Then, the introduction to Japanese wooden building. At last, the research purpose and logical framework is shown.

In Chapter 2, LITERATURE REVIEW OF ROBOTIC CONSTRUCTION. The purpose of this chapter is to place the research in this thesis in the context of historical and state-of-the-art examples and to summarize the areas of focus of this research. The main research background of this paper is the digitization process of construction manufacturing and the current status of robotics in construction manufacturing, especially the development history and research focus of in-situ robotic construction. The premise of the study is that robotics is clearly superior to traditional construction manufacturing in terms of energy environment, socio-economics and labor market.

In Chapter 3, METHODOLOGY. This thesis addresses the research objectives and designs two experimental study cases. The two experiments explored the construction of wooden buildings by two types of robots described in Chapter 2, respectively. The objects of the two experiments are wooden buildings with the same design drawings, and the experimental objectives are accomplished using a stationary robot and a mobile robot.

In Chapter 4, CASE STUDY 1: STATIONARY ROBOT CONSTRUCTION. The case study in this chapter is the reconstruction process of a wooden building by a stationary robot and explores digital construction strategies and processes. The accomplishments of the experiment can be summarized as follows: First, to design the digital construction parameters for the complete construction steps, optimize the movement of the robot arm to avoid collisions at the construction site, and enable the robot to complete the construction of wooden buildings independently, and verify the feasibility and applicability of robotic construction of wooden buildings through experiments. Secondly, actual robotic construction was completed to verify the possibility of integrating parametric design and robotic manufacturing processes into building construction projects. Finally, it provides the program and experimental basis for the next mobile robot research.

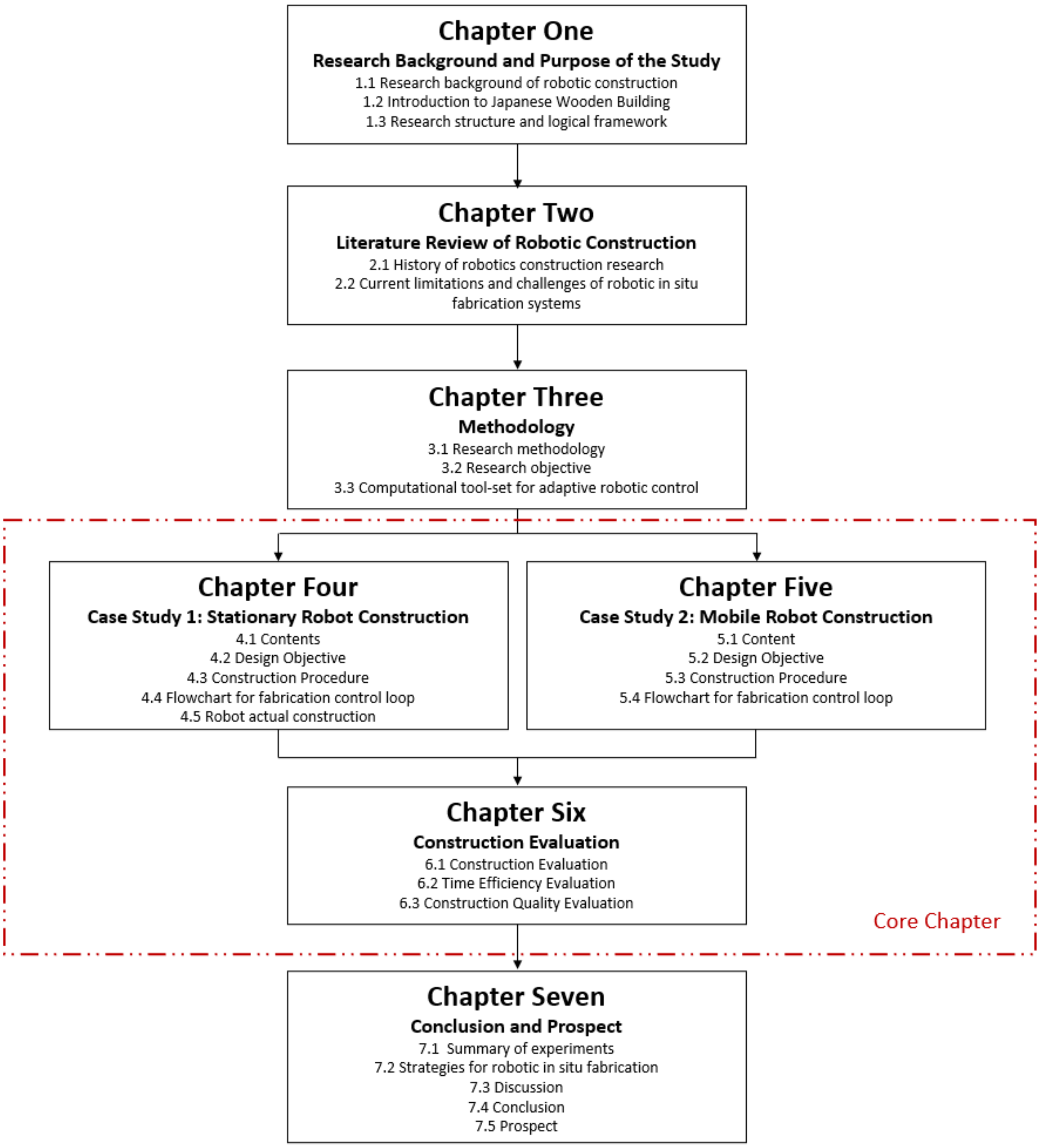
In Chapter 5, CASE STUDY 2: MOBILE ROBOT CONSTRUCTION. In this chapter, we will take the in-situ construction simulation experiment of a complete wooden building as an example to explore the possibilities and challenges of continuous building construction that exceed the static workspace of robots. in this study, an integrated multi-science application approach combining robotics, laser scanning and positioning technology with building construction makes robotic on-site construction possible and marks the possibility of integrating parametric design and robotic manufacturing processes into building construction projects. The high efficiency and stability of this technology in the construction process will greatly influence the construction efficiency and construction accuracy, thus bringing obvious benefits to the natural and economic environment.

In Chapter 6, CONSTRUCTION EVALUATION. Construction evaluation is one of the main focuses of this experiment. The comparison between manual construction and robotic on-site construction experiments allows the advantages and disadvantages of two different construction methods for the same timber building to be identified. This chapter shows the advantages of robotic construction in terms of natural and economic environment, and the reasons for choosing robotic construction in terms of quantitative data. The manual construction building and the robotic construction building in our thesis have the same building plan, but due to the different construction methods, the building structure and construction process are different, and have a greater impact on the final construction efficiency. In this chapter, the efficiency of both sides is evaluated mainly in terms of time efficiency evaluation and construction quality evaluation.

In Chapter 7, CONCLUSION AND PROSPECT. This chapter begins with a summary of the two experiments in this thesis. Through the implementation of two continuity case studies, the results of the study show that robots can build full-scale wooden buildings at scale directly on the construction site. Then summarizes strategies and techniques for robotic in-situ fabrication and discusses the results of the completed study and the limitations that exist. At last, a conclusion of each Chapter is concluded.

# 王 璐 博士論文の構成

## Research on Construction Performance Evaluation of Stationary and Mobile Robots in Wooden Block Stacking Method



# TABLE OF CONTENTS

## CHAPTER 3: METHODOLOGY



## CHAPTER 4: CASE STUDY 1: STATIONARY ROBOT CONSTRUCTION

*Chapter 1*

# ***RESEARCH BACKGROUND AND PURPOSE OF THE STUDY***

**CHAPTER ONE: RESEARCH BACKGROUND AND PURPOSE OF THE STUDY**

## 1.1 Research background of robotic construction

### 1.1.1 Application Status of Robotic in Architecture

Advanced digitalization and automation technologies are profoundly impacting almost all manufacturing and industrial sectors and are especially the biggest beneficiaries for those industries that rely on manufacturing processes where parts can be moved around the manufacturing plant (1-3). Additionally, as the mindset is shifting towards sustainability, reusability, and low-carbon society, robots are becoming increasingly popular in the manufacturing and industrial sectors (4). According to Tsai and Chang (2012), permanently sustainable development is a term that is now appearing in various areas of social and economic life. Dupuisani et al. (5, 6) argued that the sustainability of the industry can be improved by increasing productivity and economic efficiency. Additionally, of all sectors, the construction industry has been an important part of the world's economy and environment and is receiving increasing attention under the global sustainability development (7). This is not only because buildings account for more than 30% of global greenhouse gas (GHG) emissions and more than 40% of global energy consumption (United Nations Environment Programme 2009) (8), but also because automation in the construction field is considered to be effective in improving construction efficiency and construction stability, reducing worker injuries, reducing waste of resources and manpower, and creating economic value. In addition to the above aspects, robots can also perform construction duties that are impossible or unsafe for humans to perform (9). Therefore, automation and robotics have been regarded as leading areas of innovation in construction (8); the field of building construction, however, has little to gain from them and faces many challenges (10).

The construction industry differs from mass manufacturing in that it is an activity associated with the creation of physical artifacts. Mass manufacturing is a product designed for mass production. In contrast, building construction products are large and unique in form, and they may be produced on-site in temporary disorder and chaos, with workers on site. Manual assembly processes on building sites are still heavily dependent on manual labor, by comparing the manual process of rebar assembly for the National Congress Palace in Brasilia in 1959 (top) with the manual caisson construction on a building site in Singapore in 2018 (bottom) (11). Smaller components of a building are made in a dedicated factory and then transported to the building site for a final assembly led by manual labor, but it is difficult to adapt these parts to inaccuracies in the building site and the construction process during installation, which breaks the digital process chain between design and manufacturing.

In the area of off-site fabrication, digital construction has become relatively common. While prefabrication certainly provides many benefits--particular in terms of simplifying the integration of automated processes into assembly workflows--prefabrication also imposes a number of important limitations in the architectural and construction-related context. Since prefabricated building components are not produced at their final location, the question of transportation limits the overall scope of applications. It first implies that material has to be transported twice--once as feedstock material to the intermediate location of the factory, and from there in a pre-assembled state to the construction site. The extents of these prefabricated components are limited by the size and weight permitted for transportation and lifting into the final position (11). Moreover, the production of prefabricated building components generally refers to sub-assemblies of a building and therefore parts of a larger whole. These sub-assemblies pose the challenge of joints and interfaces in between them during their final assembly on the building site. It requires prefabricated sub-assemblies to be fabricated with high accuracy, since adjustments that are potentially necessary, can only take place in the connections and joints between them. As exemplified by the experiments on large shell timber buildings conducted by Tongji University in China (12).

While the construction industry has begun exploiting the benefits of using robots and automation in prefabrication, directly on building sites, however, the level of automation is lower in the direction of on-site prefabrication on construction sites compared to the area of off-site prefabrication, no enabling robotic technology exists to date that allows robotic systems to be integrated into in situ construction processes (13, 14). Examples of this can be seen with companies such as Fastbrick Robotics for automated mobile bricklaying (15) or nLink for the automation of drilling on-site (16). There are a number of fundamental technological challenges that prevent the extensive deployment and utilization of robotic systems performing fabrication tasks directly on building sites. These challenges can be summarized into two main points:

1). *Architectural scale:* Typically, in the case of robotic on-site construction, the static workspace of a construction robot is smaller than the size of the building to be constructed, so the size of the construction machine constrains the size of the building that it can build. The robot must be moved or installed in order to reach the final location of the assembled parts on the construction site. These assemblies of a building can no longer be segmented into smaller parts, but they must be fabricated by the robot as one continuous structure at the final location. Therefore, the construction of large buildings usually exceeds the static working space of the robotic system.

2). *Accuracy:* Many approved robot prefabrication processes rely on structural conditions such as a complete knowledge of the factory environment and perfect control of the stationary robot system. However, the robot fabrication process in the field lacks a perfect structural environment and a complete knowledge of the construction site surroundings. In addition, mobile robots also missing a fixed link to the surrounding environment. In this way, the robots must be able to localize themselves and have their end-effectors positioned to cover the entire work area globally. In moreover, they must be able to perceive and handle the discrepancies between the designed and built dimensions of the building site, the unpredictability of the construction material behaviors, and the fabrication-related tolerances during the assembly of the building structure (11).

In short, the successful integration of robotic systems into the on-site construction process relies on the integration of architectural design, robotic operational planning and on-site fabrication into a unified system (11). Fundamental technological challenges, many of them have thus far hindered the automated assembly of building elements directly on construction sites. Therefore, construction robots are still in their infancy in terms of single-point development and small batch trials in the production of components and on-site construction and have not yet been achieved on a large scale (9).

Based on this, recent research has moved in the direction of on-site digital fabrication, where buildings (or building components) are fabricated autonomously on-site, generally referred to as in situ fabrication (13). And, by directly integrating digital design with the construction workflow, the use of robots on the construction site opens up the possibility of establishing a continuous digital process chain. In such a robotic construction process, digital models can both define the geometry and serve as instructions for its production process. But in addition to that, machine-related fabrication logics and material-related constraints can become design drivers in the development of an architectural project (11, 17, 18).

In order for robots to be fully functional on construction sites, they must be portable, capable of moving around, the ability to "perceive" the surrounding environment, and the ability to process received data or information. Not only that, but robots should also be able to handle bulky or heavy loads, such as beams or prefabricated panels (which can weigh several tons), and they should also be able to handle fragile materials such as tiles, fittings or glass.

Until about 12 years ago, robots were considered for architecture and design. There are various factors that make industrial robots such suitable tools for architects and designers. Especially since architectural projects often require the fabrication of large, complex, three-dimensional elements. Now in our age of digitalization, virtualization, and automation, the development of robotics is very fast. Numerous pioneers and research teams develop robotic technology to take over dangerous or highly repetitive tasks improving quality, productivity and efficiency. Here we delve into the roles that robots are starting to play in construction and look at how they will affect our industry in the future. The use of robots, combined with digital design tools, means a new aesthetic becomes possible, with novel shapes and patterns that would be nearly impossible to achieve without the automated machines: industrial manipulators that are extremely precise and good at repetition. Arguably the most prevalent type of construction robot at the moment is the mechanical arm. While stationary versions of these robots have been in operation in factories and on manufacturing assembly line for years, portable adaptations are now being developed for use in all manner of tasks on construction sites. Able to be programmed to perform a range of repetitive and labor-intensive activities such as moving materials, typing rebar, building masonry and even 3D printing structures, these robots are have a huge impact on the industry reducing accidents and greatly increasing productivity.

### 1.1.2 State-of-the-art robotic systems for in situ fabrication in architecture

Next, I will introduce several representative robot types in the construction robot industry. There are two main systems of construction robotics: -- Stationary robotic systems and Mobile robotic systems (19-21). this division is irrespective of the robotic system's customization for tasks-specific operations, or the material system used(11).

Different in situ construction tasks require the use of different types of robotic systems. The fabrication of construction components associated with CAD models often requires absolute positioning of the robot's end-effectors in a global work area. The purpose of this review is to show that different approaches exist to address the challenge of absolute positioning depending on the type of robot system used (11).

1). *Stationary robotic systems:*

Stationary robot systems usually consist of a gantry system. The advantage of a gantry system is that the entire system has fixed mechanical linkages. This makes possible a simple operation of the end-effectors in terms of absolute positioning and control in the working space. Even if such a gantry system lacks some stiffness, in most cases the mechanical linkage still allows model-based and analytical approaches to calibrate the accuracy of the system.

In 2017, Printhuset (22) demonstrated the first example of integrating this layer-based concrete extrusion process into a stationary robotic system for in situ construction. Their demonstration object Building On Demand (BOD) shows the fabrication of a structure for a 50 ㎡ office hotel. The building was constructed in layers by extruding concrete through nozzles. The nozzle was carried by a large 8m×8m×6m gantry system and erected on the building site. The printing speed is 2.5m/min, the layer width is about 50mm to 70mm, and the layer height is about 20mm. the extruded structure is a double-leaf hollow structure, so it can be filled with other types of materials later, such as to improve insulation or structural properties (11).

A third method for robotic in situ extrusion of materials was demonstrated by the WASP BigDelta clay extrusion robot (23). in 2016, the robot demonstrated the wall construction process of a small building outdoors. A delta robot with a diameter of 6 m and a height of 12 m was positioned on an open field. This stationary robot extrudes in layers with a mixture of soil and straw. Including the waiting time required for the material to dry, the system was built at a rate of about 600 mm/day.

These two examples, Printhuset and WASP BigDelta, demonstrate the in-situ production of single-material structures using a stationary robotic system. The structures fabricated are direct translations of a given numerical model designed within the constraints of the material system. However, the static workspace of these large stationary robotic systems needs to be larger than the structure being fabricated. Thus, the size of the robotic system ultimately limits the size of the build. In addition, these robotic systems are considered to offer only a limited number of 3 degrees of freedom. This is suitable for horizontal layered extrusion processes, but hardly makes the robotic systems suitable for more complex robotic manipulation tasks. In addition to these limitations, setting up large stationary robotic systems at the job site usually requires a lot of manual work (11, 24-26).

1). *Mobile robotic systems:*

In contrast to the limited workspace of stationary robotic systems, mobile robots can create structures with a larger static workspace than their own. Their mobility can be divided into ground mobility and aerial mobility. Since aerial robots provide mobility in all three dimensions, since their mobility is not limited by the ground, their characteristics have been used for construction purposes, for example by Mirjan et al (27). However, they are first limited by low payload capacity and limited degrees of freedom, limited robustness considering environmental effects, and further limited by high energy consumption, thus making these systems convenient for construction robots in general. Ground mobile robots, on the other hand, meet both the dexterity and flexibility requirements of construction tasks and the high load requirements. They can be moved around the site and in some cases even over the structures they are building. They also do not require as much work to be installed on site compared to fixed systems.

However, unlike stationary robotic systems that have fixed mechanical connections throughout the installation, mobile robotic systems lack mechanical reference points. Therefore, mobile robots rely on advanced sensing and control solutions to achieve global positioning accuracy (19, 28). One possibility is to use an external positioning and fixed tracking system, a tracker that can locate the robot end-effector within its visible range. Another possibility is the use of sensing solutions that come with the robot and can sense and record features of the robot's surroundings. They allow the robot to obtain its own position relative to the registered features.

**wide-range semi-mobile robotic systems:** Wide-range semi-mobile robotic systems consist of an extended manipulator and a mobile base. The mobile base allows these robots to drive to the building site. However, due to their wide-range static workspace that can cover the size of a building, they are eventually used as stationary and fixed-base robots.

Hadrian 105 and its successor Hadrian X were developed by Fastbrick Robotics (15) in 2015. The robot is expected to provide a fully automated brick deposition system for the fabrication of well-structured walls. These brick walls can be flexibly fabricated on a flat layout. The robot features a 30 m long boom mounted on a truck. It includes a feeding system at the end that is said to be capable of placing bricks at a rate of 1,000 per hour. To track the position of the end-effector within the workspace to compensate for boom compliance, the robotic system utilizes an externally mounted laser-based reference system. However, the type, speed, and accuracy of the system were not specified. In addition, it is not shown that the system was relocated during construction.

A similar approach was demonstrated by the Digital Construction Platform (DCP) (21, 29) developed at the MIT Media Lab. The wide-range robotic machinery consists of a 6 m long hydraulic arm and an industrial-type arm attached at the end. This composite robotic arm system is mounted on a track-based mobile platform. The arm is used for general positioning and the robotic arm is used for fine positioning. The motion control of the arm is guided by an external laser tracking system, which allows the robot arm to compensate for oscillations that occur during the drive. A bucket mounted at the end of the hydraulic arm illustrates the possibility of using construction sites to excavate materials. In addition, the solar panel mounted on the back makes the robot energy autonomous. This autonomy will allow the mobile robotic system to operate in environments where electrical energy is not available. A demonstrator in 2017 showed the fabrication of an insulated fixed formwork for an open dome structure with a diameter of 14.6 m. However, the case study showed that the system could also be used as a fixed-base robot once positioned in the center of the work site and able to fabricate structures within the static range of the boom.

**Mid-range mobile robotic systems:** Mid-range mobile robot systems are characterized by the use of an arm-based manipulator mounted on a mobile base. Through repositioning, they are used to create structures that extend beyond their own static workspace.

One of the pioneering representatives of this arm-based mobile robot was discovered in 2012 by the Gramazio Kohler Research group, called DimRob (14). The system was developed to explore robotic brick assembly processes that were previously developed directly for prefabrication in the field.

DimRob consists of an industrial robot arm with a tracked mobile base. The end-effector is equipped with a vacuum gripper for pick and place tasks, in addition to sensors such as a laser rangefinder or Kinect camera. This allows the system to sense object deviations and react to them during brick assembly. In contrast to relying on external tracking devices, the project also proposes the concept of using on-board sensors to scan the environment to position the robot. This project explored the opportunity to combine human cognitive skills with machine skills related to accuracy and endurance. In this case study, the geometry of the brick wall was generated based on visual commands from a human operator. DimRob then assembled the brick wall based on tracking the shape of the motion.

The project most similar to DimRob is the company CyBe Construction. Since 2013, they have been developing mobile robotic systems for on-site concrete extrusion (30). Their CyBe R is an entry-level fixed 3D concrete printer. This printer is ideal for research institutes, universities, and suppliers performing in-house testing, prototyping, or precast production. The ABB robotic arm is attached on a metal frame which is secured to the floor. The mix-pump system moves CyBe mortar through a concrete pump hose to the robotic arm, which then 3D prints in the programmed location. The robot itself is controlled via a control unit that runs CyBe software.

Another approach to achieve mobility is the mid-range mobile robot MULE (31, 32), which has been developed by Construction Robotics since. It stands for Material Unit Lift Enhancer and, described as a "cobotics" innovation, is more like a strong assistant that allows a mason to place CMUs more efficiently than possible without the help. The MULE ML150 is designed to place material weighing up to 150 pounds. Masonry work can be repetitive, time-consuming, and physically demanding. Finding ways to increase productivity with less physical fatigue has long been a goal for the industry. In recent years, advancements in automated and robotic construction technologies have brought about improvements that allow masons to place more and heavier masonry units in less time and with fewer people. This robot uses existing scaffolding systems and usually moves as a rail system around the periphery of the construction site. The company claims that with this system, it surpasses the manual bricklaying process in terms of cost and speed.

Using MULE reduces the needed crew size, so it could be easy to connect the dots between assisted construction and less jobs for masons. However, there's another view. Yes, customers see reduced crew size as costing less. But that can also mean that they have more money for other jobs, and the increased speed of completion could mean that masons actually end up getting more work. The quality of wall alignment also improves with using this type of lift assist equipment. This technology could also be something to draw younger generations into the masonry trade (33).

Dharmawan et al (34, 35) also proposed a similar concept. The robot also utilizes construction site scaffolding as a track system for the robot mobile platform. The portable mobile platform consists of a mounting system, mounted on a beam, and can carry a light industrial robot arm. This allows the robot to reach high places on the construction site. The system simulates the on-site welding of structural components of a jack-up oil drilling tower. Since a welding task is restricted to a defined local area, the robotic system relies only on the relative positioning to the track pipe welds. Therefore, the project first focused on refining the positioning accuracy of the robot end-effectors relative to the support rails (scaffold beams).

Hot wire cutting robot: One particularly prominent example is Odico Formwork Robotics who have developed a robot that uses "hot wire cutting" to develop complex double curved concrete moulds (36). Traditionally this time consuming and costly process was used sparingly in construction. Now, these robots can be programmed to create intricate formwork moulds with a higher degree of accuracy than a human worker and in a fraction of the time, unlocking complex design and helping to make them a reality.

**Short-range mobile robotic systems:** This category describes very small-scale mobile robotic fabrication systems. Although these short-range robots are limited by their low load capacity, they can automatically climb the structure being fabricated. By taking advantage of the potential to move with the expansion of prefabricated structures, these robots can reach higher heights without the need for additional scaffolding.

One famous example of such small-scale and short-range mobile fabrication robots is automatic "Rover" of Construction Site: robots are also entering the construction industry in the form of autonomous rovers equipped with high-definition cameras and sensors that allow them to navigate their way around sites. Able to identify and avoid obstacles, robots such as “EffiBOT”, developed by French robotics firm Effidence, can follow workers, carrying tools and materials. Even more advanced is this rover by Doxel that uses high-definition cameras and “Light Imaging, Detection and Ranging” (or LIDAR) sensors to carry out building site inspections, comparing progress with design models and programmes.

Other example, the Minibuilders project -- developed at the IAAC Barcelona in 2015 -- shows the utilization of small-scale mobile robots for a continuous clay extrusion process. A structure is fabricated through depositing clay material through a nozzle that is carried by a small mobile robot. Moreover, such a robot is climbing the structure while actually fabricating it. This allows it to build structures substantially larger than itself. First, a mobile foundation robot is depositing the ground layers of the clay material by tracking and following a curve previously marked on the ground. After this, a gripping robot is attached to the fabricated foundation layers and continues the material deposition process while climbing the structure. Through positioning the nozzle of the mobile robot sideways relative to the layers underneath, the system also allows to produce slightly doubly curved geometries.

The project Mobile Robotic Fabrication System for Filament Structures, demonstrates a new production process for filament structures. It proposes multiple semi-autonomous wall climbing robots to distribute fiber filament, using any horizontal or vertical surface, or even existing architecture, to support the new structures (37). Compared to larger scale industrial robots that are limited by position and reach, these robots are enabled with movement systems and a collection of sensors that allow them to travel and interact accurately along typical ground, walls, roofs, and ceilings. One can imagine a fabrication process where an operator arrives to the scene with a suitcase housing all the necessary robots and materials to create a large structure. These agile mobile robotic systems move robotic fabrication processes beyond the constraints of the production hall, exposing vast urban and interior environments as potential fabrication sites.

The reviewed examples show that robotic on-site manufacturing shows great potential to expand the field of application to digital fabrication. It could fundamentally change the workflow and production chain of construction sites as we know them today. Although the robotic systems analyzed are still in an early experimental state, the in-situ approach shows many advantages compared to prefabrication. Since the fabrication takes place where the structure still exists, there is no need to build a factory elsewhere.

The application of construction robots is mainly in four aspects: design, construction, demolition, and operation and maintenance. In terms of design, it mainly refers to Autodesk. At present, it has been planning how to make robots replace CAD and become a partner of designers, instead of simply satisfying the assistant tools of becoming designers. At present, there are few design tools in the construction market, and to some extent, it still cannot meet the needs of modern architectural design; the construction aspect is the largest part of the demand for construction robots, and it is also the link for the development of robots. The robot construction is divided into factories and sites. In both areas, on-site construction is still a difficult point for robotic applications. Operation and maintenance is a persistent application field for construction robots, involving many areas of operation and maintenance such as pipeline inspection, security, cleaning, and management. In terms of demolition, in addition to blasting, the demolition of large buildings and the reuse of resources in the future will be a problem for the huge buildings in the future, and robots will come in handy.

The review further notes that a construction site, despite its obvious challenges, also offers a variety of features that can facilitate its robotic enhancements. While the construction site environment is not structured and evolving like a factory, it does provide some structural and organizational features. For example, a building typically contains areas that can be divided into floors, walls, ceilings, columns, rooms and corridors. This allows robotic sensing solutions to sense and automatically register these areas and store them in the appropriate topology. In addition, depending on the building task, the building site contains defined and controlled operational areas. Thus, the construction site can be classified as a semi-structured environment In addition, the existence of a defined digital blueprint of the construction site and the elements to be produced are considered as a priori knowledge. The same applies to the knowledge of material properties and behavior, so that they can be modeled a priori according to the needs of the operation. This a priori knowledge plays an important role in the design of advanced manufacturing control algorithms for field-operated robotic systems. Thus, in many cases, task planning as well as perception and decision processes can be facilitated and limited to a defined and localized domain. Furthermore, the use of this a priori knowledge can enhance the perception of the environment and the interpretation of the information obtained. Finally, many examples show that humans in the field can be used to assist robotic procedures - especially those requiring cognitive skills - thus facilitating the integration of robots into existing construction workflows. Relocating the robot between operations may require manual assistance, especially if the robot repositioning is an incidental event in the overall workflow. Finally, robotic systems rely heavily on manual support for material delivery. Once approached, the material can be further robotically processed. For example, material assembly through automated pick-and-place or feeding procedures, or material extrusion processes through pumping procedures(11).

While we are only just beginning to see what robotics could do for construction there are already more advanced robots in development that could one day replace humans in certain industries and job roles altogether.

Though the robotic architectures thus far are limited in size, the architects are currently exploring the idea of applying robotic fabrication to the design and construction of high-rise buildings.

This thesis explores how the digital process chain can be extended from the architectural design to the final assembly on the building site. It also investigates whether robotic on-site fabrication of wood buildings can be an alternative to robotic prefabrication and manual on-site construction. In situ fabrication is the goal of digitally automated construction in the building industry. A building differs from a structure in that the final assembly of a building has to happen in situ—directly at its final and definite location. In this paper, we emphasize that the experimental object is a complete building, which makes it more necessary for the building to be built on the site, rather than being manufactured in a factory like a structure or building component.

### 1.1.3 Advantages of robotic construction

This paper focuses on the digital process of construction manufacturing and the application of robotics in construction manufacturing, and the research is carried out on the premise of its obvious advantages over traditional construction manufacturing in terms of natural, economic, and social environments.

1). Natural Environment Improvement

In the context of exploding populations, scarce resources, and global warming, the construction industry needs to develop cleaner, more efficient, and customizable building systems faster (38). In particular, automated systems are often able to perform repetitive tasks more precisely and quickly than humans, increasing construction efficiency and making the environmental benefits of their advantages obvious.

The construction sector is a highly active industry, responsible for 40% of global energy consumption, 38% of global greenhouse gas emissions, 12% of global potable water use, and 40%

of solid waste generation in developed countries (8, 39), mainly due to the trend of frequently delayed trends in the construction industry playing a significant role in this data. When crews have to work longer hours, it means that fossil-fuel-powered equipment takes longer to use, resulting in more pollution. The efficiency of the robots means less delay and time savings. As a result, the entire construction project will take less time, which means less time to run heavily polluting machines. As construction robots become more efficient, they will make a greater contribution to reducing emissions (8).

Meanwhile, the high-precision nature of the construction robots allows them to make fewer mistakes, thus saving time and resources and reducing waste. By consuming fewer resources and having shorter machine run times, the building construction process reduces the environmental impact (8).

2). Economic Environment Influence

The economic environment also plays a key role in the practical application of construction robotics. A downward economic environment and a plunge in construction activities could limit the development of construction automation and robotics. In turn, improved construction productivity and lower construction costs can increase long-term economic values, and these are significant drivers for adopting robotics (40).

The traditional construction industry is facing the challenge of large but not excellent, especially under the influence of the Coronavirus disease 2019, the traditional construction method of the construction industry has been greatly impacted, and the rough development mode is unsustainable. The development of construction automation and robotics can improve long-term economic potential, one of the most important aspects of which is reflected in the ability to change the construction labor market. Robotic construction can largely reduce the number of construction workers and worker contacts and can better adapt to the demands of building construction in the era of the epidemic.

Attention needs to be paid to the impact of automation on a sustainable labor market. The construction phase of the building also needs to maintain a stable and harmonious labor market. Automation and robotics can alleviate labor shortages, but they can also lead to large labor surpluses and high unemployment rates, which inevitably pose a threat to the sustainability of society. Therefore, to minimize these negative impacts, continuous training in irreplaceable skills is essential, which can attract workers to highly skilled technologies to gradually shift the workforce from heavy manual labor to light physical or mental labor (41).

3). Social Environment Improvement

Robotic construction reduces the number of workers while replacing them with robots to perform hazardous and heavy labor tasks, ensuring worker safety and creating a better working environment (8). For example, heavy and low-skilled repetitive tasks such as bricklaying, which can cause back strain and other injuries to workers, can be better replaced by robots. At the same time, robotic construction sites are relatively safe and environmentally friendly, minimizing disruption to the surrounding neighborhood.

Historically, the construction industry has been inefficient and harmful to the environment, but robots are changing that. The impact of automation and robotics on environmental, economic, and social sustainability during the construction phase is multifaceted. The adoption of automation and robotics has the ability to reduce environmental impacts and improve resource efficiency, long-term economic value, productivity, quality, worker, industry, and public well-being (8).

**Table 1-1 The advantages of robotic construction in terms of natural, economic, and social environments aspects**

| | | |
|---|---|---|
| Natural | Improve resource efficiency | Integration of construction process |
| | | Components reuse |
| | Reduce impacts on the environment | Reduce waste |
| | | Optimize energy efficiency of machines |
| | | Urban mining with high-rise buildings |
| Economic | Potential to improve long-term economic values | Reduce labor cost |
| | | Reduce construction costs with stories |
| | | Increase or reuse identical buildings |
| | Improve productivity and quality | Improve time efficiency |

| | | |
|---|---|---|
| | | All-weather adaptability |
| | | Improve accuracy |
| Social | Improve the well-being of workers/industry | Better working environment |
| | | Reduce hazardous and heavy work on site |
| | | Alleviate skilled labor shortage problems |
| | | Attract high-skilled talents |
| | Improve the well-being of public | Minimizing disturbance to site neighbors |

## 1.2 Introduction to Japanese Wooden Building

### 1.2.1 Japanese Wooden Building

Every year, with the increasing awareness of environmental issues, people are trying to reduce greenhouse gas emissions. Carbon dioxide is fixed by plants, oceans and some microorganisms. Even if trees are harvested, they can fix carbon dioxide for a long time as they do not burn or corrode. By using a large amount of wood as building materials in buildings, this property can reduce the impact on the environment and can be considered as a solution.

Japan is a country with frequent natural disasters. Therefore, Japanese builders are never free from the regional criteria – the significant horizontal loads of frequent earthquakes and typhoons. Wood post-and-beam construction is useful when designing for typhoon and earthquake resistance. Wood itself is a lightweight, renewable resource. It also has excellent seismic properties. So most historical Japanese buildings are made of wood. Such buildings manifest the technology and culture of the period when they were built. Wooden buildings, which showed unique designs native to their region, were built using techniques of their era.

On the other hand, forests cover 70% of Japan's national land. trees were planted soon after the war to build houses. However, with the passage of time, mountains have been abandoned, and now

70% of building materials are imported. Therefore, in the case of abandoned mountain areas, the soil on the ground is exposed, the roots of trees are stretched strongly, and the ability to store water is lost, resulting in floods, landslides and fallen trees and other disasters. In addition, because sunlight does not reach the ground, enough nutrients cannot be allocated to trees, resulting in weak mountain areas.

Therefore, the environmental burden can be reduced by reducing trees in mountainous areas, planting trees and achieving stable growth, and the future use of domestic timber can be promoted to activate the domestic forestry in Japan at the same time. Through the ongoing process of planting, thinning, logging and other maintenance processes, Japan produces sufficient high-quality timber for domestic use and export as well. In Japan, wood has the characteristics of easy access to materials. Therefore, the production, manufacture, use, and ultimately the demolition process of wood structures has little impact on the environment and meet the development requirements of low-carbon economy and circular economy, as shown in Figure 1-1. So I chose Japanese wooden architecture as my research object.

**Fig. 1-1 Traditional Japanese wooden house.**

### 1.2.2 Use of Japanese Cryptomeria

The Cryptomeria japonica（スギ） is a unique tree species in Japan, as shown in Figure 1-2. It has a long history of afforestation and can be traced back to Yoshino Forestry and Kitayama Forestry in the Muromachi era about 500 years ago. Sugi is a commercially important softwood species widespread within Japan from the northern end of the main island to Yakushima Island (42). It is characterized by a straight growth of the trunk and a very large length. And the wood fiber is very straight, because it is easy to open with a knife, so it has been used for building materials since long ago. Even in the post-war expansion of afforestation, the area of cedar trees planted everywhere is the largest acreage in Japan (about 4.47 million hectares), accounting for about 12% of the country's land area, and is commercially grown for many construction purposes, accounting for 75% of the wood use in Japan(42). However, due to the lack of strength of fir as a construction material and the high cost caused by domestic labor costs, it has not been effectively utilized, and the waste of plantation forest is particularly obvious.

**Fig. 1-2 Japanese cedar flooring.**

80% of the domestic use of wood is cheap imported materials, which is also a problem from the perspective of worldwide conservation of forest resources(43). On the other hand, in Japan's domestic construction industry, the market for laminated materials that can be used as a structural material is expanding rapidly. From 1990 onwards, domestic use in the decade of 2000 has expanded by about 10 times. So, it is of great benefit to be able to effectively use this unique Japanese tree species in the construction industry. Therefore, I chose the type 105 timber as the building material for the robotic wood building construction and completed the next experimental study.

### 1.2.3 Status of Wood Use in Construction Industry

Wood is the major renewable resource for construction(44), and had been chosen as the preferred building material for the following reasons(45).

First, it is relatively inexpensive compared to other building materials suitable for outdoor application. Second, depending on the type of wood and how it is applied, it possesses great durability and strength compared to its weight. Third, it gives the flexibility to be processed into different shapes and lengths, which makes it an adjustable component. Fourth, it is sustainable; a construction material available on the local market and a resource growing again.

In recent years, with the widespread promotion of wood as a building material, in addition to natural wood, new wood composites have emerged. With the development of the times and technology, modern wood-framed buildings use new materials, new processes and factory-accurate production. Compared with traditional wood-framed buildings, they are more environmentally friendly, comfortable and durable, energy-saving and structurally safe(45). Excellent seismic and sound insulation properties are superior to reinforced concrete structures and masonry structures. At the same time, a large number of modern wood structure construction methods and theoretical systems have emerged. Compared with the traditional wood structure, the progress has become obvious. Since then, the modern wood structure industrialization pattern has gradually emerged(46, 47).

The current status of research in the area of wood structure has some problems. The timber construction sector is limited mainly to the mechanical processing of individual components and their manual assembly. This method involves high resource consumption because of material cutting procedures, like milling, as well as a high degree of manual labor. Here, robotic systems are extremely useful — not only can their use lead to significant time savings, but their ability to transfer digital design data directly to 1:1 assembly operation enables the fully automated construction of non-standard timber structures.

## 1.3 Research structure and logical framework

### 1.3.1 Research purpose and core content

This study investigated the construction of a building in the same plane by two construction methods completed by a stationary robot and a mobile robot. The first experiment is the reconstruction of a target building by a stationary robot, as shown in figure 1-3, involving three objectives. First and most importantly, the design of digital construction parameters for the complete construction steps. Also optimize the robot arm movement mode to avoid collisions at the construction site, so that the robot can independently complete the construction of the wooden building, and to verify the feasibility and applicability of robot construction of the wooden building from the experiment. Secondly, for buildings of the same design and size, the construction efficiency and construction accuracy of robot construction and manual construction are compared to verify the superiority of robot digital construction over traditional construction mode. Finally, it is hoped that this experiment will lead to the exploration of an assembly strategy for the development of robotic on-site fabrication of wooden buildings.

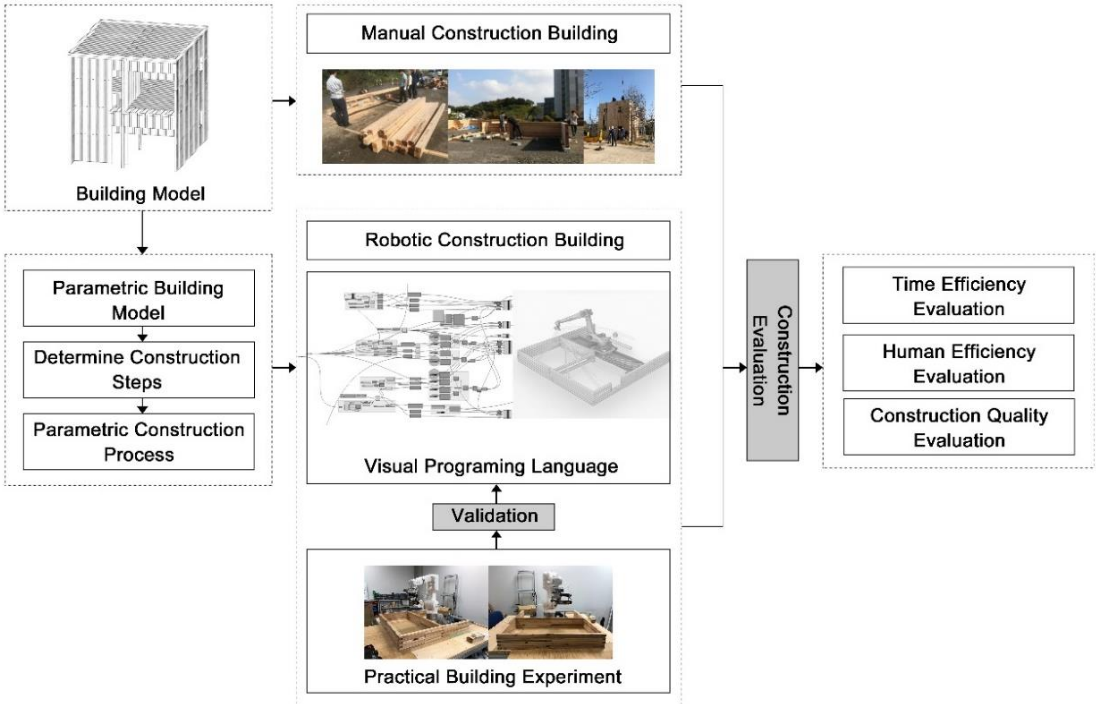



**Fig. 1-3 A conceptual framework for stationary robotic construction of timber house.**

In the second experiment, we will take the in-situ construction simulation experiment of a complete wooden building as an example to explore the possibilities and challenges of continuous building construction that exceed the static workspace of robots., as shown in Figure 1-4, whose building structure, erection method, and structural connections need to be adapted to the construction steps of the mobile robot. The on-site construction experiment of the mobile robot has three basic focuses. Firstly, it is a construction process integrated with an automated method, where the parametric building model is adapted to the mobile robot's construction method and the scanned and sensed construction site; secondly the experiment also integrates and validates the scanning and positioning system during the experiment so that the robot can perform construction tasks from multiple locations. Finally, it is hoped that the experiment will allow the exploration of assembly strategies for the development of on-site fabrication of wooden structure movable robots.

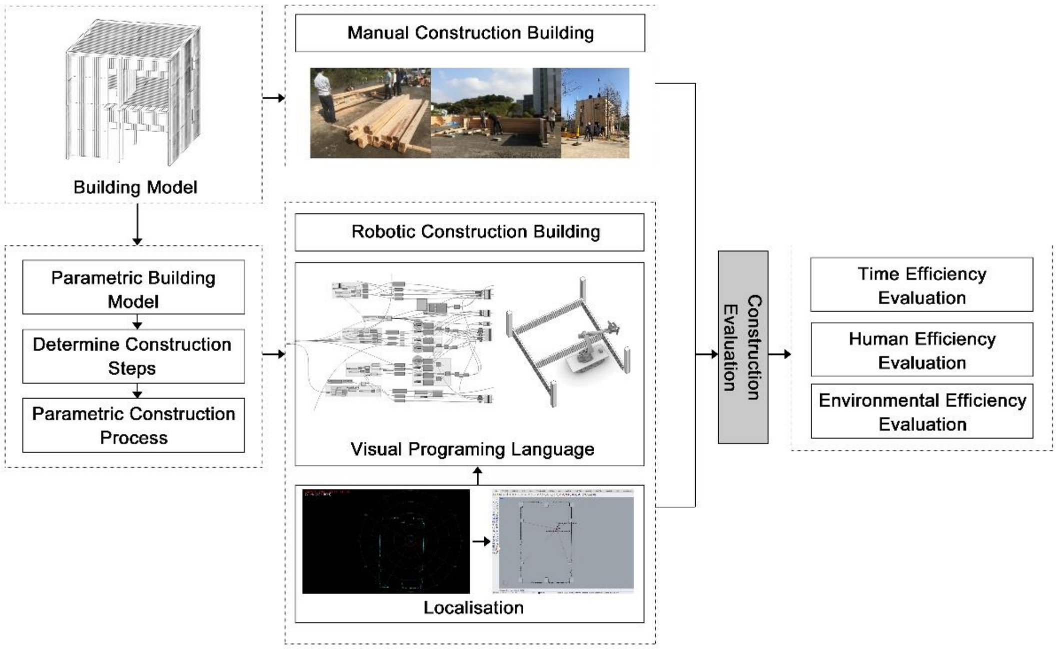



**Fig. 1-4 A conceptual framework for mobile robotic construction of timber house.**

### 1.3.2 Method

The above outlined subjects require an integrated and multidisciplinary approach that allows the development and validation of robotic field construction methods in the architecture and digital fabrication fields.

In this scope, several fundamental challenges must be addressed:

①. Integration of design with adaptive fabrication control:

The integration of design and adaptive control methods in robotic field manufacturing processes requires the embedding of computational toolsets in the architectural design and planning environment. Its implementation involves the development of adaptive manufacturing control algorithms and the implementation of dedicated robot control interfaces.

②. Integration of robotic sensing technologies:

The design and implementation of experiments with mobile robots requires the integration of state-of-the-art robotic sensing technologies, which must perform sensing tasks for several purposes as follows:

Mapping: This involves the integration of appropriate robotic sensing technologies to perceive the building site environment.

Localization: This involves the integration of appropriate robot sensing technology for robot localization.

Fabrication survey: This involves the integration of appropriate robotic sensing technology for the local measurement of the performed operational tasks.

③. Robotic fabrication:

In order to develop suitable robotic in-situ construction methods using ground mobile robots, it is necessary to study the basic potential and limitations of mobile robot manufacturing.

### 1.3.3 Chapter content overview and related instructions

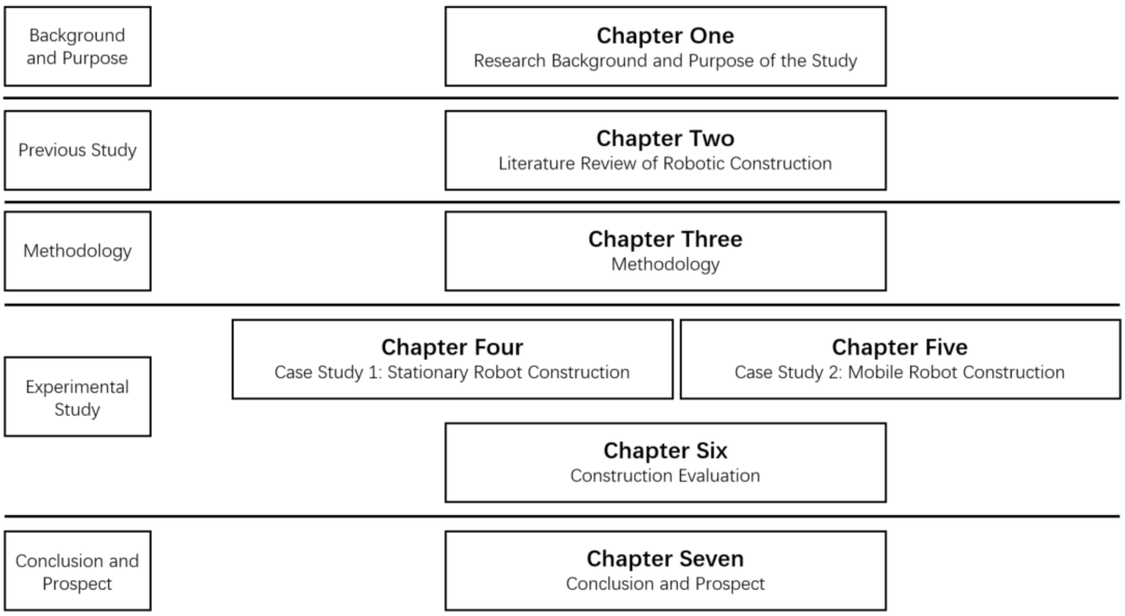



**Fig 1-5 Chapter name and basic structure**

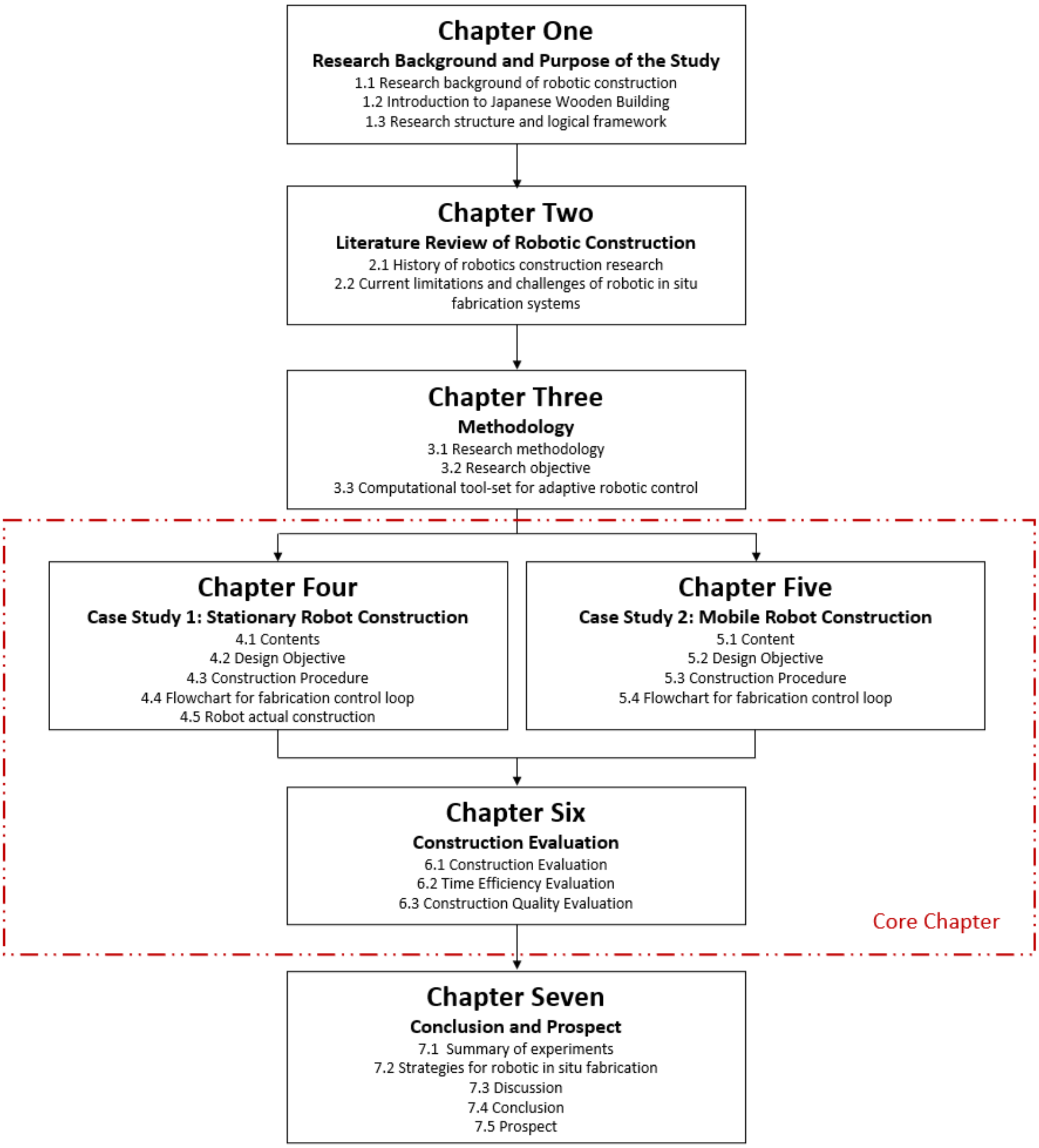



**Fig 1-6 Brief chapter introduction**

In Chapter 1, Research Background and Purpose of the Study:

The research backgrounds of robotic construction are introduced in Chapter1, which is including the current status of robotic in architecture. And introduced several representative robot types in the construction robot industry. As well as the advantages of robotic construction, its obvious advantages over traditional construction manufacturing in terms of natural, economic, and social environments. Then, the introduction to Japanese wooden building. At last, the research purpose and logical framework is shown in order to support reviewers understand the content of this paper.

In Chapter 2, Literature Review of Robotic construction:

The purpose of this chapter is to place the research in this thesis in the context of historical and state-of-the-art examples and to summarize the areas of focus of this research. Section 2.1 reviews the history of robotic construction. section 2.2 describes the state of development of robotic construction in construction today, along with the limitations and challenges it faces, especially in the field of on-site fabrication.

In Chapter 3, Methodology:

This Chapter describes the research methods used in this paper. The target building of this study and the process of its manual construction are also presented in Section 3.2. This section also describes the building materials, the construction tools, and the software base required for the experiment. The computational toolset for adaptive robot control in robotic construction is presented in Section 3.3, which includes the sensing system and adaptive control process for robotic field manufacturing.

In Chapter 4, Case Study1: Stationary Robot Construction:

The case study in this chapter is the reconstruction process of a wooden building by a stationary robot and explores digital construction strategies and processes. Section 4.2 describes the target buildings of the experiment and their construction in groups. section 4.3 is the focus of the experiment, with a detailed analysis of each step to complete the experiment and its parameterization process. section 4.4 outlines the construction process of the experiment. In section 4.5, the actual operational construction process of the experiment is described.

In Chapter 5, Case Study2: Mobile Robot Construction:

In this chapter, we will take the in-situ construction simulation experiment of a complete wooden b Construction evaluation is one of the main focuses of this experiment. The comparison between manual construction and robotic on-site construction experiments allows the advantages and disadvantages of two different construction methods for the same timber building to be identified. The following section shows the advantages of robotic construction in terms of natural and economic environment, and the reasons for choosing robotic construction in terms of quantitative data. The manual construction building and the robotic construction building in our thesis have the same building plan, but due to the different construction methods, the building structure and construction process are different, and have a greater impact on the final construction efficiency.

In Chapter 6, Construction Evaluation:

Construction evaluation is one of the main focuses of this experiment. The comparison between manual construction and robotic on-site construction experiments allows the advantages and disadvantages of two different construction methods for the same timber building to be identified. This chapter shows the advantages of robotic construction in terms of natural and economic environment, and the reasons for choosing robotic construction in terms of quantitative data.

The manual construction building and the robotic construction building in our thesis have the same building plan, but due to the different construction methods, the building structure and construction process are different, and have a greater impact on the final construction efficiency.

In Chapter 7, Conclusion and Prospect:

This chapter begins with a summary of the two experiments in this thesis. Through the implementation of two continuity case studies, the results of the study show that robots can build full-scale wooden buildings at scale directly on the construction site. Section 7.2 summarizes strategies and techniques for robotic in-situ fabrication. Section 7.3 discusses the results of the completed study and the limitations that exist. Section 7.4 is the conclusion of each Chapter is concluded.

## Reference

1. Buchli J, Giftthaler M, Kumar N, Lussi M, Sandy T, Dörfler K, et al. Digital in situ fabrication-Challenges and opportunities for robotic in situ fabrication in architecture, construction, and beyond. Cement and Concrete Research. 2018;112:66-75.

2. Gharbia M, Chang-Richards A, Lu Y, Zhong RY, Li H. Robotic technologies for on-site building construction: A systematic review. Journal of Building Engineering. 2020;32:101584.

3. Touaibi R, Koten H. Energy Analysis of Vapor Compression Refrigeration Cycle Using a New Generation Refrigerants with Low Global Warming Potential. Journal of Advanced Research in Fluid Mechanics and Thermal Sciences. 2021;87(2):106-17.

4. Kramberger A, Kunic A, Iturrate I, Sloth C, Naboni R, Schlette C. Robotic Assembly of Timber Structures in a Human-Robot Collaboration Setup. Frontiers in Robotics and AI. 2021;8.

5. Du Pisani JA. Sustainable development–historical roots of the concept. Environmental sciences. 2006;3(2):83-96.

6. Ayres RU, Turton H, Casten T. Energy efficiency, sustainability and economic growth. Energy. 2007;32(5):634-48.

7. Yi L, Hiroatsu F. Incentives for Innovation in Robotics and Automated Construction: Based on a Tripartite Evolutionary Game Analysis. Sustainability.

2022;14(4):2475.

8. Pan M, Linner T, Cheng HM, Pan W, Bock T, editors. A framework for utilizing automated and robotic construction for sustainable building. Proceedings of the 21st International Symposium on Advancement of Construction Management and Real Estate; 2018: Springer.

9. Ardiny H, Witwicki S, Mondada F. Are autonomous mobile robots able to take over construction? A review. 2015.

10. Abioye SO, Oyedele LO, Akanbi L, Ajayi A, Delgado JMD, Bilal M, et al. Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. Journal of Building Engineering. 2021;44:103299.

11. Dörfler K. Strategies for robotic in situ fabrication: ETH Zurich; 2018.

12. Yuan PF, Chai H, Yan C, Zhou JJ. Robotic fabrication of structural performance-based timber gridshell in large-scale building scenario. 2016.

13. Giftthaler M, Sandy T, Dörfler K, Brooks I, Buckingham M, Rey G, et al. Mobile robotic fabrication at 1: 1 scale: the in situ fabricator. Construction Robotics. 2017;1(1):3-14.

14. Helm V, Ercan S, Gramazio F, Kohler M, editors. Mobile robotic fabrication on construction sites: DimRob. 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems; 2012: IEEE.

15. FastBrick Robotics [updated 2018. Available from: https://www.fbr.com.au/.

16. Nlink Drilling Robot [updated 2018. Available from: https://www.nlinkrobotics.com/.

17. Leach N. Digital morphogenesis. Architectural Design. 2009;79(1):32-7.

18. Kolarevic B. Digital morphogenesis and computational architectures. 2000.

19. Ardiny H, Witwicki S, Mondada F, editors. Construction automation with autonomous mobile robots: A review. 2015 3rd RSI International Conference on Robotics and Mechatronics (ICROM); 2015: IEEE.

20. Dharmawan AG, Sedore BWC, Foong S, Soh GS. An agile robotic system mounted on scaffold structures for on-site construction work. Construction Robotics. 2017;1(1):15-27.

21. Keating SJ, Leland JC, Cai L, Oxman N. Toward site-specific and self-sufficient robotic fabrication on architectural scales. Science Robotics. 2017;2(5):eaam8986.

22. 3D Printhuset - The BOD 2018 [Available from: https://3dprinthuset.dk/the-bod/.

23. BigDelta WASP 12m Archives-3D Printers | WASP 2017 [Available from: https://www.3dwasp.com/en/tag/bigdelta-en/.

24. Khoshnevis B. Automated construction by contour crafting—related robotics and information technologies. Automation in construction. 2004;13(1):5-19.

25. Bosscher P, Williams II RL, Bryson LS, Castro-Lacouture D. Cable-suspended robotic contour crafting system. Automation in construction. 2007;17(1):45-55.

26. Bock T, Linner T. Construction Robots: Volume 3: Elementary Technologies and Single-task Construction Robots: Cambridge University Press; 2016.

27. Augugliaro F, Zarfati E, Mirjan A, D'Andrea R, editors. Knot-tying with flying machines for aerial construction. 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS); 2015: IEEE.

28. Katz D, Kenney J, Brock O, editors. How can robots succeed in unstructured environments. In Workshop on Robot Manipulation: Intelligence in Human Environments at Robotics: Science and Systems; 2008: Citeseer.

29. Keating SJ. From bacteria to buildings: additive manufacturing outside the box: Massachusetts Institute of Technology; 2016.

30. 3D concrete printers 2022 [Available from: https://cybe.eu/technology/3d-printers/.

31. Construction Robotics 2018 [Available from: https://www.construction-robotics.com/.

32. Construction Industry Robotics Application Report 2018 [Available from: https://36kr.com/p/1723105181697.

33. Robotic Assisted Lifting 2021 [Available from: https://www.masonrymagazine.com/blog/2021/06/29/robotic-assisted-lifting/.

34. Sedore B, Dharmawan A, Soh G, Otto SFK, editors. Pose accuracy of a mobile robotic system mounted on scaffold structures. Proceedings of the 14th IFToMM World Congress; 2015: 國立臺灣大學機械系.

35. Chen X, Dharmawan AG, Foong S, Soh GS. Seam tracking of large pipe structures

for an agile robotic welding system mounted on scaffold structures. Robotics and Computer-Integrated Manufacturing. 2018;50:242-55.

36. This Robot Could Build Zaha Hadid Architects' Next Project 2018 [Available from: https://www.theb1m.com/video/this-robot-could-build-zaha-hadid-architects-next-project.

37. Mobile Robotic Fabrication System for Filament Structures 2015 [Available from: https://www.icd.uni-stuttgart.de/teaching/master-theses/itech-m-sc-2015-mobile-robotic-fabrication-system-for-filament-structures/.

38. Dubor A, Izard J-B, Cabay E, Sollazzo A, Markopoulou A, Rodriguez M, editors. On-site robotics for sustainable construction. Robotic Fabrication in Architecture, Art and Design; 2018: Springer.

39. Agustí-Juan I, Habert G. Environmental design guidelines for digital fabrication. Journal of cleaner production. 2017;142:2780-91.

40. Pan M, Linner T, Pan W, Cheng H-m, Bock T. Influencing factors of the future utilisation of construction robots for buildings: A Hong Kong perspective. Journal of Building Engineering. 2020;30:101220.

41. Willmann J, Knauss M, Bonwetsch T, Apolinarska AA, Gramazio F, Kohler M. Robotic timber construction—Expanding additive fabrication to new dimensions. Automation in construction. 2016;61:16-23.

42. About the Japanese cedar 2020 [Available from: https://www.japan-yakisugi.com/japanesecedar.

43. Anagnostou G. The influence of traditional Japanese timber design and construction techniques on contemporary architecture and its relevance to modern timber construction. Gottstein Fellowship Report. 2018:1-107.

44. Heräjärvi H, Lehtonen O, Hiltunen A, Muilu T, Verkasalo E, Lanvin J, et al. Building with wood as a driver for sustainable development in rural regions. Background and Methodology for Analysis of Socio-Economic Impacts on Rural Development and Rural-Urban Integration Through Wood Construction, Deliverable. 2021;1.

45. Leszczyszyn E, Heräjärvi H, Verkasalo E, Garcia-Jaca J, Araya-Letelier G, Lanvin J-D, et al. The Future of Wood Construction: Opportunities and Barriers Based on Surveys in Europe and Chile. Sustainability. 2022;14(7):4358.

46. Heesterman M, Sweet K. Robotic Connections: Customisable Joints for Timber Construction. 2018.

47. Hynynen A. Future in Wood? Timber Construction in Boosting Local Developments. European spatial research and policy. 2016;23(1):127-39.

*Chapter 2*

# *LITERATURE REVIEW OF ROBOTIC CONSTRUCTION*

**CHAPTER TWO: LITERATURE REVIEW OF ROBOTIC CONSTRUCTION**

## 2.1 History of robotics construction research

The purpose of this chapter is to place the research in this thesis in the context of historical and state-of-the-art examples and to summarize the areas of focus of this research.

The main research background of this paper is the digitization process of construction manufacturing and the current status of robotics in construction manufacturing, especially the development history and research focus of in-situ robotic construction. The premise of the study is that robotics is clearly superior to traditional construction manufacturing in terms of energy environment ， socio-economics and labor market.

### 2.1.1. From the structured towards the unstructured conditions

In recent years, the use of on-site automation and robotics in the construction industry has not been widespread, as there are not many suitable automation systems (1). Research on construction robotics and automation started in the 1980s, and since then, developments in robotics sciences have led to a wide range of robotic platforms with varying degrees of autonomous construction modes (2). In contrast to mobile robots used on the construction site, earlier automated site construction was carried out by stationary robotic systems. The goal was to increase the efficiency and productivity of the industry. These initial approaches were motivated by the need to recreate the well-structured environment of a prefabrication plant directly on the construction site. A highly institutionalized environment and a rigorously planned production process can provide the necessary means for a robotic system to be implemented within (3, 4). And a largely automated building integration system initiated by contracting companies and containing a complete integrated information management system from planning to construction, a concept known as computer integrated construction (CIC) (5, 6). However, this system is large and customized for a specific construction site. the Obayashi Corporation’s Automated Building Construction System (ABCS) (7-9), and the Big-Canopy system (10), or the Shimizu Corporation’s Manufacturing System by Advanced Robotics Technology (SMART) (5), developed for the company's robotic construction of high-rise buildings. These vertically moving in-situ building construction sites provide a fully enclosed, clearly defined and systematic framework for work. The automated overhead crane system is integrated into a massive scaffolding structure for the on-site assembly of structural members and prefabricated subassemblies. These components are automatically lifted from the unloading area on the ground. In terms of organization. A central information management system allows the entire process to be monitored and coordinated.

The first conceptual work on using mobile robots for on-site building construction dates back to the 1990s (2). As an alternative to stationary robotic systems, the EU Robot Assembly System for Computer Integrated Construction (ROCCO) (11, 12) and the Bricklaying Robot for Use on the Construction Site (BRONCO) (6) were among the earliest semi-mobile robotic projects developed for construction sites. According to the CIC concept, the aim of these wide-range robotic systems is to automate the block assembly in terms of building plans. Due to the high power and weight, the prototype robots for each experimental assembly were equipped with hydraulic drive systems. However, due to the low accuracy of the hydraulic actuator, the control of the robot required the support of an external laser tracking system. While the tracking system was the robot's final achievement of approximately ±20 mm end-effector positioning accuracy, additional passive compliance devices mounted on a custom pneumatic fixture were necessary. Overall, the pick and place process cycle time for a block added up to approximately 30s, including a laser tracking cycle time of 8-10 seconds, which means that the process is very slow (11, 13).

Further, the robot "Dimrob", could be used in a leisurely building construction scenario and required the use of static support legs to make it a movable fixed-base robot (14).

The overall work was slow due to the low accuracy of the hydraulic actuators it operates and the need for external laser tracking system support. In the 1980s and 1990s, these aforementioned attempts to integrate robotics into building construction sites (4) were either expensive and limited flexibility factory-style robotic systems or heavy and therefore slow robotic systems. For example, the weight of a large factory-style robotic installation including robots and cranes is about 2,000 tons. It turns out that customizing this robotic construction system for a variety of other building types that differ from the demonstrated high-rise is too expensive, if not impossible. On top of that, customizing a highly specialized robotic system to perform different building tasks is obviously difficult (13). These reasons may have contributed to the lack of impact and the difficulty in the widespread industry adoption of early robotic systems (13)

### 2.1.2. The reprogrammable machine in architecture and digital fabrication

The fragmentation of architectural practice between the act of design and the production of buildings is already deeply rooted in the principles of industrial specialization and segmentation(15). This is mainly due to the mutual lack of reciprocal information between the digital and physical domains.

At the turn of the 21st century, advances in digital fabrication and the use of programming machines led to a new paradigm in robotic construction. In particular, the use of additive robotic manufacturing techniques, which began in 2005 in construction research, marks a complete paradigm shift in this regard. Where design knowledge flows became clear and generated a new convergence of design computation and physical artifact fabrication processes (13, 16).The use of universal and programmable machines offers architects the possibility to transform architectural expressions. Primarily, this has allowed architects to represent a geometric shape as much as the means of its production (15). Additionally, it has allowed architects to create and fabricate in a design space with infinite variations. On the verge of returning to a pre-industrial production model, the process of making architecture can once again be explored beyond the shackles of standardization, in addition to saving on customization (17).

Today, many companies are using robotic automation in on-site construction, but mostly applied to very specific subtasks. For example, the "In situ Fabricator" proposed by ETH is a class of mobile robot specifically designed for on-site digital fabrication, but the subject of this experiment is not a complete full-size building (13, 18). A recently developed bricklaying robot has worked incredibly fast, constructing walls six times faster than a human (19). Another case proposes an optimization process implemented in the design stage of the construction project via static performance criteria to automatically search for the best picking location within the reach of the robot arm, which subsequently influences assembly implementation in the construction job site (20).

Other cases study demonstrates how robotic involvement allows architects to pursue complex timber shell designs and constructions(21-23). By utilizing the adaptive geometry system, the design and construction of the Timer Structure Enterprise Pavilion at the Horticultural Expo were accomplished with a high degree of precision (24).

Because of the unstructured nature of the construction environment, which makes human–robot interaction challenging, human proximity and vulnerability in interaction impose severe limitations on human and robotic activities in shared environments (2, 25). The study in (26) used multiple node robots in collaboration to meet the construction needs of large-scale structures.

For another reason, such as positioning. In (27-29), quasi-fixed-base full-size mobile systems capable of printing large-scale foam structures for whole-house 3D printing were presented , but the limited movable fixed-base units do not require robotic repositioning. At present, research teams such as the school of architecture of Tsinghua University in China and the University of Nantes in France have studied and entered the stage of industrialization promotion (30).

These challenges mean that automated construction using mobile robots is not yet ready for the commercial market (2). To date, no robotic platform has been able to fully satisfy the requirements for autonomous mobile robotic architectural construction of an equal scale.

The above description of the development of robotic building construction shows that, triggered and facilitated by digital tools and robotic fabrication, architects have rediscovered their interest in production methods. Related to this is a focus on matter and its behavior and performance related areas, where material processes are inherently chaotic compared to the digital realm. The behavior of matter during robotic manipulation can be uncertain and unpredictable (31-33). In many cases, this uncertainty proves that a purely model-based fabrication approach is ineffective (34, 35). However, robotic systems are not limited to allowing information to flow in only one direction, i.e., not just from the computer model to the material realm. With the use of sensors, information can also flow in the opposite direction, eventually enabling information interaction (36, 37). In a feedback-driven manufacturing process, sensing data is collected during the ongoing manufacturing process and is used to inform the robot control. This approach allows the robot program to adapt to the behavior of the material, according to the desired output during the fabrication process (37). In this way, a material-aware construction process can be established. In this way, the robot building process becomes malleable to material stimuli and, in addition to understanding it as a way to achieve accuracy, it allows to release the generative properties of an integrated design and manufacturing process (38-41).

## 2.2 Current limitations and challenges of robotic in situ fabrication systems

### 2.2.1. Uncertain of building site environments

The building site environment often exhibits deviations and dimensional tolerances compared to the digital blueprints. Such discrepancies can occur if the digital model of the building site does not depict the actual built condition very accurately and in detail, as in the case shown in (42), where the entity was not able to build exactly as the plan envisioned. The exposure of the building site to the external climate may also lead to deviations in the building elements and thus in their digital blueprints. In addition, building sites are not static but evolve over time and change as construction proceeds. The potential unpredictability of the physical realm interferes with the predetermination of digital building plans. Ultimately, however, it is this dilemma that has driven architectural research in this field. In the context of robotic on-site manufacturing, robotic sensing technologies must allow for the fact that these robots must be able to sense their immediate environment in order to support all necessary information in the manufacturing process.

Thus, to enable a robust and accurate construction process, the site construction robot needs to be able to handle the uncertain quality of the construction site. It needs to support the adaptation of existing digital blueprints to accommodate the deviations typically found on construction sites. This requires it to be able to sense the construction site environment using vision or laser-based sensing solutions and map it prior to manufacturing. The creation of such a map involves acquiring a set of images (using vision-based sensors) or laser distance measurements (using a laser rangefinder) and then fusing these data to construct a 3D representation of the measurement space. This solution for identifying valid building site geometry - later called mapping and alignment - is presented in the experimental section of Chapter 4 of this paper.

### 2.2.2. Localization of the robot

Robotic systems are used in on-site fabrication where they are used to produce building assemblies on the job site with reference to digital blueprints. This requires systems that can precisely locate the end-effector with absolute accuracy throughout the job site. In contrast to stationary systems, mobile robots lack a fixed mechanical connection to their environment and therefore rely on sensing solutions to locate their position and precisely position the tracking system installed outside the end-effector within the global workspace(13). Examples of research on these tracking systems are projects of SAM100 (43), Hadrian (44), and MIT's DCP(28). However, the use of these sensors is still limited by several key aspects. Firstly, maintaining clear visibility of the space without occlusion can cause difficulties, especially when building non-standard and geometrically differentiated structures. Secondly, visibility constraints limit the overall size of the working area. To overcome these limitations, vision- or laser-based positioning sensing solutions can be integrated into the robot. Avoiding the dependence on externally installed sensing devices can support the autonomy and flexibility of mobile robotic systems. The potential of on-board sensing for robot localization has been demonstrated in the DimRob (14) project, for example using a Kinect camera to scan landmarks (45), or in Dharmawan et al (46) using a laser rangefinder to determine the position of constructed artifacts.

### 2.2.3. Integration of design and in situ robot fabrication processes

To date, building planning software has focused solely on the geometric definition of building components and their spatial relationships. However, robotic fabrication requires that the design be closely integrated with the construction process. This extends the scope of design to the definition of the construction logic and the sequence of robotic tasks. This allows robot programs to be planned and executed in a feed-forward manner, assuming that the relevant robot actions will be successful. However, for robotic in-situ construction processes, this approach is not sufficient. Instead, such in-situ construction requires that the design intent be integrated directly with the physical construction process. Incomplete knowledge of the environment must be accomplished by sensing the uncertainties associated with materials, site, and fabrication. This includes the fact that the impact of robot movements on the construction process must be continuously monitored. The sensing data obtained can then inform the automated decision-making processes in the ongoing fabrication process to achieve the desired design.

This paper attempts to propose solutions to the problems of site positioning, human-robot interaction, design and completion of stationary robot and mobile robot site construction experiments for the same wooden building. And verifies the feasibility and applicability of wooden building with mobile robot construction from the experiment. This challenge raises many different levels of questions regarding design, construction, and research. Finally, the system needs to be integrated into the layout system and architectural design software for seamless interaction between design and construction. Overall, we find that addressing robotic fabrication itself poses a multidisciplinary challenge.

## Reference

1. Loveridge R, Coray T. Robots on construction sites: The potential and challenges of on-site digital fabrication. Science Robotics. 2017;2(5):eaan3674.

2. Ardiny H, Witwicki S, Mondada F. Are autonomous mobile robots able to take over construction? A review. 2015.

3. Taylor M, Wamuziri S, Smith I, editors. Automated construction in Japan. Proceedings of the Institution of Civil Engineers-Civil Engineering; 2003: Thomas Telford Ltd.

4. Bock T, Langenberg S. Changing building sites: Industrialisation and automation of the building process. Architectural Design. 2014;84(3):88-99.

5. Yamazaki Y, Maeda J. The SMART system: an integrated application of automation and information technology in production process. Computers in Industry. 1998;35(1):87-99.

6. Gambao E, Balaguer C, Gebhart F. Robot assembly system for computer-integrated construction. Automation in Construction. 2000;9(5-6):479-87.

7. Miyakawa H, Ochiai J, Oohata K, Shiokawa T, editors. Application of automated building construction system for high-rise office building. International Symposium on Automation and Robotics in Construction; 2000.

8. Ikeda Y, Harada T, editors. Application of the automated building construction system using the conventional construction method together. Proceedings of 23rd International Symposium on Automation and Robotics in Construction; 2006.

9. Chu B, Jung K, Lim M-T, Hong D. Robot-based construction automation: An application to steel beam assembly (Part I). Automation in construction. 2013;32:46-61.

10. Wakisaka T, Furuya N, Inoue Y, Shiokawa T. Automated construction system for high-rise reinforced concrete buildings. Automation in Construction. 2000;9(3):229-50.

11. Pritschow G, Dalacker M, Kurz J, Gaenssle M. Technological aspects in the development of a mobile bricklaying robot. Automation in Construction. 1996;5(1):3-13.

12. Andres J, Bock T, Gebhart F, Steck W. First results of the development of the masonry robot system ROCCO: a fault tolerant assembly tool. Automation and Robotics in Construction XI. 1994;11:87-93.

13. Dörfler K. Strategies for robotic in situ fabrication: ETH Zurich; 2018.

14. Helm V, Ercan S, Gramazio F, Kohler M, editors. Mobile robotic fabrication on construction sites: DimRob. 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems; 2012: IEEE.

15. Callicott N. The tacit component and the numerical model: representation in computer-aided manufacture and architecture. The Journal of Architecture. 2003;8(2):191-202.

16. Kohler M, Gramazio F, Willmann J. The robotic touch: how robots change architecture. Park books Zurich; 2014.

17. Carpo M. The second digital turn: design beyond intelligence: MIT press; 2017.

18. Giftthaler M, Sandy T, Dörfler K, Brooks I, Buckingham M, Rey G, et al. Mobile robotic fabrication at 1: 1 scale: the in situ fabricator. Construction Robotics. 2017;1(1):3-14.

19. Bock T, Linner T. Construction Robots: Volume 3: Elementary Technologies and Single-task Construction Robots: Cambridge University Press; 2016.

20. Ali AK, Lee OJ, Song H. Robot-based facade spatial assembly optimization. Journal of Building Engineering. 2021;33:101556.

21. Oesterle S. Performance As A Design Driver in Robotic Timber Construction. 2009.

22. Eversmann P, Gramazio F, Kohler M. Robotic prefabrication of timber structures: towards automated large-scale spatial assembly. Construction Robotics. 2017;1(1):49-60.

23. Helm V, Knauss M, Kohlhammer T, Gramazio F, Kohler M. Additive robotic fabrication of complex timber structures. Advancing wood architecture: a computational approach. 2016:29-42.

24. Yuan PF, Chai H, Yan C, Zhou JJ. Robotic fabrication of structural performance-based timber gridshell in large-scale building scenario. 2016.

25. Goodrich MA, Schultz AC. Human-robot interaction: a survey: Now Publishers Inc; 2008.

26. Leder S, Weber R, Wood D, Bucklin O, Menges A. Distributed Robotic Timber Construction: Designing of in-situ timber construction system with robot-material collaboration. ACADIA 2019. 2019.

27. Furet B, Poullain P, Garnier S. 3D printing for construction based on a complex wall of polymer-foam and concrete. Additive Manufacturing. 2019;28:58-64.

28. Keating SJ. From bacteria to buildings: additive manufacturing outside the box: Massachusetts Institute of Technology; 2016.

29. Subrin K, Bressac T, Garnier S, Ambiehl A, Paquet E, Furet B. Improvement of the mobile robot location dedicated for habitable house construction by 3D printing. IFAC-PapersOnLine. 2018;51(11):716-21.

30. 3D Printing Concrete House / Professor Xu Weiguo's team from the Tsinghua University School of Architecture. 2021 [Available from: https://www.archdaily.com/photographer/xwg-archi-studio-at-tsinghua-university.

31. Dörfler K, Ernst S, Piškorec L, Willmann J, Helm V, Gramazio F, et al., editors. Remote material deposition. International Conference, COAC, ETSAB, ETSAV; 2014.

32. Vasey L, Baharlou E, Dörstelmann M, Marshall Prado V, Schieber G, Menges A, et al. Behavioral design and adaptive robotic fabrication of a fiber composite compression shell with pneumatic formwork. 2015.

33. Rust R, Gramazio F, Kohler M. Force adaptive hot-wire cutting. Advances in architectural geometry. 2016.

34. Feigenbaum EA. Artificial intelligence: themes in the second decade. STANFORD UNIV CA DEPT OF COMPUTER SCIENCE; 1968.

35. Negroponte N. Soft architecture machines: MIT press Cambridge, MA; 1975.

36. Dörfler K, Rist F, Rust R. An experimental approach to integrating digital and physical design methods. 2012.

37. Menges A. Material computation: Higher integration in morphogenetic design: John Wiley & Sons; 2012.

38. Vasey L, Maxwell I, Pigram D. Adaptive part variation. Robotic Fabrication in Architecture, Art and Design 2014: Springer; 2014. p. 291-304.

39. Menges A. The new cyber‐physical making in architecture: Computational construction. Architectural Design. 2015;85(5):28-33.

40. Brugnaro G, Baharlou E, Vasey L, Menges A. Robotic softness: an adaptive robotic fabrication process for woven structures. 2016.

41. Knight T. Craft, performance, and grammars. Computational Studies on Cultural Variation and Heredity: Springer; 2018. p. 205-24.

42. Tang P, Huber D, Akinci B, Lipman R, Lytle A. Automatic reconstruction of as-built building information models from laser-scanned point clouds: A review of related techniques. Automation in construction. 2010;19(7):829-43.

43. Construction Robotics 2018 [Available from: https://www.construction-robotics.com/.

44. FastBrick Robotics [updated 2018. Available from: https://www.fbr.com.au/.

45. Helm V. In-situ-Fabrikation: Neue Potentiale roboterbasierter Bauprozesse auf der Baustelle: ETH Zurich; 2014.

46. Chen X, Dharmawan AG, Foong S, Soh GS. Seam tracking of large pipe structures for an agile robotic welding system mounted on scaffold structures. Robotics and Computer-Integrated Manufacturing. 2018;50:242-55.

*Chapter 3*

# ***METHODOLOGY***

**CHAPTER THREE: METHODOLOGY**

## 3.1. Research methodology

This thesis addresses the research objectives and designs two experimental study cases. The two experiments explored the construction of wooden buildings by two types of robots described in Chapter 2, respectively. The objects of the two experiments are wooden buildings with the same design drawings, and the experimental objectives are accomplished using a stationary robot and a mobile robot.

In Case Study 1 of this thesis, we will take the in-situ construction experiment of a complete wooden building using a stationary robot, as shown in Figure 3-1, and addresses three goals, critical to the success of utilizing autonomous robots in construction. First and most importantly, the design of digital construction parameters for the complete construction steps. Also optimize the robot arm movement mode to avoid collisions at the construction site, so that the robot can independently complete the construction of the wooden building, and to verify the feasibility and applicability of robot construction of the wooden building from the experiment. Secondly, for buildings of the same design and size, the construction efficiency and construction accuracy of robot construction and manual construction are compared to verify the superiority of robot digital construction over traditional construction mode. Finally, it is hoped that this experiment will lead to the exploration of an assembly strategy for the development of robotic on-site fabrication of wooden buildings.

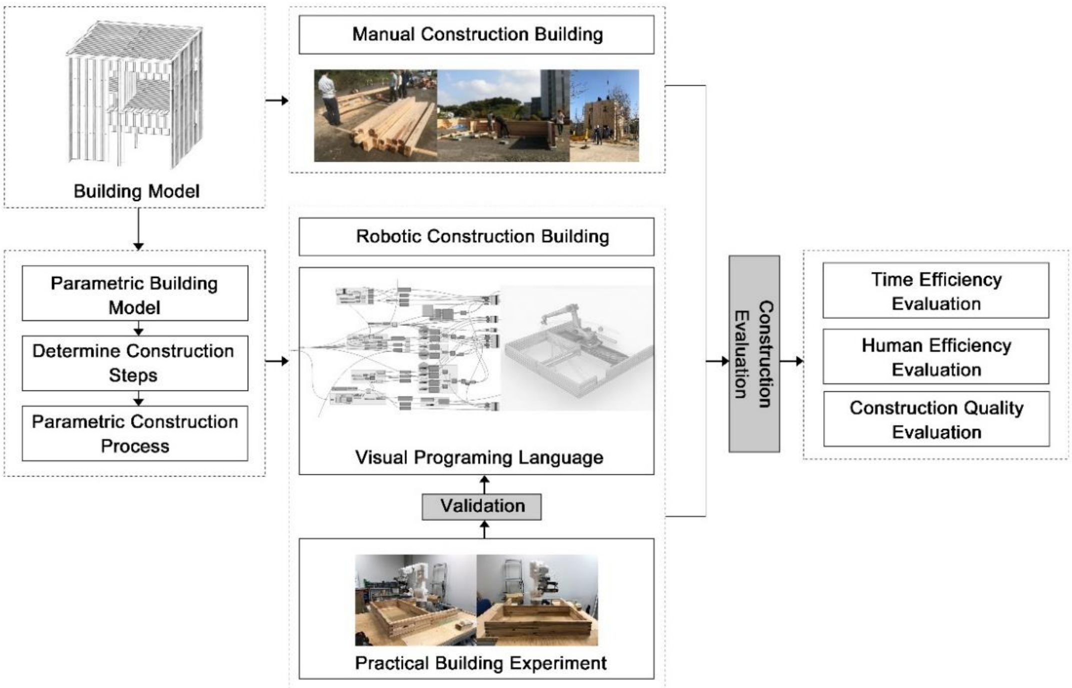



**Fig. 3-1 A conceptual framework for stationary robotic construction of timber house.**

In Case Study 2 of this thesis, we will take the in-situ construction simulation experiment of a complete wooden building using a mobile robot as an example to explore the possibilities and challenges of continuous building construction that exceed the static workspace of robots, as shown in Figure 3-2, whose building structure, erection method, and structural connections need to be adapted to the construction steps of the mobile robot. The on-site construction experiment of the mobile robot has three basic focuses. Firstly, it is a construction process integrated with an automated method, where the parametric building model is adapted to the mobile robot's construction method and the scanned and sensed construction site; secondly the experiment also integrates and validates the scanning and positioning system during the experiment so that the robot can perform construction tasks from multiple locations. Finally, it is hoped that the experiment will allow the exploration of assembly strategies for the development of on-site fabrication of wooden structure movable robots.

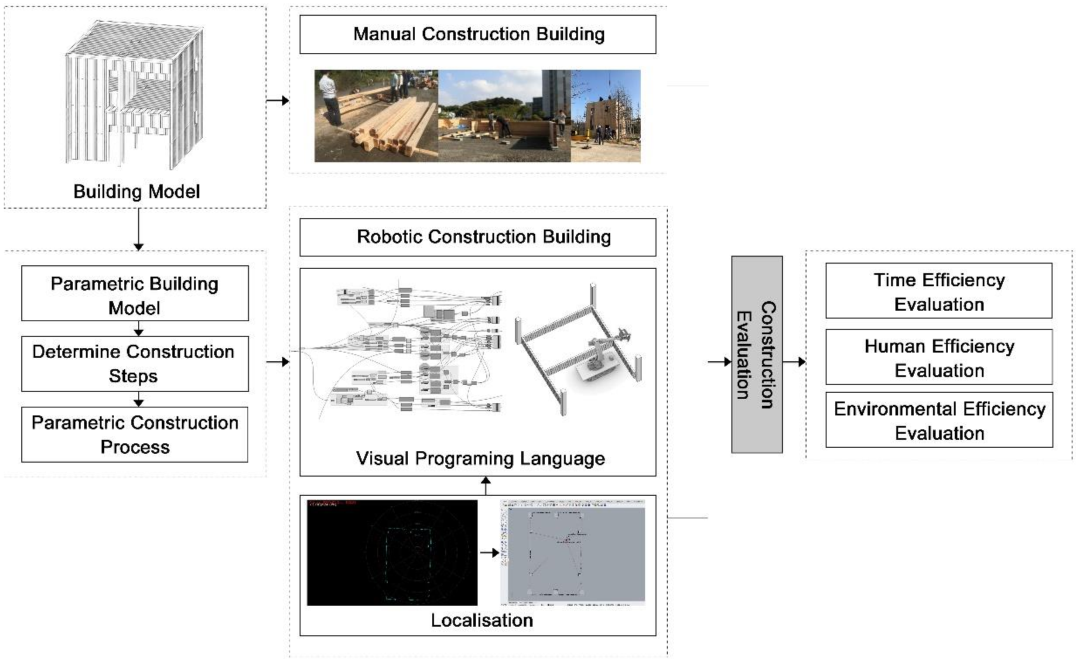



**Fig. 3-2 A conceptual framework for mobile robotic construction of timber house.**

The main difference between the two experiments is whether the construction site and the robot itself need to be scanned and localized. The motivation for the experiments in both cases is one and the same, and it can even be said that Case Study 2 is a further exploration based on Case Study 1. After exploring the digital construction parameters for the complete construction steps, the construction of wooden buildings should be adapted to different robotic construction methods, which will be described in detail for each of the two cases in Chapter 4.

## 3.2. Research objective

### 3.2.1. Research objective construction

The target building was a two-story timber house, which was manually constructed, as shown in Figure 3-3 and Figure 3-4. This thesis focused on the feasibility and specific construction steps of constructing this wooden building on site with a stationary robot and a mobile robot and compared the advantages and disadvantages of manual construction and mobile robot construction in terms of software modeling, construction efficiency, and construction difficulty.

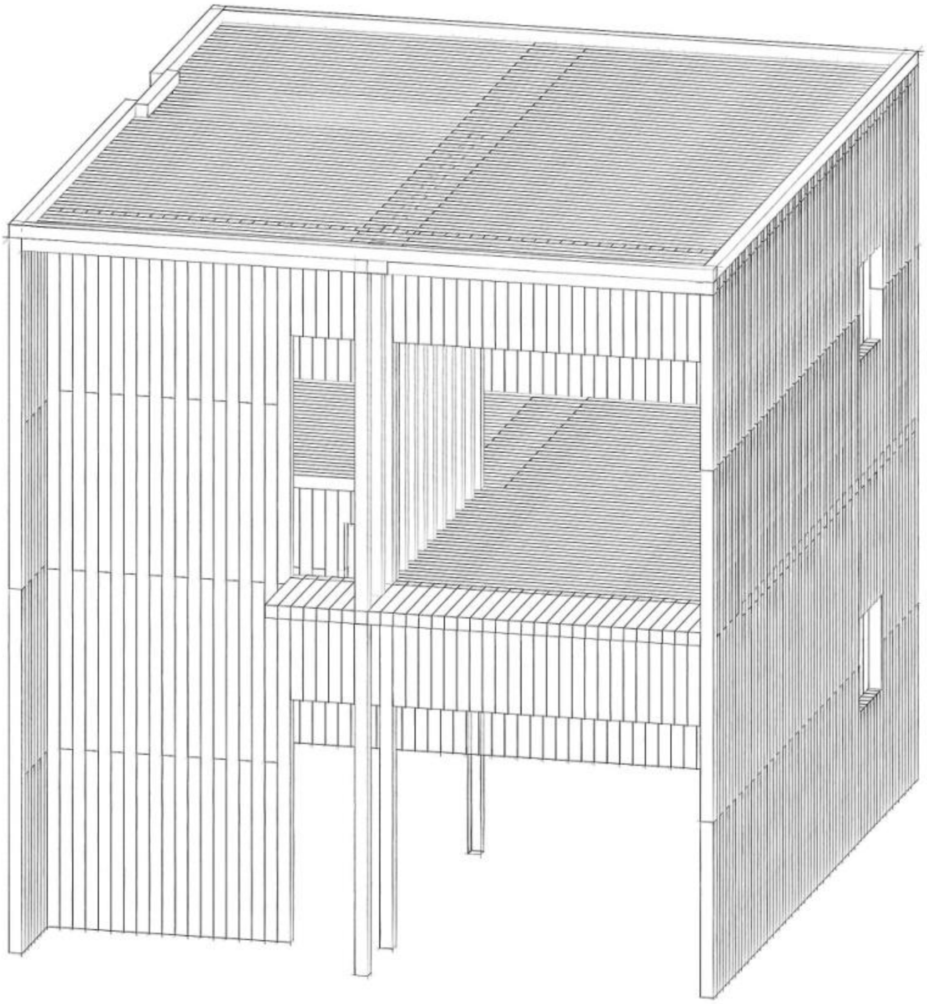


**Fig. 3-3 Axonometric projection of the timber house.**

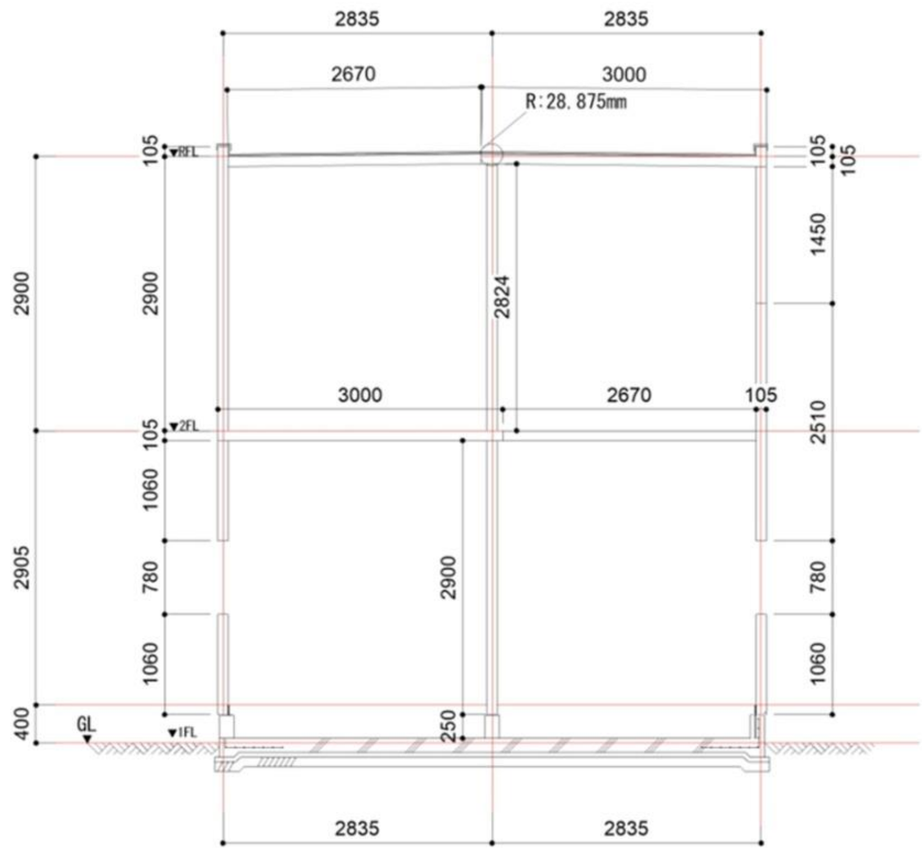



**Fig. 3-4 Section of the timber house.**

The target timber house has been designed and built by the students of the research laboratory. It is not built by professional workers and is not a standardized building, thus it is subject to errors and delays during construction due to the unprofessionalism of the students. The house is now completed and in operation, as shown in Figure 3-5.

**Fig. 3-5 Building construction site (left) and interior view after completion (right).**

In the constitutive method, the plan is divided into seven units. As shown in Figure 3-6, each unit is divided into seven units A, B, C, D, E, F, and G from north to south. Each unit is constructed by a unit perpendicular to the ground. For ease of construction, each unit is set to 8 to 10 layers. Since seams are formed when each piece of wood is joined, in order to ensure the stability of the lap joint structure, the wood is alternately laminated during the lap joint to prevent the seam of the lower layer of wood from overlapping the seam of the upper layer of wood.

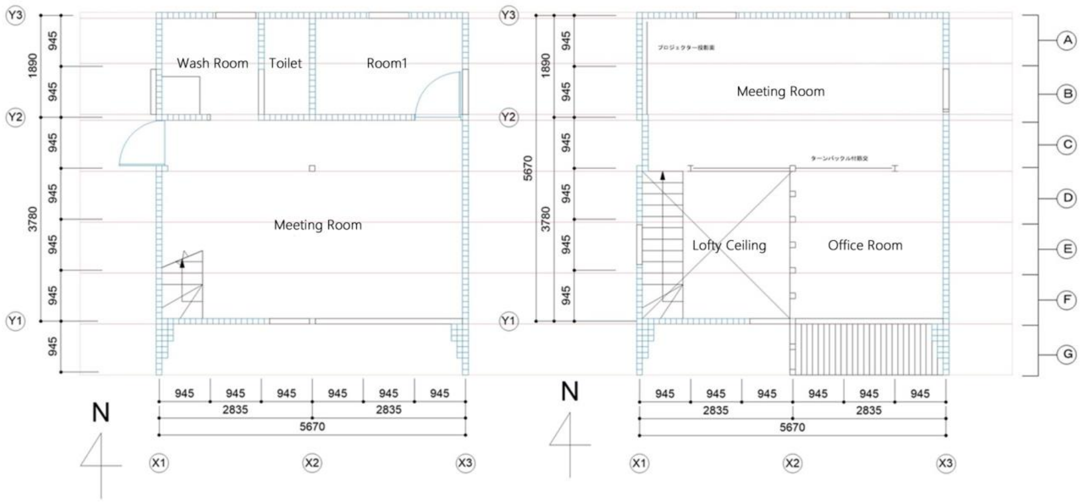



**Fig. 3-6 The unit assembly of the timber house.**

### 3.2.2. Manual construction procedure of research objective

Construction efficiency is affected by many factors when building by manual work. Because the construction depends on manual work, the constructor has a decisive influence on the construction efficiency. First of all, the construction efficiency largely depends on the construction experience of the constructor. From the results of the completion of this construction, for the same previous inexperienced constructors, the efficiency of the construction is significantly higher than the previous period. The proportion of experienced and inexperienced constructors in the constructor team is different, and the construction efficiency is also very different. Secondly, the working conditions of the constructor will also affect the work efficiency: for example, the construction of the unit D is the most difficult, because this unit contains stairs, resulting in a long construction time, excessive fatigue of the builder, and a significant decrease in construction efficiency, as shown in Figure 3-7.

**Fig. 3-7 Setting up the scene photos of Unit D (left) and another unit (right).**

Since the construction work is located outdoors, the construction efficiency is also affected by the weather. It is difficult to complete the construction work in bad weather such as heavy winds and rains. The temperature at work will also affect the work efficiency of the constructor and affect the overall construction efficiency.

Manually building a house requires manual participation in all aspects. The main actions include cutting timbers, handling timbers, unit construction, and unit connection, as shown in Figure 3-8 to Figure 3-11.

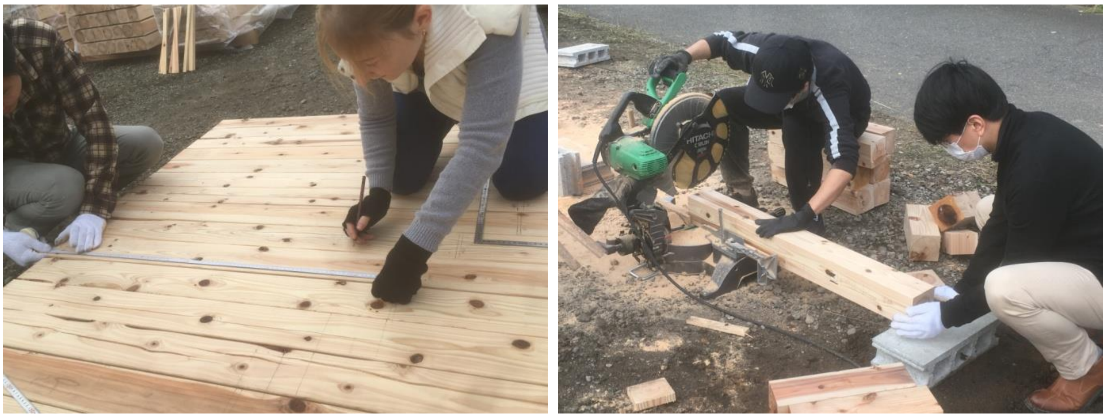


**Fig. 3-8 Cutting timbers.**

Cutting: First mark the length of the wood to be cut. When cutting, the chainsaw gear should be perpendicular to the surface of the wood. Basically, two people are required to do the cutting work so that they can perform safe and effective work. After the cutting is completed, the length of the cut wood needs to be marked directly on the wood so that the members of the same length can be divided and distinguished, as shown in Figure 3-8.

**Fig. 3-9 Handling timbers.**

Handling: The handling of wood also requires two people to ensure the safety and effectiveness of the work, as shown in Figure 3-9

**Fig. 3-10 Unit construction.**

Construction: Each unit needs to be built according to the design drawings, and the wooden rods of corresponding lengths are overlapped. The difficulty in setting up different units is different, and the number of constructions will be different, which will cause a big difference in the final construction time, as shown in Figure 3-10.

**Fig. 3-11 Unit connection with glue and nail.**

Connection: Each connected wooden stick is glued and nailed, and the work efficiency is related to the artificial proficiency. In the case of the same builder, the post-build efficiency is significantly higher than the previous period, as shown in Figure 3-11.

### 3.2.3. Building Material System

The target building was constructed of wood, mainly because of the environmental properties and economic benefits of wood, and because the choice of building materials is critical to the construction of renewable buildings. The building material system for the wooden building consists of Japanese cedar. the Japanese cedar is considered the most economically important plantation tree in Japan, and it is estimated that "sugi" constitute approximately 40 % of all plantation timbers and 20% of the entire manmade forest area in Japan (1)[24]. Wood is a major renewable resource for the construction industry and was selected as the preferred building material for the following reasons. Firstly, in terms of the sustainability of wood, a building material available in the local market, Japanese cedar, was selected for this experiment, as it is the most important economic artificial tree species in Japan, and its artificial forest has a short cultivation period for quick maturity and obvious environmental and economic benefits (2)[25]; further, waste wood is a valuable resource that can be recycled. Secondly, it is relatively cheap compared to other construction materials suitable for outdoor applications. Thirdly, depending on the material properties of the wood, it has high durability and strength compared to its weight and can be flexibly processed into different shapes and lengths, making it an adjustable component in construction (3)[11].


**Fig. 3-12 Japanese structural cedar (left) (4)is a cost-effective building material (right)**

### 3.2.4. Experimental Robotic Set-Up

For the construction part, I need to start from the two aspects of hardware and software. Today, most of the construction robots use robots made by KUKA manufacturers, as shown in Figure 2.1.1. KUKA is a German manufacturer of industrial robots and solutions for factory automation. The robots are used in many application areas, such as material handling, loading, and unloading of machines, palletizing and depalletizing. Also, we use the robots in construction. The most critical component of a robot is its robotic arm. Compared to regular five-axis CNC machines, robotic arms offer a much larger workspace at significantly lower costs. It's also important to note that architects and designers are not only using the robotic arms for "traditional" fabrication, but are also exploring the use of robots in an artistic way. There are projects where robots paint with light, are used as 3D printers, or even move cameras in the movie industry.


**Fig. 3-12 KUKA robot (Image: KUKA_KRC Basic programming) (5).**

① Control System

② Robot Arm (Robotic mechanical system)

③ Handheld operation (KUKA smart PAD)

The KUKA robot used in the actual experiments in Chapter 4 is shown in Figure 3-13. The left picture shows the handheld operator. The right picture shows the robot arm with the end-effector installed.


**Fig. 3-13 KUKA robot handheld operation (left) and the robot arm with the end-effector (right) in this experiment.**

The end-effector of the KUKA robot is also part of the robot hardware. The same type of robot can be installed with different tools according to the actual work needs. For some special actions, the tool needs to be designed to make the robot better adapt to the work. Due to the different types of work, the tools of KUKA robots are very different and have a wide range of uses.

This thesis experiment requires the robot to perform multiple steps in the construction process, including gripping the timbers, applying glue, nailing, and placing the timbers, which requires the robot's end-effector to have a gripper for picking up and moving the timbers and a nail gun for nailing, as shown in Figure 3-14.


**Fig. 3-14 The end-effector of KUKA robot in the case study.**

### 3.2.5. Software of construction robot- KUKA|prc

The demand for robots in the creative industries and manufacturing industries is very different. In many aspects of manufacturing, robots often need to work in repetitive tasks, but in the field of architecture, designers will constantly try new ideas, and we often need robots to complete creative projects. KUKA|prc, as shown in Figure 3-15, builds upon the accessible visual programming system Grasshopper, which is a part of the CAD software Rhinoceros 3D. Out of a collaboration between KUKA, Rhinoceros, and Grasshopper, KUKA/prc allows designers to not only control robots with a program already widespread in the architectural profession, but to simulate the actual fabrication process digitally. It provides the robotic building blocks to directly integrate a KUKA robot into a parametric environment. Instead of writing code, simple function-blocks are connected with each other and the results immediately visualized. This feedback allows architects to quickly move from the programming environment to the robot, or from design to fabrication.

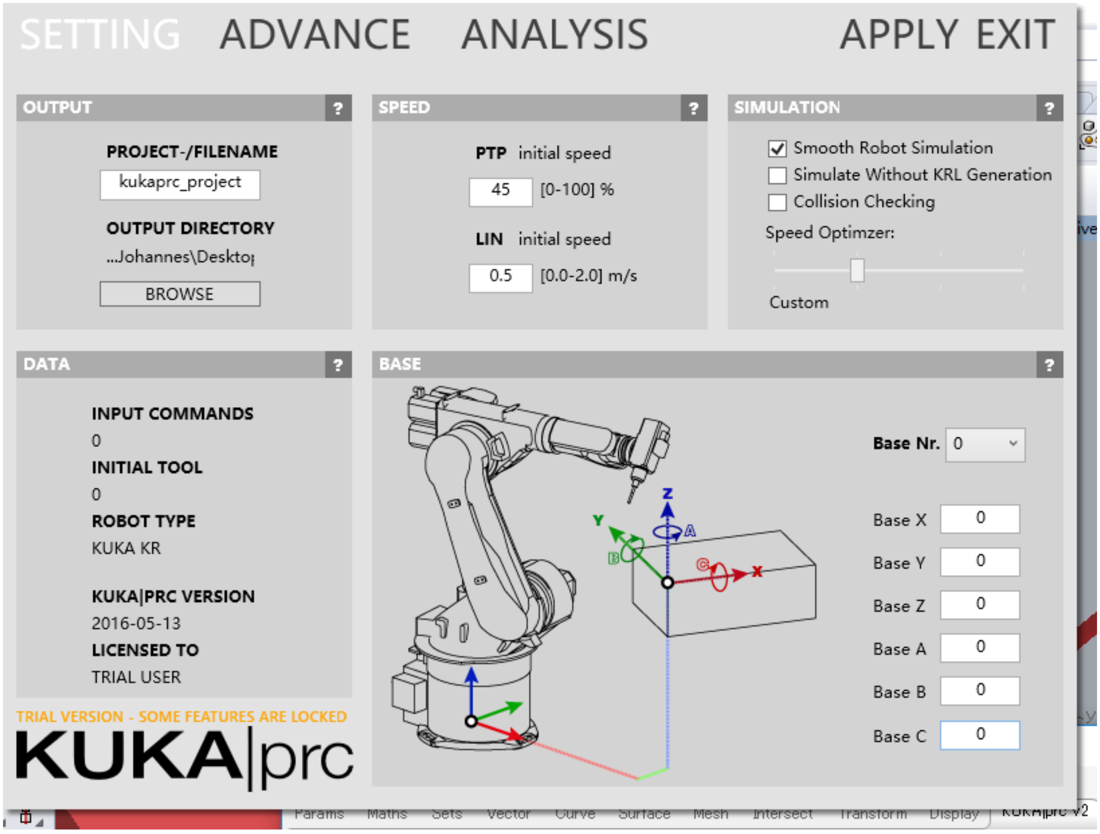



Fig. 3-15 KUKA|prc operation interface.

KUKA|prc learning is the basis of design, mastering how KUKA|prc is applied in grasshopper, and transmitting visual design results to robots to implement operations is the focus of learning.

### 3.2.6. Adhesives for building connections

According to the actual test, the adhesive used in the experiment was a 1:5 mixture of these two glues, as shown in Figure 3.16. The use of these two water-soluble glue in proportion to the mix, can ensure that the experimental adhesive can be quickly solidified without delaying the construction of the next layer of timbers, but also to ensure that the adhesive dries between the sticky object stability.

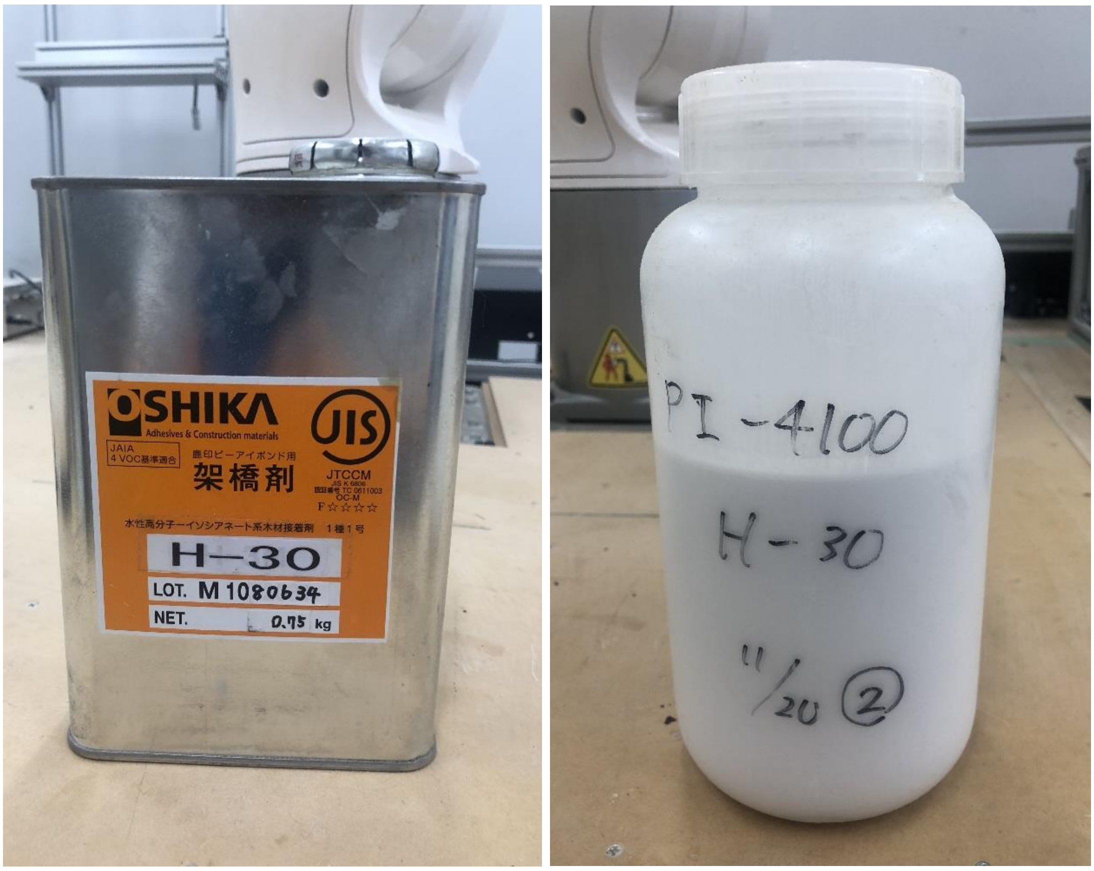



**Fig. 3-16 The adhesive used in the experiments was a mixture of these two glues.**

## 3.3. Computational tool-set for adaptive robotic control

### 3.3.1. Sensing tasks for robotic in situ fabrication

In case study 2 in Chapter 5 of this thesis, a mobile robot is used for a construction activity that is beyond the static working range of the robot. The theoretical premise for completing this build is that the robot is capable of performing sensing tasks during the build process, as follows.

3.3.1.1. Mapping and alignment

Prior to fabrication, the sensing system of the corresponding robot must acquire a set of measurements of the entire construction site environment or some of its entities. The acquired data are then fused to construct a 3D representation of the measurement space, called a reference map. In the measurement calibration step, the created map is aligned with the CAD model of the building site and the conversion between the two is estimated accordingly. If the CAD model or some of its features substantially deviate from the map perceived and constructed by the robot, then the CAD model must be adapted to the dimensions of the valid measurements.

3.3.1.2. Localization

During the fabrication process, the robot must sense and estimate its position at the building site. For this localization process, the reference map created in the previous mapping step is used as the source of information. Using this known map as a reference, the pose transformation of the robot is estimated.

3.3.1.3. Fabrication Survey

During the fabrication process, the robot must also measure the structure it is building. Since the manufacturing survey is local, it is always performed at the currently estimated robot pose. This survey allows the robot to perceive uncertain material behavior and to record geometric deviations of the assembled structure with respect to the reference geometry. The survey also allows the robot to register inaccuracies in the current robot attitude estimate and to improve the local positioning of the end-effector (6).

### 3.3.2. Adaptive fabrication control

Subsequently, sensing data from multiple sources must be fed back to the design environment for adaptive manufacturing control, see Figure 3-17. Prior to manufacturing, feedback from the construction site is used to calibrate the workspace so that the CAD model of the construction site is consistent with the conditions in the field. During fabrication, the fabrication controller monitors the difference between the reference geometry of the fabricated part and the estimated dimensions from the sensor feedback through information from the sensors; multiple sources here are estimates of the robot's pose and assembly geometry. The controller is then used to generate a control action to achieve the desired performance criteria, and this control action allows the robot operation process to be adjusted incrementally towards the globally defined reference geometry. In the specific context of the experiments in this paper, generating these control actions is not a time-sensitive process. Furthermore, the interval between sensing and operation is adjusted according to the structure and material system of the respective experiment.

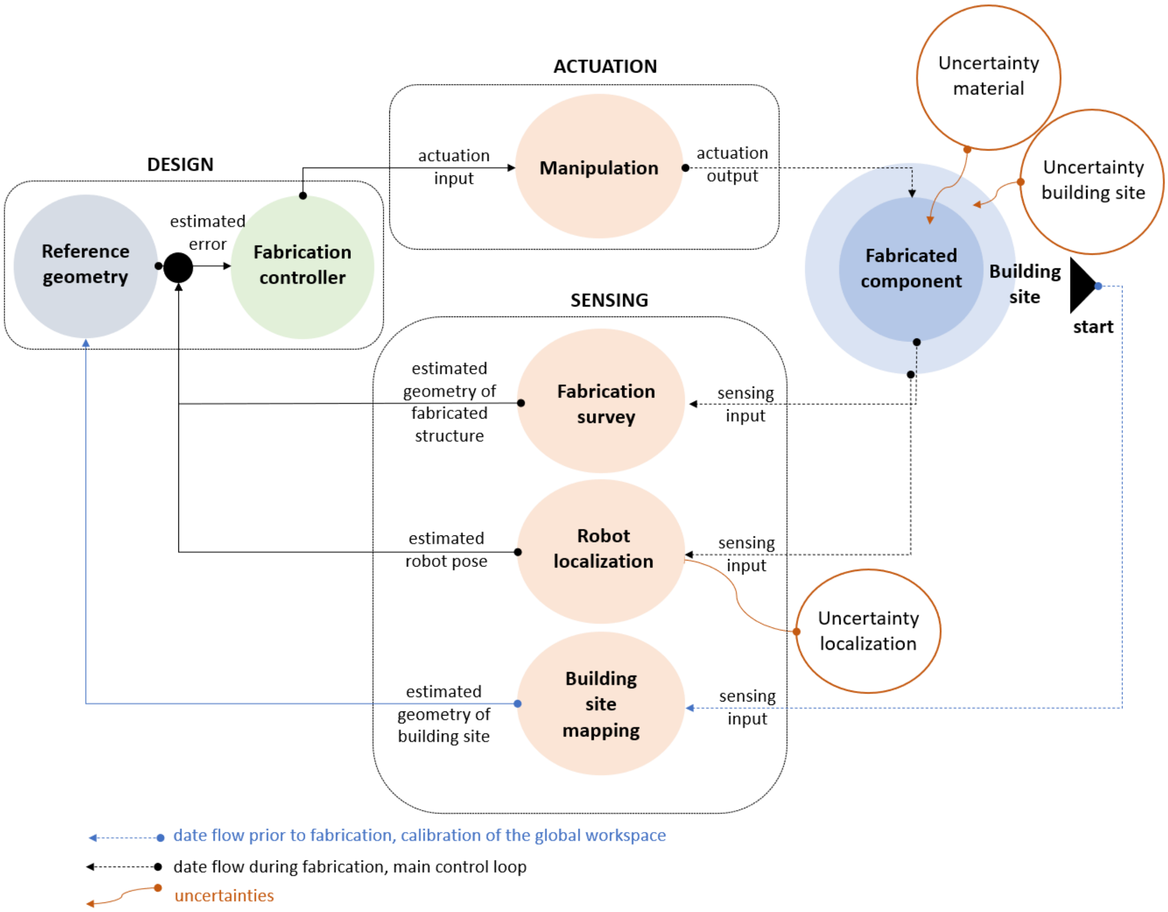



**Fig. 3-17 Geometric-based closed-loop control.**

## Reference

1. Anagnostou G. The influence of traditional Japanese timber design and construction techniques on contemporary architecture and its relevance to modern timber construction. Gottstein Fellowship Report. 2018:1-107.

2. Kohler M, Gramazio F, Willmann J. The robotic touch: how robots change architecture. Park books Zurich; 2014.

3. Yuan PF, Chai H, Yan C, Zhou JJ. Robotic fabrication of structural performance-based timber gridshell in large-scale building scenario. 2016.

4. High-quality wooden products made from Kagoshima cedar and cypress 2022 [Available from: http://www.pref.kagoshima.jp/ad10/sangyo-rodo/rinsui/documents/86190_20210224133757-1.pdf.

5. KUKA 2022 [Available from: https://www.kuka.com/.

6. Dörfler K. Strategies for robotic in situ fabrication: ETH Zurich; 2018.

# *Chapter 4*

## ***CASE STUDY 1: STATIONARY ROBOT CONSTRUCTION***

## CHAPTER THREE: CASE STUDY 1: STATIONARY ROBOT CONSTRUCTION

## 4.1. Contents

This thesis presents the process of using robots in the construction of timber buildings and the analysis of the experimental results through two experiments. Case study 1 experiment involved the construction of a timber building using a stationary robot; Case study 2 experiment involved the construction of a timber building using a mobile robot under the construction logic of Case study 1, with the introduction of a sensing system to assist in completing the experiment. Due to the different construction methods, the experiments differed in terms of construction mode, cell grouping, robot participation mode, and development of assembly strategies. The next section describes the two case experiments in detail.

The case study in this chapter is the reconstruction process of a wooden building by a stationary robot and explores digital construction strategies and processes.

## 4.2. Design Objective

### 4.2.1. Objective Building

The target building is a wooden-framed two-story building with a floor area of 32.1 ㎡, as shown in Figure 4-1. The building uses 105 mm timber, which is the most common size of cedar lumber used for construction in Japan, and the standardized size improve the constructability of designs and studies. The floor plan is set in a simple form and the modules are set in multiples of 105 mm timber (105 x 9 = 945 mm) for the overall design.

The building's design is stored within the fabrication data structure. This data structure is built upon a graph, within which the nodes of the graph represent the individual timbers--including their parameters, such as position, rotation, neighborhood, and the built-state. In addition, the graph allows the discrete assembly sequences to be computed from it (1, 2).

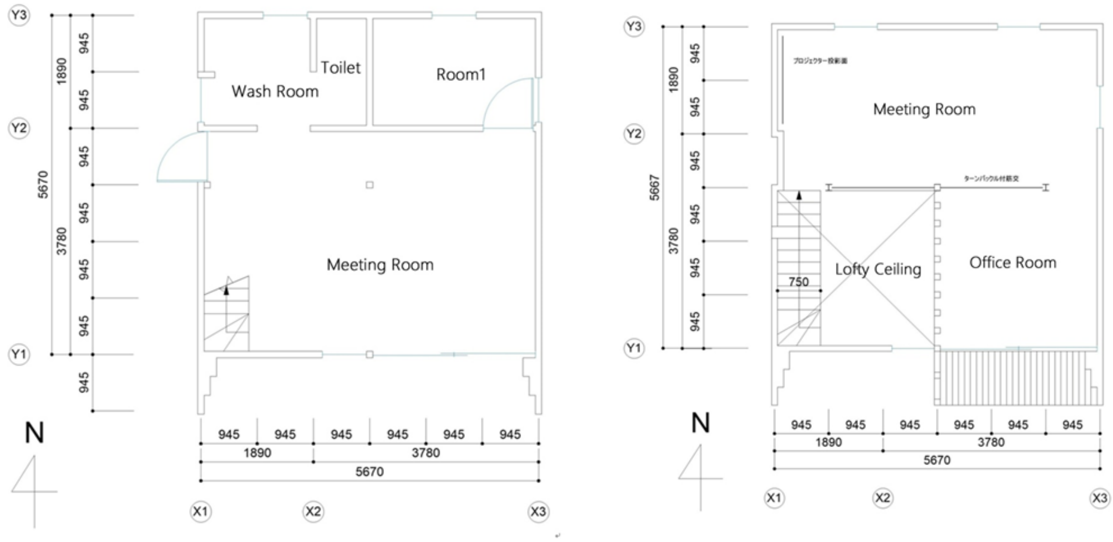



**Fig. 4-1 The two-story floor plan of the building: the first floor (left) and the second floor (right).**

### 4.2.2. Experimental Robotic Set-up

In the simulation experiment, a KUKA robot with a 3.6m radius of the robot arm was selected for the stationary robot and paired with a 5m long Y-axis slide., as shown in Figure 4-2.

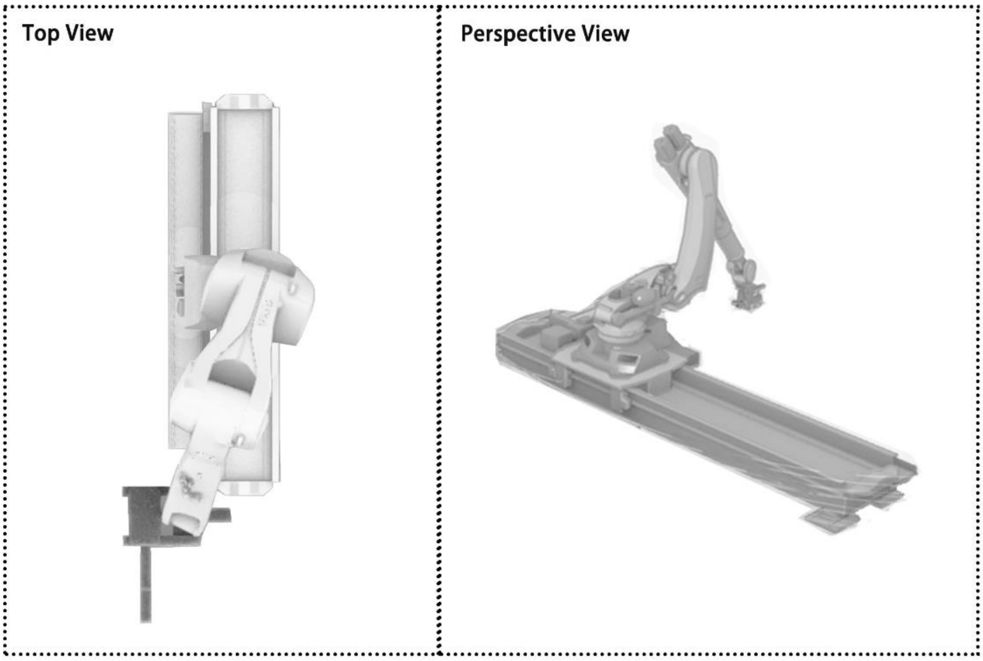



**Fig. 4-2 Top view (left) and perspective (right)of the stationary robot with a Y-axis slide rail .**

The robot arm length in the laboratory is 900 mm, which is limited by its model and cannot be used for the 1:1 scale building construction in the previous simulation experiment. Therefore, the practical building experiment was built by the robot at 1:5 scale of the original building. The Figure 4-3 below shows the KUKA robot that completed the actual experiment.


**Fig. 4-3 The construction robotic set-up is customized for the fabrication of timber buildings.**

To implement the various steps of timber frame construction, the construction robot is equipped with an end-effector that consists of a gripper for pick and place procedures and an air nail gun for performing drive-in-nails routines, as shown in Figure 4-4.

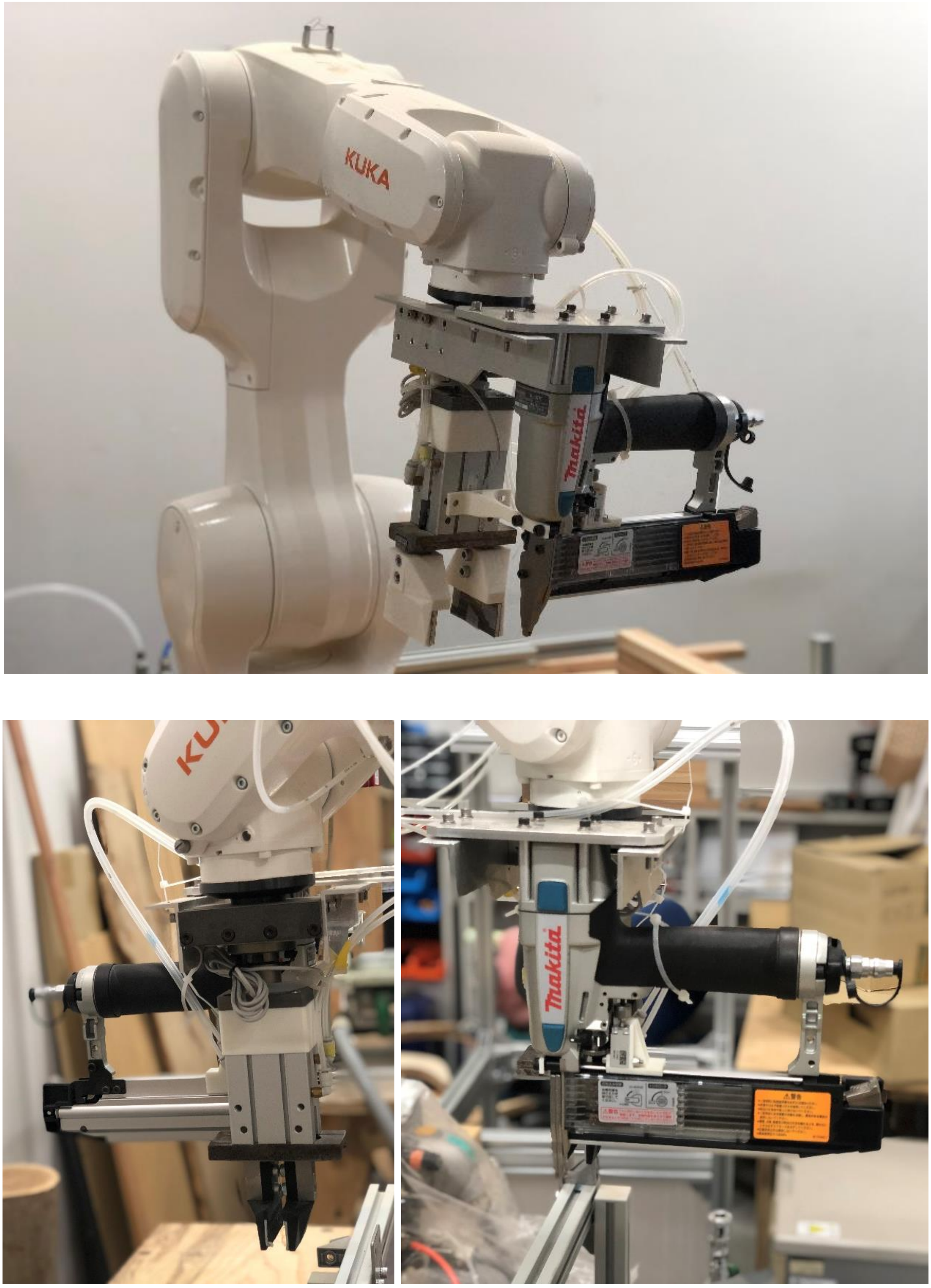



**Fig. 4-4 The end-effector for robot.**

### 4.2.3. Fabrication Sequence for Robot Fabrication

In this construction method, the plan is divided into seven units. As shown in Figure 4-5 and

Figure 4-6, the building is divided from north to south into seven units A, B, C, D, E, F, and G, which are perpendicular to the ground. To facilitate construction, each unit was set up with 6 to 9 layers. After completing the construction of each unit, the building eventually used a crane to erect the units. Since the joints are formed as each piece of timber is joined, to ensure structural stability, the timber is alternately laminated during the lapping process to prevent the joints of the lower timber from overlapping the joints of the upper timber.

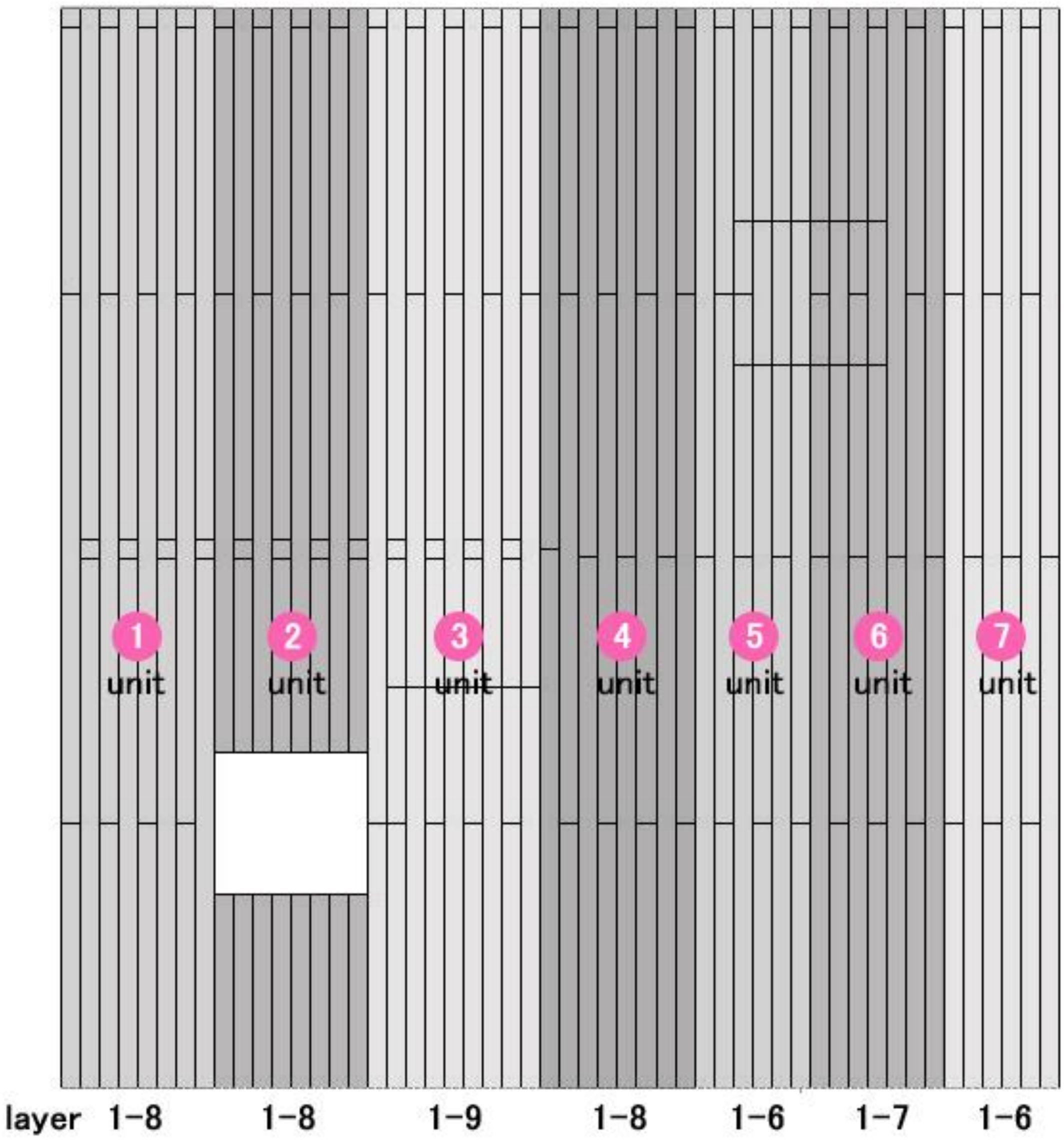



**Fig. 4-5 Unit division of the building.**

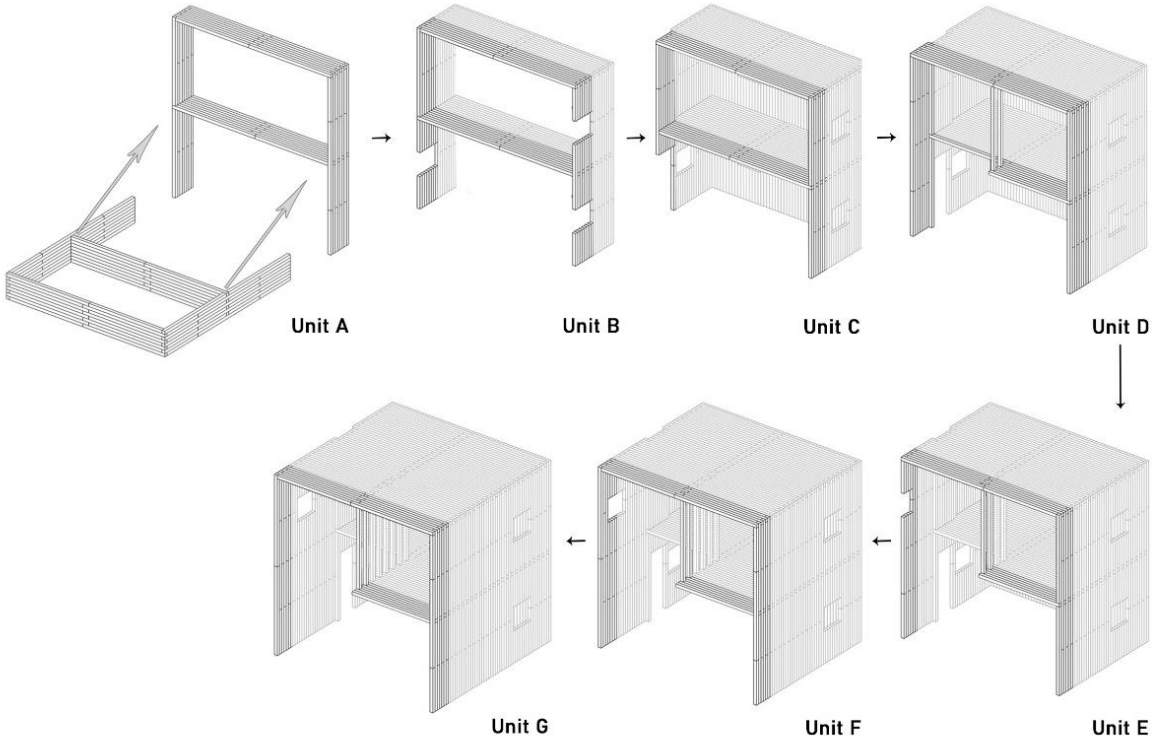



**Fig. 4-6 Unit assembly of the building.**

### 4.2.4. Connection of The Building

The structural construction of the building is divided into two main parts: the joints in the timber and the connection of the structural units. In the construction of each unit, the timbers of the same layer are not connected, and the timbers components are connected between layers by applying glue and nails, which can be done by robots in the subsequent construction operations, as shown in Figure 4-7. The connection between the units also requires glue and nails, which need to be lifted by a crane and connected manually to complete the construction as shown in Figure 4-8. A total of 818 nailing points and 405 gluing points were required for the entire structure.

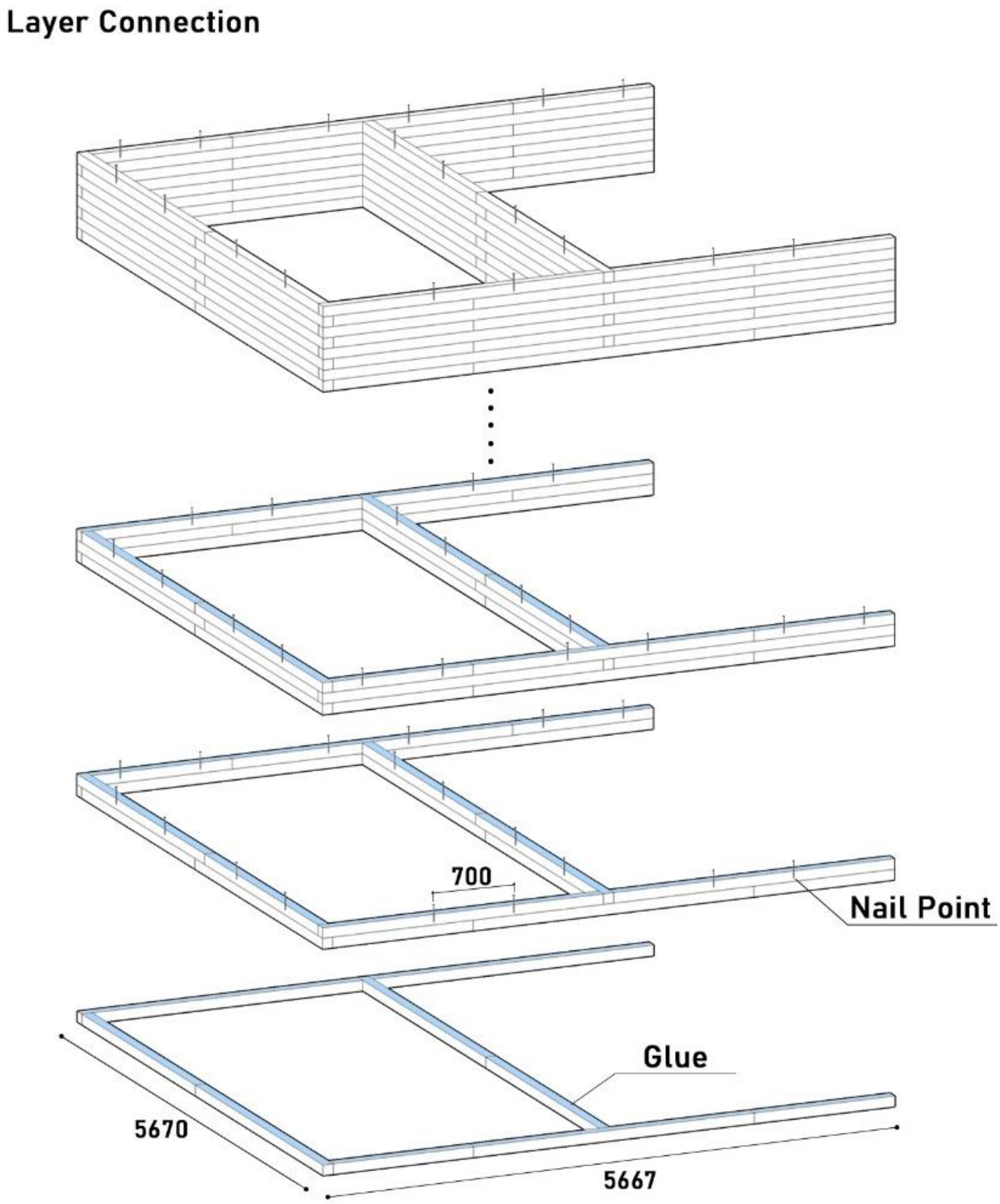



**Fig. 4-7 Layer connection of the building.**

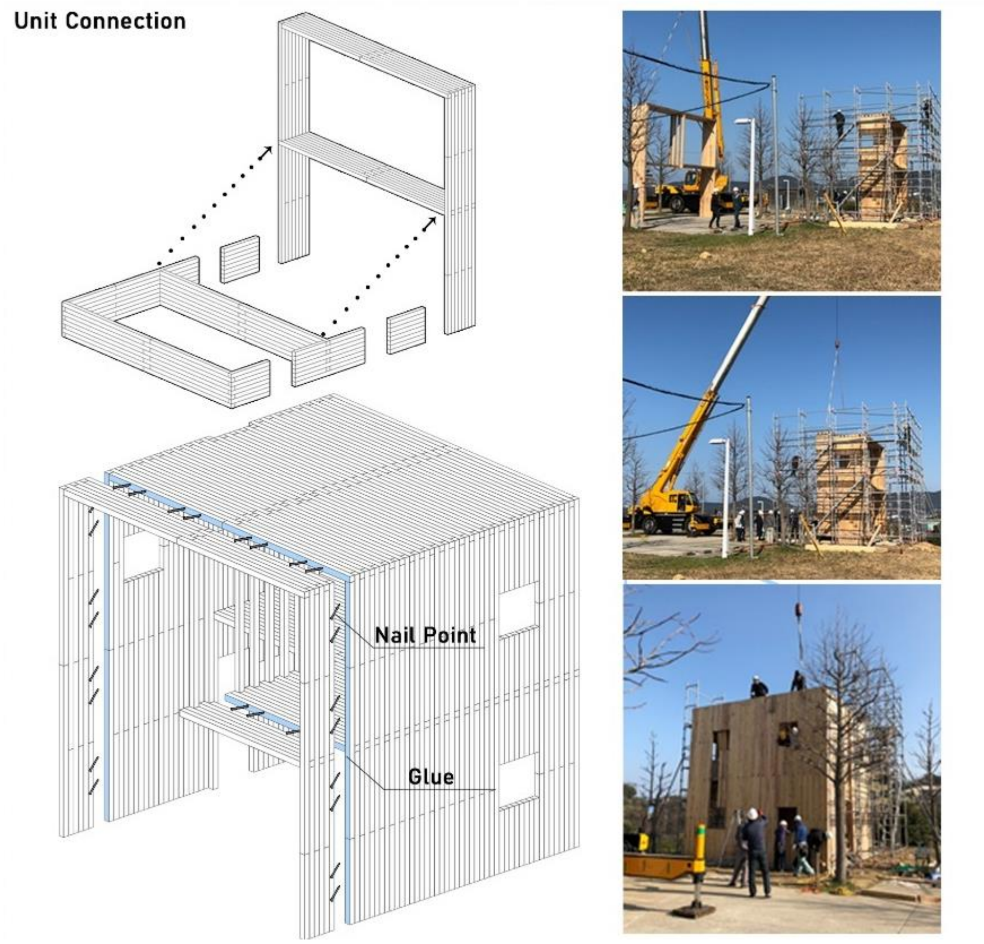



**Fig. 4-8 Unit connection of the building.**

### 4.3. Construction Procedure

#### 4.3.1. Determine the operable range of the robot

A total of 422 timbers were required to construct a timber frame building with a length of 5.565m, a width of 5.775m, and a height of 5.905m. Since the building was built in units, the most numerous units had 9 layers and the height of the unit was 0.945m, which required a robotic arm with an operable range greater than 5.905*5.775*0.945m.

Before starting the fabrication process, the construction range of the robot and the Y-axis slide combination should be determined first. To begin with, a set of points is placed around the robot at 50 mm intervals in the positive direction of the XYZ axis. Next, the robot reach points (green part) are calculated using KUKA | prc analysis. Then, stack all the points on the Z-axis to 360 degrees, and then stack all the points on the Z-axis to 270 degrees. Finally, the cube with the largest side length is extracted from the point grouping, and the reconstructed building cell is located inside this cube Figure 4-9.

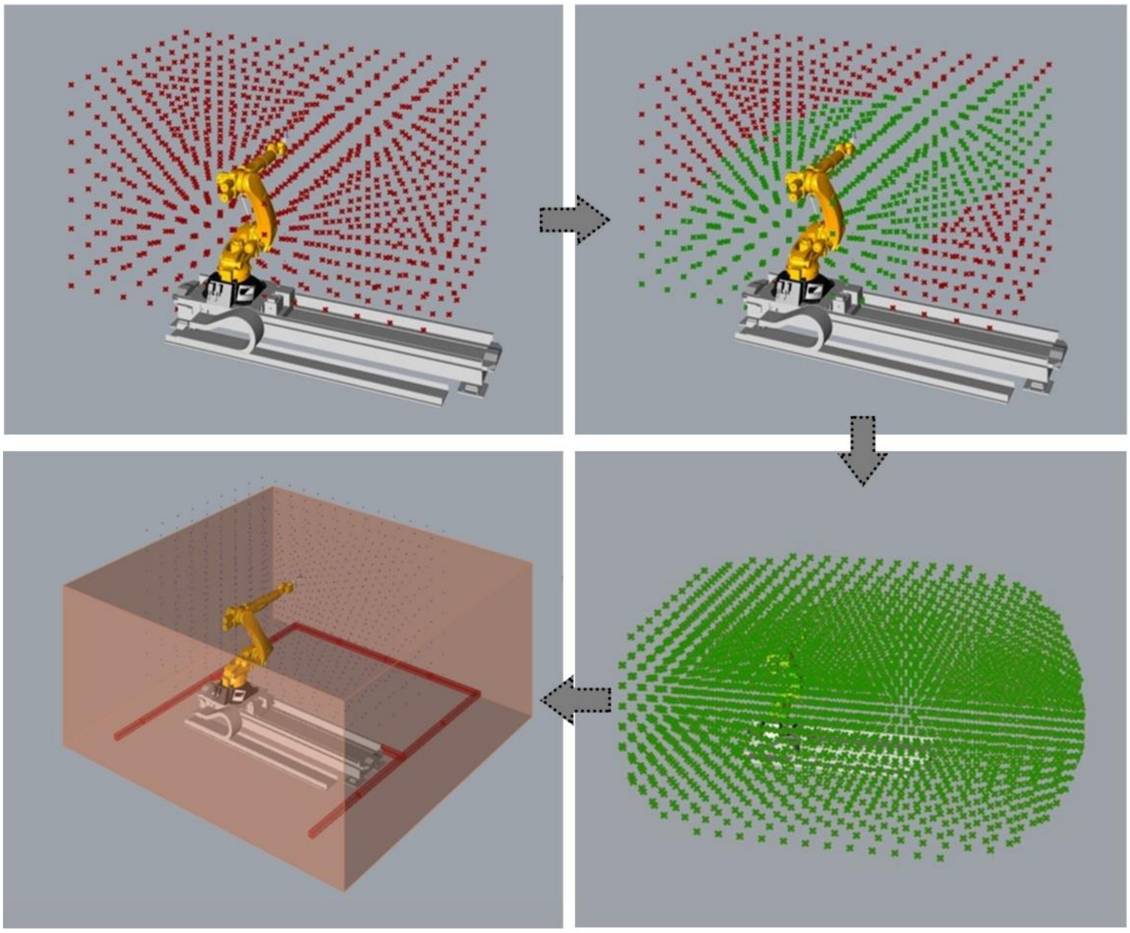


**Fig. 4-9 The process of determining the operable range of a robot.**

### 4.3.2. The process of building construction

The combination of the construction robot and the Y-axis chute can effectively complete the construction task of each unit of the target building. The robot places the timber in the construction order from bottom to top according to the construction logic of each unit and applies glue and nail to the necessary timber, as shown in Figure 4-10.

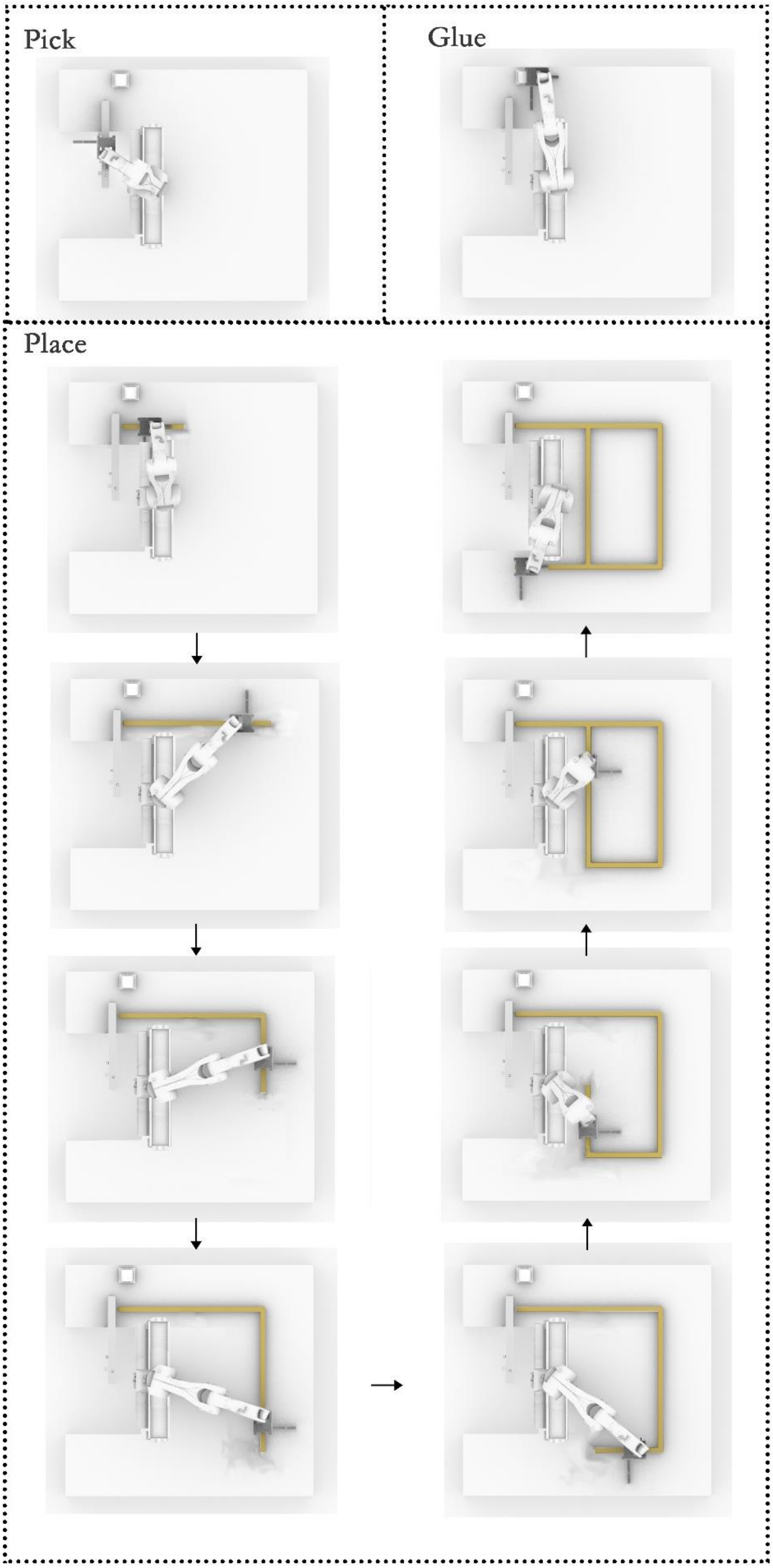



**Fig. 4-10 Snapshot of the process of building one unit by the robot.**

Each unit is constructed in the same way. After the robot construction of all seven units is completed, each unit is combined to form a complete building, as shown in Figure 4-11.

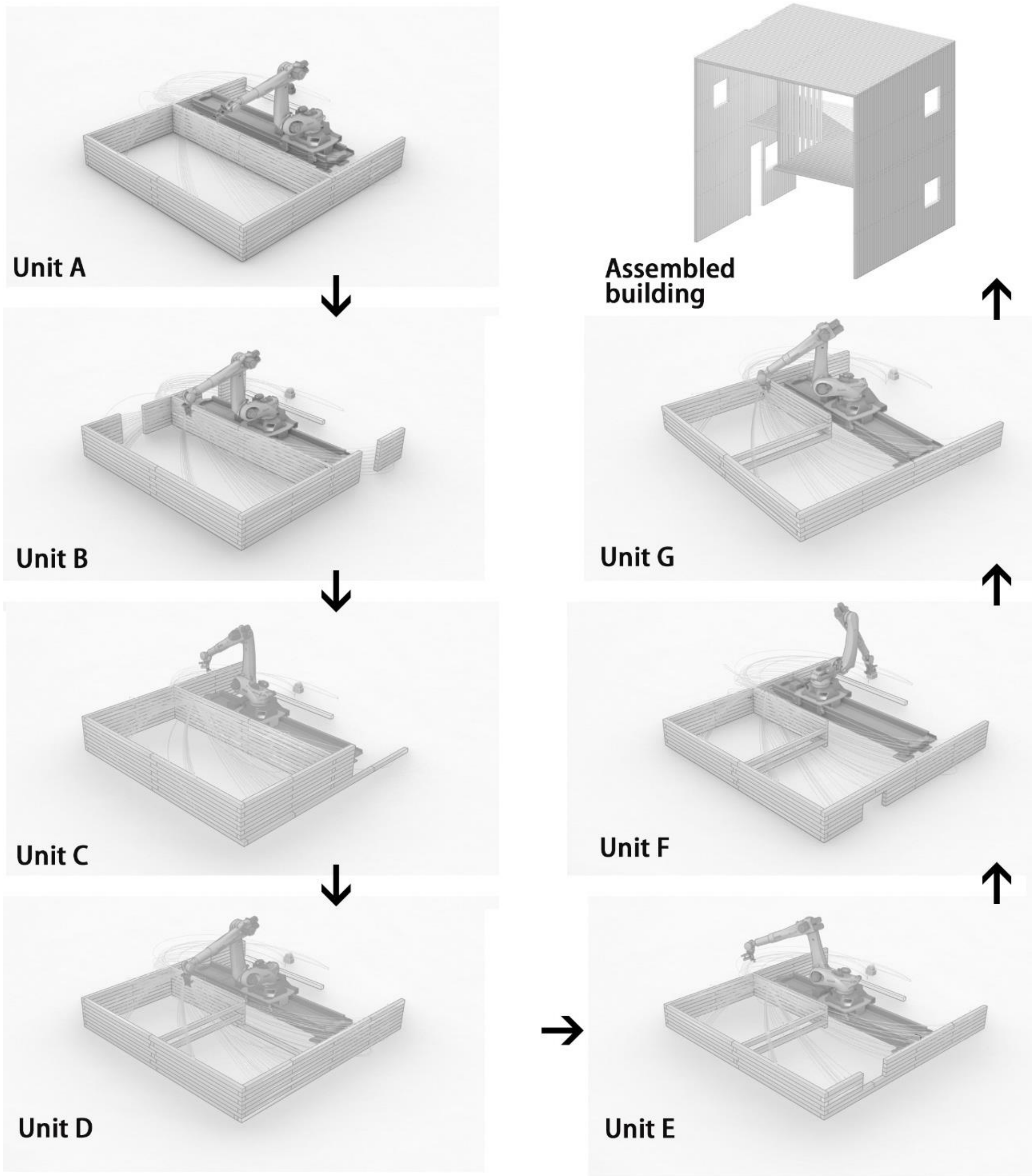



**Fig. 4-11 Snapshots of the entire building with seven units built by the robot.**

### 4.3.3. Digital building model

Robotic construction introduces a digital process to the original design industry. In the experiment, the first step in the use of robotic construction of the target building was to digitize the building model for further manipulation of the robot program. Since the KUKA robot software is on board the grasshopper software, the next step is to reconstruct the building model using grasshopper.

The building needs to be divided into 7 units for construction, and the grasshopper reconstruction is also rebuilt in groups according to 7 units from Unit A to Unit G.

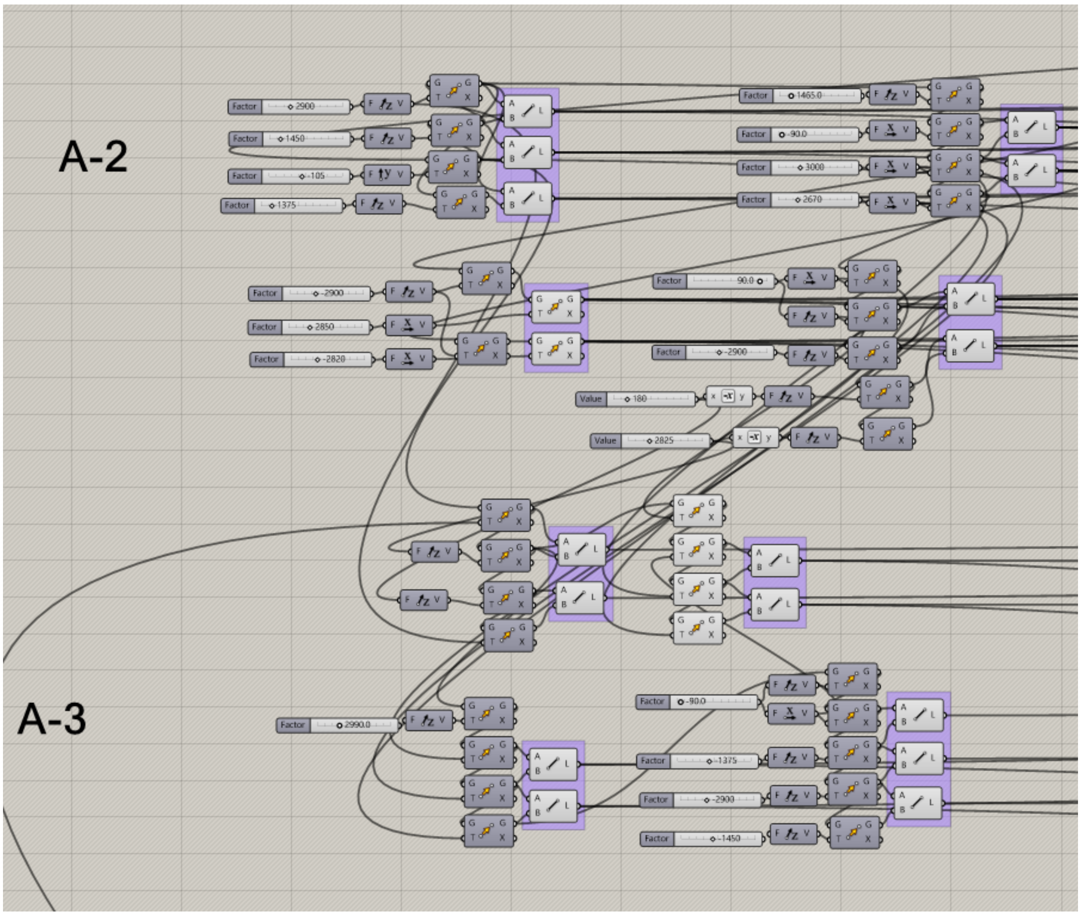
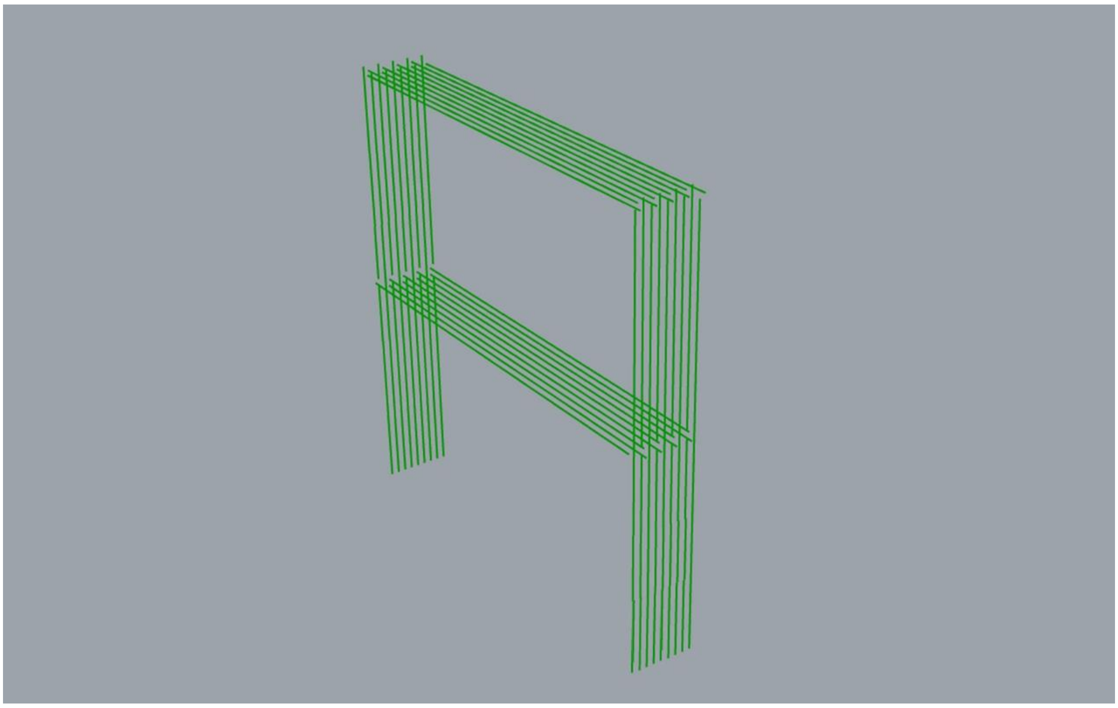



**Fig. 4-12 Unit A designed in grasshopper.**



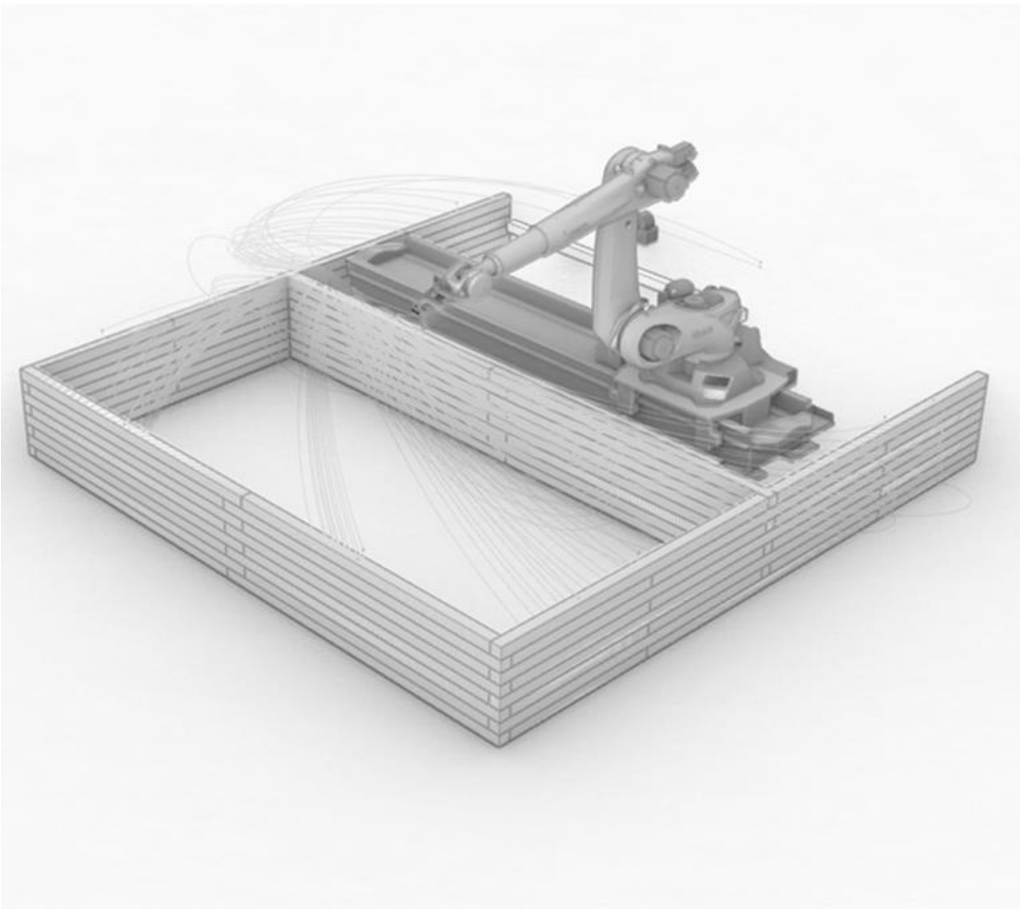


**Fig. 4-13 Unit A model in grasshopper.**

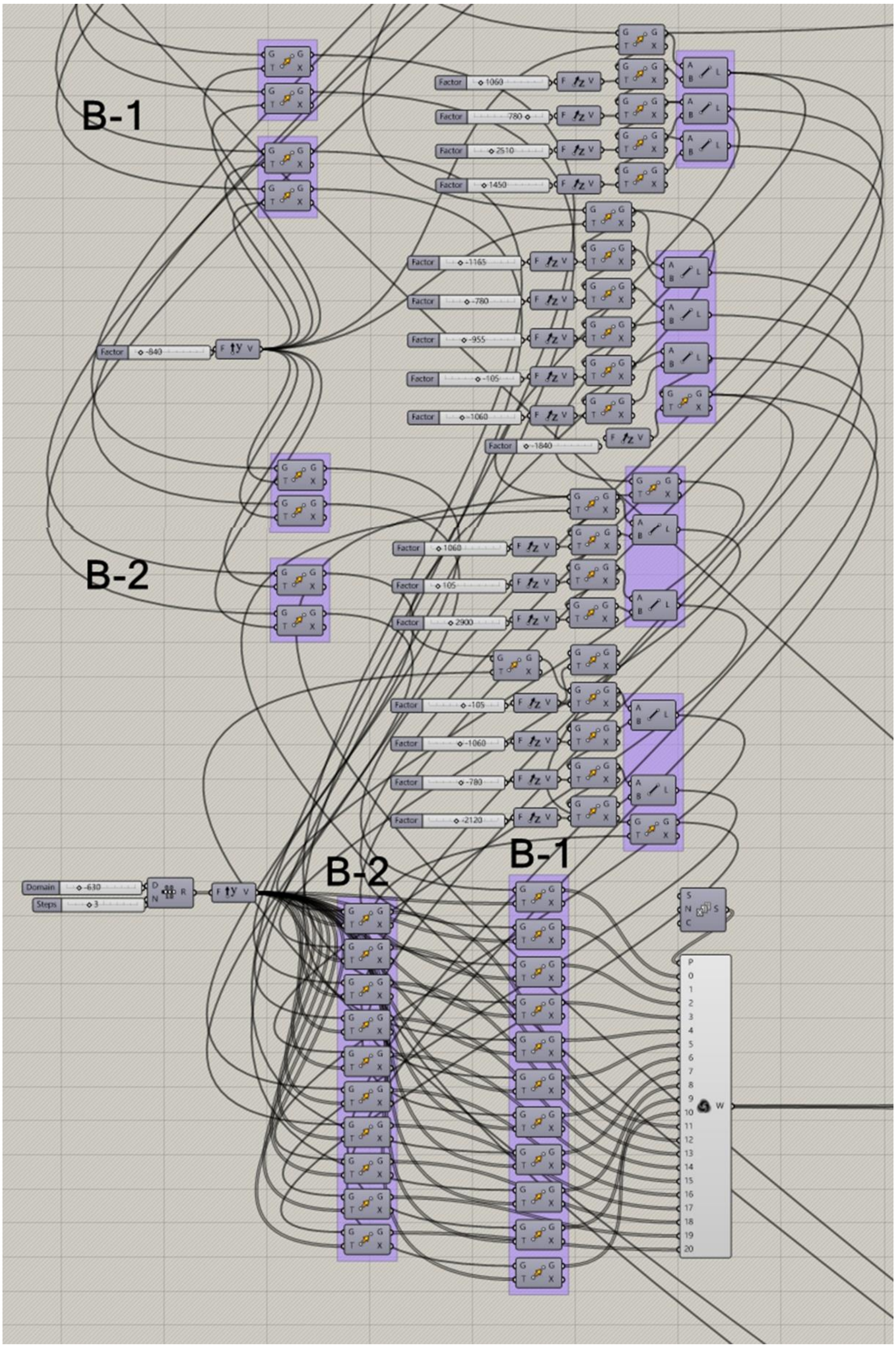
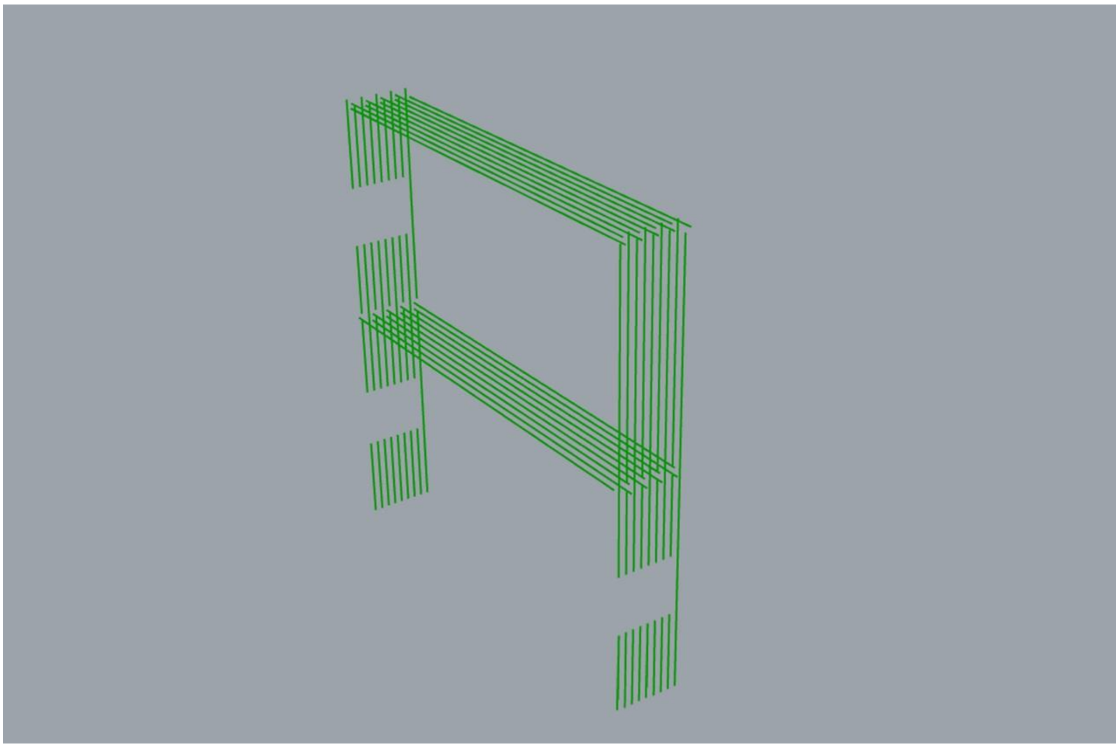



**Fig. 4-14 Unit B designed in grasshopper.**



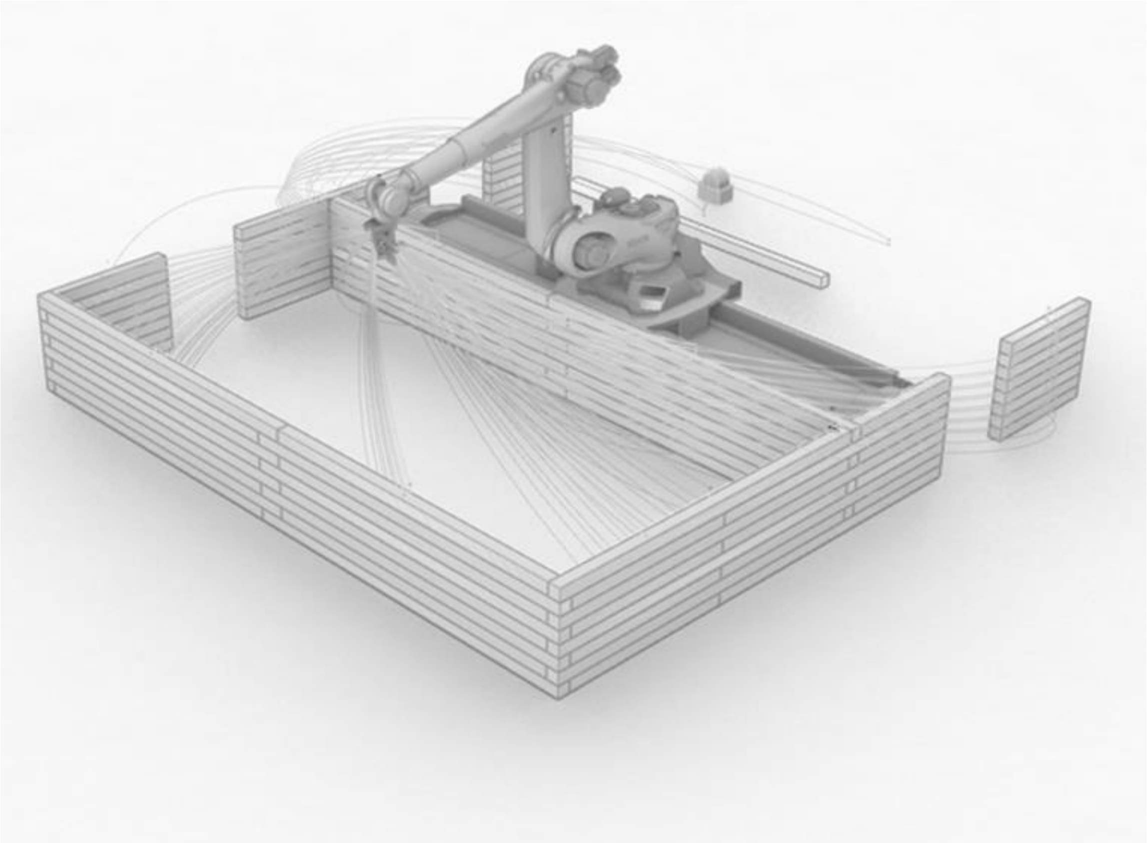


**Fig. 4-15 Unit B model in grasshopper.**

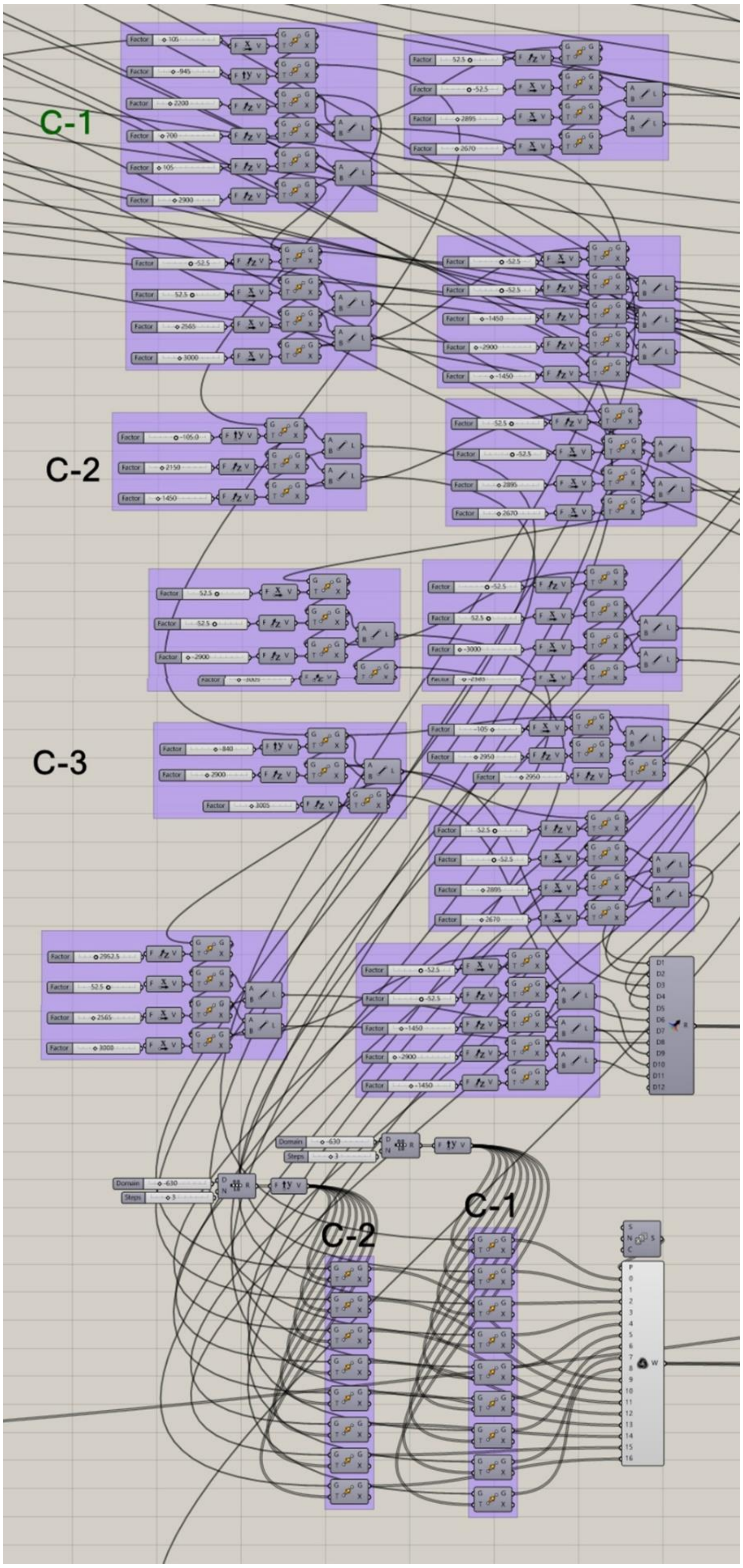



**Fig. 4-16 Unit C designed in grasshopper.**

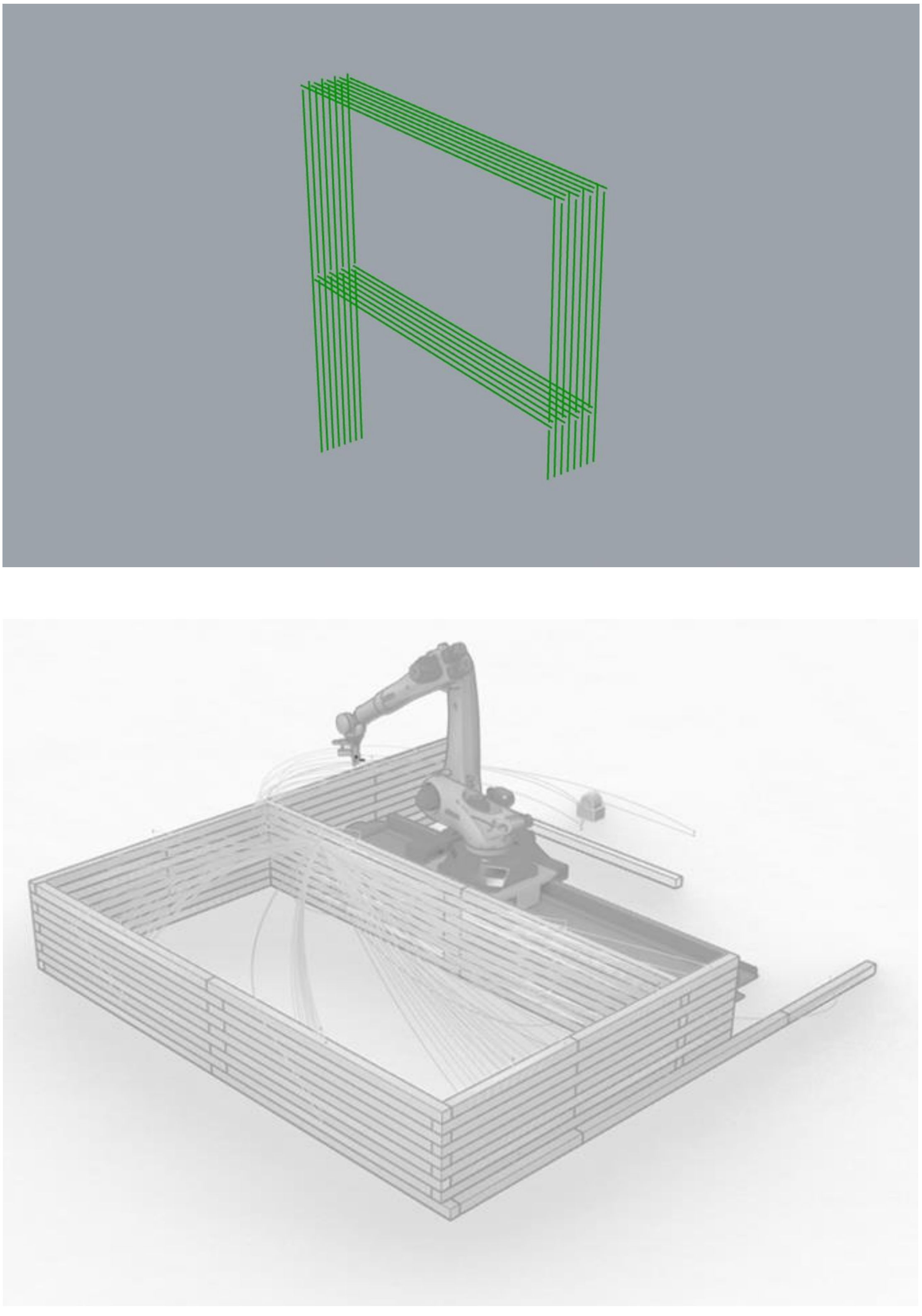


**Fig. 4-17 Unit C model in grasshopper.**

The unit A/B/C combination mode is similar, and the main components of each unit are alternately spliced in two sets of stitching forms. These three units contain the side doors and some windows of the building, belonging to the rear half of the building. This part of the building space is divided into upper and lower floors, with slabs separated in the middle, as shown in from Figure 4-12 to Figure 4-17.

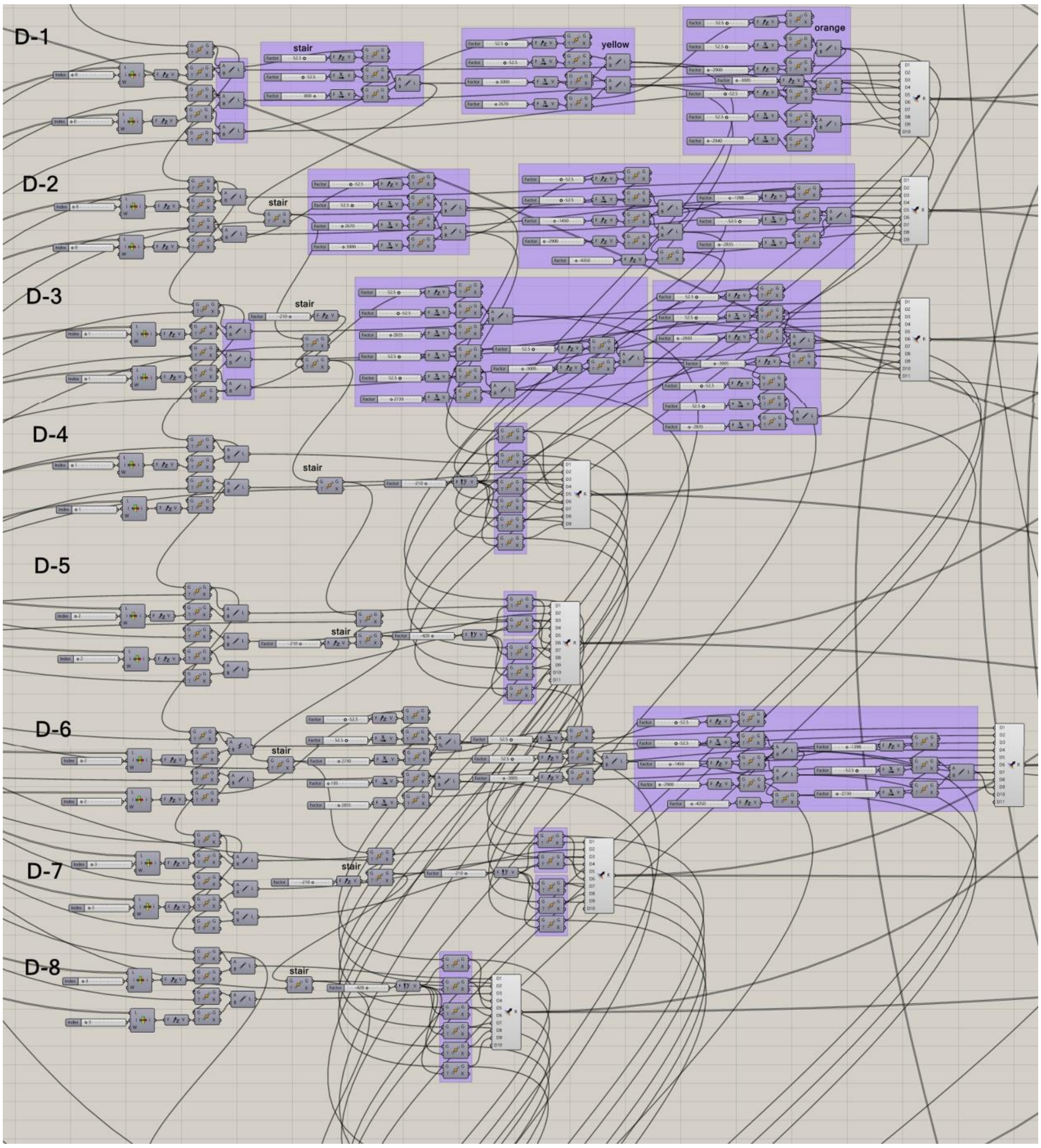



**Fig. 4-18 Unit D designed in grasshopper.**

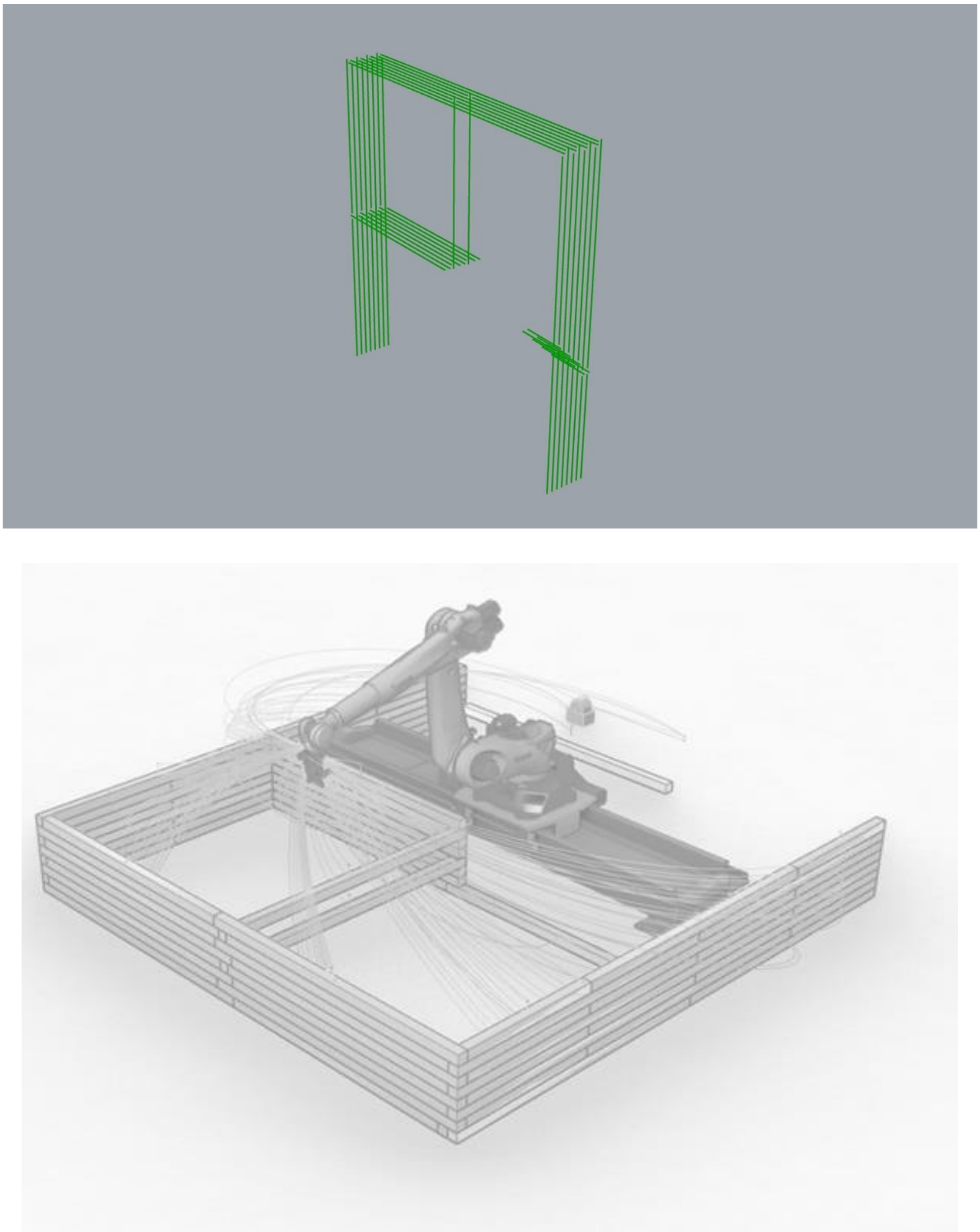


**Fig. 4-19 Unit D model in grasshopper.**

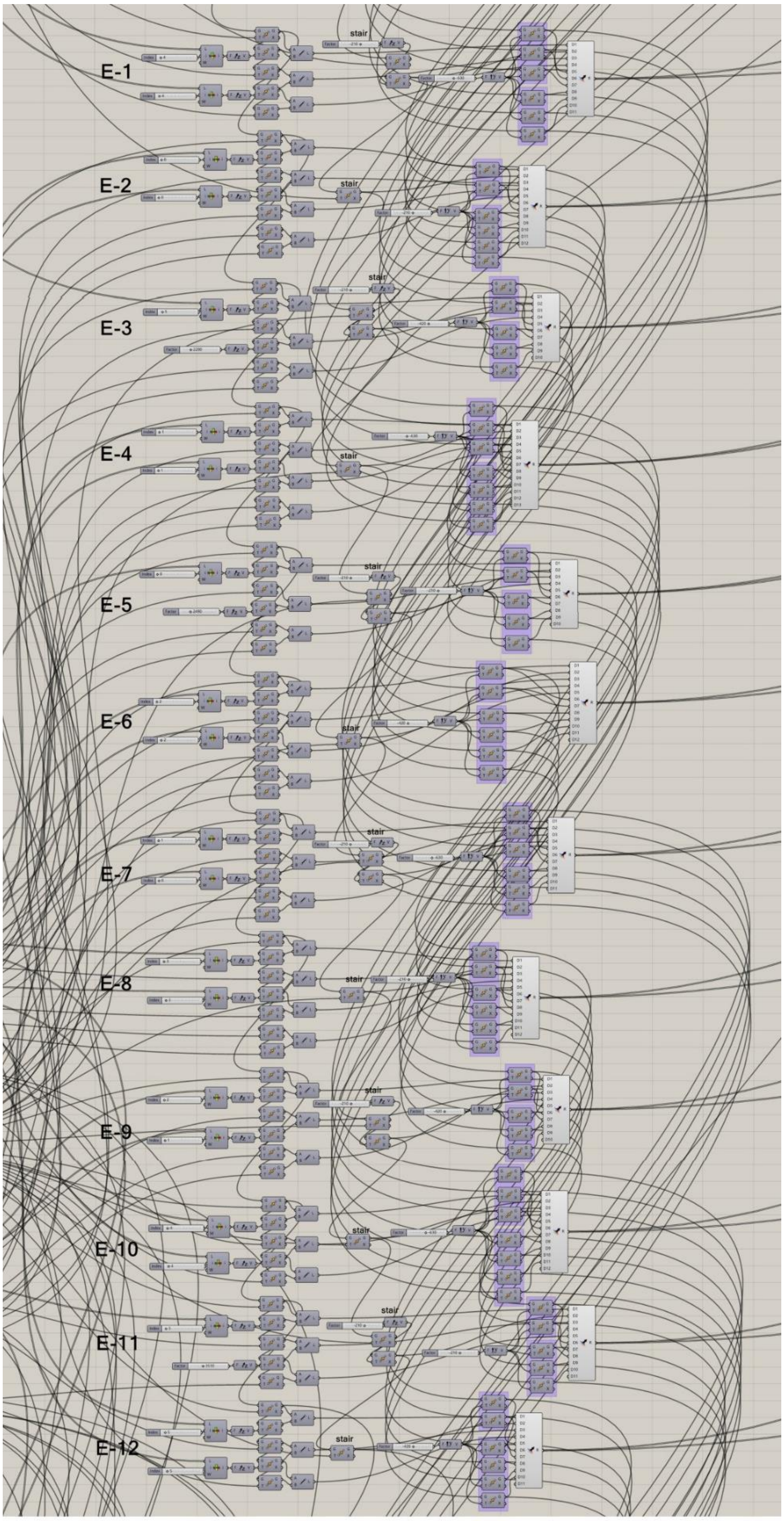
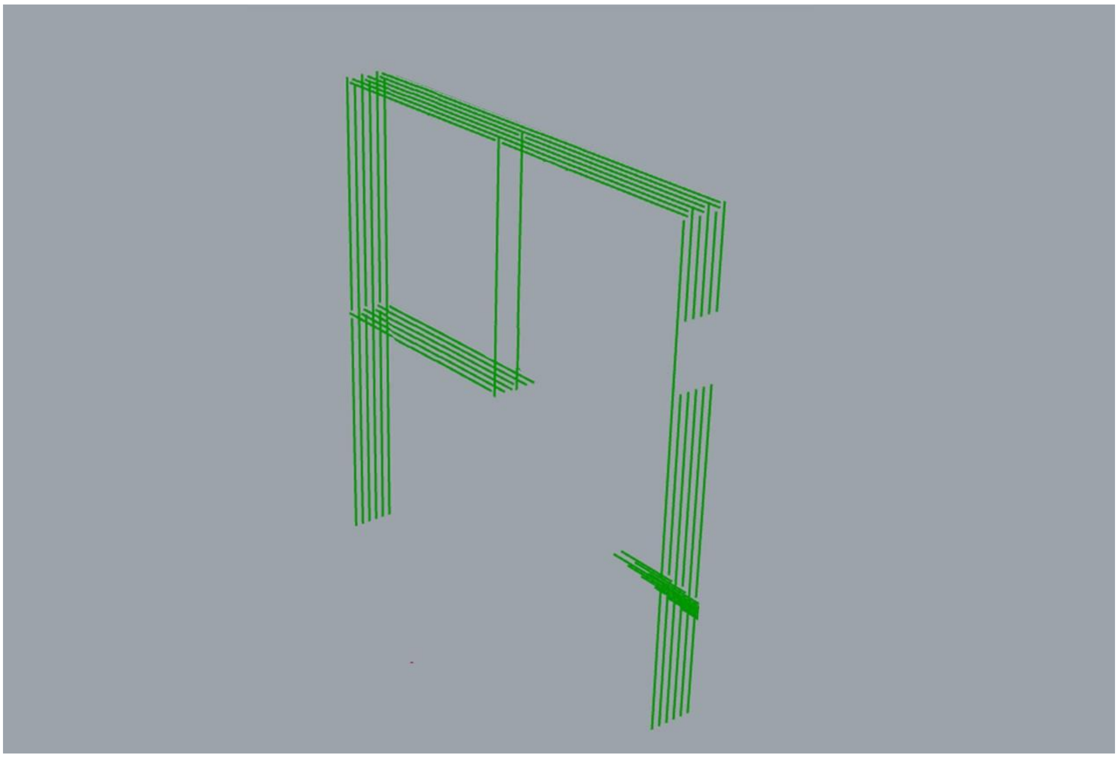



**Fig. 4-20 Unit E designed in grasshopper.**



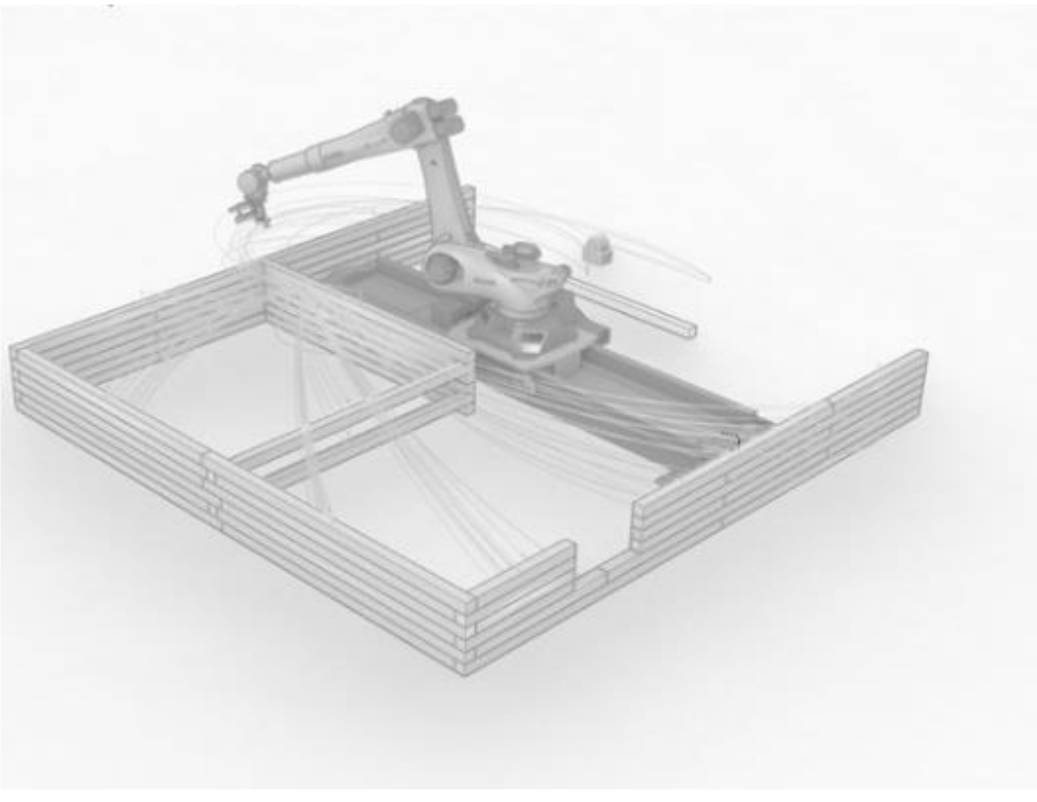


**Fig. 4-21 Unit E model in grasshopper.**

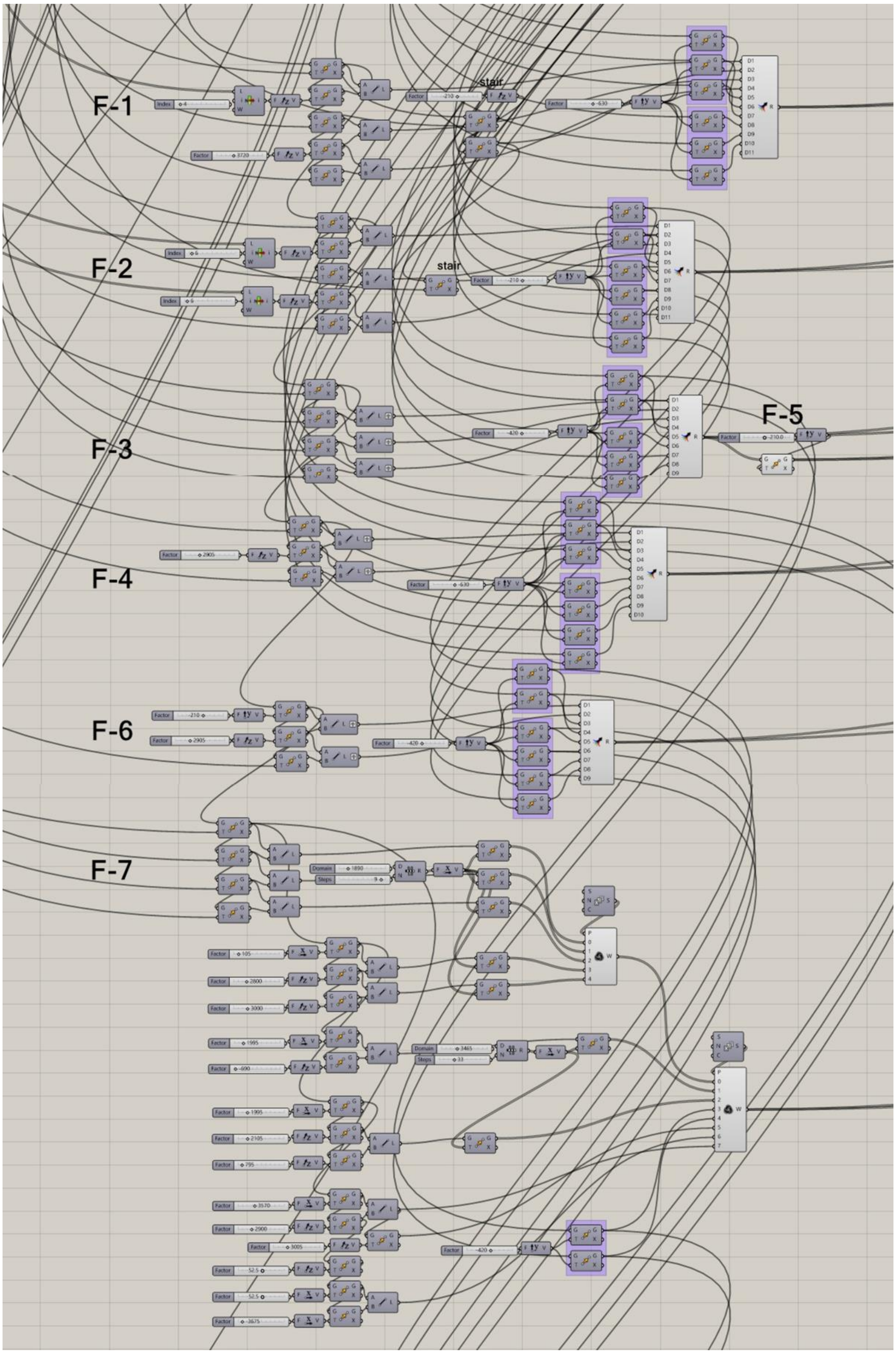
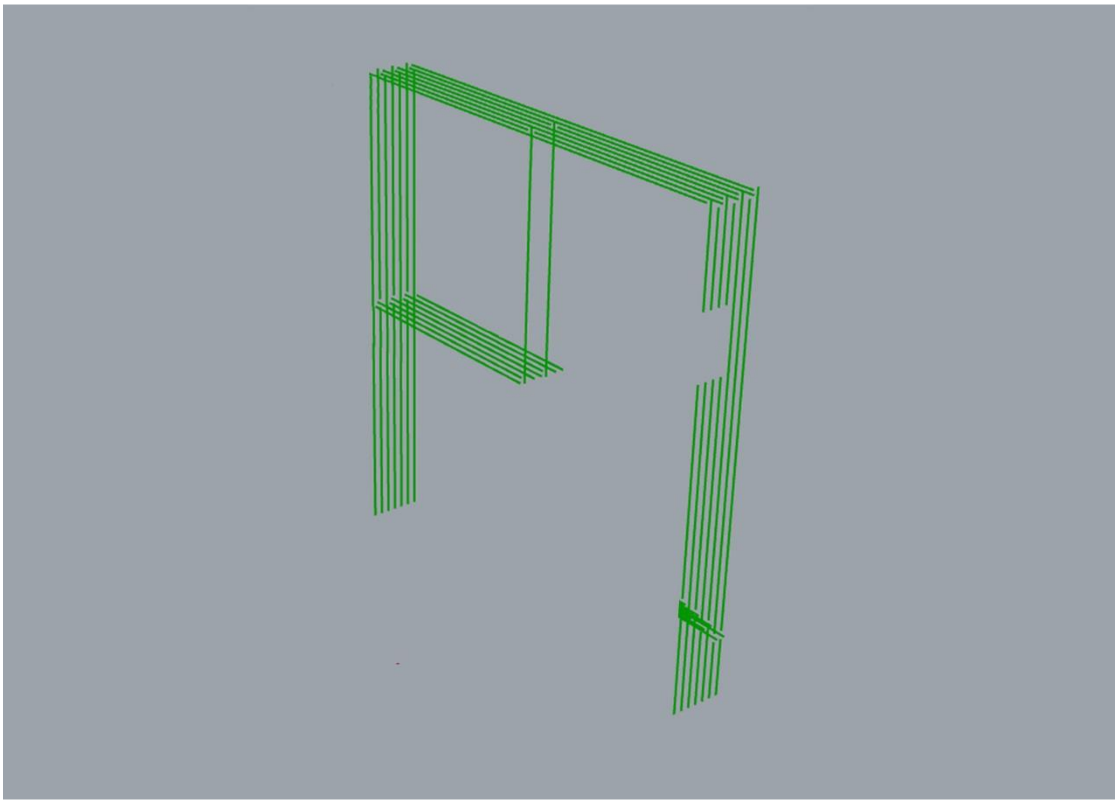



**Fig. 4-22 Unit F designed in grasshopper.**



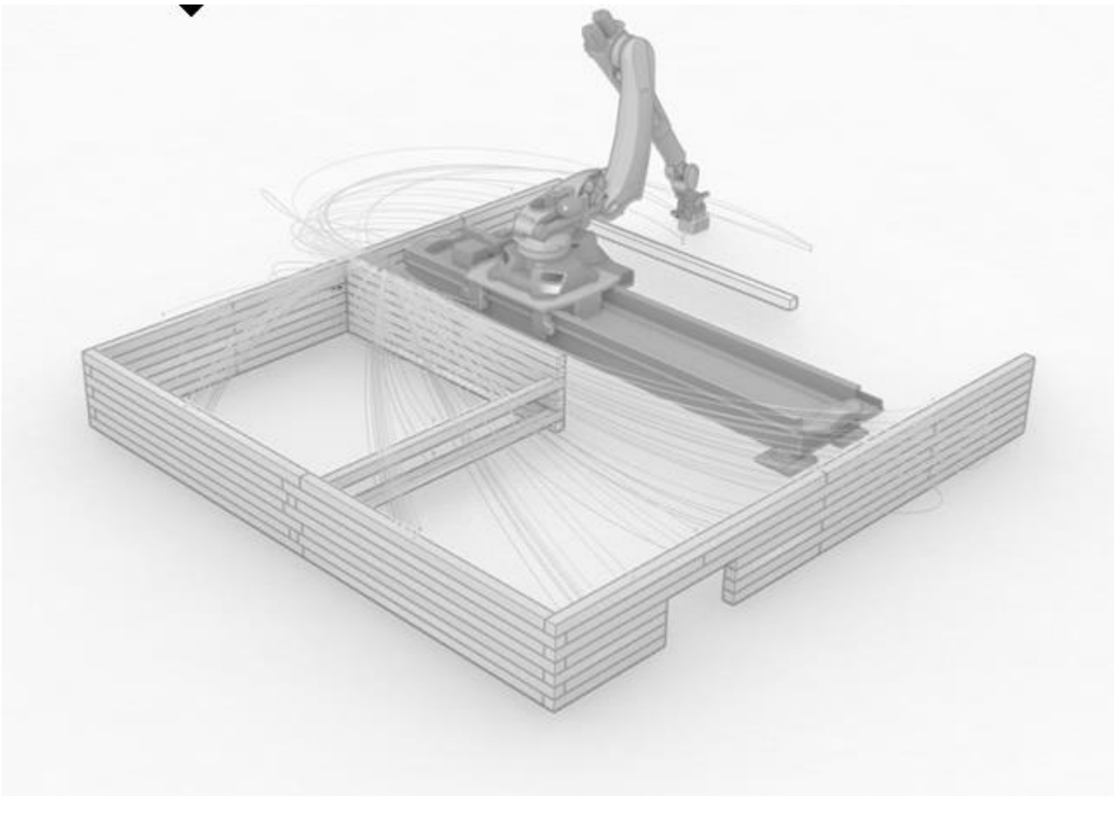


**Fig. 4-23 Unit F model in grasshopper.**

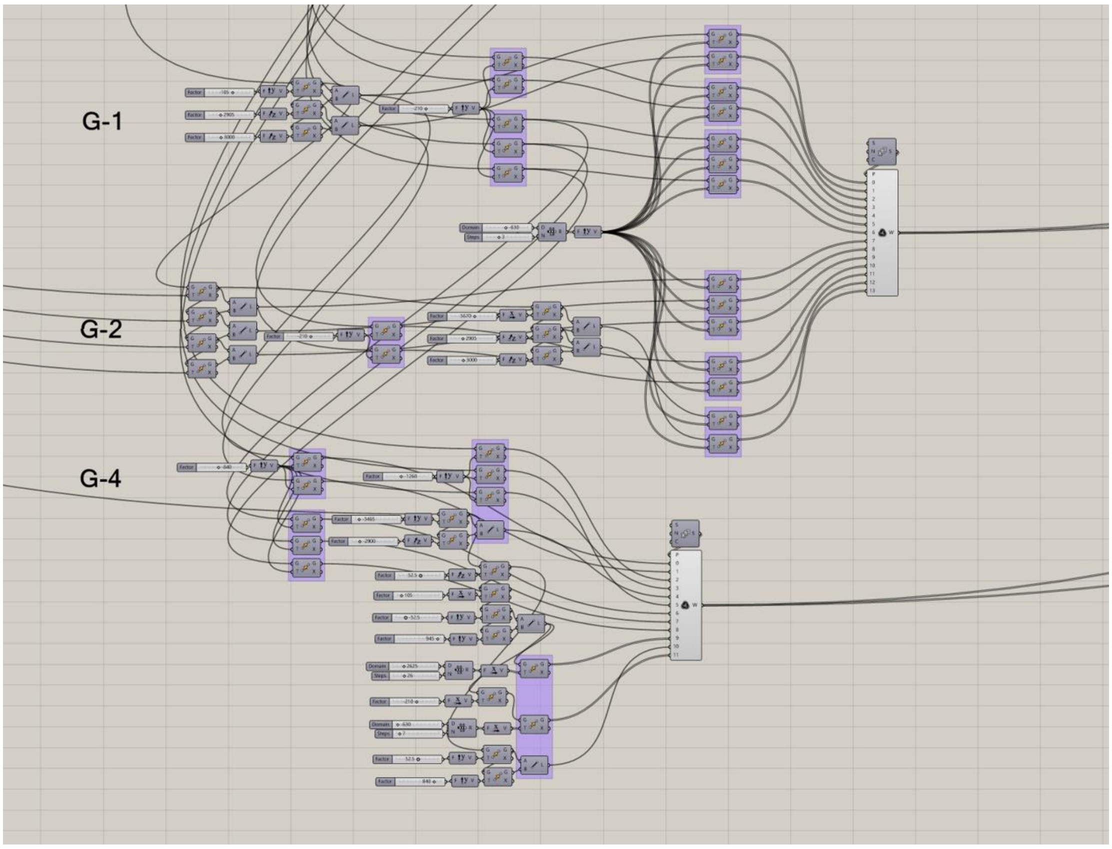
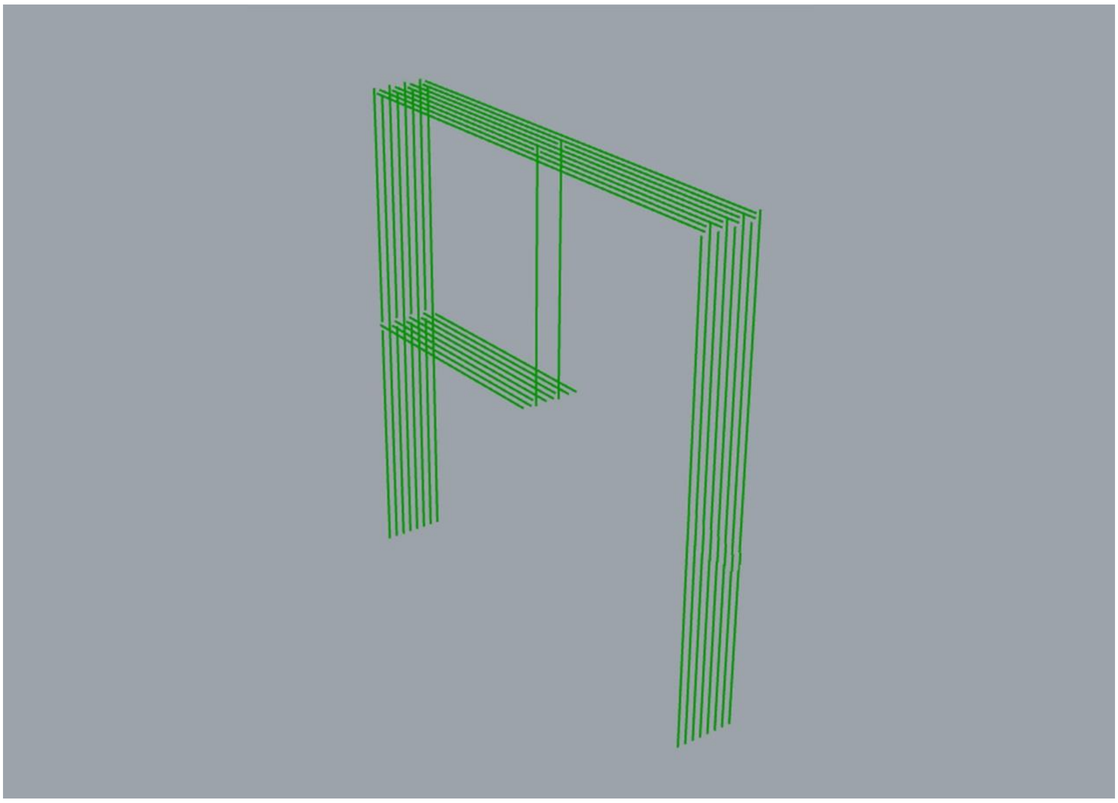



**Fig. 4-24 Unit G designed in grasshopper.**



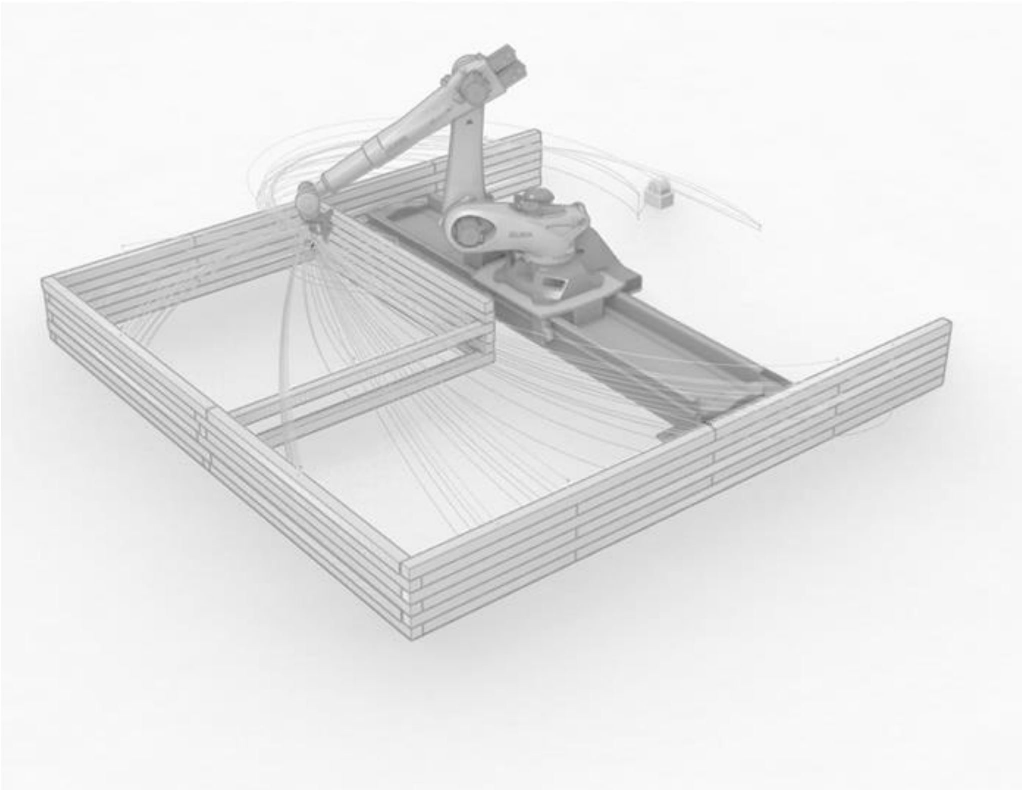


**Fig. 4-25 Unit G model in grasshopper.**

The next four units D/E/F/G, the connecting stairs between the first floor and the second floor on the west side wall of the building. As a result, each unit module on the west side wall surface is different, and the repeated weaving cannot be performed regularly. Therefore, the three units cannot weave the same modular unit regularly like the previous unit and need to be stitched one by one, as shown in from Figure 4-18 to Figure 4-25.

The stair step height is 42mm, and each step width is two module unit widths, which is 42mm. In the process of digital modelling with grasshopper, the law of stair construction can be used to build this staircase with an arithmetic progression. This is also a bit more convenient for digital modelling software than traditional modelling software.

Not only is the staircase modular, but the upper and lower timbers that are connected to the stairs are also modular in length and can be quickly modelled using the arithmetic progression.

**4.3.4. Robot construction steps**

The purpose of using robots in the construction field is to minimize the amount of manual use in the construction process. Four steps are replaced: pick timbers; Glue; place timbers and nail.

Pick: Throughout the robot building process, the robot arm grasps the timber as the first step, and the grasping point set in the robot construction program is the midpoint of the timber. This step requires an operator to provide the timber in real-time and to position the midpoint of the timber at the gripping point of the robotic end-effector, as shown in Figure 4-26 to 4-28.

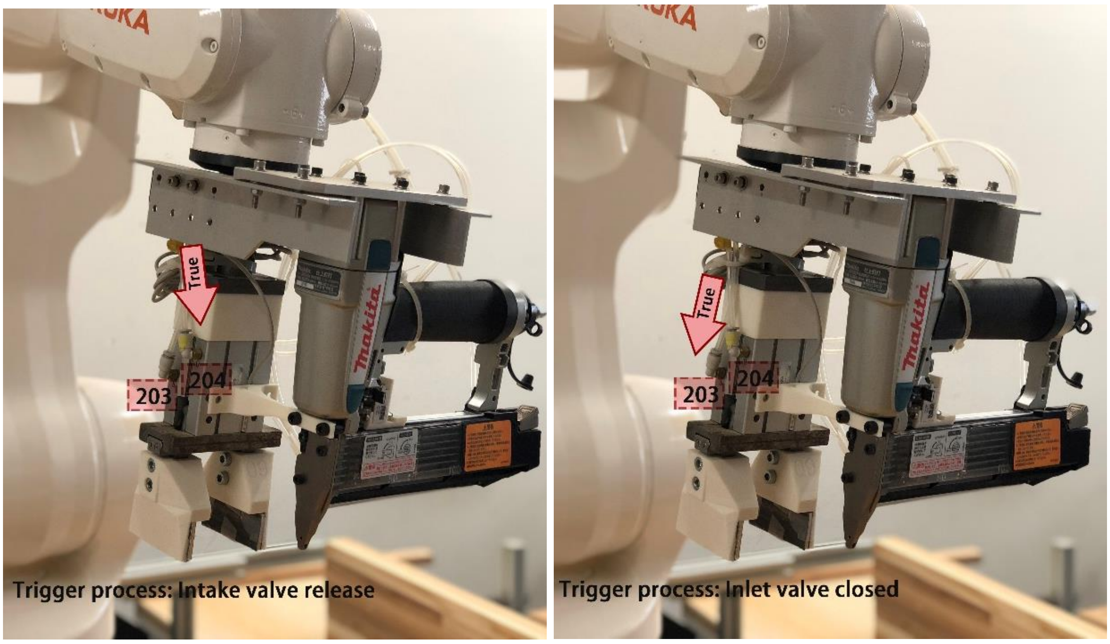



**Fig. 4-26 Implementation process of program operated gripper.**

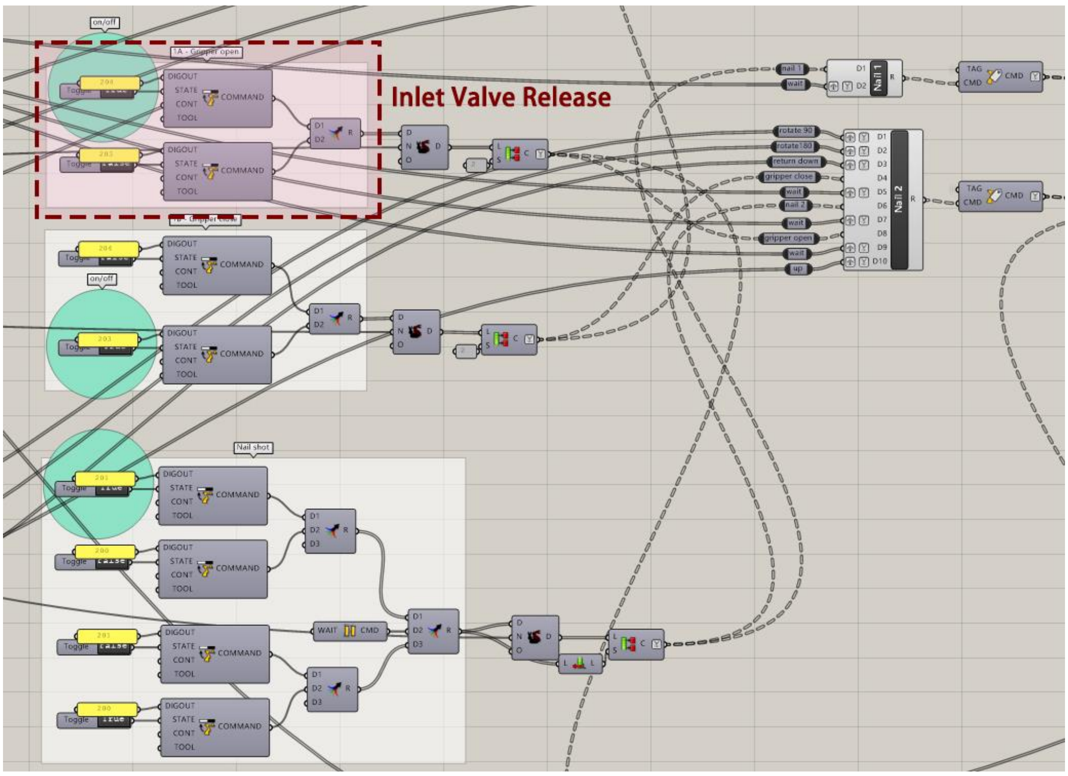



**Fig. 4-27 Procedure for releasing valve of gripper in grasshopper.**

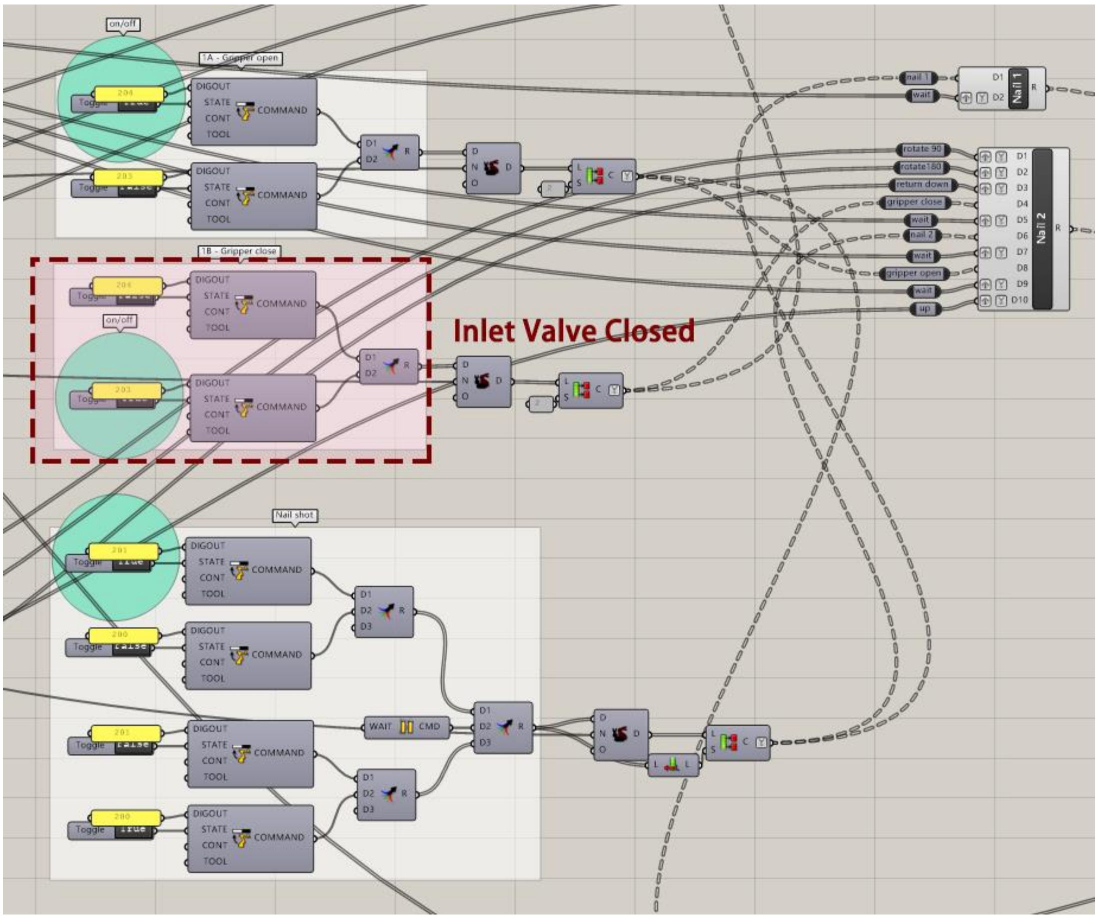



**Fig. 4-28 Procedure for closing valve of gripper in grasshopper.**

Glue: The connection between the timber is made using an adhesive connection and a nail joint connection, both of which are performed by a robot. The device for the adhesive connection is a glue box, which consists of a box filled with waterborne polymer wood adhesive and a roller on which the glue can be picked up. The robotic end-effector grips the timbers, and its trajectory is along a line segment with the uppermost side of the roller as the midpoint. The length of the glue smear is the longest length of the timbers used in the construction, thus ensuring the effective length of each stick t, as shown in Figure 4-29.

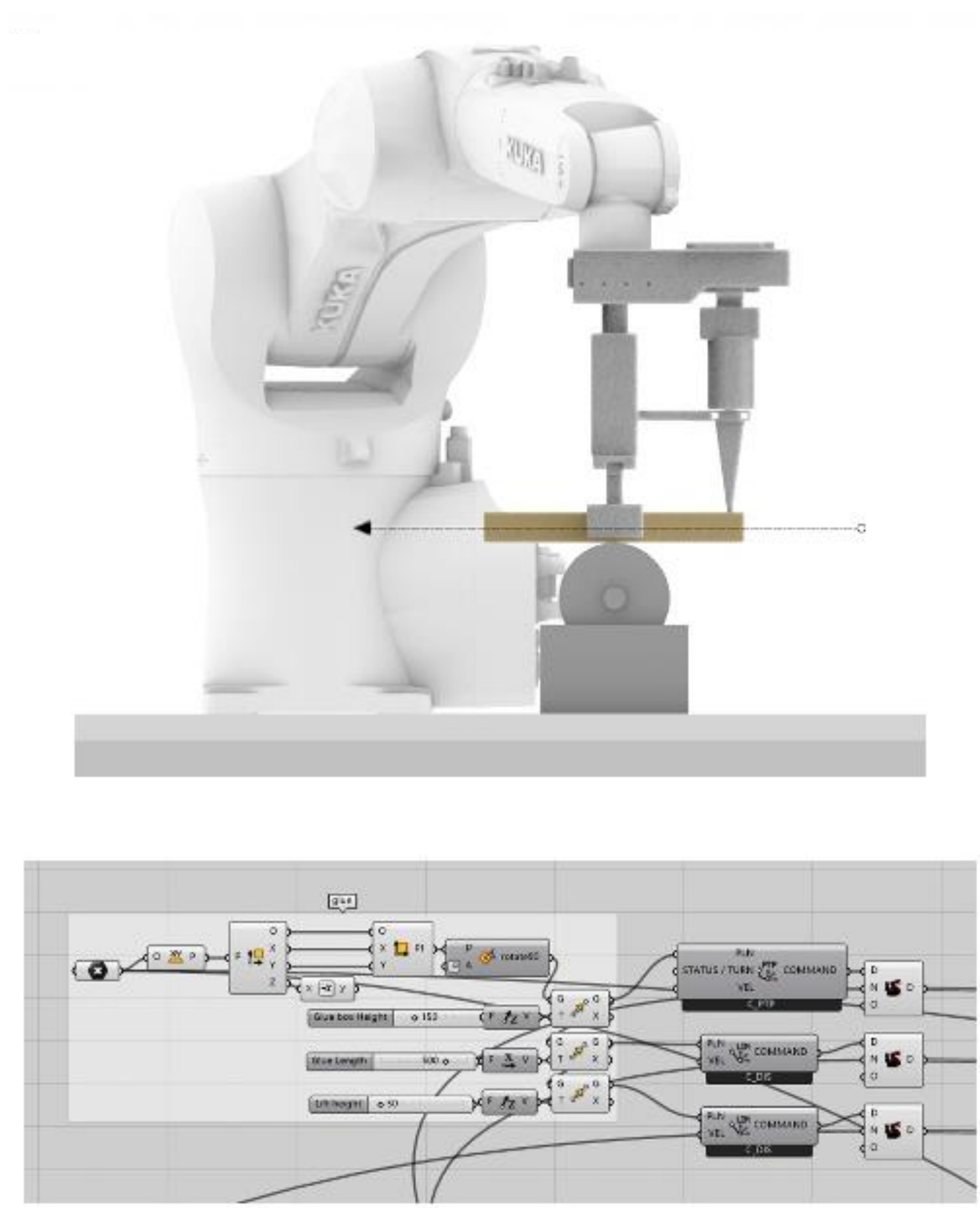



**Fig. 4-29 Robot construction step: glue.**

The first layer of each unit does not need to be coated with glue, so the program should be set up to separate the first layer of each unit from the other layers and implement different construction steps, as shown in figure4-30.

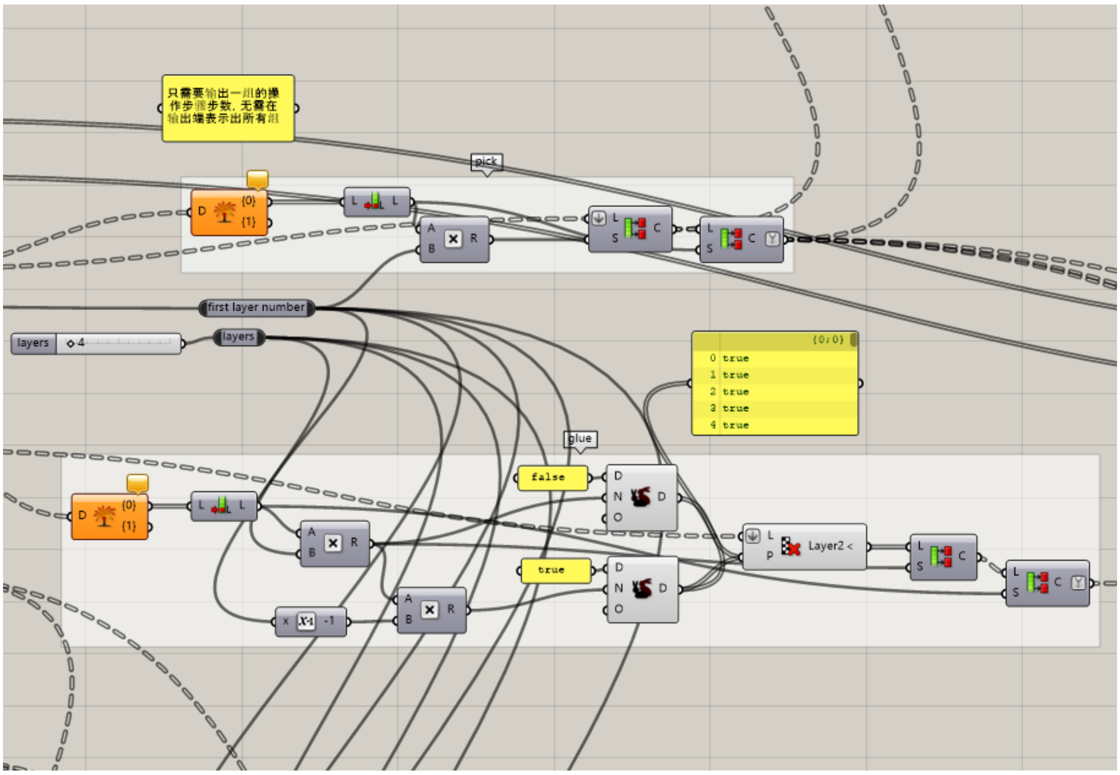



**Fig. 4-30 Divided in grasshopper the first layer of each unit.**

Nail: The robotic end-effector also incorporates an air nail gun that fires nails longer than the width of the timber. When the air nail gun fires the nail, the timber is placed in the set position and the gripper remains in the timber's gripping position. When nailing to the other side, the robot A6 axis rotates 180 degrees and then performs the same operation t, as shown in Figure 4-31. The first layer of each unit does not have the glue and nail step.

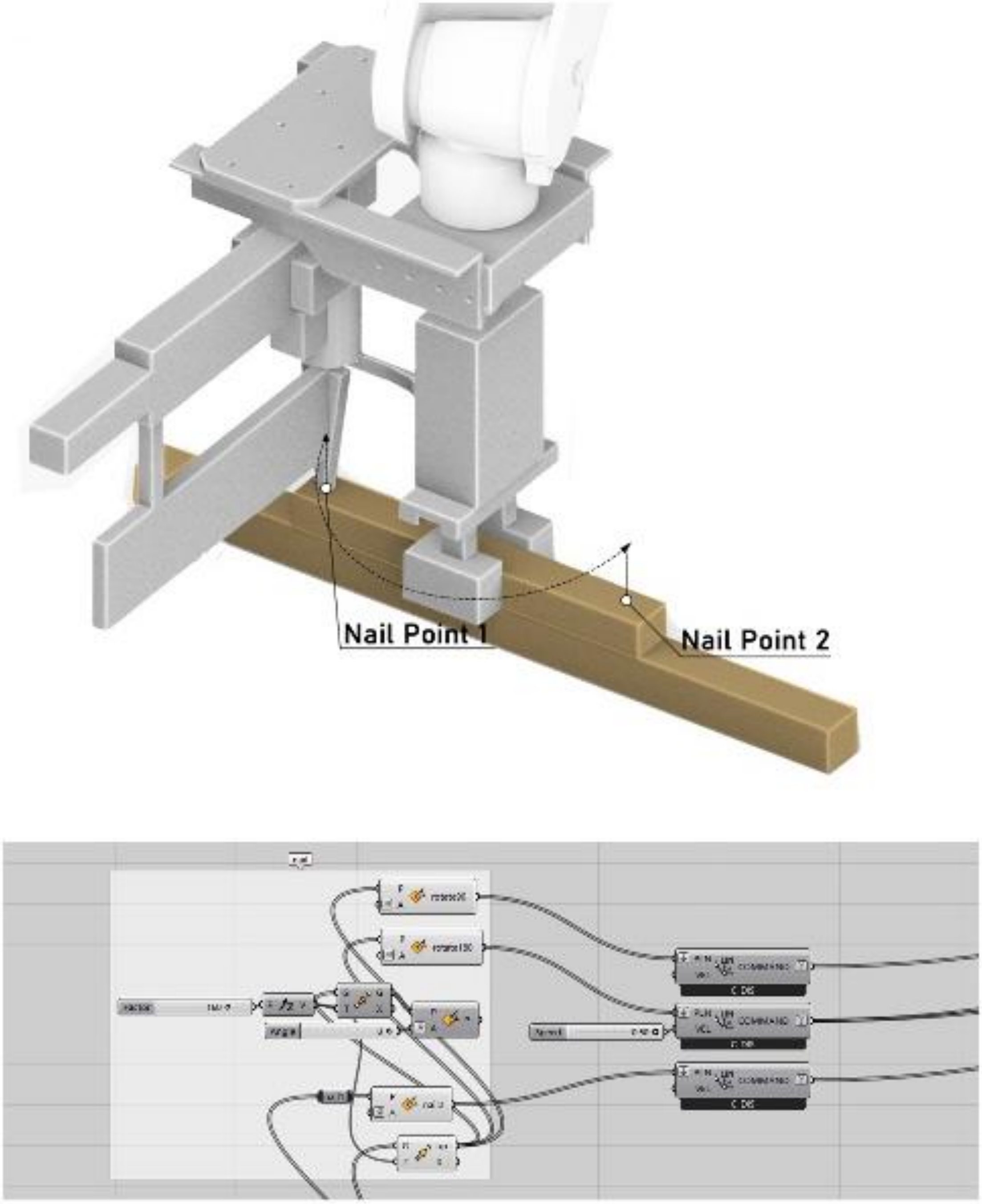



**Fig. 4-31 Robot construction step: nail.**

The nailing process mainly relies on the program to intervene in the trigger of the air nail gun, as shown in the Figure 4-32 to 4-34, the air nail gun has two channels of air intake and air release, when the 200 air release channel is opened, the air nail gun valve is opened and the nail gun starts nailing. When the 201-air inlet channel is opened, the valve is closed and the nail gun stops nailing. This a process to complete a nail.

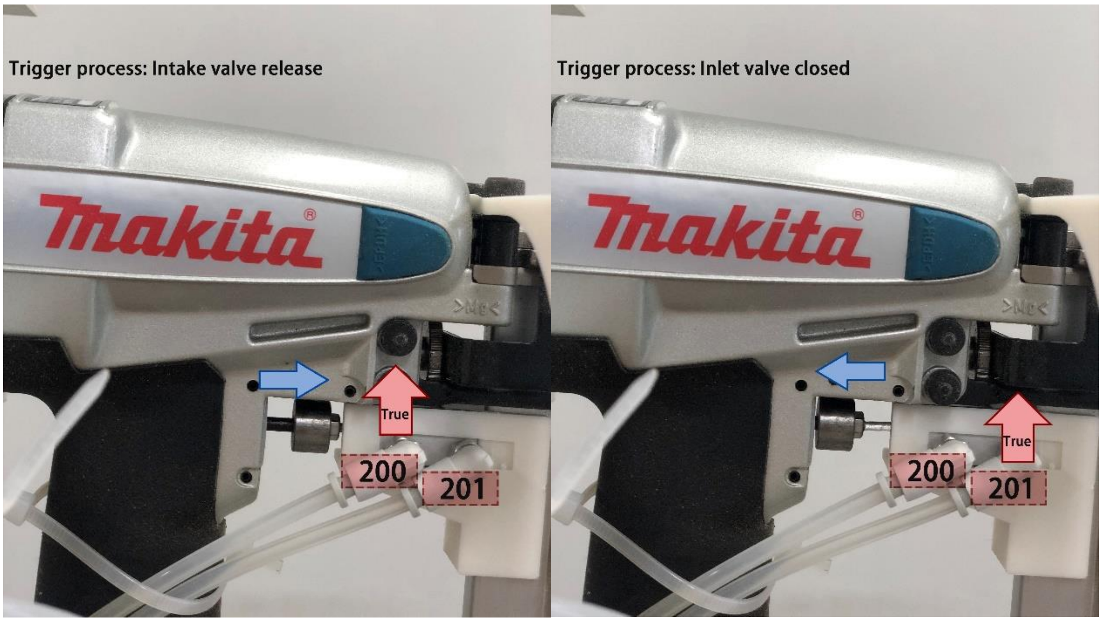



**Fig. 4-32 Implementation process of program operated air nail gun.**

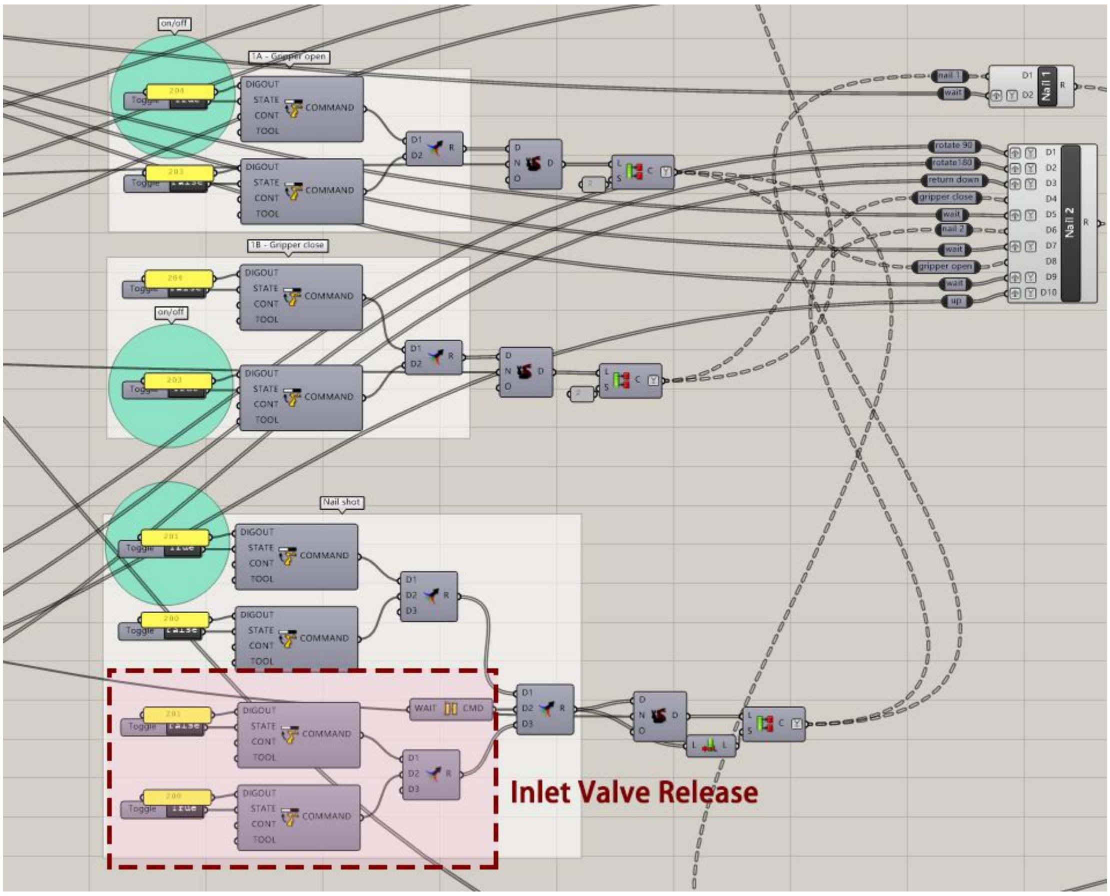



**Fig. 4-33 Procedure for releasing valve of air nail gun in grasshopper.**

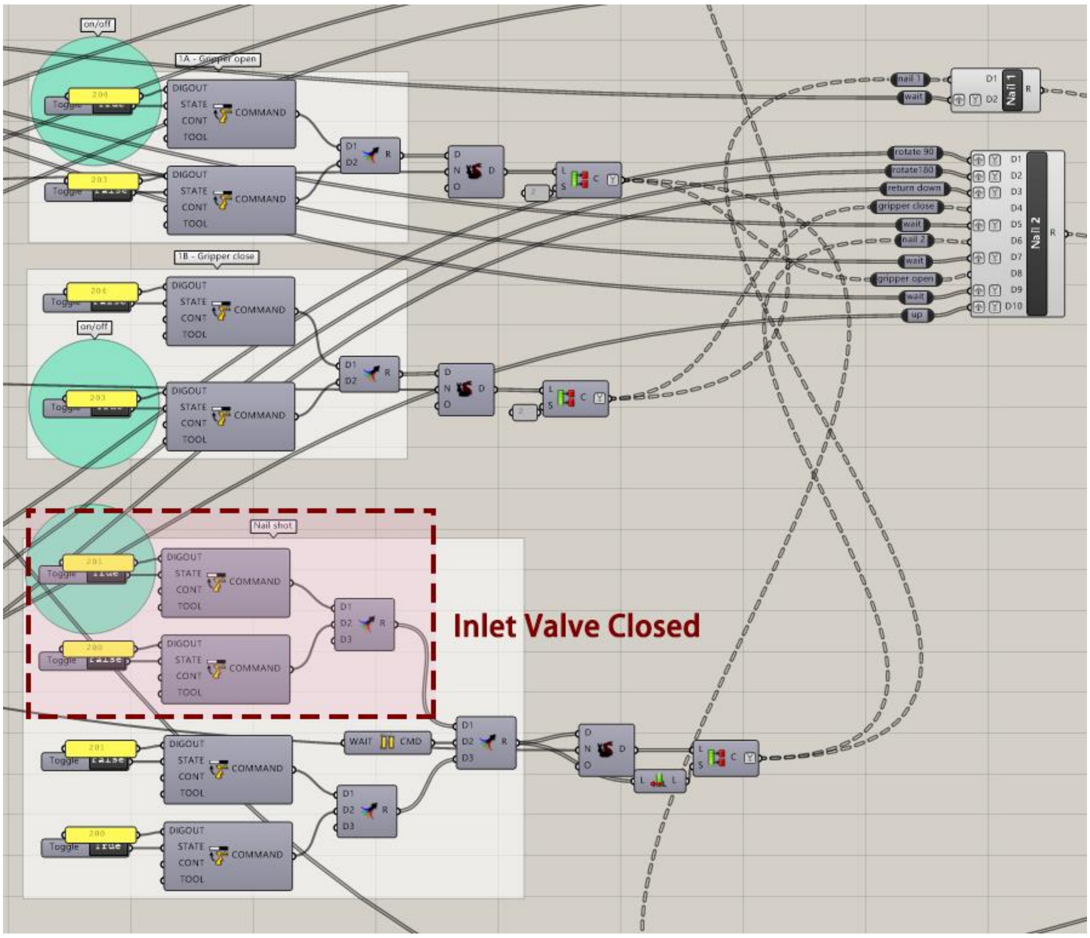



**Fig. 4-34 Procedure for closing valve of air nail gun in grasshopper.**

Place: In this step, to prevent the timber from colliding with the surrounding timbers in the process of placing, the motion path of the robot arm cannot be the LIN movement method of straight-line motion between two points but needs to be the PTP+LIN movement method through the main rotation of the fifth axis of the robot, as shown in Figure 4-35.

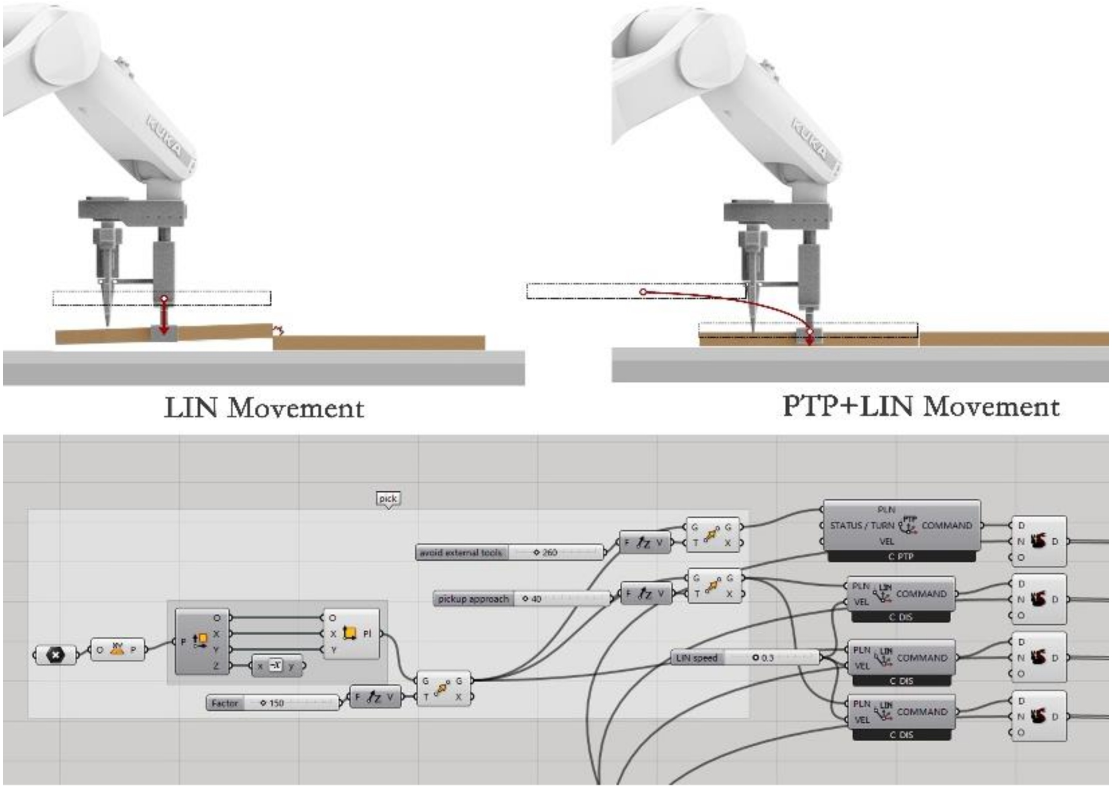



**Fig. 4-35 Robot construction steps: pick and place.**

It is important to note that the building is divided into 7 units to complete the construction of individual units, each unit of the first layer of timbers do not need to apply glue and nailing steps, so the first layer of the construction process is different from the other layers, here you need to deliberately separate the first layer only to carry out the pick and place procedure, as shown in Figure 4-36.

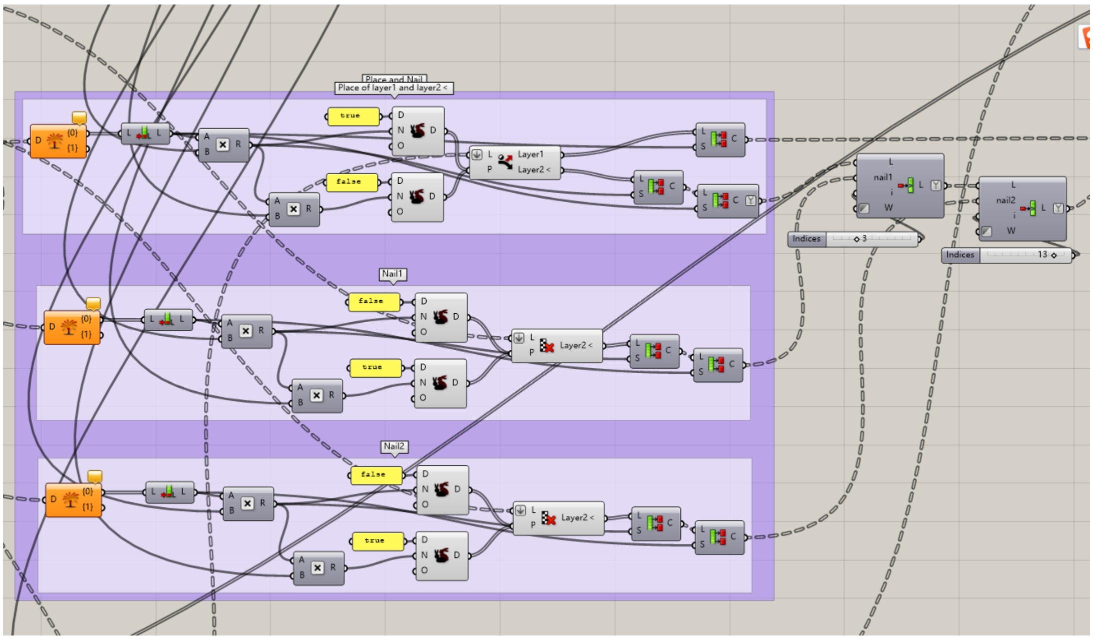



**Fig. 4-36 Separate out the first layer of each unit in grasshopper.**

After completing the program instructions for each construction task, each step needs to be merged into an orderly collection of instructions in accordance with the specific operating procedures at the time of construction to facilitate the subsequent provision of task instructions to the robot, as shown in Figure 4-37.

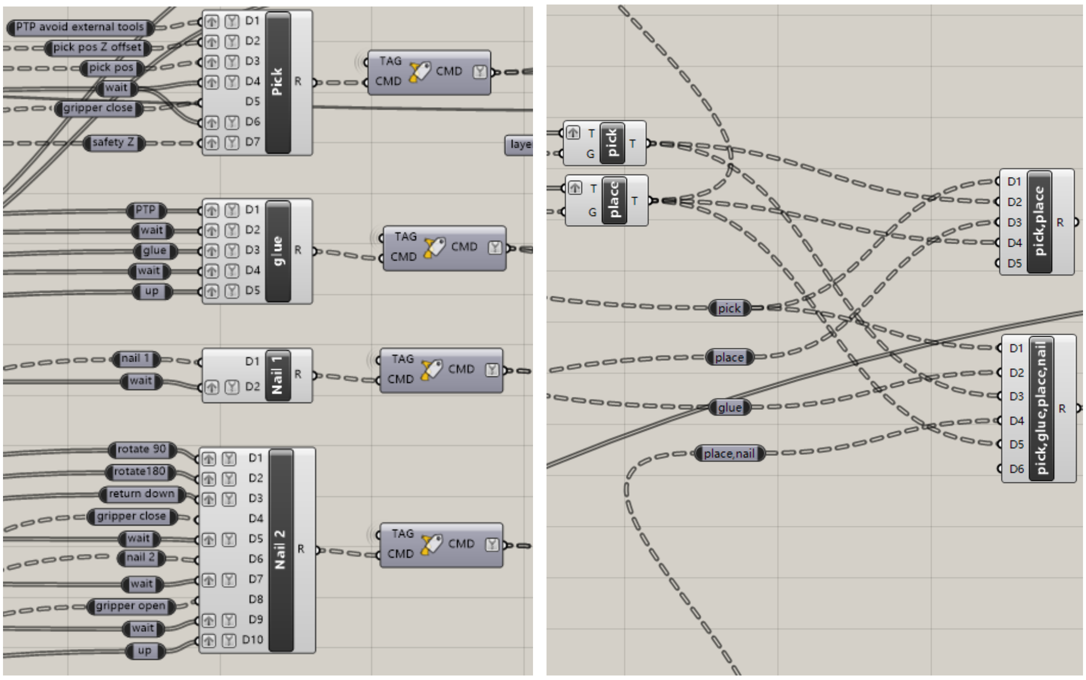



**Fig. 4-37 Construction steps need to be merged into an orderly collection of instructions.**

### 4.3.5. Error correction

Because the accuracy of gripper jaws manufactured by robotic installation or 3D printing is not necessarily high, it was necessary to fine-tune the toolpath to match the error of the final experimental system constructed before this experiment. Therefore, the placement plane at the TCP position during placement was rotated according to the measured error, as shown in from Figure 4-38 to Figure 4-40.

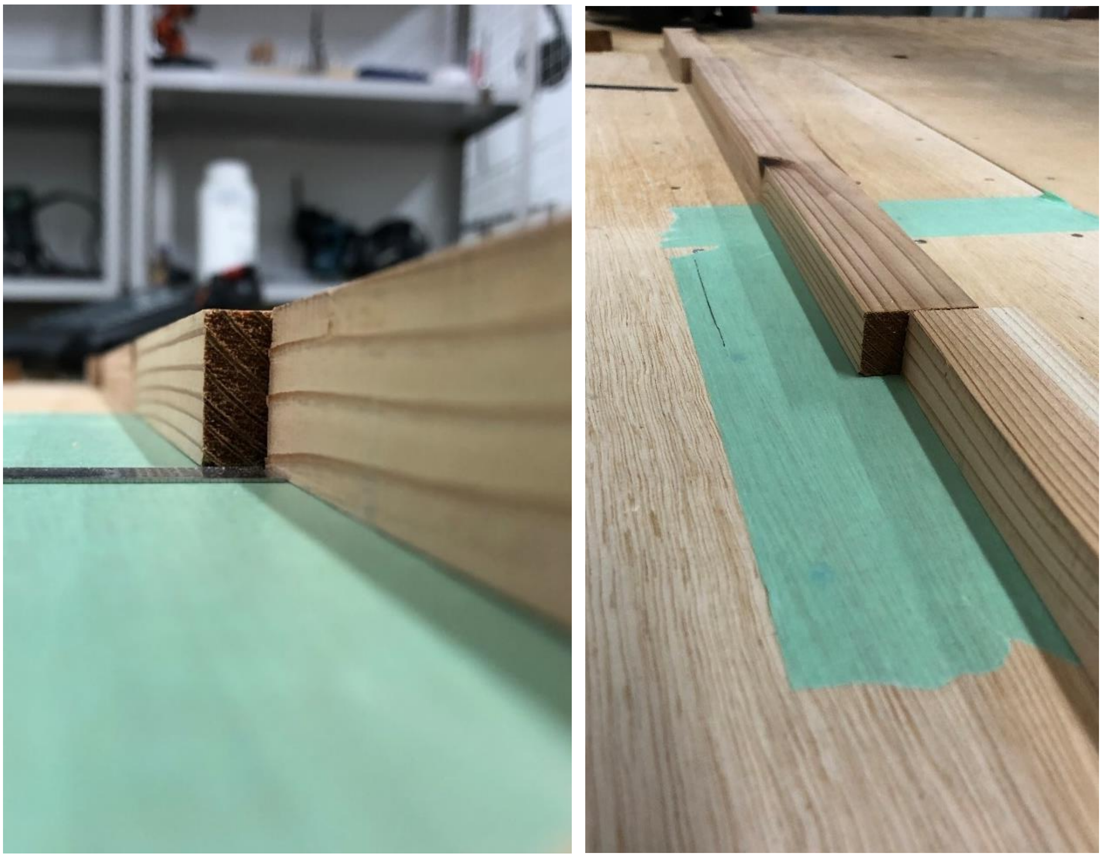


**Fig. 4-38 Errors in the construction process.**

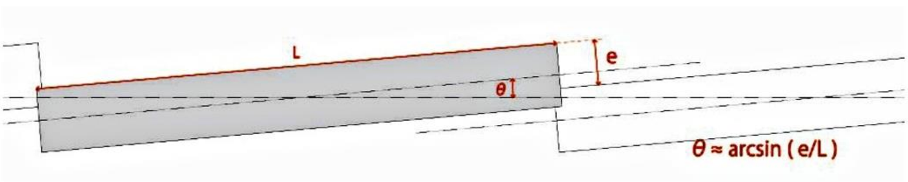



**Fig. 4-39 Principle of correction error.**

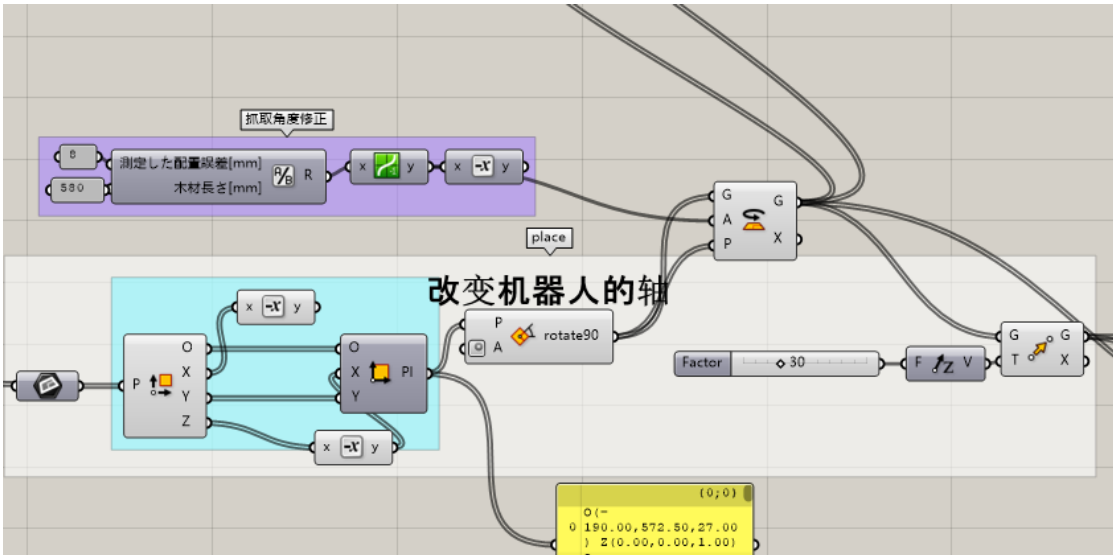



**Fig. 4-40 Procedure for correction of errors in grasshopper.**

### 4.3.6. Data Export

Before the data can be exported, the task commands need to be merged and "add tool off" added to the last line of the command, as shown in Figure 4-41.

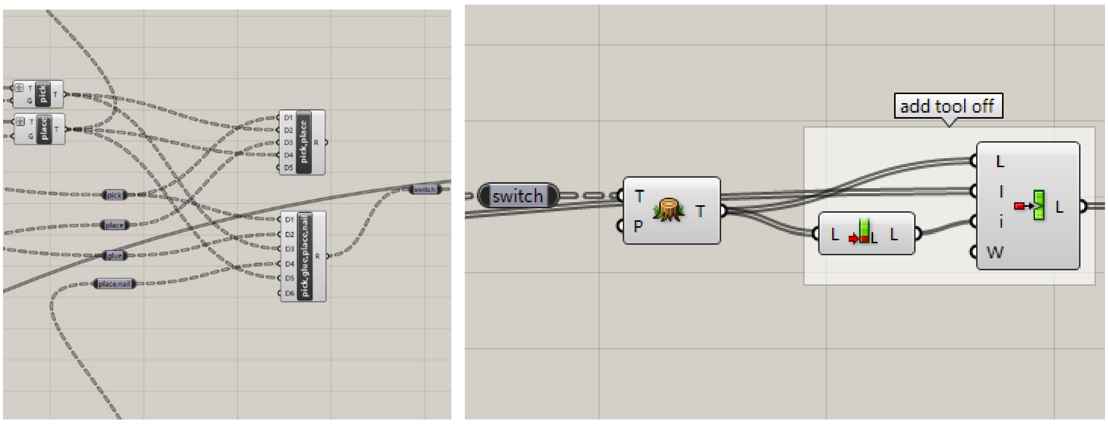



**Fig. 4-41 The command of “add tool off”.**

Before analyzing and exporting the construction data, basic settings of the robot and tool head should be completed first, and the parameters suitable for this test should be adjusted before proceeding to the next valid data export, as shown in Figure 4-42 and Figure 4-44.

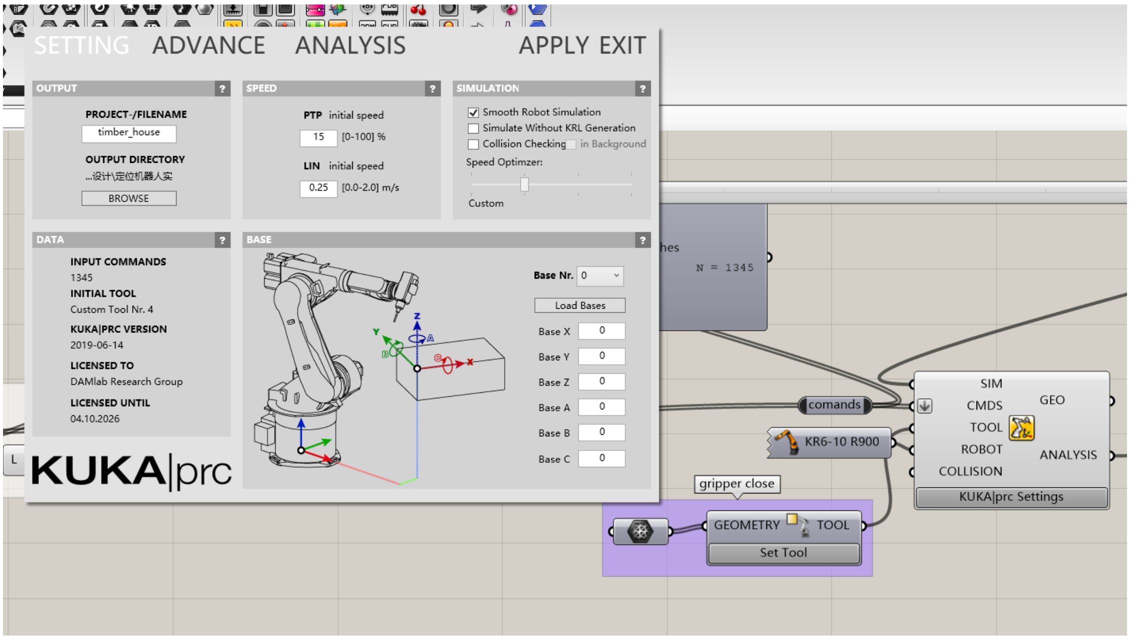



**Fig. 4-42 KUKA | prc settings.**

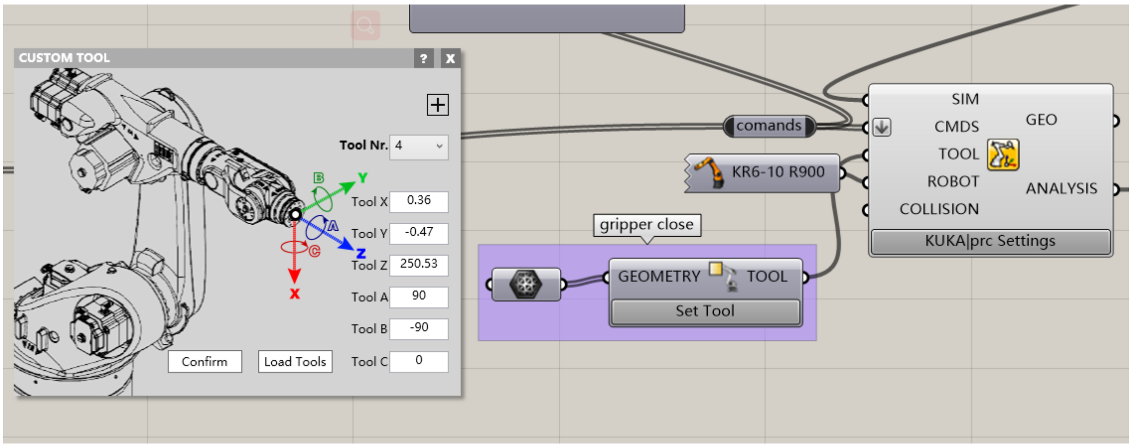



**Fig. 4-43 Set tool in grasshopper.**

The most important data to be verified in this experiment is the construction time in order to compare it with the real construction time and thus verify the accuracy of the simulated time in the program. The displayed time can be directly expressed as minutes by calculation in grasshopper, as shown in Figure 4-44.

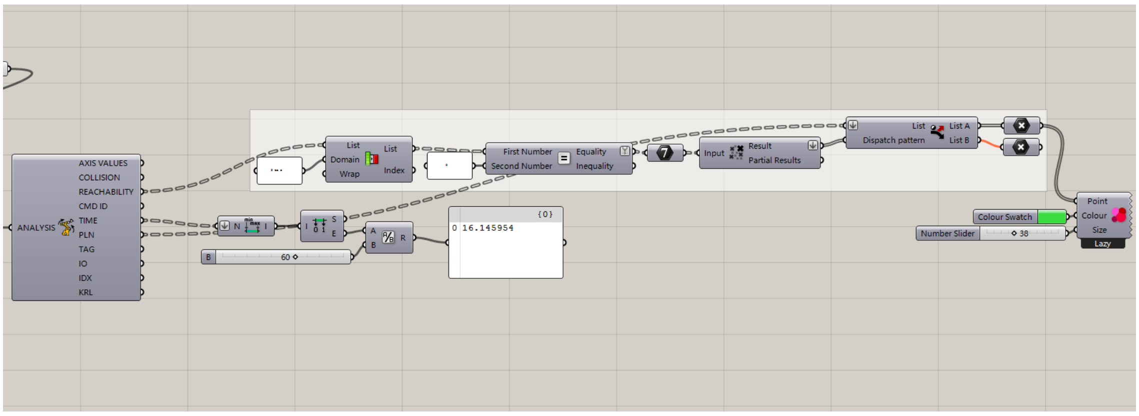



**Fig. 4-44 Procedure for correction of errors in grasshopper.**

### 4.4. Flowchart for fabrication control loop

The logic of robotic construction is the same as manual construction in that each unit is built separately in building order. Compared to manual construction, robotic construction requires the digital process of converting each step of the construction instructions into information that can be received by the robot through the software grasshopper. In this process, the robot receives the instructions and encounters problems in the process of on-site operation, which can be fed back to the computer to readjust the construction process, to ensure that the robot can complete the construction on site.

The following flowchart outlines this fabrication control loop, which controls the robotic nodes for accomplishing the building's fabrication as shown in Figure 4-45.

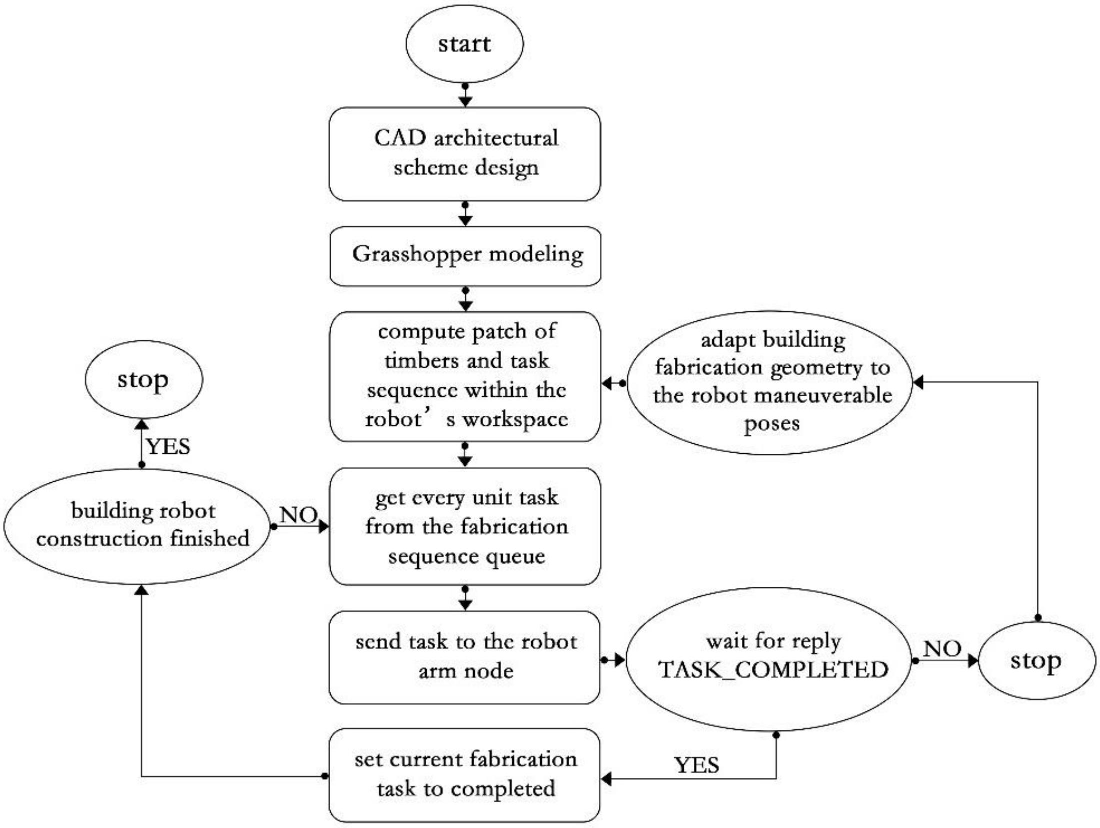



**Fig. 4-45 Flow chart for the timber building's fabrication control loop.**

### 4.5. Robot actual construction

The robot arm length in the laboratory is 900 mm, which is limited by its model and cannot be used for the 1:1 scale building construction in the previous simulation experiment. Therefore, the practical building experiment was built by the robot at a 1:5 scale of the original building. In grasshopper, reduce the size of the original model to 1/5, as shown in Figure 4-46. The practical construction used the same parametric construction tasks, and the robot received and performed the same construction tasks, aiming to verify the rationality and implement ability of the construction logic and procedures of the previous simulation experiment. Also, the rationality of the efficiency of the simulation experiment was verified based on the practical construction experiment time.

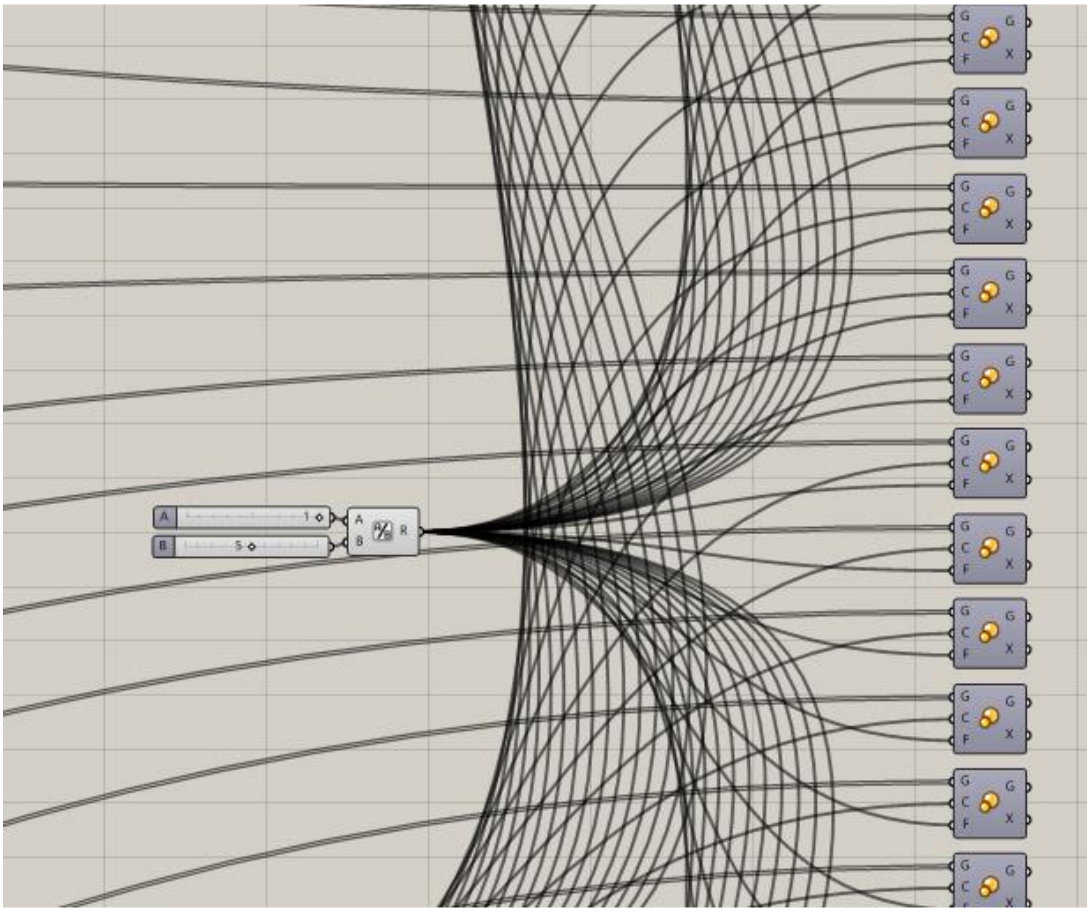


**Fig. 4-46 Reduction of the original model size to 1/5 in grasshopper.**

Below as shown in from Figure 4-47 to Figure 4-52 are photos of the construction process on site.

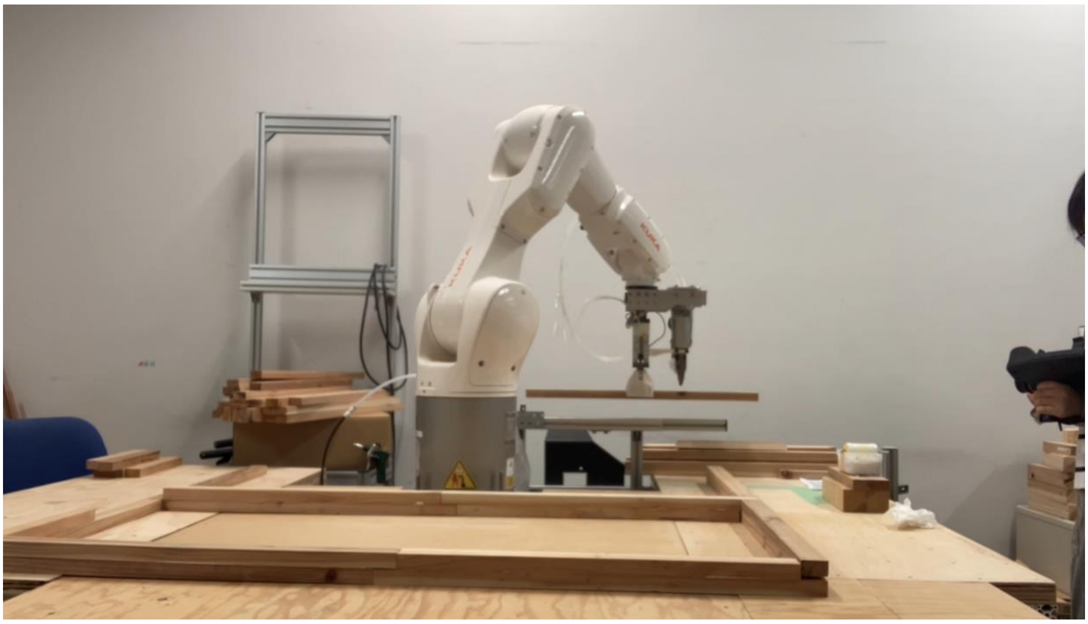


**Fig. 4-47 Live photos of robot picking action.**

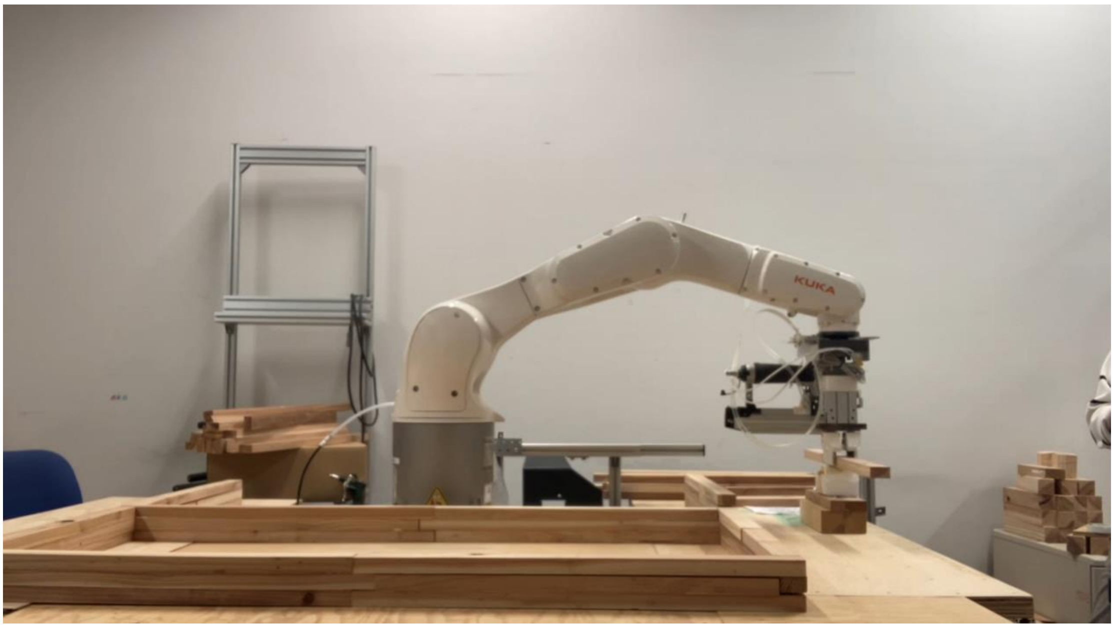



**Fig. 4-48 Live photos of robot nailing action.**

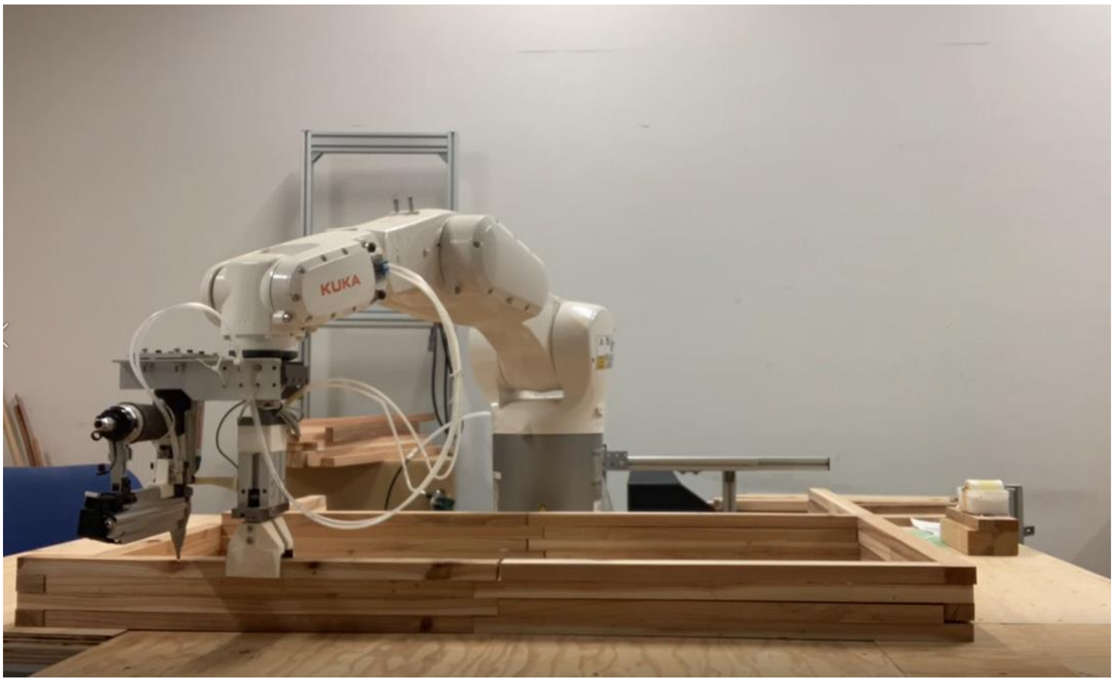



**Fig. 4-49 Live photos of robot nailing action**

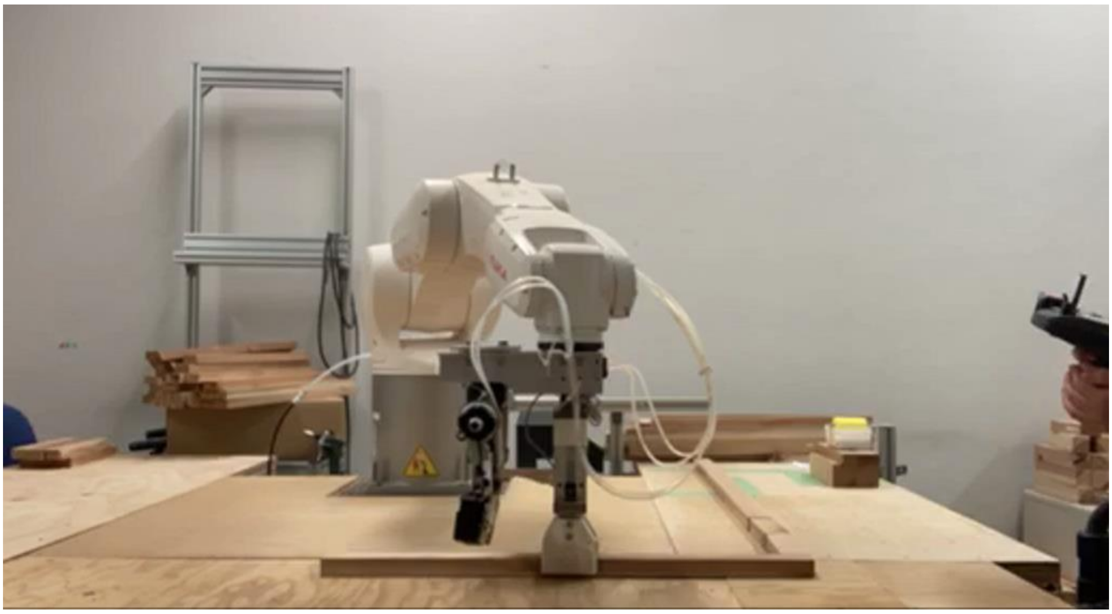


**Fig. 4-50 Live photos of robot placing action.**


**Fig. 4-51 Complete the construction of a unit.**


**Fig. 4-52 Complete the construction of a unit.**

As shown in Table 4-1, the construction time for each unit of the building is shown for two construction scales, due to the different construction scales, the construction time for the 1:5 scale practical construction is less than the construction time for the 1:1 scale simulation experiment under the same construction procedure, but the proportional the construction time difference between the simulation experiment and the practical construction is always within the range of 2.54-2.62, which is very stable, indicating that the construction time is relatively stable under the same parametric construction task, and it can be verified that the construction time measured by the equal proportional simulation experiment is similar to the real-time of the practical construction.

Table 4–1. The proportional construction time difference between the simulation experiment and the practical construction.

| Unit | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1:1 Scale Simulation Experiment Time (Min) | 89.8 | 105.9 | 94.8 | 87.8 | 67.0 | 77.6 | 64.7 |
| 1:5 Scale Practical Construction Time (Min) | 34.9 | 40.4 | 37.4 | 34.0 | 25.7 | 29.8 | 24.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| The proportion of construction time difference | 2.57 | 2.62 | 2.54 | 2.58 | 2.61 | 2.60 | 2.62 |

The accomplishments of the experiment can be summarized as follows: First, to design the digital construction parameters for the complete construction steps, optimize the movement of the robot arm to avoid collisions at the construction site, and enable the robot to complete the construction of wooden buildings independently, and verify the feasibility and applicability of robotic construction of wooden buildings through experiments. Secondly, actual robotic construction was completed to verify the possibility of integrating parametric design and robotic manufacturing processes into building construction projects. Finally, it provides the program and experimental basis for the next mobile robot research.

**Reference**

1. Dörfler K. Strategies for robotic in situ fabrication: ETH Zurich; 2018.

2. Dorfler K. Mobile Robotic Brickwork, Automation of a Discrete Robotic Fabrication Process Using an Autonomous Mobile Robot Robotic Fabrication in Architecture. Art and Design. 2016:204-17.

*Chapter 5*

# *CASE STUDY 2: MOBILE ROBOT CONSTRUCTION*

## CHAPTER FIVE: CASE STUDY 2: MOBILE ROBOT CONSTRUCTION

## 5.1 Contents

The previous study case explored the construction of a building by a stationary robot within the static range of the robot and the Y-axis slide. Considering that the scale of the building is not limited to the size of the wooden building that is the target of the study, the stationary robot is unable to meet the larger scale of building construction, and based on this, a mobile robot capable of building construction beyond the static working range is considered.

In this chapter, we will take the in-situ construction simulation experiment of a complete wooden building as an example to explore the possibilities and challenges of continuous building construction that exceed the static workspace of robots. in this study, an integrated multi-science application approach combining robotics, laser scanning and positioning technology with building construction makes robotic on-site construction possible and marks the possibility of integrating parametric design and robotic manufacturing processes into building construction projects. The high efficiency and stability of this technology in the construction process will greatly influence the construction efficiency and construction accuracy, thus bringing obvious benefits to the natural and economic environment.

## 5.2. Design Objective

### 5.2.1. Objective Building

The target building was a wooden structure two-story building with a construction area of 49.93 $m^2$. To improve construction manufacturability, the floor plan was designed in a simple form for easy construction, as shown in Figure 5-1 and Figure 5-2. The building was constructed using 100 $mm^2$ cross-sectional, 600 mm-long timbers. Having the same length of timbers not only facilitates the processing and cutting of materials in the preliminary preparation but also makes it easy for the discharge operator to add timbers to the robot during the construction process.

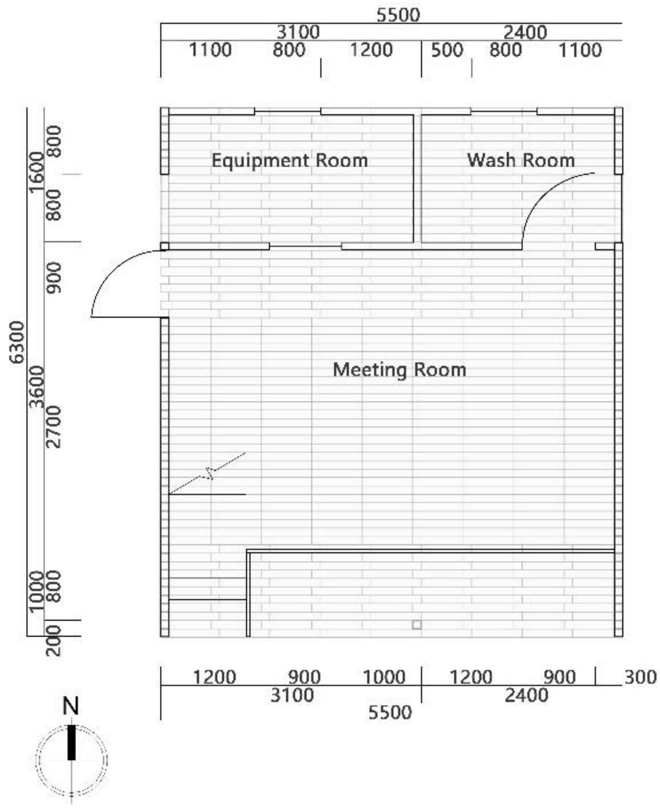



**Fig. 5-1 The first-floor plan of the building.**

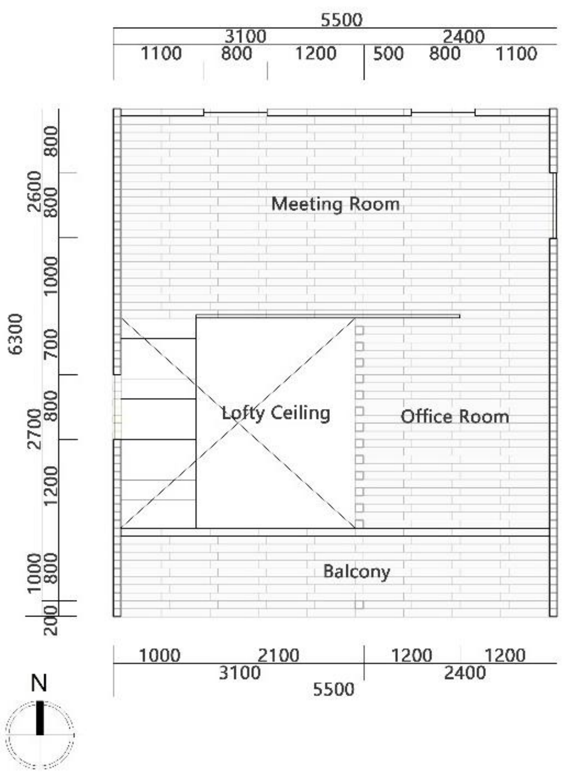



**Fig. 5-2 The second-floor plan of the building.**

### 5.2.2. Experimental Equipment Set-up

The main construction tool for this simulation experiment was a mobile robot equipped with an end effector. Its end effector is capable of performing the construction tasks for each operation step needed for this experiment and consists of a gripper for picking and placing procedures and an air nail gun for performing nail pressing procedures, as shown in Figure 5-3.

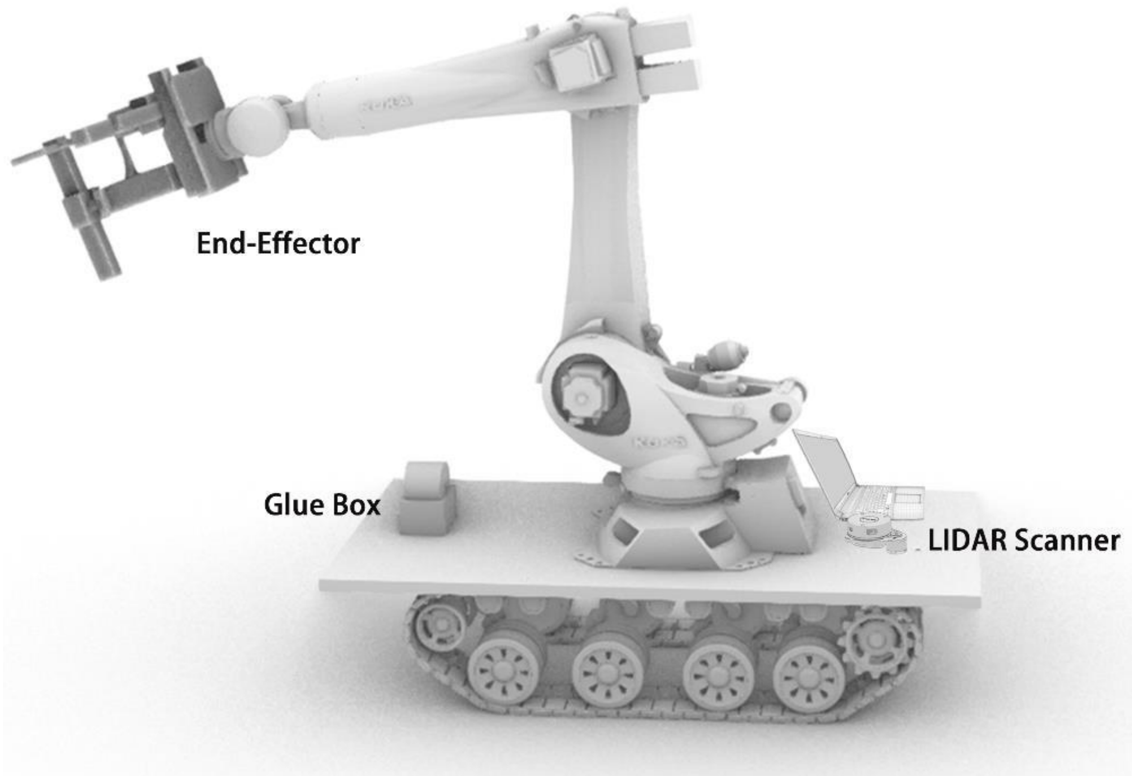



**Fig. 5-3 The mobile robot is equipped with an end effector.**

To accomplish the task of repositioning the robot after it has moved during the construction process, a LIDAR laser range scanner and a laptop computer connected to it need to be placed on the platform of the mobile robot, as shown in Figure 5-4. Once the radar is operational, it can scan the site environment in real time and can output the point cloud data through the software.


**Fig. 5-4 The LIDAR device used in the experiment.**

### 5.2.3. Fabrication Sequence for Robot Fabrication

The building was built in eight units perpendicular to the ground from A to H, as shown in Figure 5-5 and Figure 5-6. Considering the building range of robots at the same location, each unit was set to 7–9 layers. When building in groups, each unit is built lying flat on the ground, and after the robots finish building, the units are then erected vertically on the ground and connected.

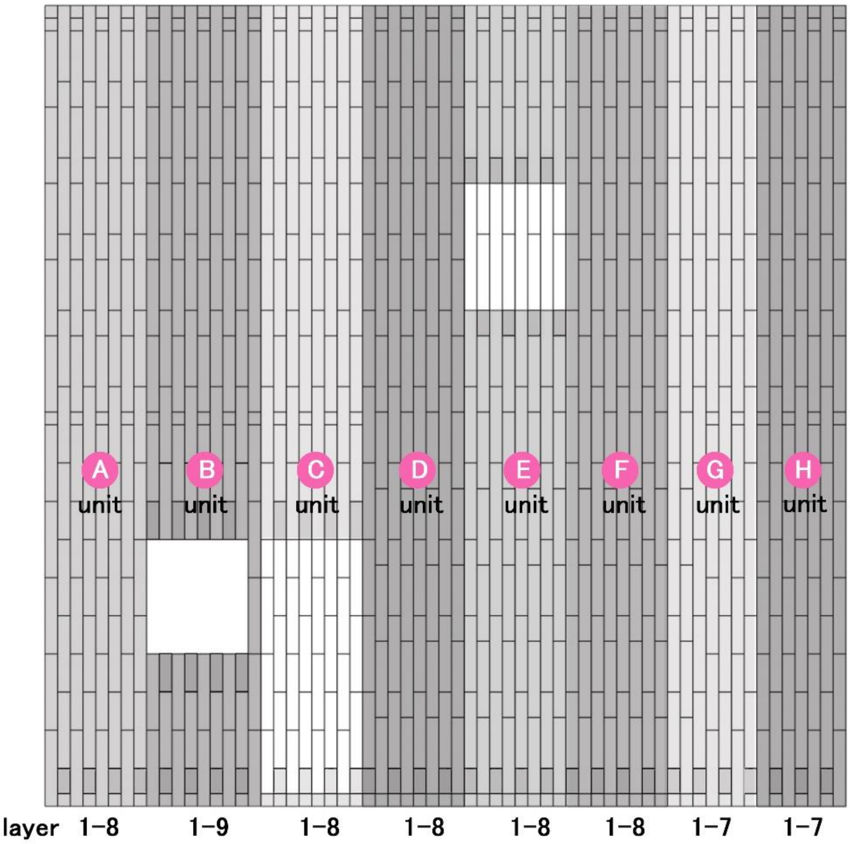



**Fig. 5-5 Unit division of the building.**

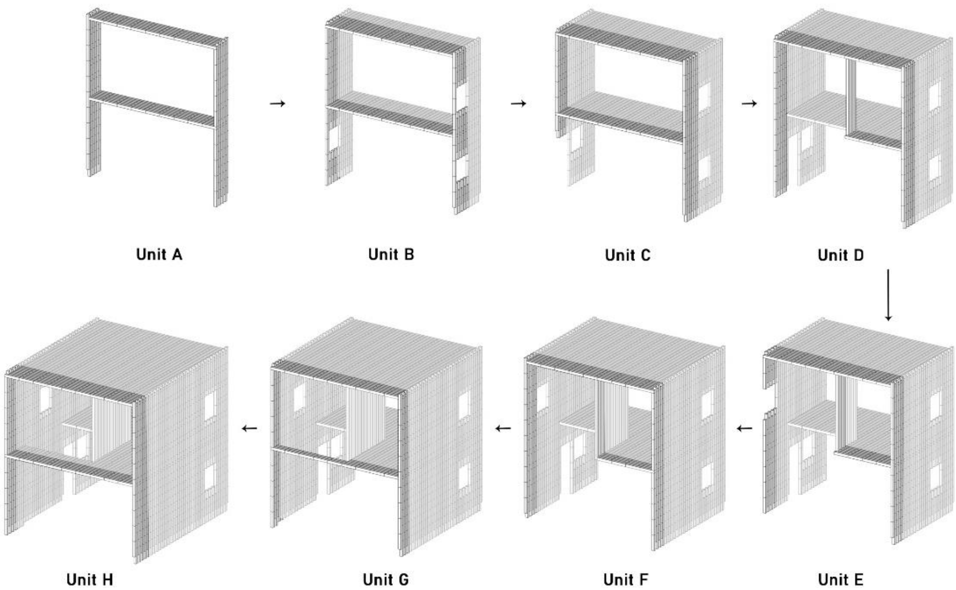



**Fig. 5-6 Unit assembly of the building.**

The arm length of the construction robot is limited, and in the face of a large building scale, the mobile robot needs to complete the construction of the complete units of the building at different locations. Therefore, a staggered arrangement of timbers in the horizontal direction was used here to form a new structure that is different from a manually constructed structure. In this experiment, a unit needs to be built in four groups, during which the mobile robot needs to undergo three changes of building positions, as shown in Figure 5-7.

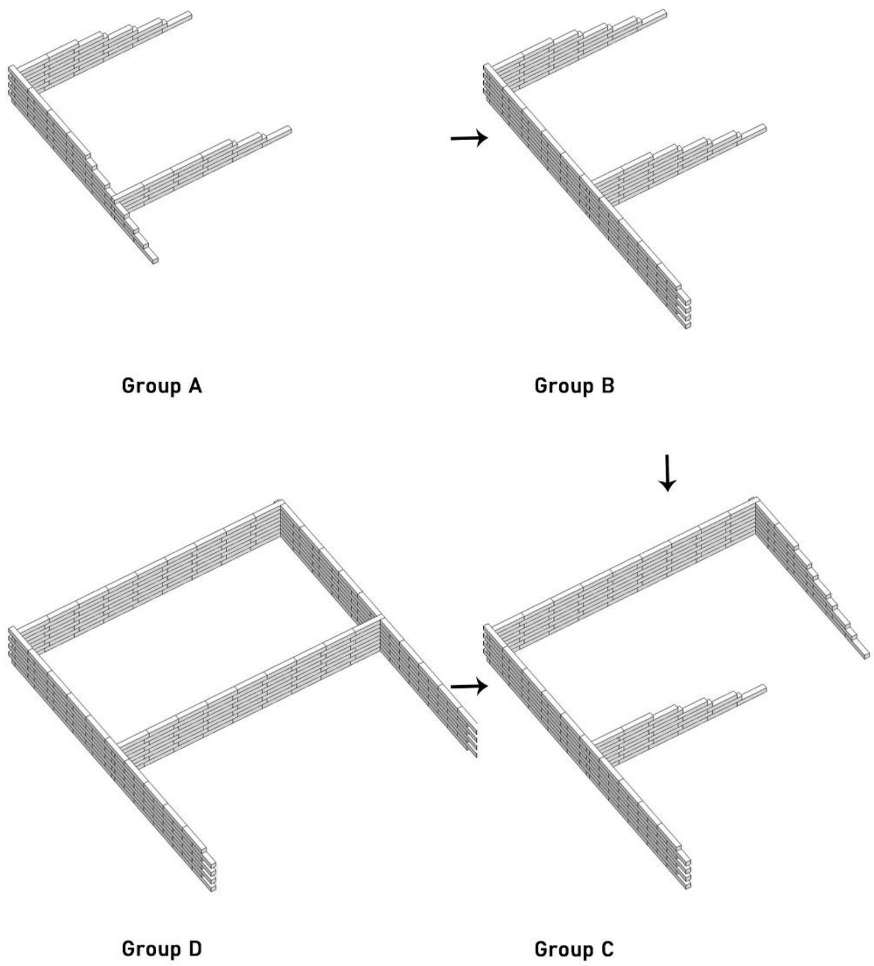



**Fig. 5-7 Mobile robot construction in four groups for each unit.**

### 5.2.4. Structure Construction

The construction process was conducted in sub-units, all operated by mobile robots. The connection between the timbers was achieved with glue and nails, as shown in Figure 5-8. Therefore, the steps of nailing and glue application are also the main tasks conducted by the robot arm, as shown in Figure 5-9.

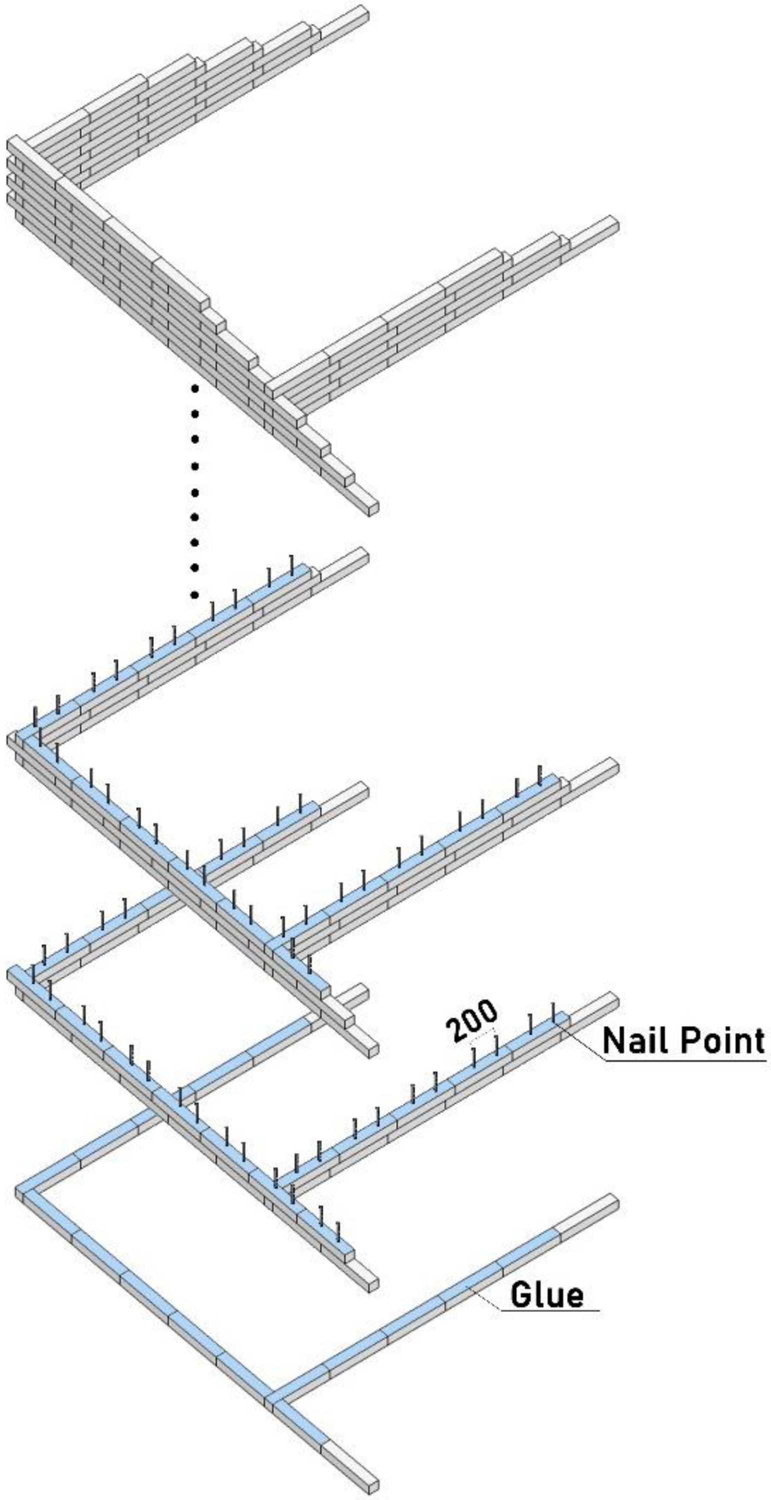



**Fig. 5-8 Layer connection of the building construction.**

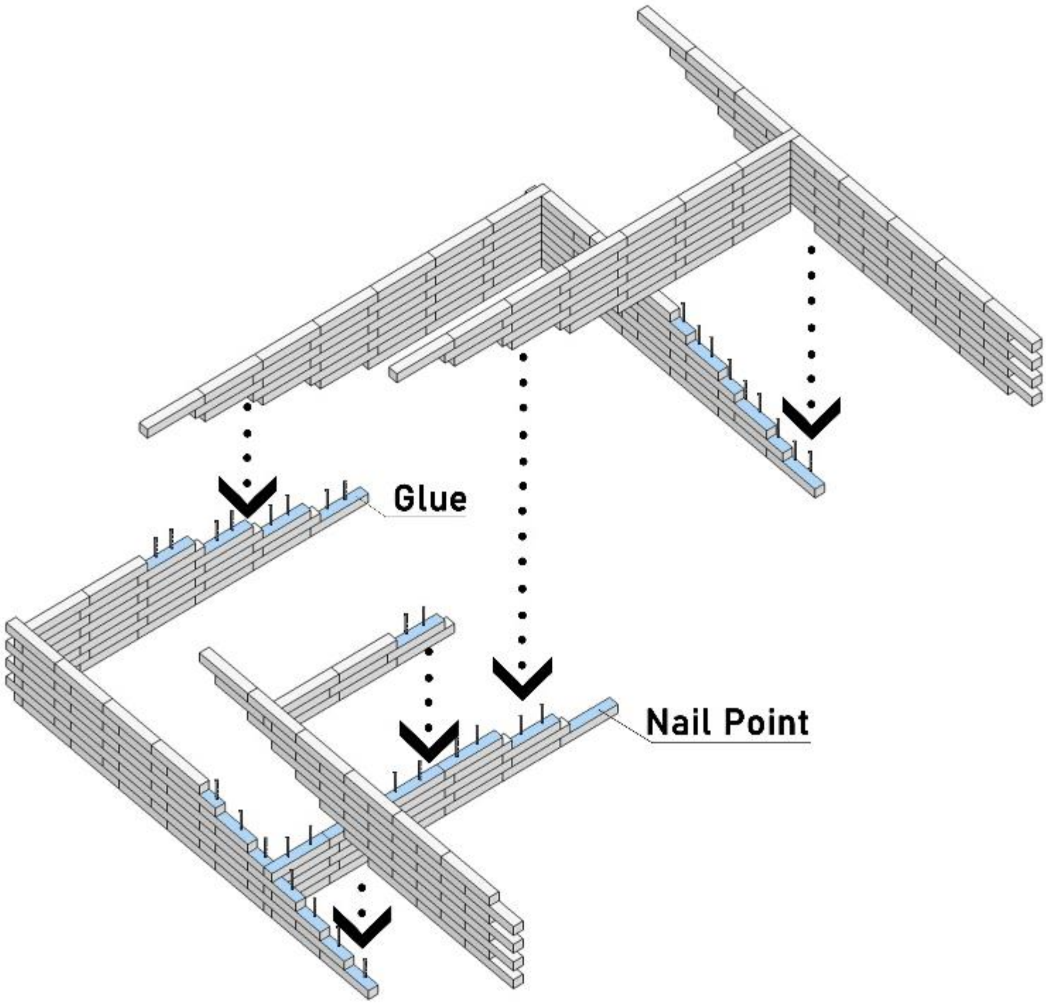



**Fig. 5-9 Group connection of the building construction.**

## 5.3. Construction Procedure

### 5.3.1. Determine the Operable Range of the Robot

A total of 2168 timbers were required to construct this building with a length of 6.3 m, a width of 5.5 m, and a height of 6.2 m. The building is divided into units, with the largest number of layers in a unit of nine; the height of the units is 0.9 m. Before the construction process begins, the first step is to determine the operable range of the mobile robot in the same location as the construction range, as shown in Figure 5-10.

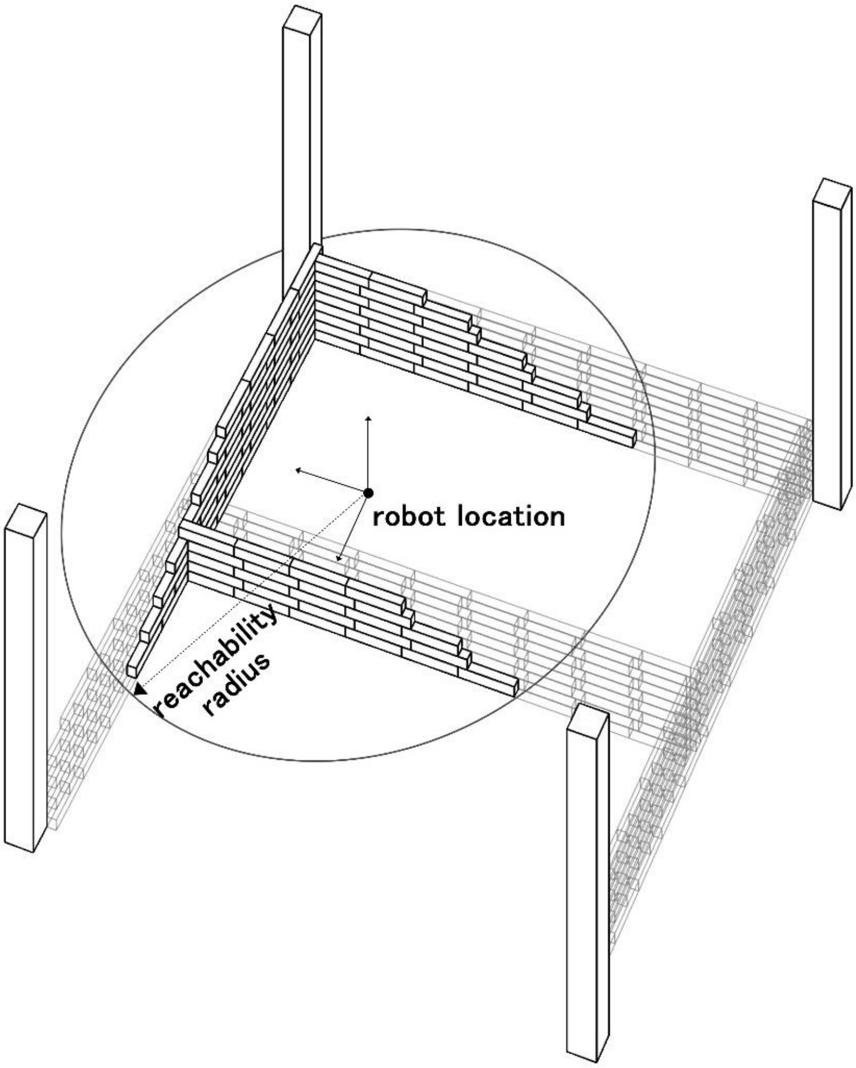



**Fig. 5-10 The robot location and its reachability constraints.**

### 5.3.2. Digital building model

After this, to satisfy the minimized number of robot relocations, it can be precomputed that the entire assembly sequence needs to be built by dividing each unit into four groups. To complete this assembly sequence, the mobile robot needs to be displaced three times and complete the construction at each of the four computed localizations. Figure 5-11 to Figure 5-26 illustrates the grouped construction process for the eight units from Unit A to Unit H. After which the robot can interactively generate the assembly sequence at its current location and within its static range.

5.3.2.1. Unit A construction process

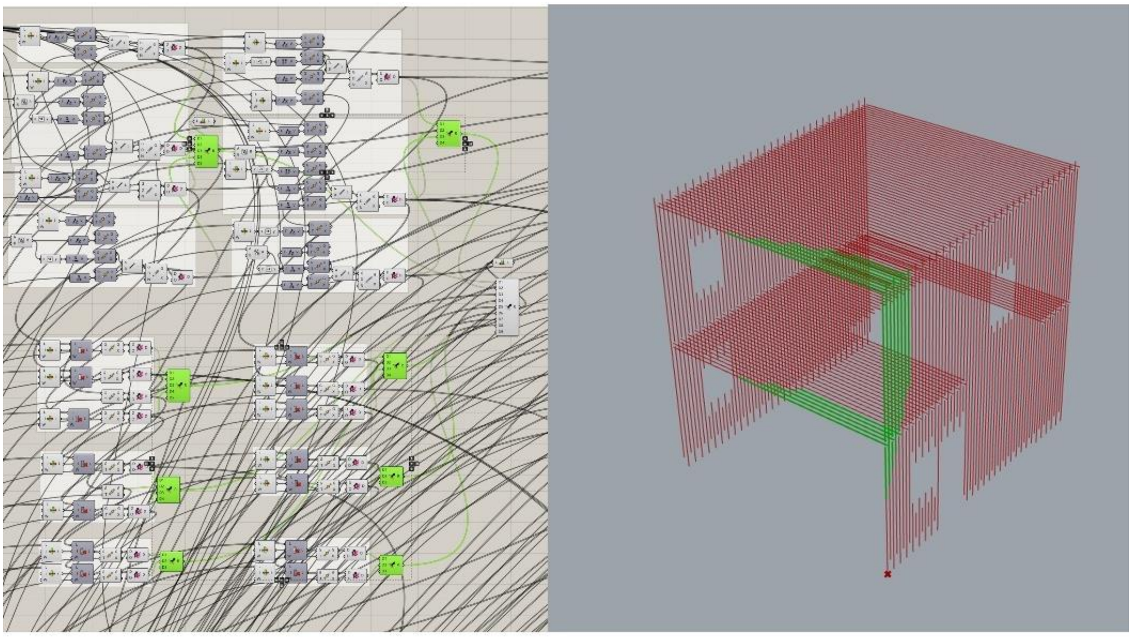


**Fig. 5-11(a) Parametric construction process of building unit A in grasshopper.**

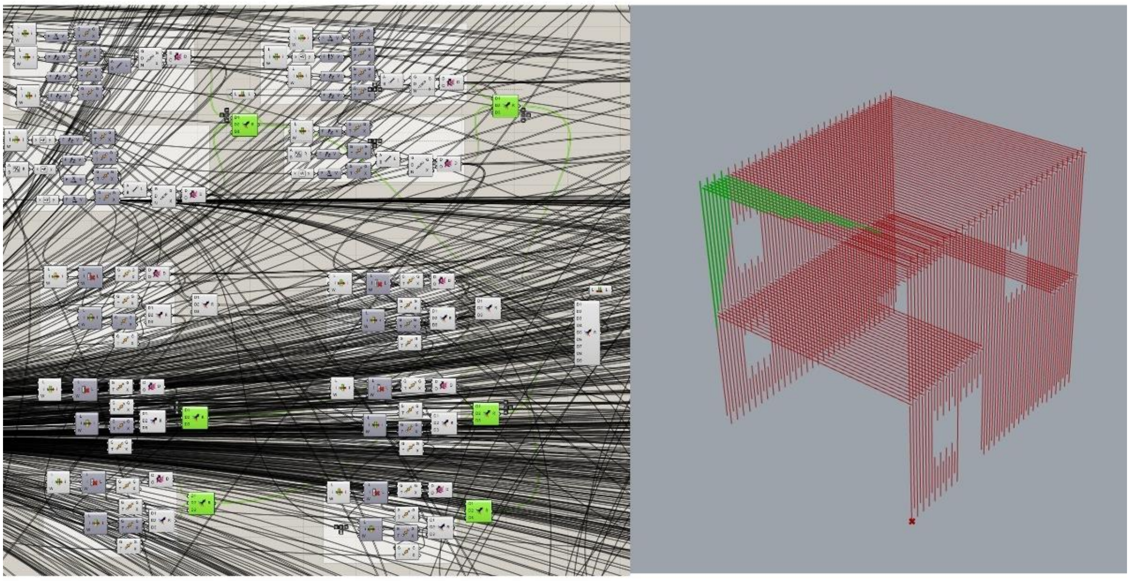


**Fig. 5-11(b) Parametric construction process of building unit A in grasshopper.**

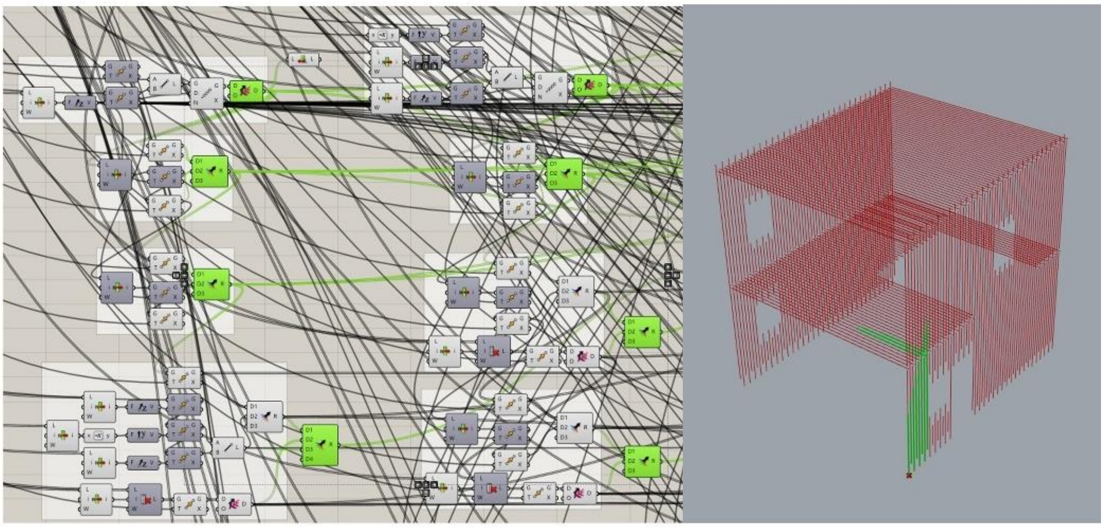


**Fig. 5-11(c) Parametric construction process of building unit A in grasshopper.**

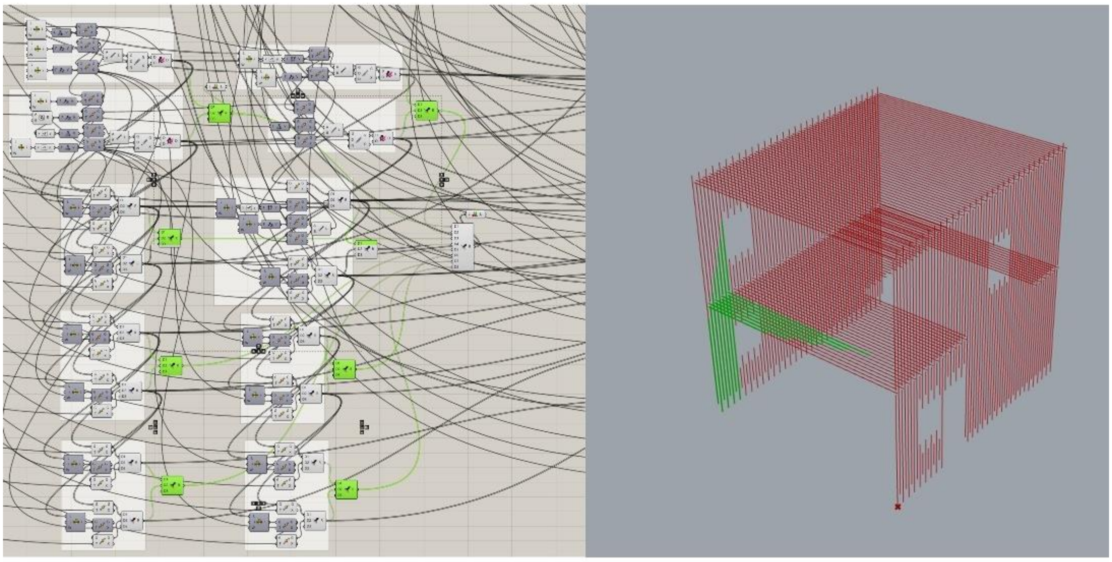


**Fig. 5-11(d) Parametric construction process of building unit A in grasshopper.**

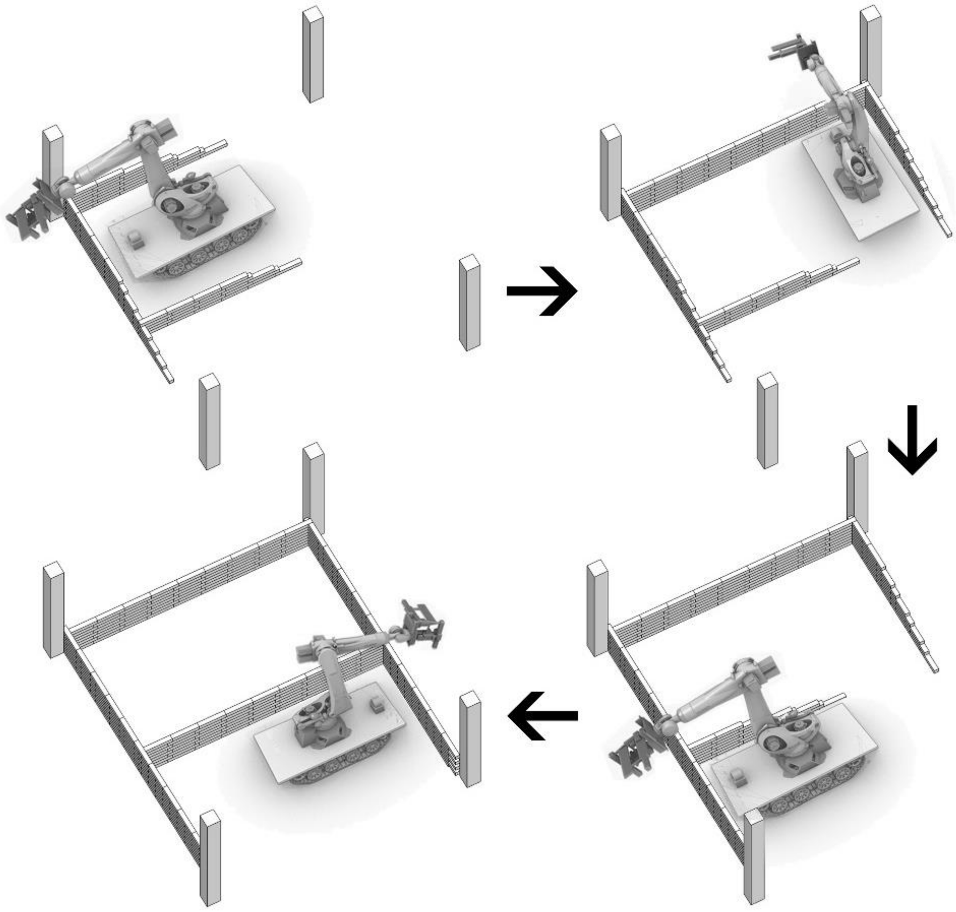


**Fig. 5-12 Snapshots of unit A with four groups built by the mobile robot.**

5.3.2.2. Unit B construction process

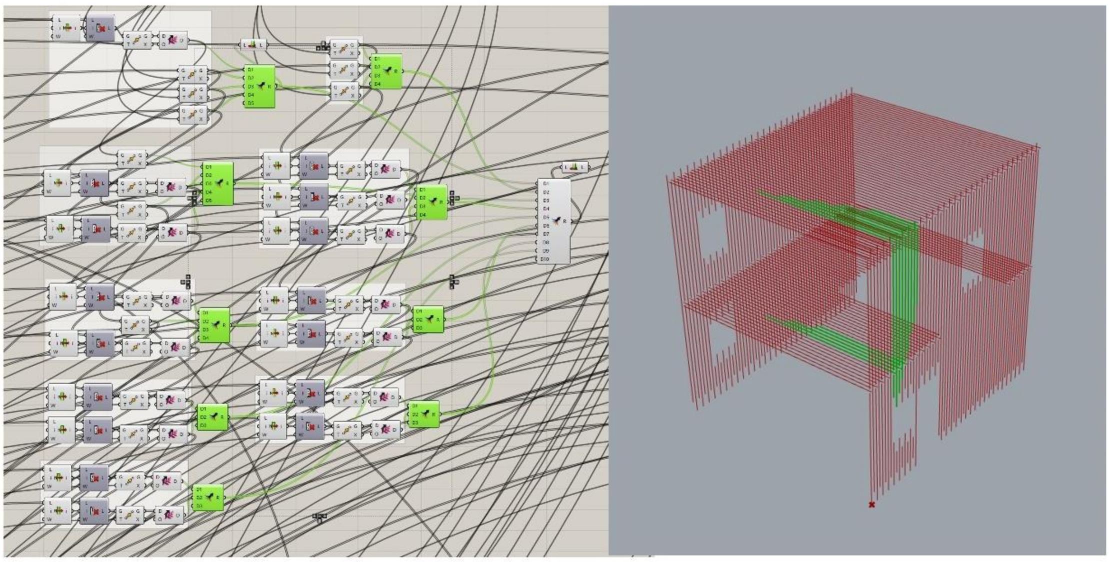


**Fig. 5-13(a) Parametric construction process of building unit B in grasshopper.**

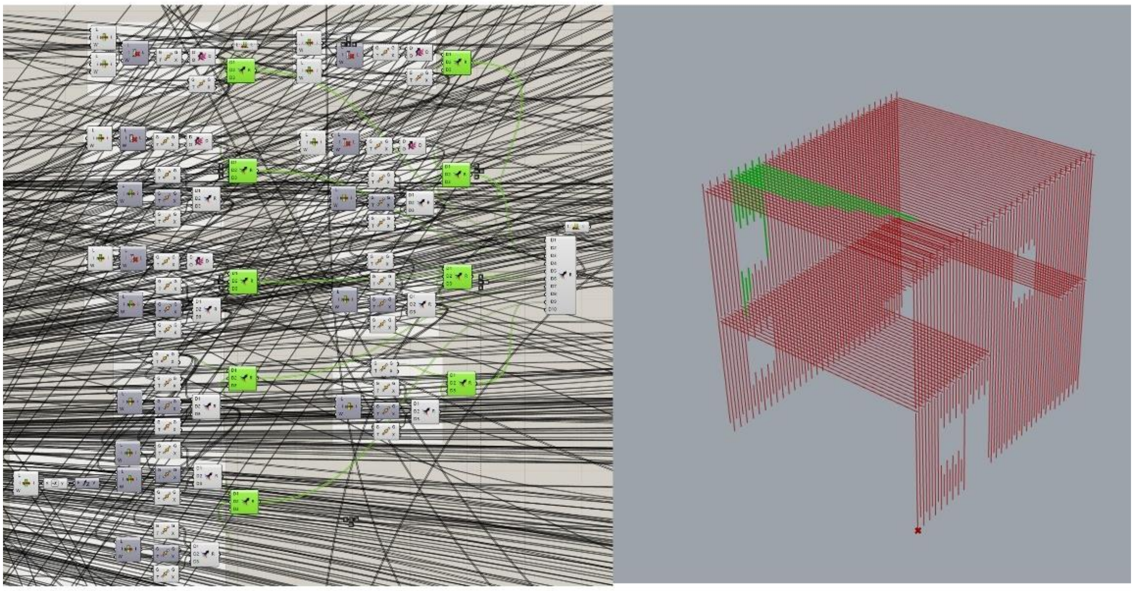


**Fig. 5-13(b) Parametric construction process of building unit B in grasshopper.**

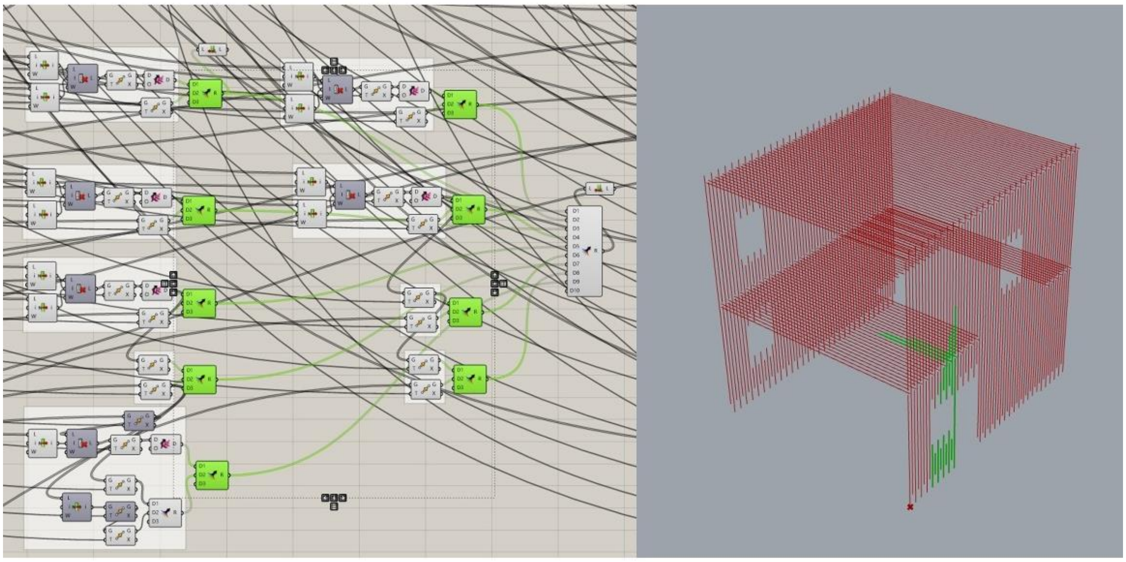


**Fig. 5-13(c) Parametric construction process of building unit B in grasshopper.**

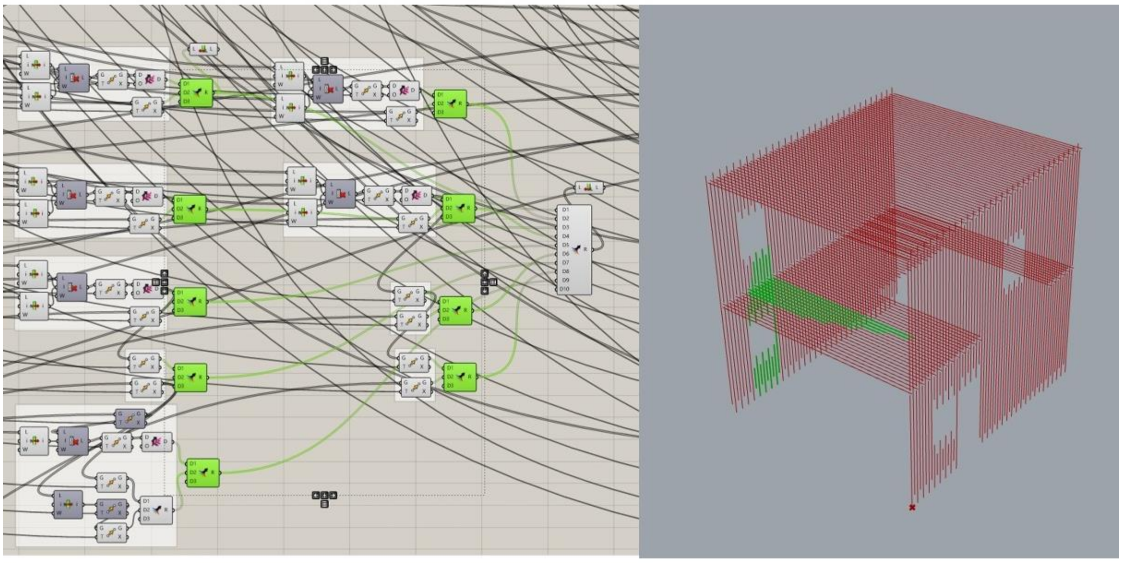


**Fig. 5-13(d) Parametric construction process of building unit B in grasshopper.**

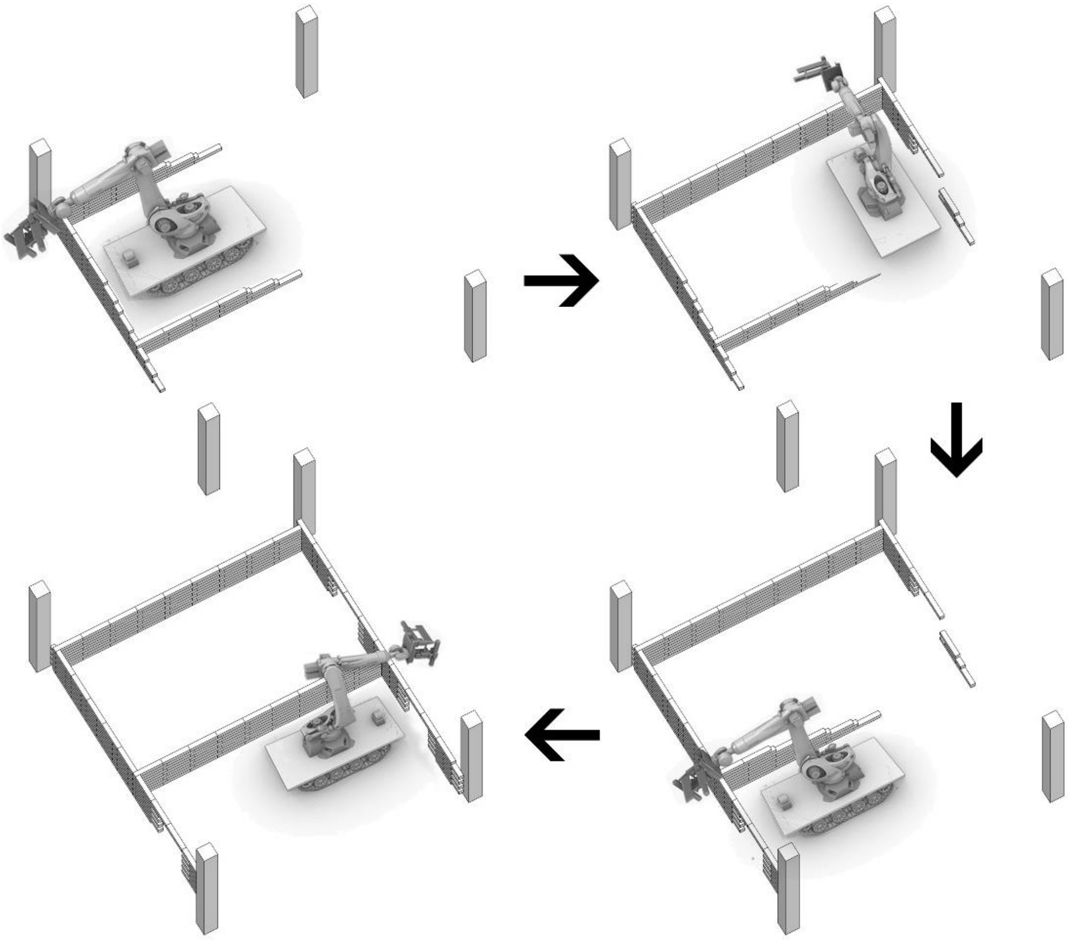


**Fig. 5-14 Snapshots of unit B with four groups built by the mobile robot.**

5.3.2.3. Unit C construction process

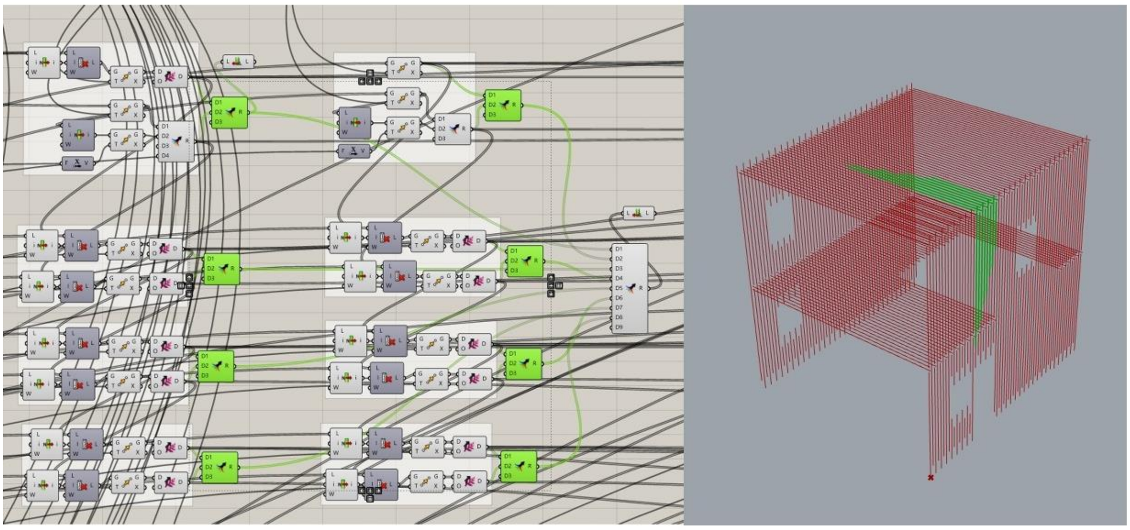


**Fig. 5-15(a) Parametric construction process of building unit C in grasshopper.**

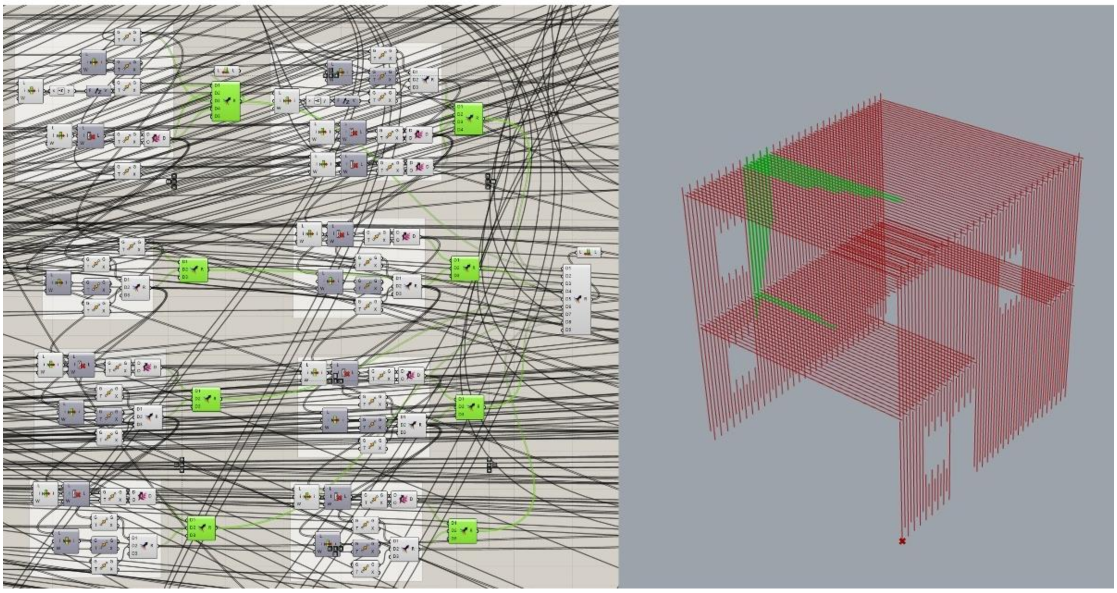


**Fig. 5-15(b) Parametric construction process of building unit C in grasshopper.**

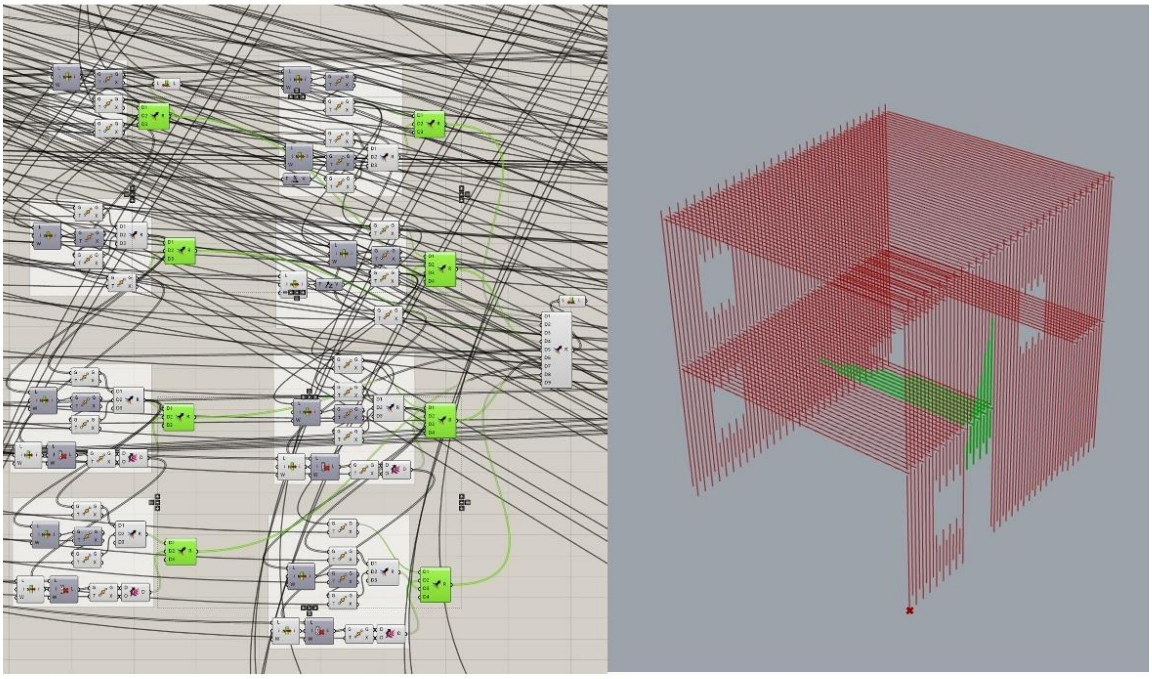


**Fig. 5-15(c) Parametric construction process of building unit C in grasshopper.**

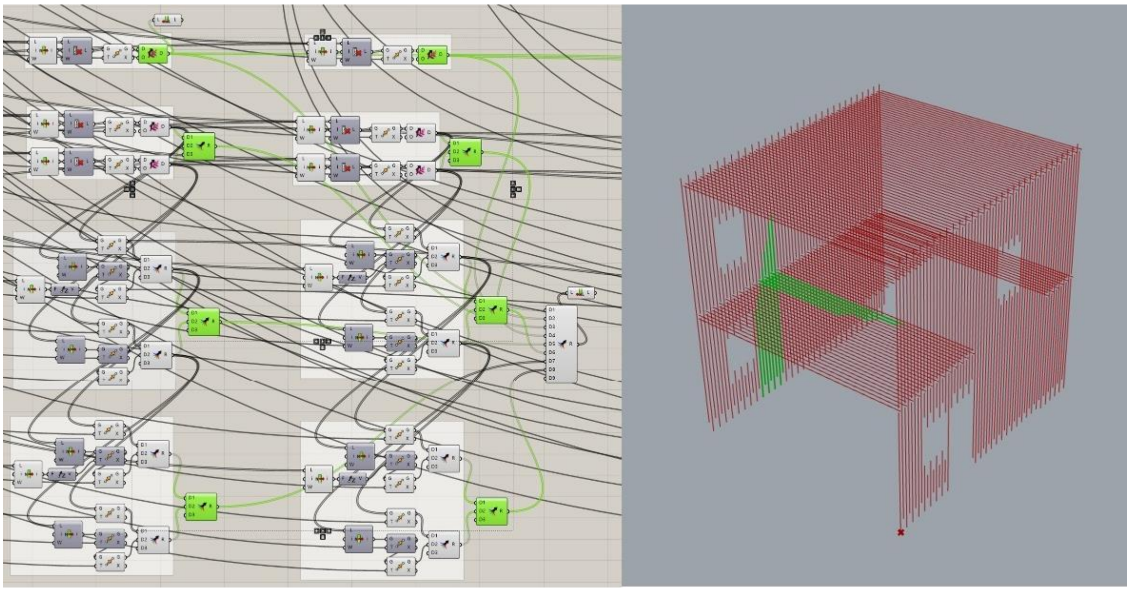


**Fig. 5-15(d) Parametric construction process of building unit C in grasshopper.**

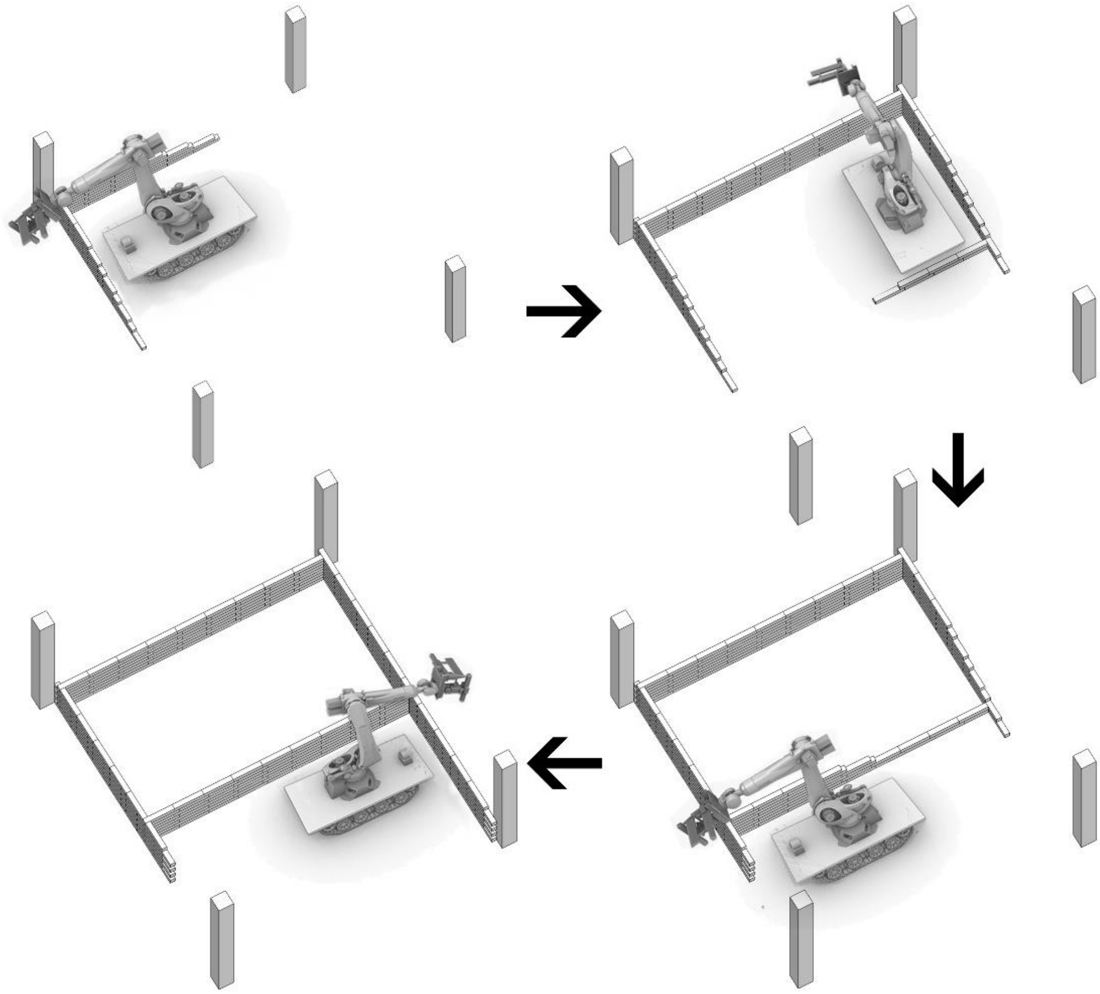


**Fig. 5-16 Snapshots of unit C with four groups built by the mobile robot.**

5.3.2.4. Unit D construction process

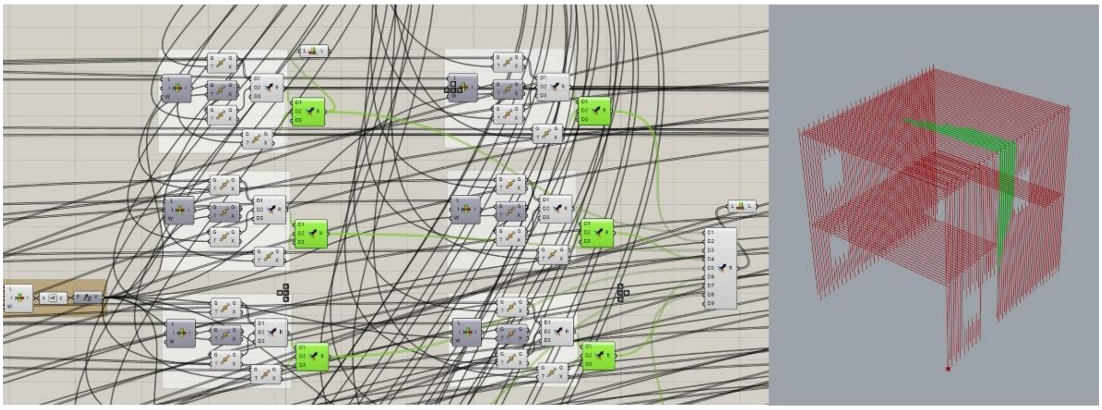


**Fig. 5-17(a) Parametric construction process of building unit D in grasshopper.**

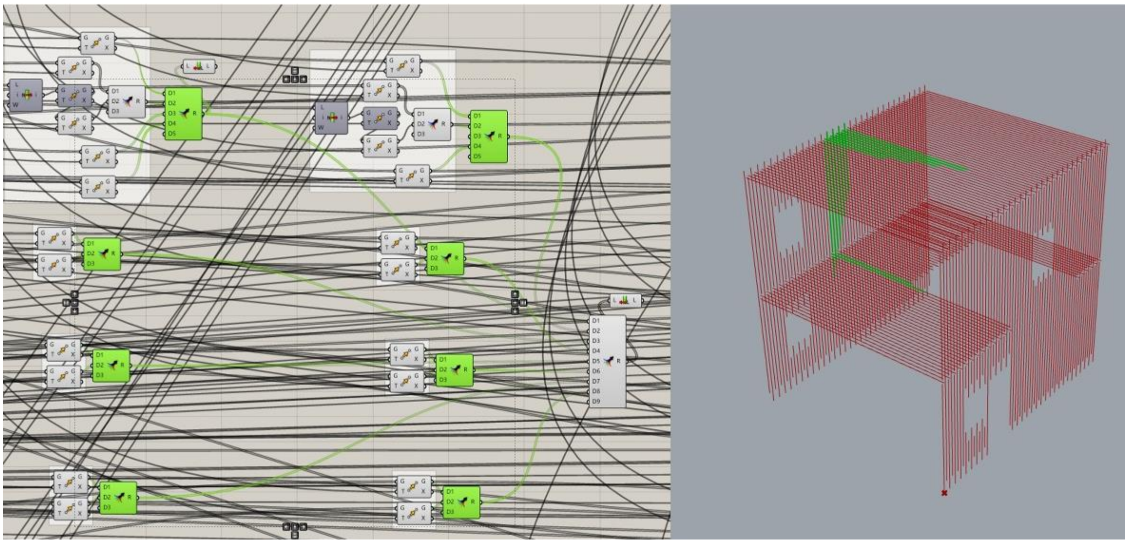


**Fig. 5-17(b) Parametric construction process of building unit D in grasshopper.**

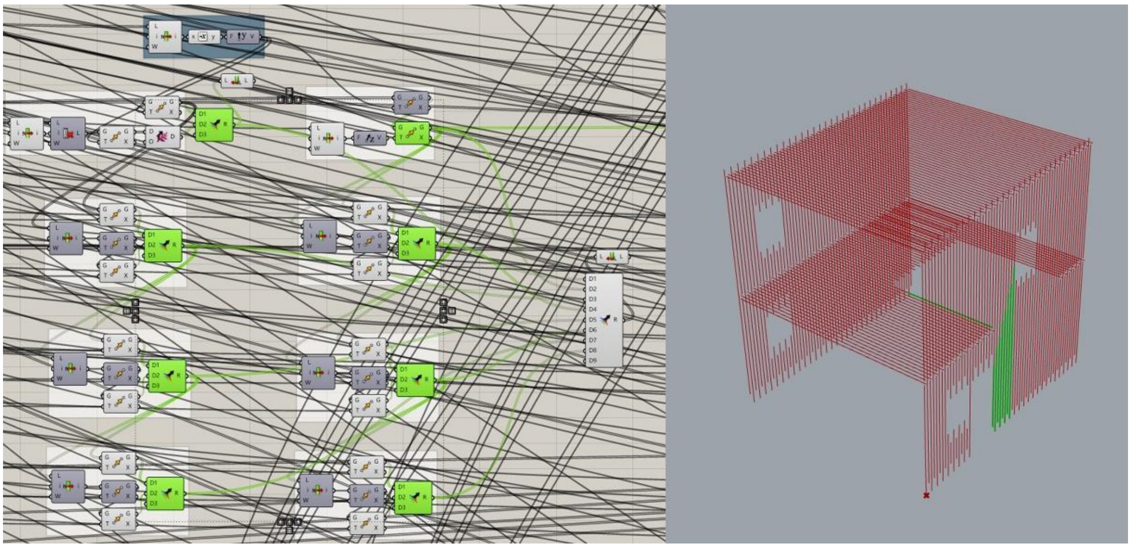


**Fig. 5-17(c) Parametric construction process of building unit D in grasshopper.**

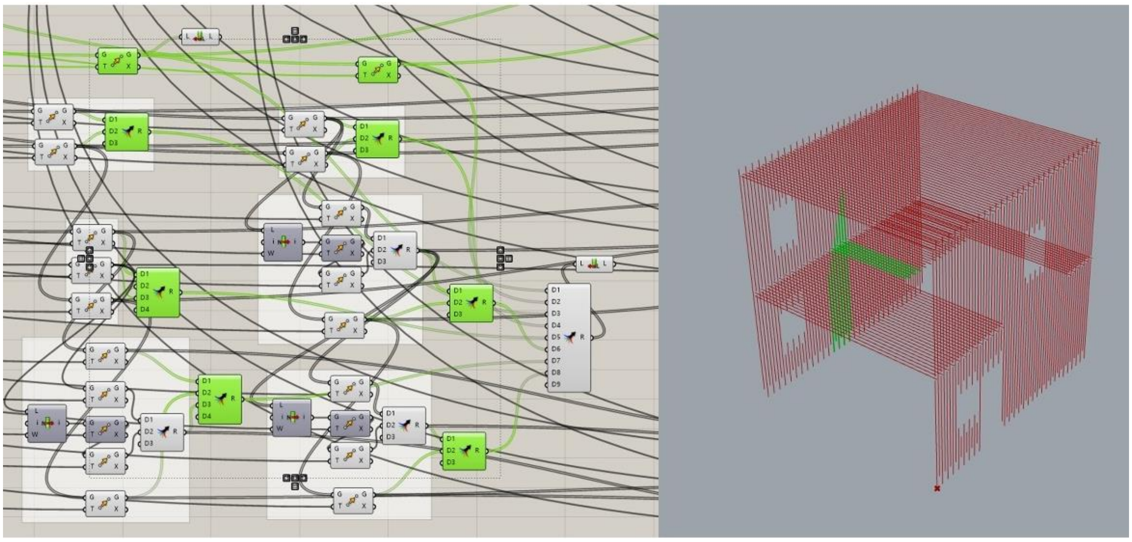


**Fig. 5-17(d) Parametric construction process of building unit D in grasshopper.**

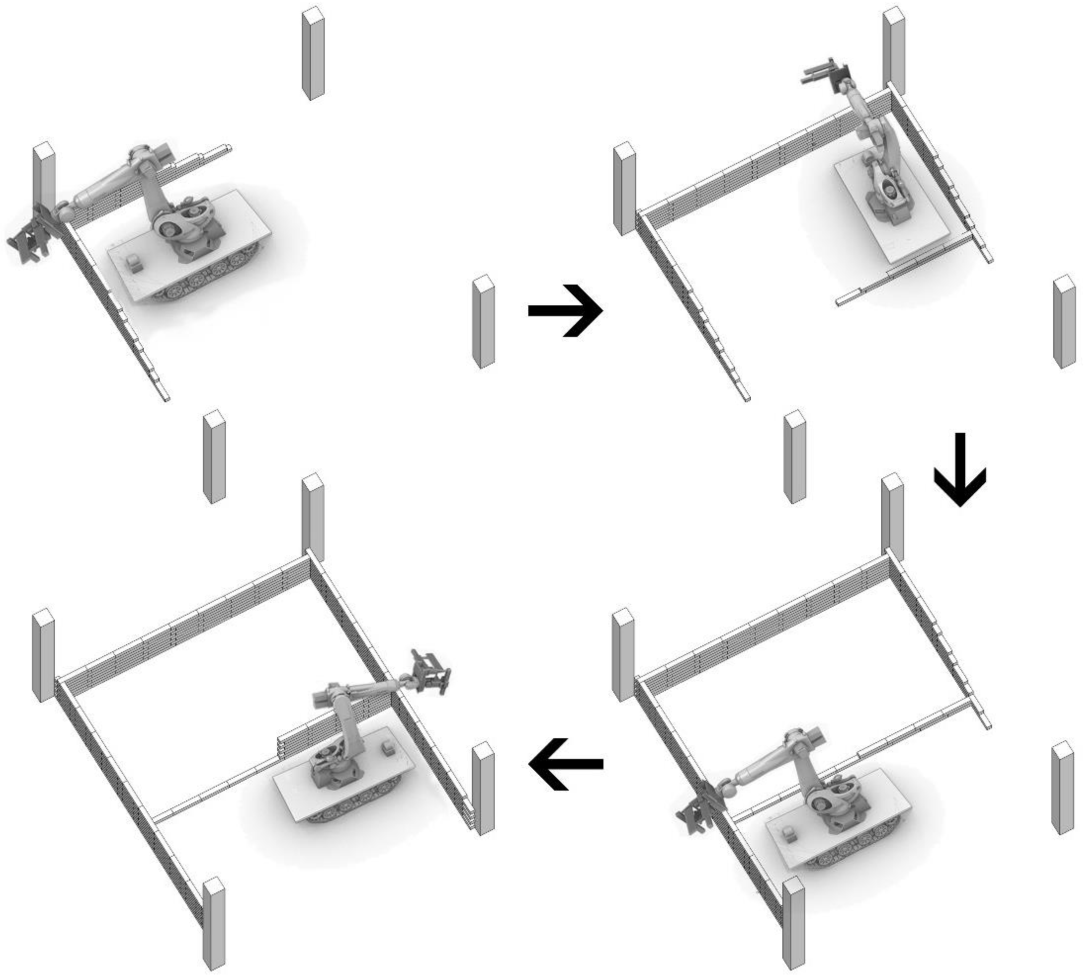


**Fig. 5-18 Snapshots of unit D with four groups built by the mobile robot.**

5.3.2.5. Unit E construction process

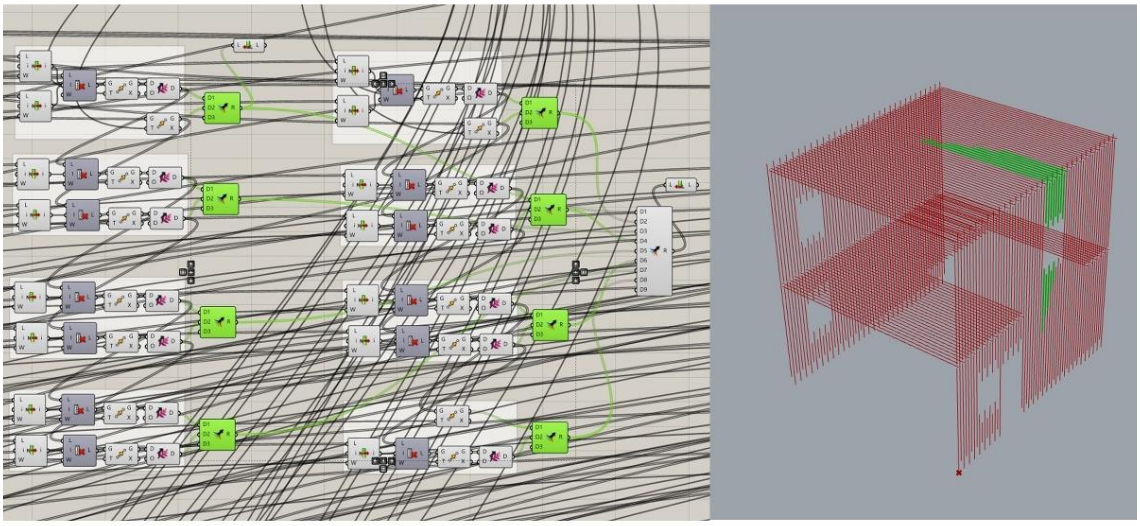


**Fig. 5-19(a) Parametric construction process of building unit E in grasshopper.**

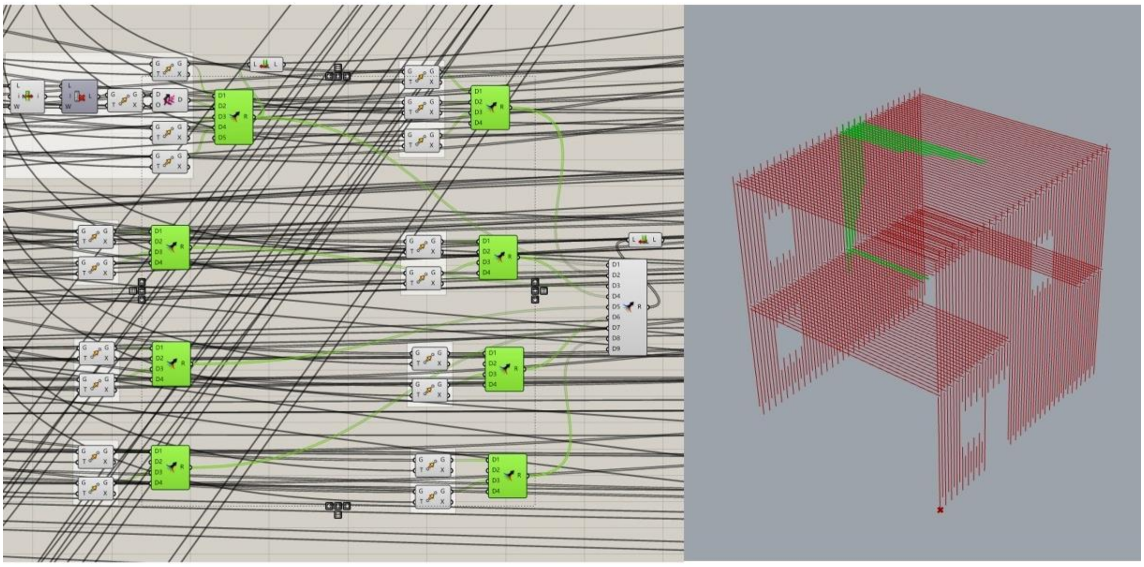


**Fig. 5-19(b) Parametric construction process of building unit E in grasshopper.**

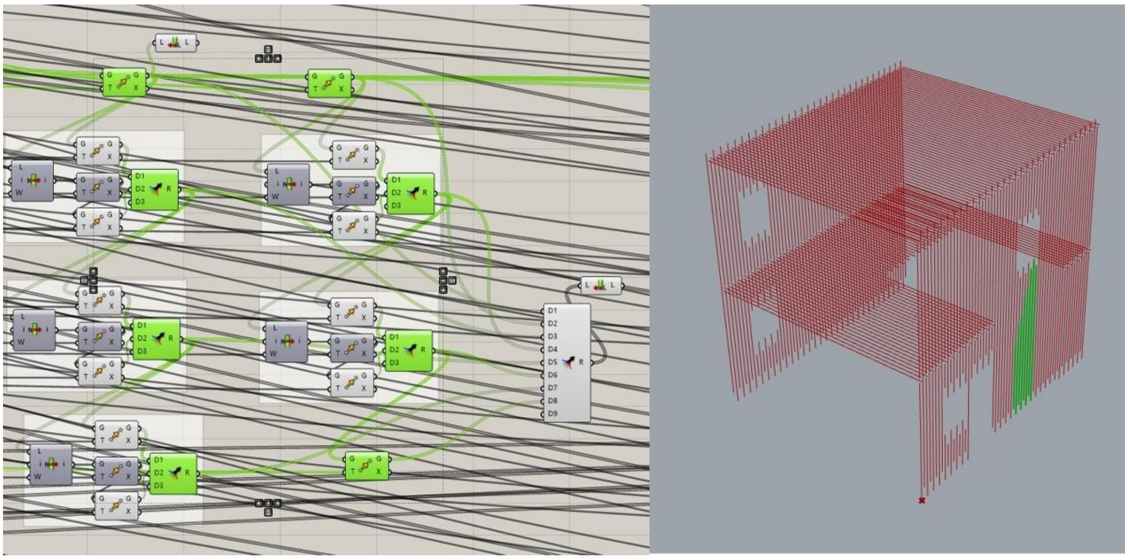


**Fig. 5-19(c) Parametric construction process of building unit E in grasshopper.**

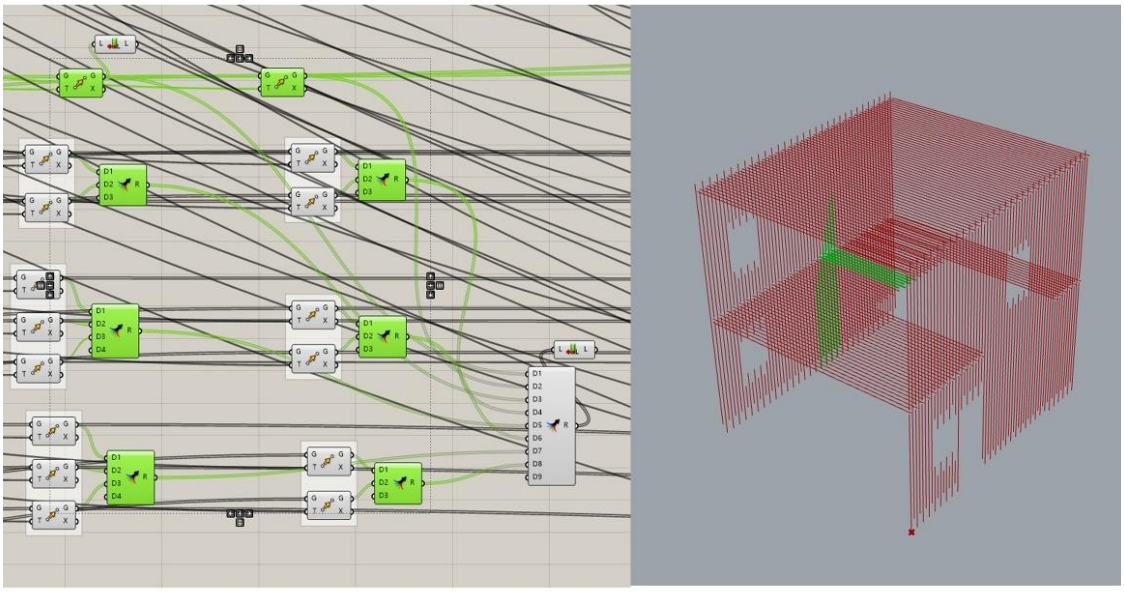


**Fig. 5-19(d) Parametric construction process of building unit E in grasshopper.**

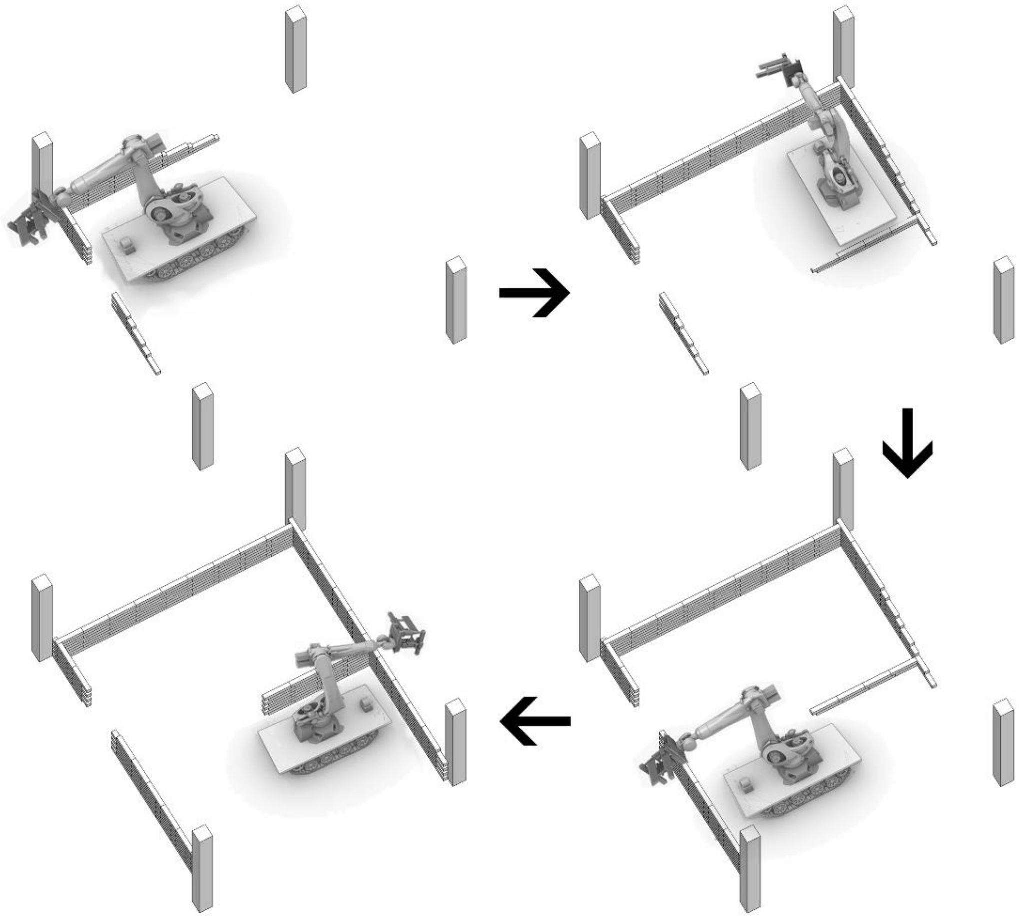


**Fig. 5-20 Snapshots of unit E with four groups built by the mobile robot.**

5.3.2.6. Unit F construction process

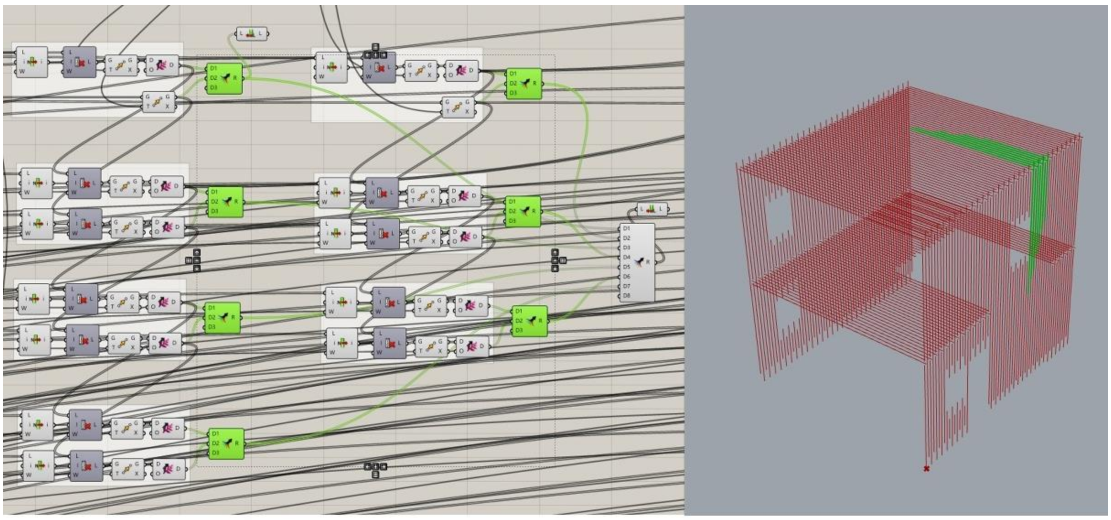


**Fig. 5-21(a) Parametric construction process of building unit F in grasshopper.**

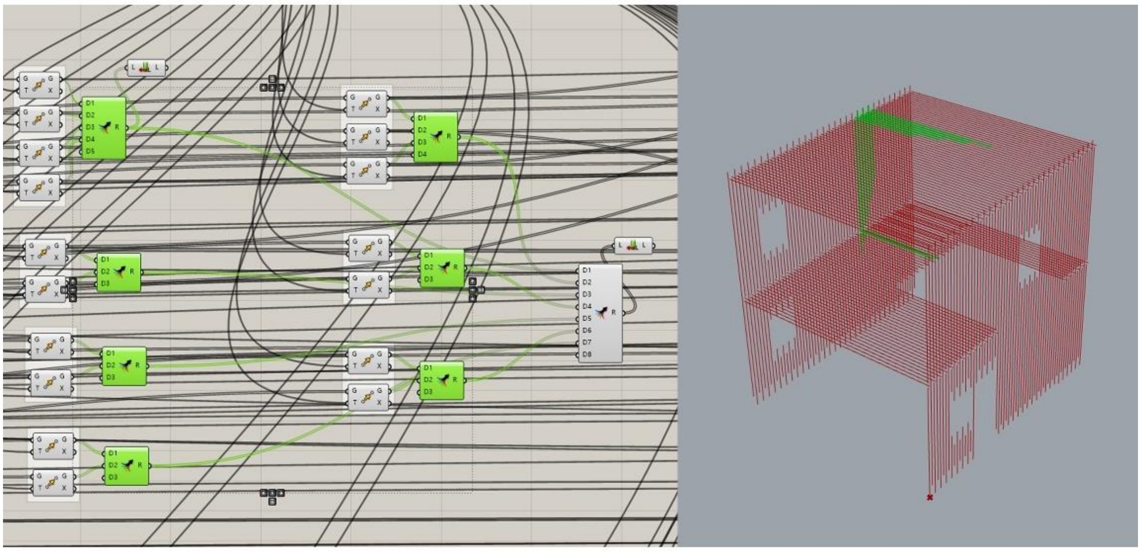


**Fig. 5-21(b) Parametric construction process of building unit F in grasshopper.**

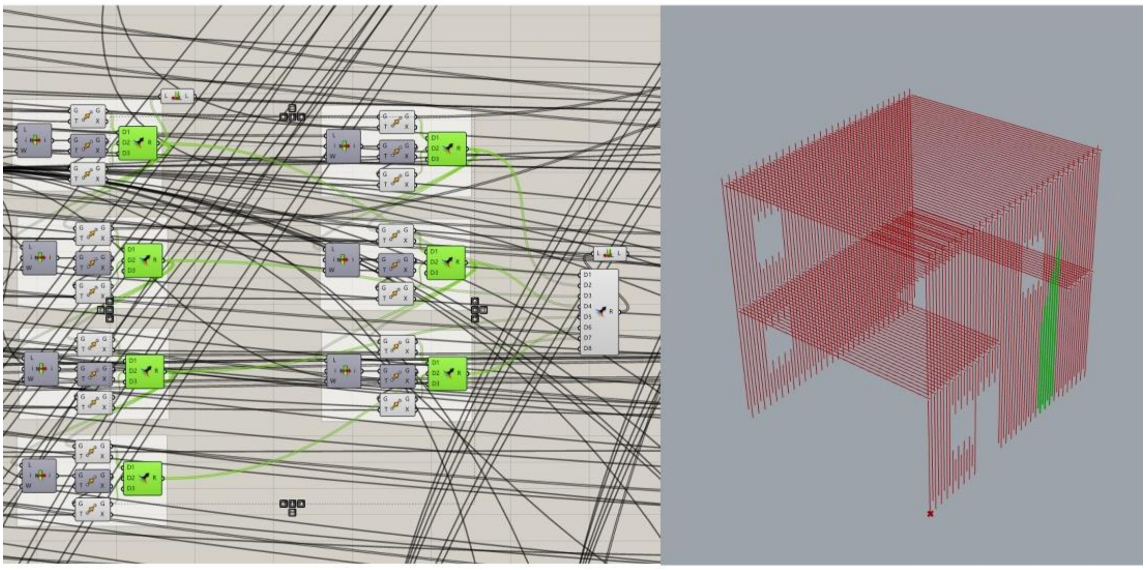


**Fig. 5-21(c) Parametric construction process of building unit F in grasshopper.**

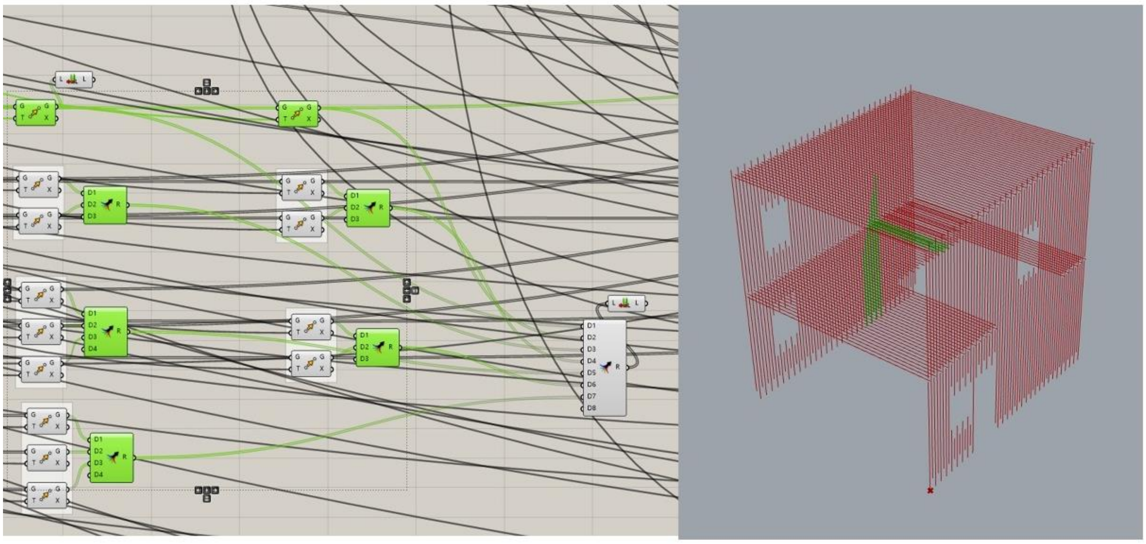


**Fig. 5-21(d) Parametric construction process of building unit F in grasshopper.**

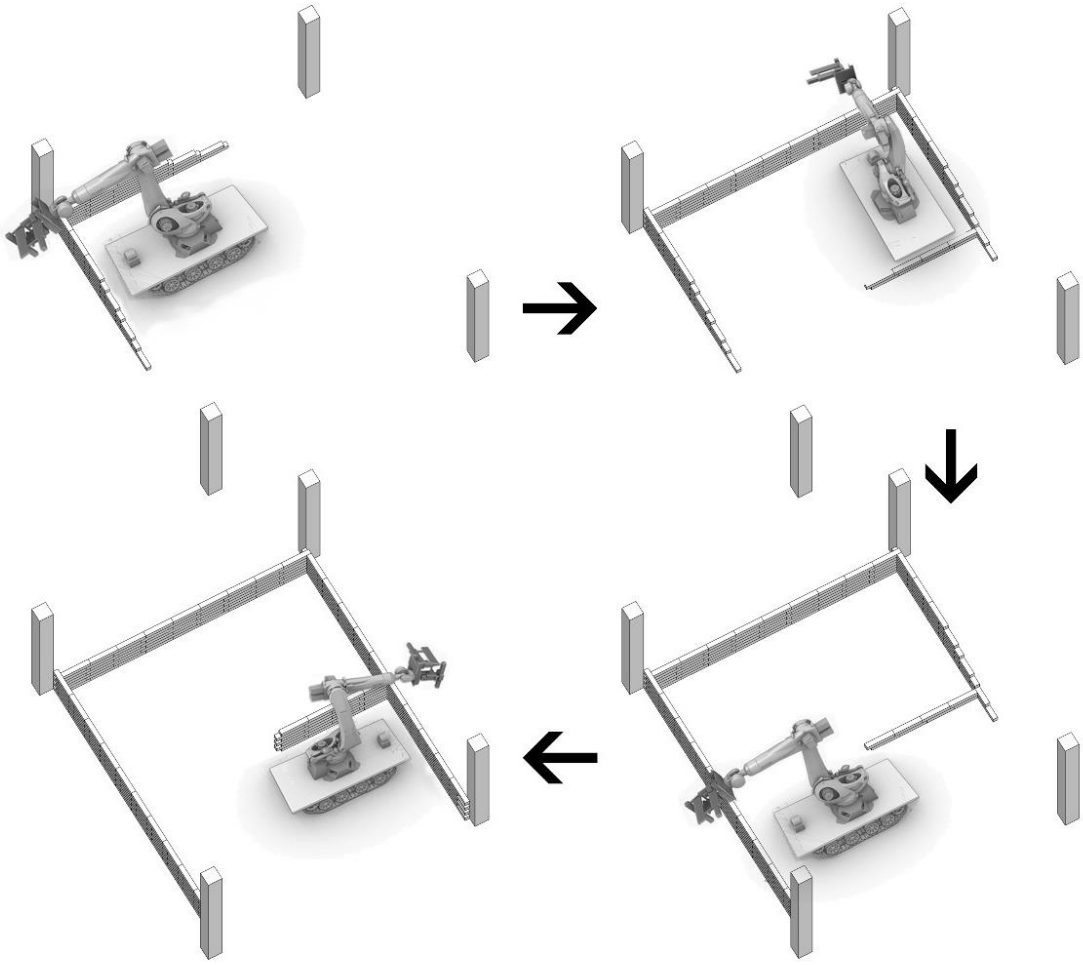


**Fig. 5-22 Snapshots of unit F with four groups built by the mobile robot.**

5.3.2.7. Unit G construction process

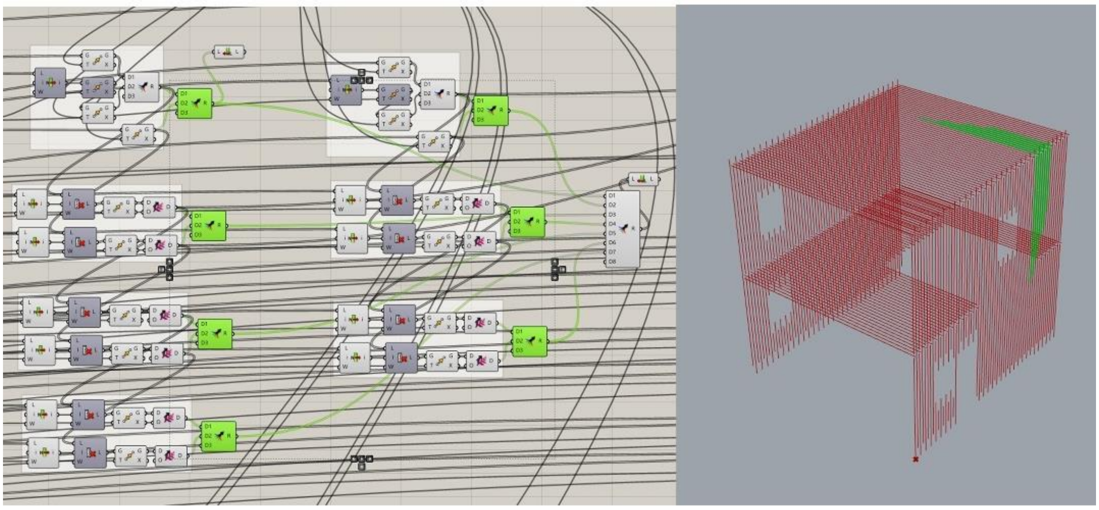


**Fig. 5-23(a) Parametric construction process of building unit G in grasshopper.**

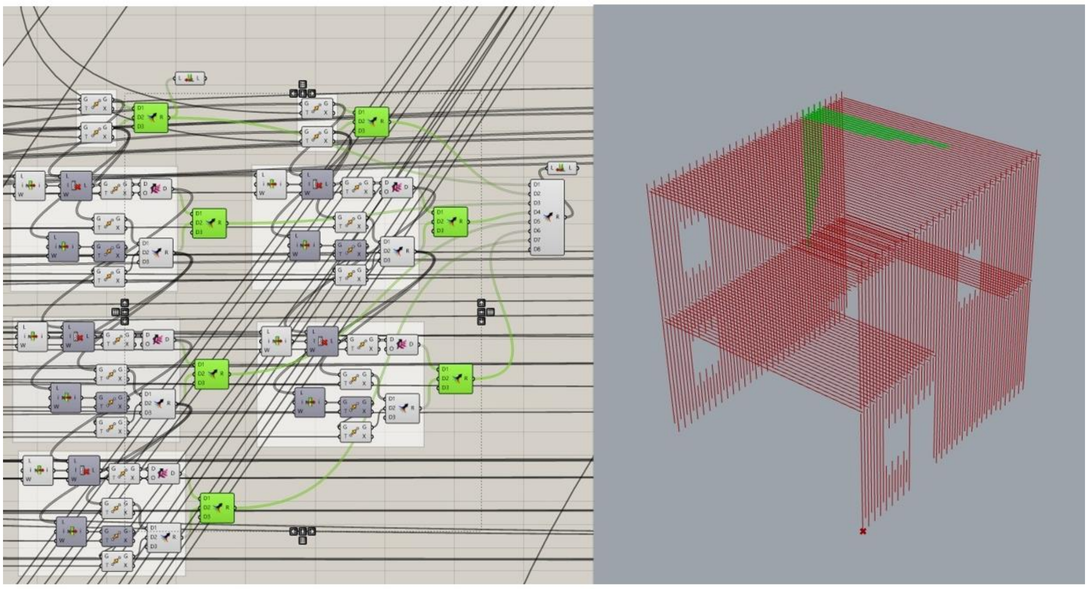


**Fig. 5-23(b) Parametric construction process of building unit G in grasshopper.**

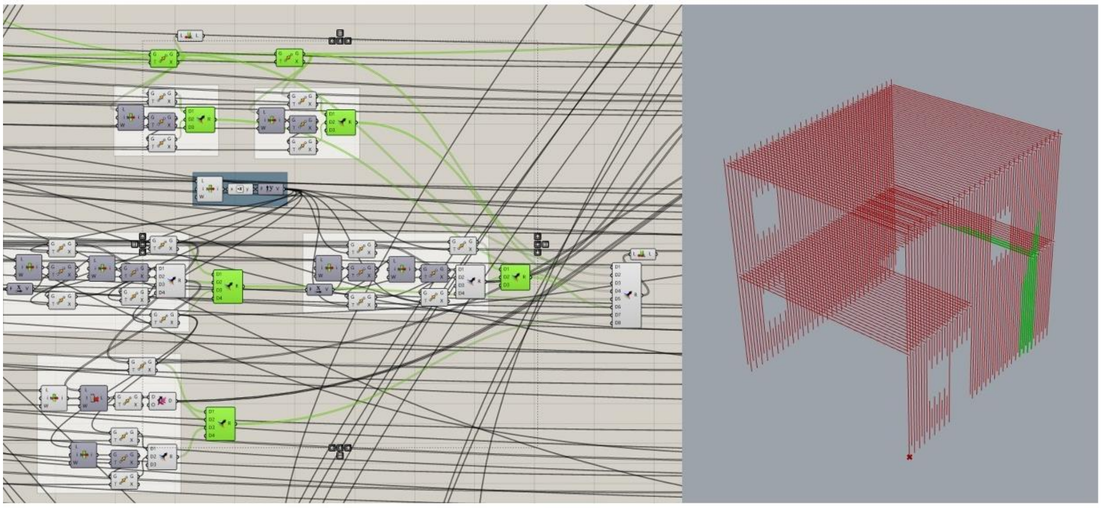


**Fig. 5-23(c) Parametric construction process of building unit G in grasshopper.**

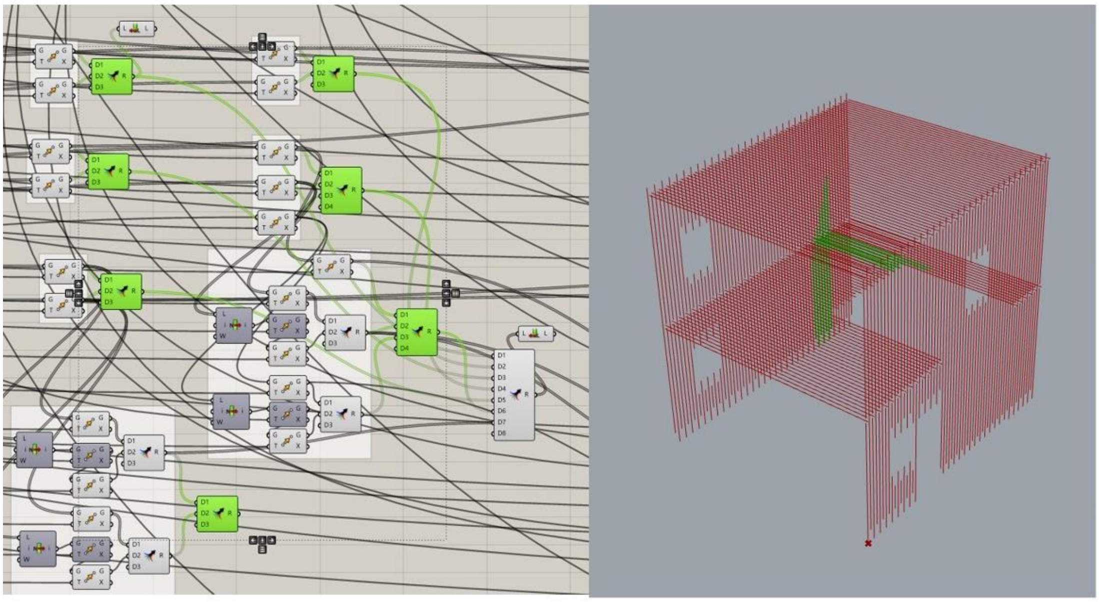


**Fig. 5-23(d) Parametric construction process of building unit G in grasshopper.**

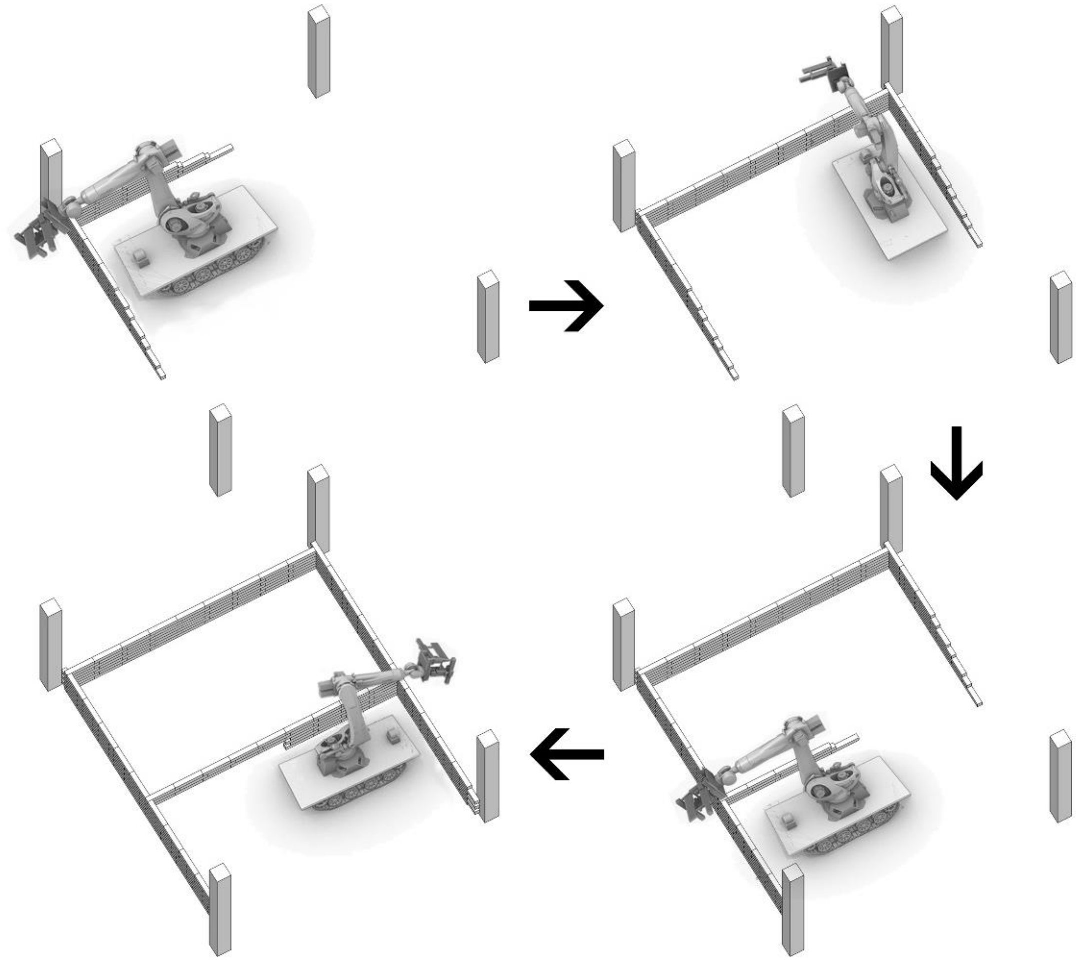


**Fig. 5-24 Snapshots of unit G with four groups built by the mobile robot.**

5.3.2.8. Unit H construction process

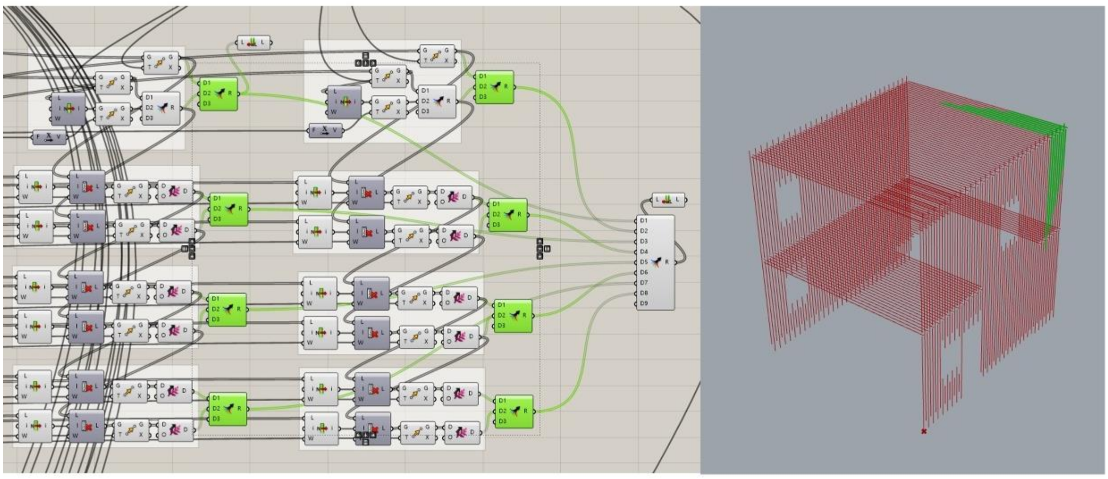


**Fig. 5-25(a) Parametric construction process of building unit H in grasshopper.**

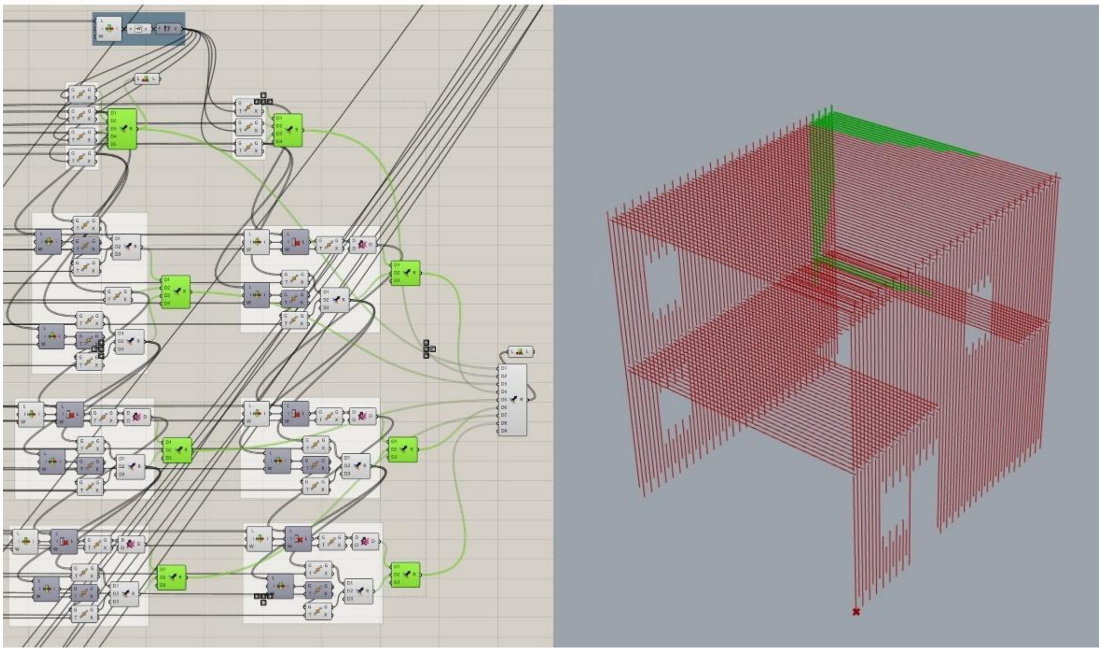


**Fig. 5-25(b) Parametric construction process of building unit H in grasshopper.**

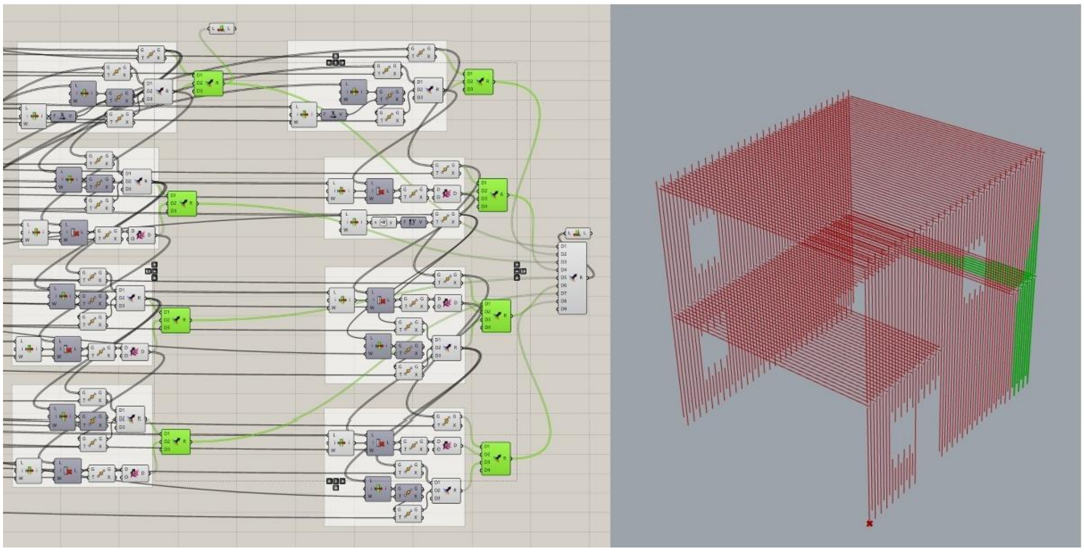


**Fig. 5-25(c) Parametric construction process of building unit H in grasshopper.**

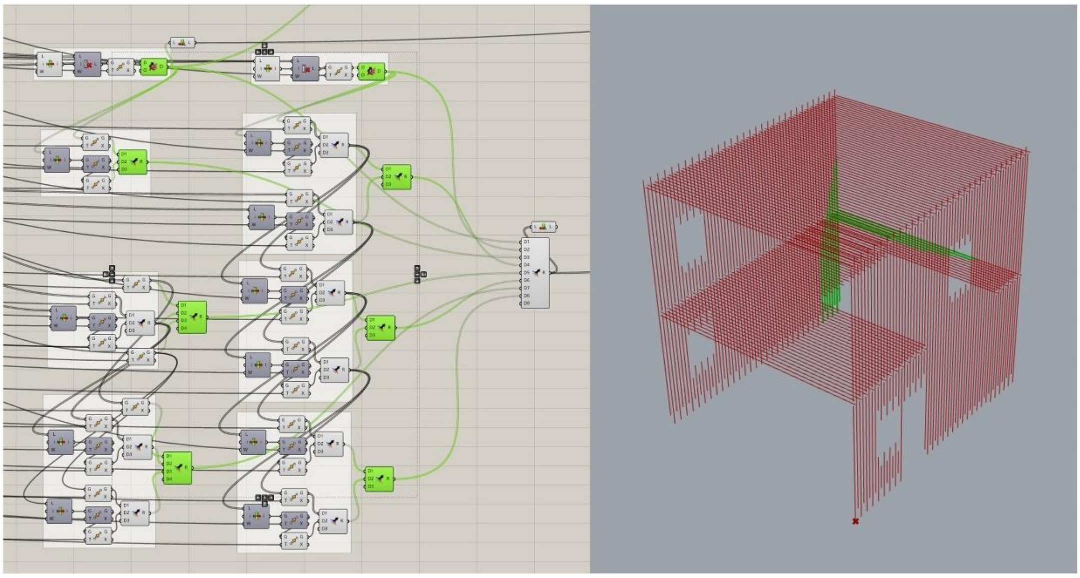


**Fig. 5-25(d) Parametric construction process of building unit H in grasshopper.**

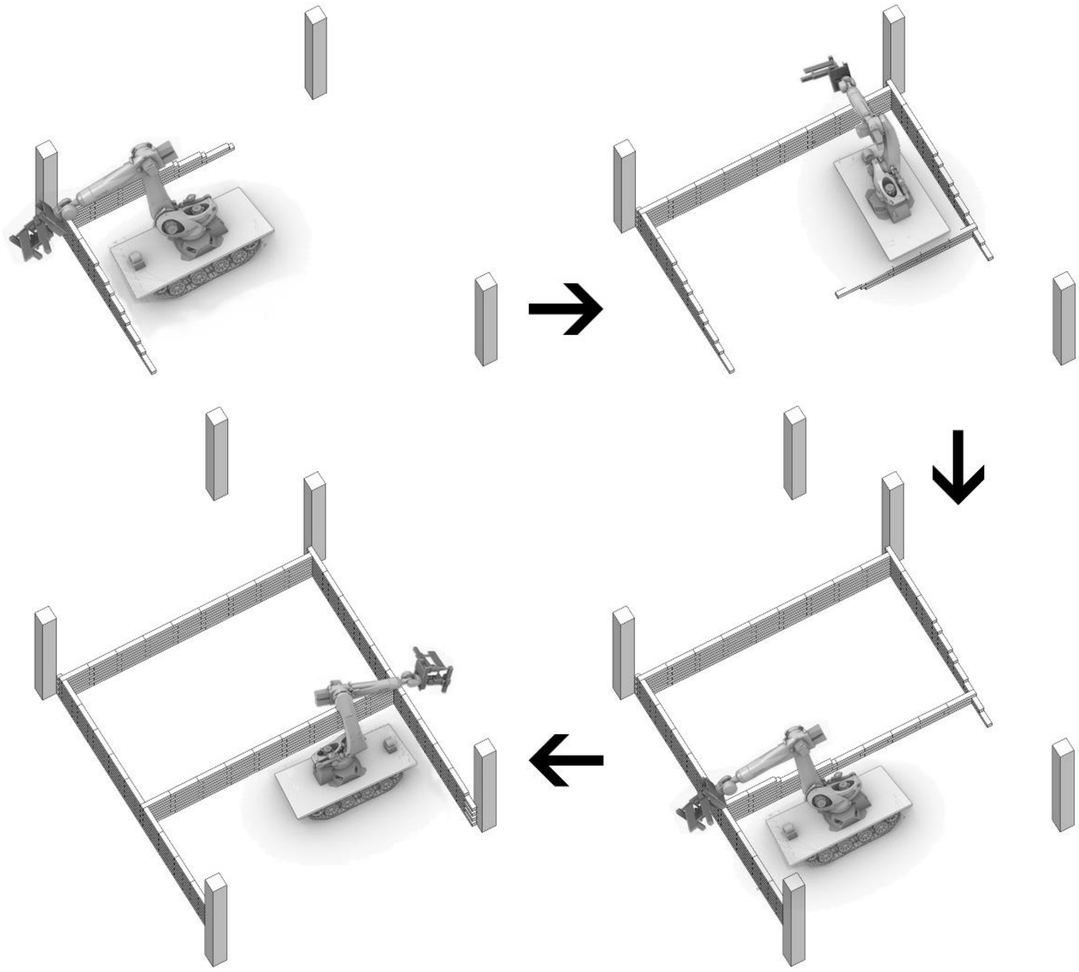


**Fig. 5-26 Snapshots of unit H with four groups built by the mobile robot.**

### 5.3.3. Robot construction steps

As in Case study 1, the mobile robot construction also has four main steps done by the robot. The robot completes the assembly sequence with the same steps in each static range to minimize the number of manual steps in the construction process. Here, the assembly sequence conducted by the robot has four main steps: picking timbers, applying glue, placing timbers, and nailing. The four steps are described in detail below, as shown in Figure 5-27.

Pick: Unlike the timbers of varying lengths used in manual construction, this experiment uses timbers of the same size and does not require the operator to deliberately identify their dimensions. The picking of the timbers is the first step in this assembly sequence. The gripping clamps on the robot’s end effector are designed to have the same picking point and are at the midpoint of each timber.

Glue: The connection between the timbers requires the application of glue and nails. In the glue application step, the robot grips the timbers and passes over the roller of the glue box in a line with the topmost point of the roller and the length of the timbers as the length. The glue box is designed as a container filled with water-based polymer wood adhesive and a roller on which the glue can be picked up.

Nail: In addition to glue application, the connection between the timbers is enhanced by nailing. The robot end-effector is equipped with an air nail gun that can be fitted with nails longer than the length of the timbers. For each timber, the air gun is used to nail two nails at a distance of 200 mm, and the nailing operation is performed by holding the timber in the set position while the air gun shoots the nails. After this, the gripper releases the timber and the robot rotates 180° in the A6 axis and then performs the same operation.

Place: In case of collision with adjacent timbers in the process of placing, instead of the LIN motion method of straight-line motion between two points, the robot needs to run the moving route of clamping the timbers with the robot's A5 axis as the main rotation PTP+LIN motion method.

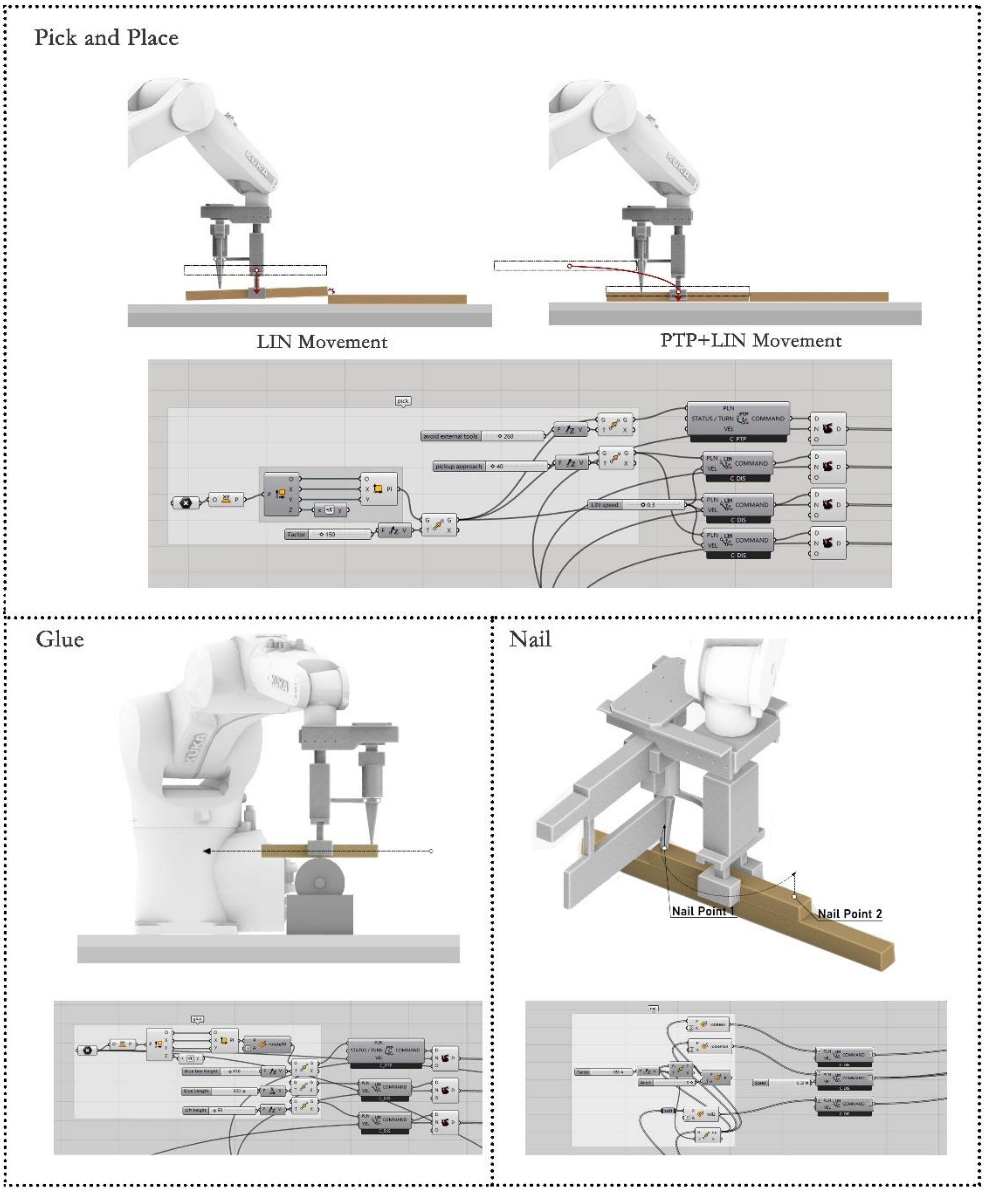



**Fig. 5-27 Robot construction steps: glue, nail, pick and place.**

### 5.3.4. Mapping, Alignment, and Localization

The first step is mapping and alignment. Before starting the fabrication process, the building site needs to be mapped by the robot from a set location. The sensing instrument used in this experiment is the LIDAR RPLIDAR A1, a laser scanning and ranging radar that can perform a 360-degree laser scan within a 12m radius of a two-dimensional plane and produce a planar point cloud map of the space in which it is located. With a sampling period of 1450 samples/week, the RPLIDAR scans at a frequency of 5.5hz and up to 10hz. The RPLIDAR A1 is divided into a laser ranging core and a mechanical part that allows the laser ranging core to rotate at high speed. After power is applied to each subsystem separately, the rangefinder core will start to rotate and scan clockwise, as shown in Figure 5-28. The user can use the RPLIDAR A1's communication interface (serial/USB, etc.) allows the user to access RPLIDAR's scanning and ranging data. The RPLIDAR A1 has its own speed detection and adaptive system, and the scanning frequency of the radar will automatically adjust to the actual motor speed.

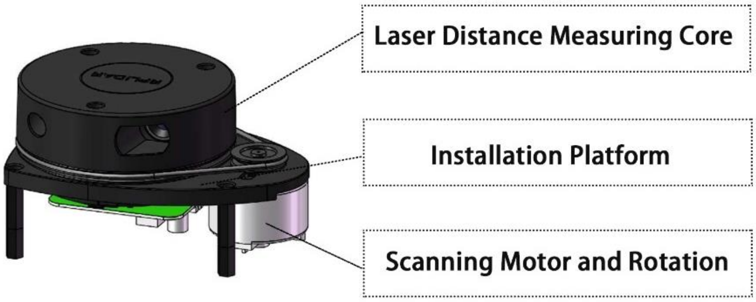



**Fig. 5-28 RPLIDAR A1 system configuration diagram.**

The RPLIDAR A1 uses laser triangulation technology, together with the high speed vision acquisition processing mechanism developed by SLAMTEC, to perform up to 8,000+ distance measurement actions per second. During each range measurement, the RPLIDAR A1 emits a modulated infrared laser signal, which is reflected by the RPLIDAR A1's vision acquisition system when it hits the target object. After the DSP processor embedded in the RPLIDAR A1, the distance value of the irradiated target object and the current angle information will be output from the communication interface, as shown in Figure 5-29.

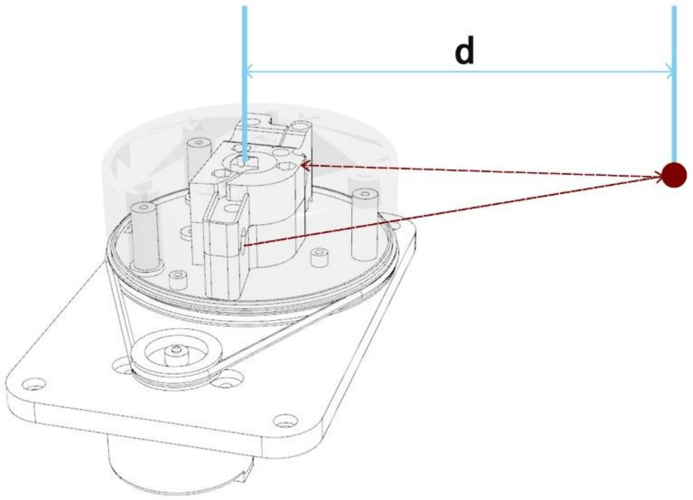



**Fig. 5-29 RPLIDAR A1 working principle diagram.**

This mapping is achieved by executing a sweeping motion by a LIDAR instrument placed on the mobile robot platform to capture an initial point cloud for each static location. Next, the existing model of the experimental construction site is aligned with the point cloud obtained from the scan.

In this experiment, the scanned building construction site dimensions may deviate from the designed CAD model dimensions, and these deviations will affect whether the designed building component locations match the realistic construction site during building construction, meaning it is necessary to scan and confirm the actual site environment before starting construction. Within this experiment, the key objects of the site are represented by additional columns immediately adjacent to each building unit, and the positions of these key objects in the CAD model are aligned with the actual scanned point cloud positions. When their as-built poses are fed back into the architectural design and planning environment and errors occur, the CAD model of the building site needs to be updated to align the design with the actual environment.

The point cloud of the construction site scanned using LIDAR is shown in Figure 5-30, and the columns marked in blue on the right are the key objects of the design. Using the interaction between the LIDAR software and the parametric modeling software, the CAD model of the design and the scanned point cloud can be matched and aligned by key objects in the same software, as shown in Figure 5-31.

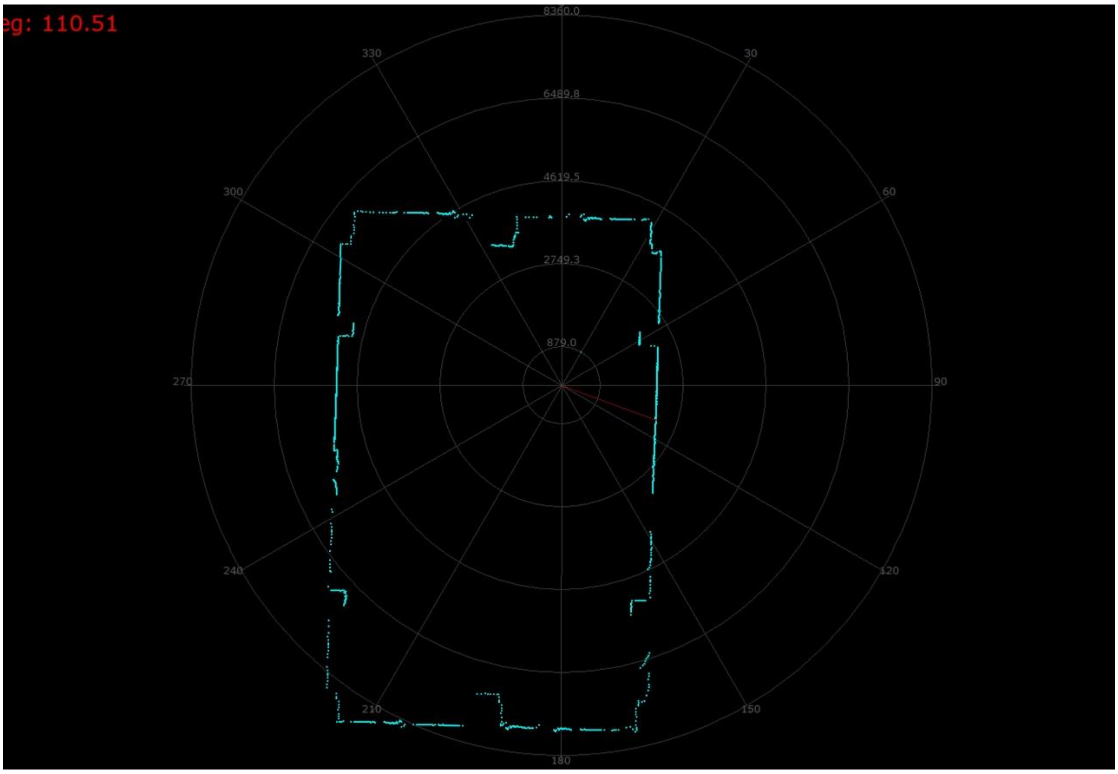



**Fig. 5-30 Mapping of the construction.**

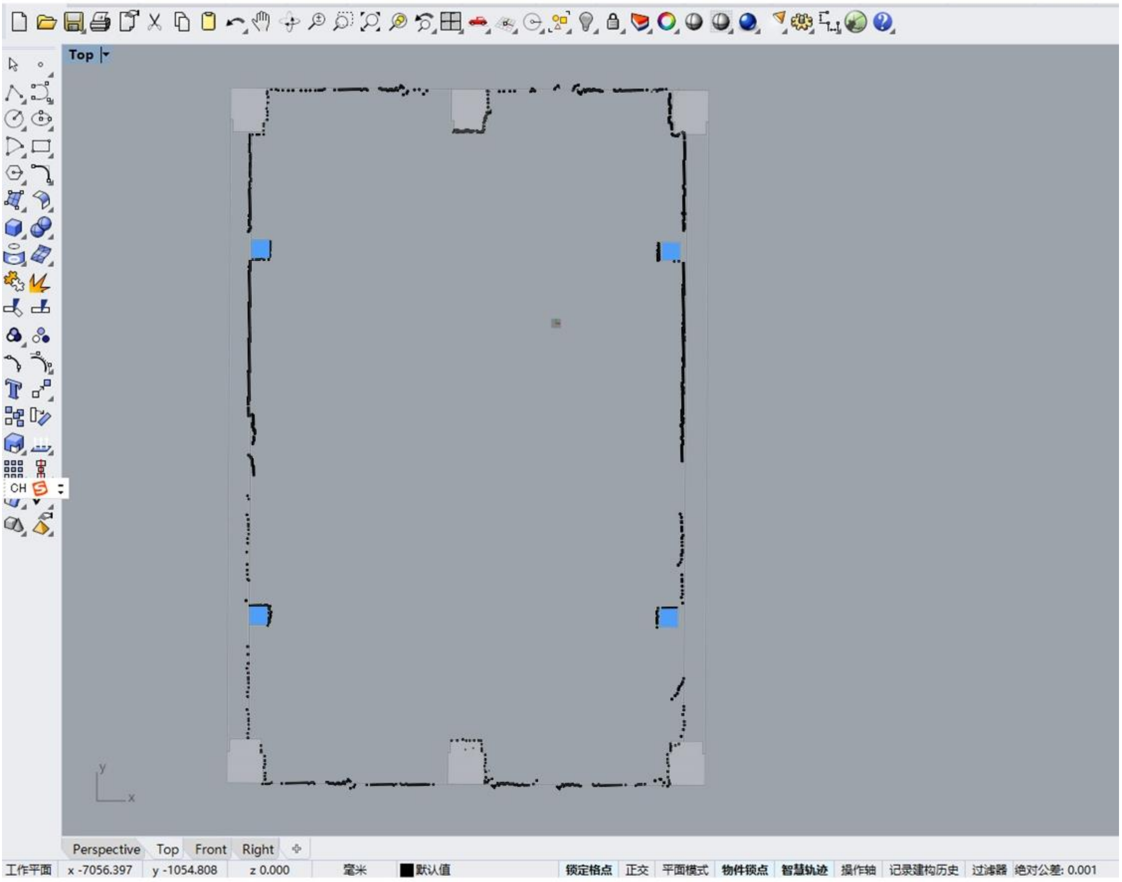



**Fig. 5-31 Alignment of the construction.**

After the site environment is determined to be aligned with the designed CAD model construction site, the robot needs to be relocated for each displacement. This requires two radar scans at each designed positioning point and the use of key objects as identification objects. First, the scanned point cloud of each positioning point is obtained and interacts with the modeling software to generate a construction site map for each point before the experiment starts the construction step; after starting the construction, each displacement of the robot is rescanned after reaching the design position, and the key objects are used to align the two scanned point clouds before and after, as shown in Figure 5-32.


**Fig. 5-32 (a) Scanning and alignment of the robot's four positioning points.**


**Fig. 5-32 (b) Scanning and alignment of the robot's four positioning points.**

If there is an error between the two scans, when the point cloud of the construction environment is aligned, the deviation of the center point of the two scans is the deviation of the robot's position after displacement. Based on the angle and distance of the difference between the two points, the deviation between the displaced robot position and the original design construction positioning point can be calculated.

① The first step is to import the point cloud coordinates of the radar scan into grasshopper.

② The second step is to calculate the XYZ values of each coordinate point.

③ The third step is to display the scanned coordinate points in grasshopper so that the errors of the different scanned coordinate points can be visualized, as shown in Figure 5-33.

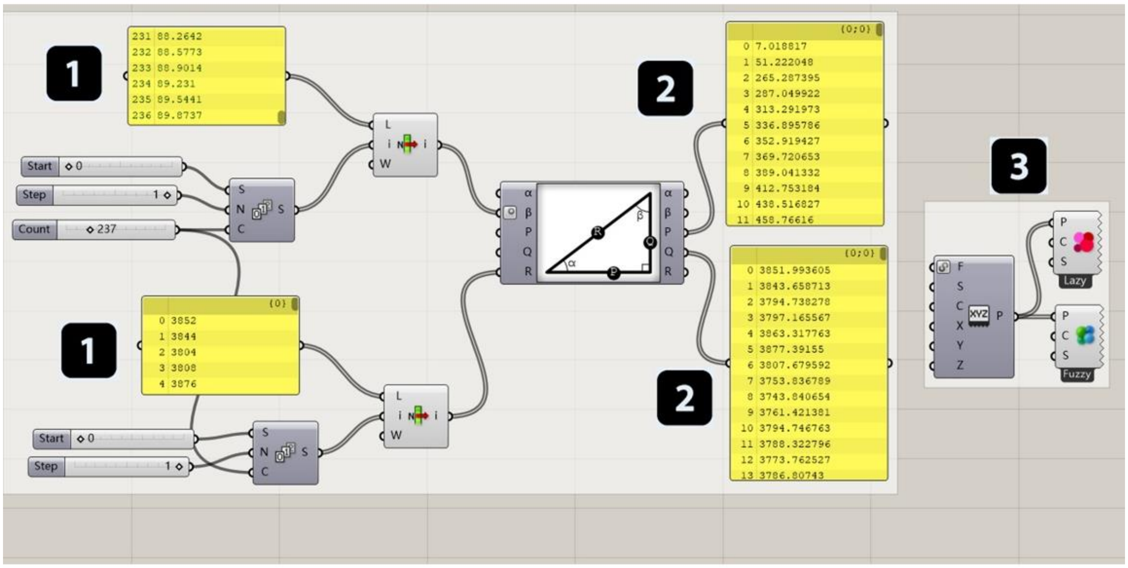



**Fig. 5-33 Visualization of point clouds from radar scans in grasshopper.**

The relationship between the position of the construction object and the original robot construction point in the designed CAD model can be modified accordingly, as shown in Figure 5-34, so that the experiment can be carried out accurately after the displacement.

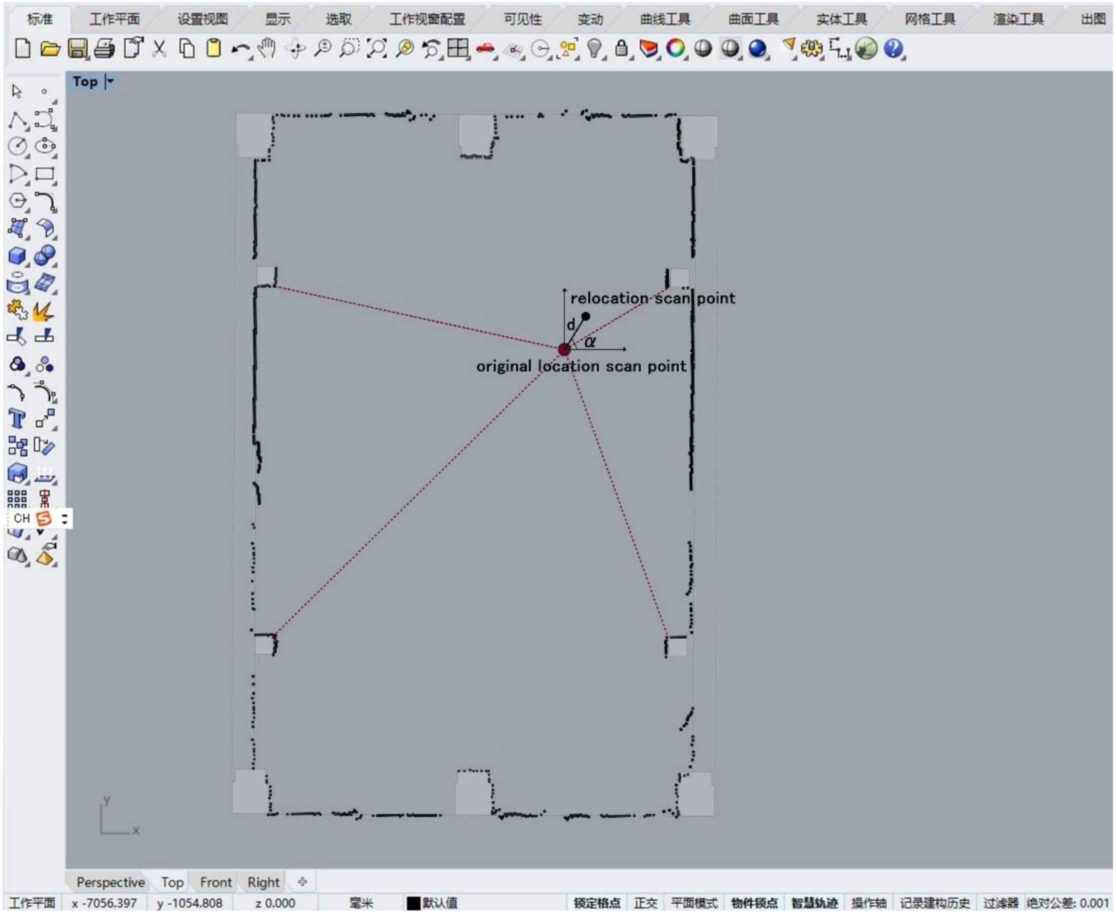



**Fig. 5-34 Mapping and alignment of the construction site.**

### 5.4. Flowchart for fabrication control loop

After the calibration process of mapping and aligning the construction area and adjusting the position of the construction object to the robot's original point, the next construction is ready to proceed. The mobile robot performs a static operation at each positioning point and then moves to the next positioning point and repeats the calibration process to complete the next set of building construction. In this process, each step of the robotic construction requires the construction instructions to be converted into digital information that the robot and LIDAR instrument can receive. This is a series of digital information that can be interacted with and adjusted in time to ensure that the entire construction process can be carried out smoothly.

The following flowchart outlines the control loop for this fabrication process, which controls the robotic nodes to complete the building fabrication, as shown in Figure 5-35.

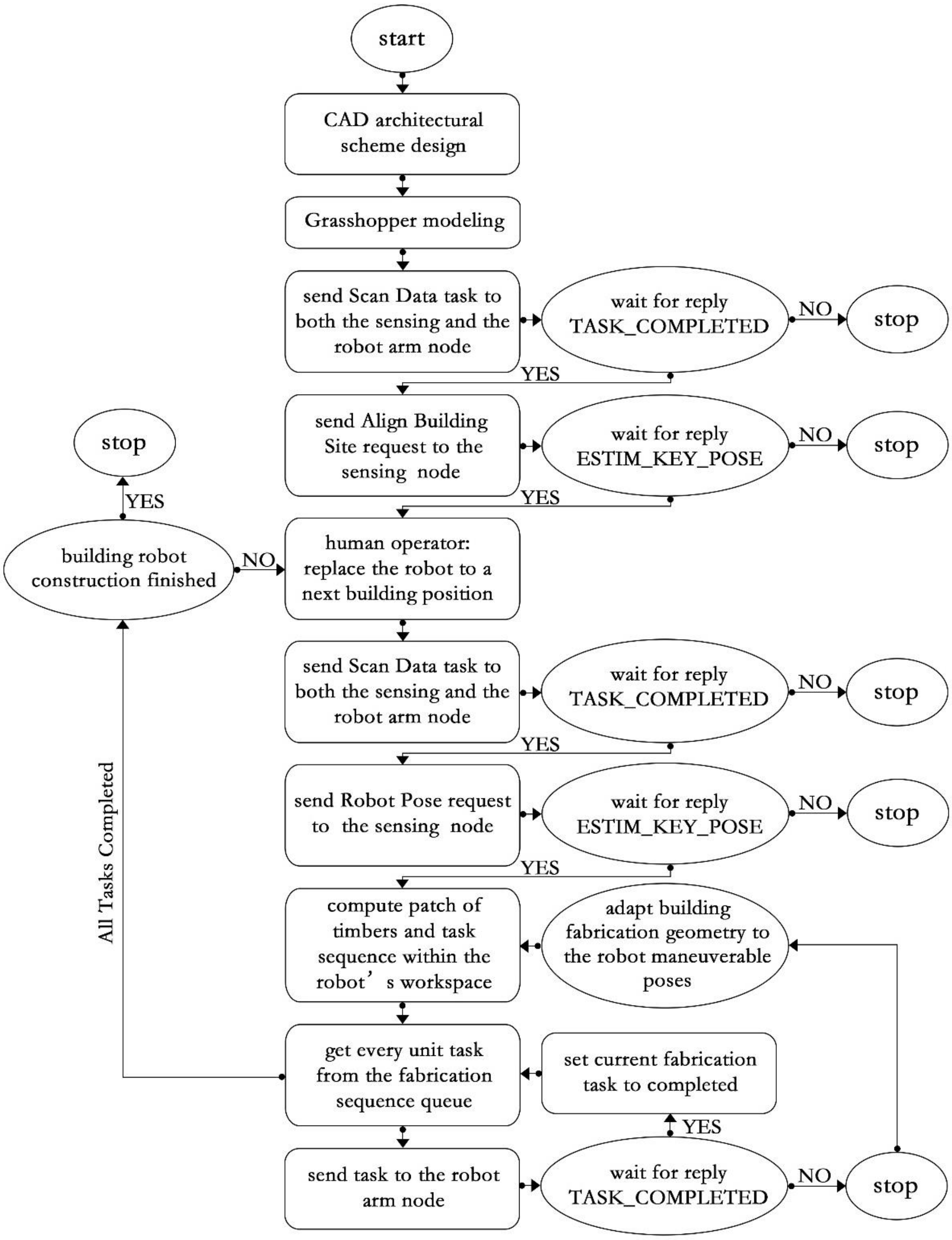



**Fig. 5-35 Flowchart for the timber building's fabrication control loop.**

A multidisciplinary approach that combines novel robotics and construction has made possible initial experiments in on-site assembly of wood buildings using site-built robots. Its successful implementation marks a step forward in the integration of robotic on-site fabrication processes.

The accomplishments of the experiment can be summarized as follows: A construction process integrated with an automated approach was accomplished and allowed the adaptation of the parametric building model to the construction method of the mobile robot and the scanning sensing of the construction site; secondly, a scanning and localization system was integrated and validated in the experiment, allowing the robot to perform construction tasks from multiple locations. Finally, a wood building mobile assembly strategy was developed that allows such wood structural units to be built continuously and integrally with minimal robot migration.

But this experiment also shows its limitations, first of all, there is a limitation on the length of the construction timber, which otherwise cannot be built in a laddered cascade using the mobile robot, which limits some of the material properties of the wood. In addition, the mapping and alignment process has limitations in that the alignment requires user-specific definitions, in particular the definition of which objects on the build site are to be registered as key objects in the obtained point cloud map, and a good initial guess where the key objects are already close to their expected locations. Further developments in these directions need to support both the automatic identification of what is defined as a key object or key feature in the environment and the partitioning of these objects into semantically meaningful predefined classes.

*Chapter 6*

# *CONSTRUCTION EVALUATION*

# CHAPTER SIX: CONSTRUCTION EVALUATION

### 6.1 Construction Evaluation

Construction evaluation is one of the main focuses of this experiment. The comparison between manual construction and robotic on-site construction experiments allows the advantages and disadvantages of two different construction methods for the same timber building to be identified. The following section shows the advantages of robotic construction in terms of natural and economic environment, and the reasons for choosing robotic construction in terms of quantitative data.

The manual construction building and the robotic construction building in our thesis have the same building plan, but due to the different construction methods, the building structure and construction process are different, and have a greater impact on the final construction efficiency.

Next, the efficiency of both sides is evaluated mainly in terms of time efficiency evaluation and construction quality evaluation.

### 6.2. Time Efficiency Evaluation

#### 6.2.1. Manual Construction

The number of completed units is five from A to E, and the unit production order is A→C→B→D→E. The construction results and work efficiency are evaluated from the construction results of the five units, and the construction evaluation is carried out.

Table 6-1 the layer construction time of each unit.

| Time(min) | Unit A | Unit B | Unit C | Unit D | Unit E |
|---|---|---|---|---|---|
| Layer 1 | 0 | 0 | 0 | 0 | 0 |
| Layer 2 | 25 | 37 | 16 | 21 | 53 |
| Layer 3 | 20 | 13 | 21 | 25 | 48 |
| Layer 4 | 15 | 14 | 22 | 14 | 34 |
| Layer 5 | 15 | 13 | 13 | 16 | 14 |
| Layer 6 | 10 | 8 | 13 | 12 | 11 |

| | | | | | |
|---|---|---|---|---|---|
| Layer 7 | 15 | 12 | 13 | 12 | 12 |
| Layer 8 | 10 | 14 | 19 | 26 | 11 |
| Layer 9 | | | 20 | 13 | |
| Layer 10 | | | | 14 | |
| Total Time | 115 | 111 | 137 | 153 | 183 |

There are many uncertainties in manual construction, which can be affected by uncertainties such as site conditions, number of constructors, and work efficiency. The building was built by students in the research lab, and there was a lack of construction proficiency and organization to ensure that each unit was built with the same number of people and work efficiency. As shown in Figure 4-1, the shortest construction time in building construction is the sixth layer of unit B, which is about 8 minutes. In addition, the longest construction time was 53 minutes for the second layer of Unit E. One of the reasons for this difference is the number of constructors. unit B has 8 people and unit E has 3 people. This is the main reason for the difference in working hours and shows that the number of people involved in the manual construction process can directly affect the construction time.

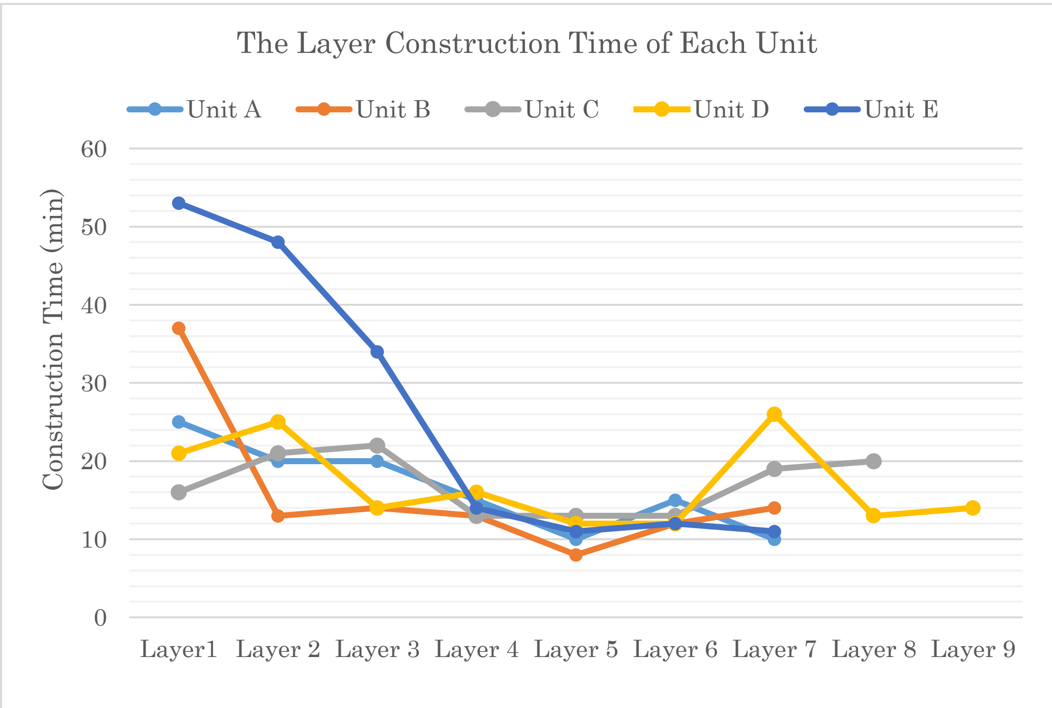



**Fig. 6-1 The layer construction time of each unit by manual construction.**

Table 6-2 shows each unit construction time and number of people.

Table 6-2 Each unit construction time and number of people.

| Unit A | Unit B | Unit C | Unit D | Unit E |
|---|---|---|---|---|
| The relationship between the combined time and the number of people | | | | |
| 115 min | 111 min | 137 min | 153 min | 183 min |
| 13 people | 8 people | 9 people | 8 people | 2.5 people |
| Each unit per group builds time(min) | | | | |
| 14.375 min | 13.875 min | 14.625 min | 15.75 min | 22.875 min |
| per group builds time | | | | 16.3 min |
| The first eight groups of time total | | | | |
| 115 min | 111 min | 117 min | 126 min | 183 min |

As shown in Figure 6-2, unit A is the least efficient and unit E is the most efficient. First, it can be concluded that in this construction, not too many constructors are needed for each unit, and more than a certain number of constructors will affect the overall project construction efficiency. Second, unit A is the first construction unit, and the constructors are not familiar with the construction process, which leads to inefficiency. It can be the conclusion that not only the number of constructors will affect the construction time, but also the efficiency and proficiency of the constructors will affect the overall construction efficiency.

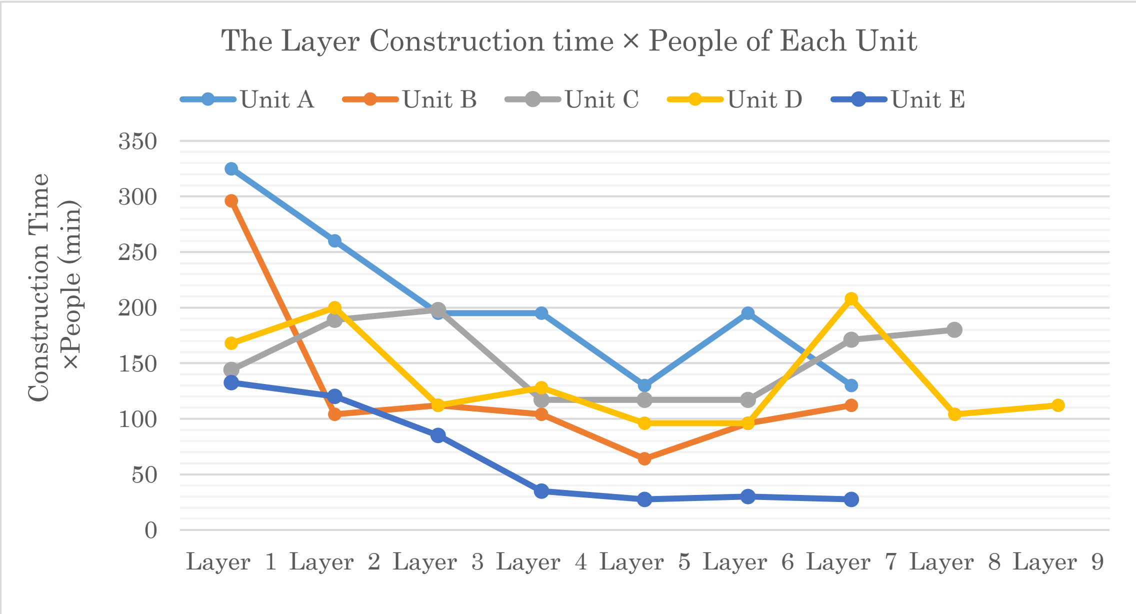



**Fig. 6-2 The layer creation time × people of each unit by manual construction.**

### 6.2.2. Stationary Robotic Construction

The stationary robot performs the construction steps in a set sequence within its static working range, which does not require human intervention. The design of the grasshopper takes into account each step of the construction process, so that the stationary robot's construction time can be calculated directly from the program and is stable, and the total construction time is related to the robot running speed set in the program, as shown in Figure 6-3. Only three operators are needed for the entire construction process: two operators place the timbers in the construction order at the pick-up point, and one operator runs the robot.

In the whole construction process, operators need to participate in a limited number of steps, and the construction time is controlled by parametric design. After meeting the number of operators required for construction, continuing to increase the number cannot improve the overall construction time. Thus, the robot construction is stable in construction time and manual use.

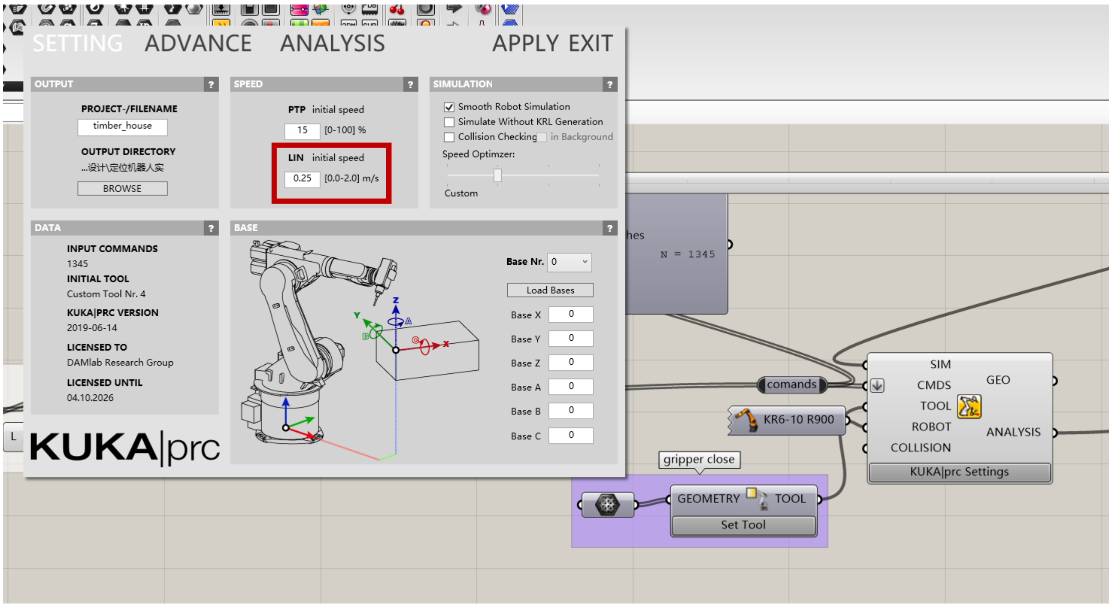



**Fig. 6-3 Setting robot running speed in grasshopper.**

The building is constructed in layers per unit, as shown in Figure 6-4, and the number of layers varies from unit to unit, and the number of timbers per layer varies, so the construction time varies, but the overall construction time is stable, as shown in Figure 6-5.

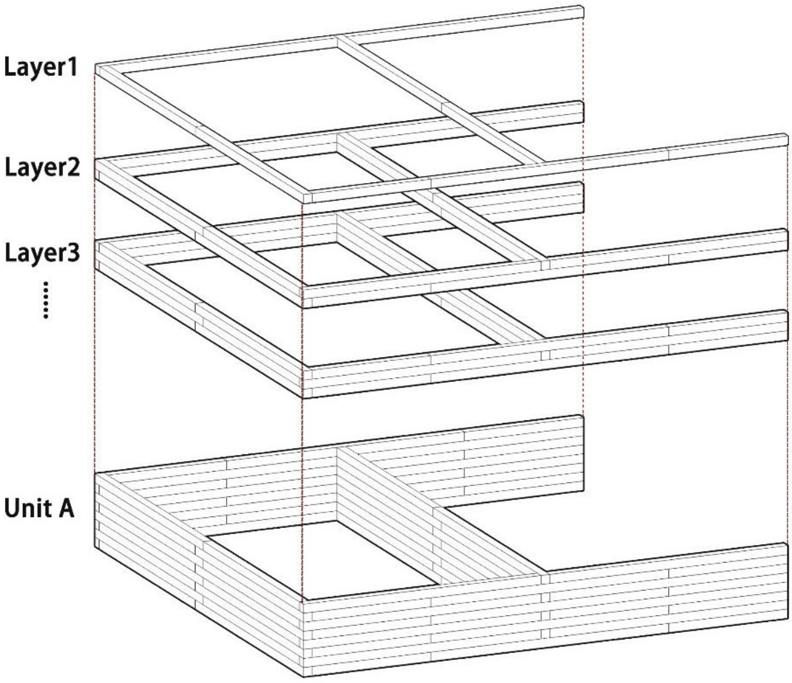



**Fig. 6-4 Layering method for stationary robot construction.**

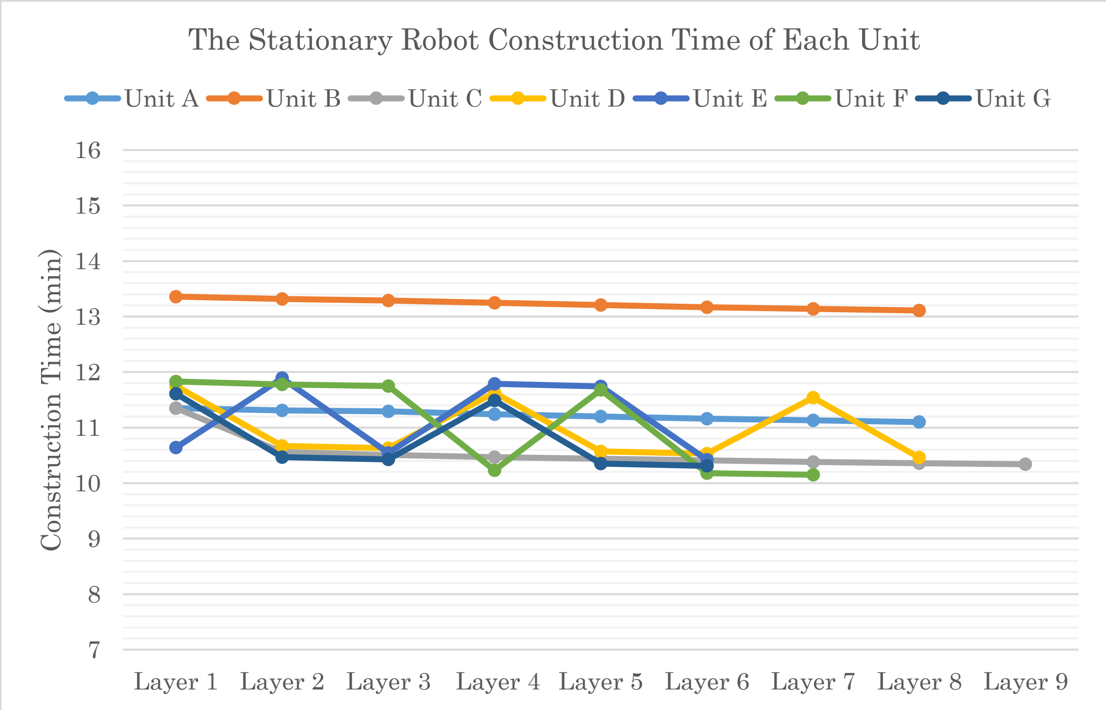



**Fig. 6-5 The layer construction time of each unit by stationary robot construction.**

### 6.2.3. Mobile Robotic Construction

Like manual construction, mobile robotic construction is done one by one for each unit, except that each unit is divided into four groups. The construction time in Table 6-3 represents the time required for the robot to build the timbers according to the specified steps within the static working range of each group. Each step of the construction process has been digitized and executed by the robot, and the construction time can be calculated from the design program and is relatively stable. The robot moves and relocates three more times during the construction of each unit, and the time for this step is also stable and calculated into the construction time of the whole unit.

Throughout the robotic construction process, operators need to be involved in a limited number of steps, so the number of operators required is small and the overall construction time is stable. This also shows that after meeting the number of operators needed for construction, continuing to increase the number of people does not improve the overall construction time. This shows that robotic construction is stable in terms of construction time and labor usage.

Table 6-3. Table of numbers relating to the mobile robot construction of each unit.

| **Uuit** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** |
|---|---|---|---|---|---|---|---|---|
| **Construct** | 303. | 292. | 268. | 261. | 244. | 224. | 234. | 295. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **ion time(min)** | 10 | 70 | 54 | 09 | 62 | 20 | 74 | 58 |
| **Robot relocation time** | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| **Number of timbers** | 305 | 294 | 276 | 269 | 248 | 231 | 241 | 304 |
| **Number of layers** | 8 | 9 | 8 | 8 | 8 | 7 | 7 | 8 |
| **Average time per layer** | 49.14 | 42.52 | 44.82 | 43.89 | 41.83 | 44.89 | 46.39 | 48.20 |
| **Number of people** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Time per layer× People** | 98.27 | 85.04 | 89.63 | 87.77 | 83.65 | 89.77 | 92.78 | 96.39 |

Because the mobile robot needs to relocate itself during the construction of each unit, each unit of the construction is not built in layers as the manual and fixed robots did before, but each unit is built in 4 groups, as shown in the Figure6-6. Therefore, mobile robot construction can only count the construction time by group, as shown in the Figure6-7.

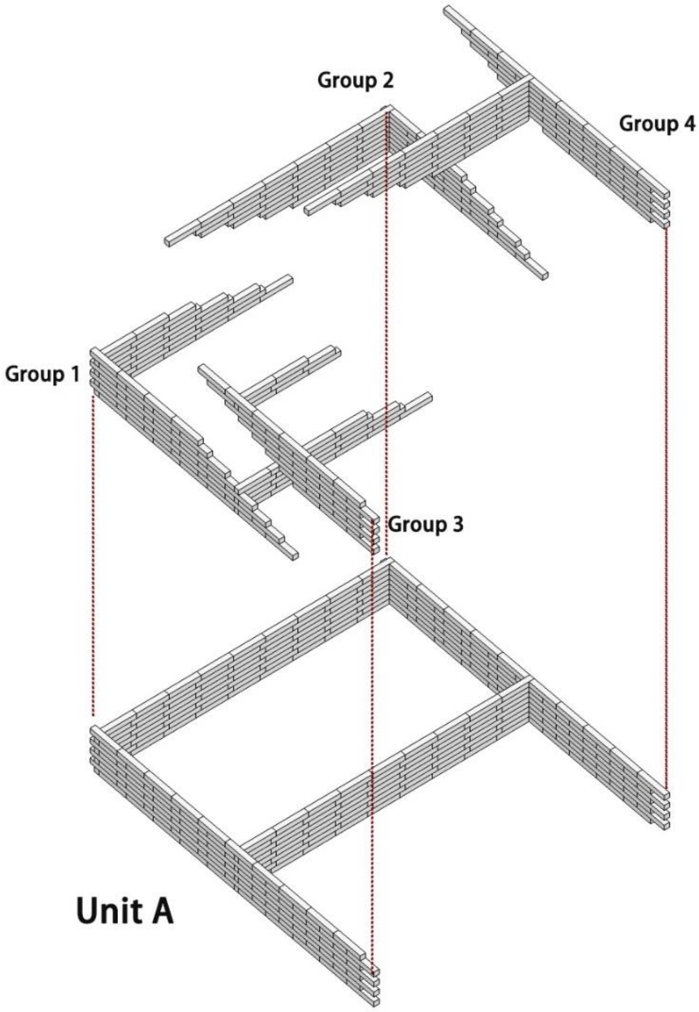



**Fig. 6-6 Grouping method for mobile robot construction.**

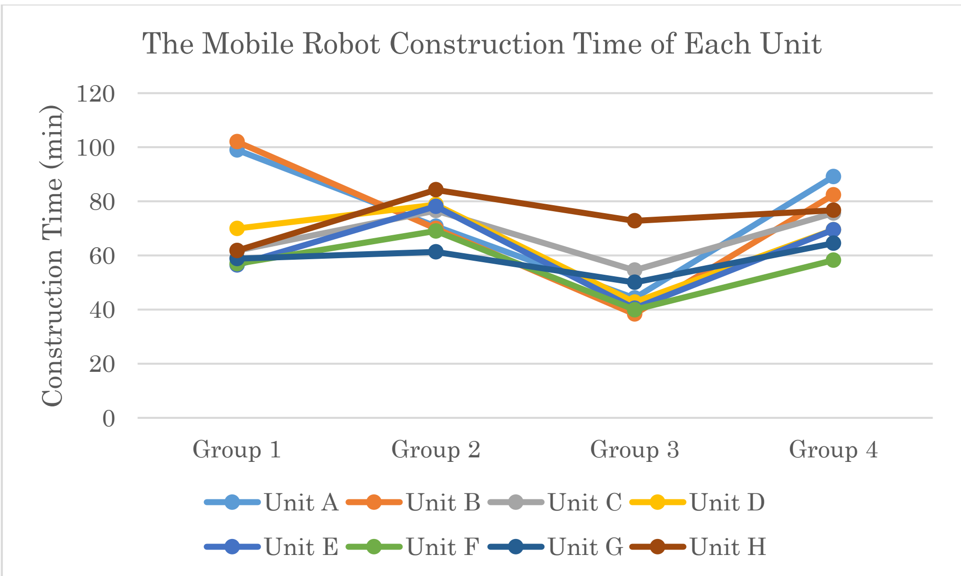



**Fig. 6-7 The group construction time of each unit by mobile robot construction.**

In order to accommodate the construction of mobile robot, short timbers of the same size are selected for staggered and overlapping construction. Compared to manual construction, the number of timbers increases, the number of robot repetitions of construction increases, and the total construction time of each unit becomes longer. However, the number of operators required for the whole construction process is smaller, and the total labor time is reduced as shown in Figure 17. Therefore, robotic construction is useful for reducing the use of labor and increasing the overall construction efficiency including the labor factor.

### 6.2.4. Comparison of the time efficiency of different construction methods

To compare the time efficiency of the three construction methods, it is first clear that due to the different construction methods, the assembly form of the building changes and the number of timbers used for each unit varies greatly, especially for mobile robot compared to manual and stationary robot construction, as shown in Figure 6-7. Mobile robot construction applies to short timbers, which greatly increases the number of timbers used to build the same building. For robotic construction, each timber is operated in the same four-step: pick-glue-nail-place, and an increase in the number of timbers means an increase in the number of robotic operations, and the total construction time increases with a significant increase in the number, as shown in Figure 6-8.

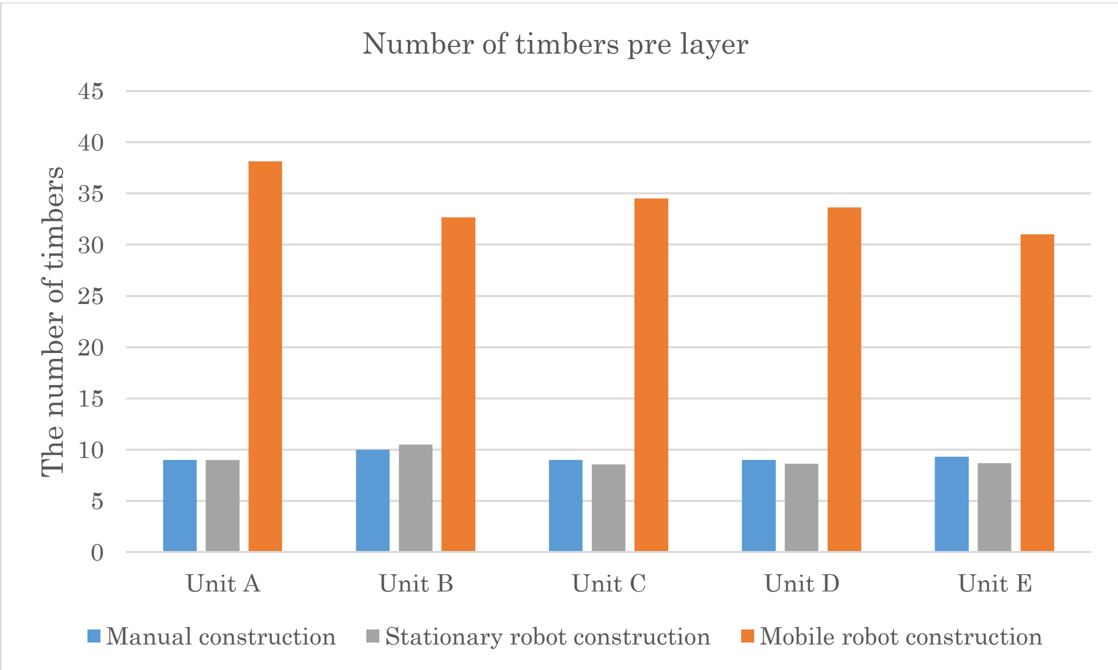



**Fig. 6-7 The comparison about number of timbers pre layer.**

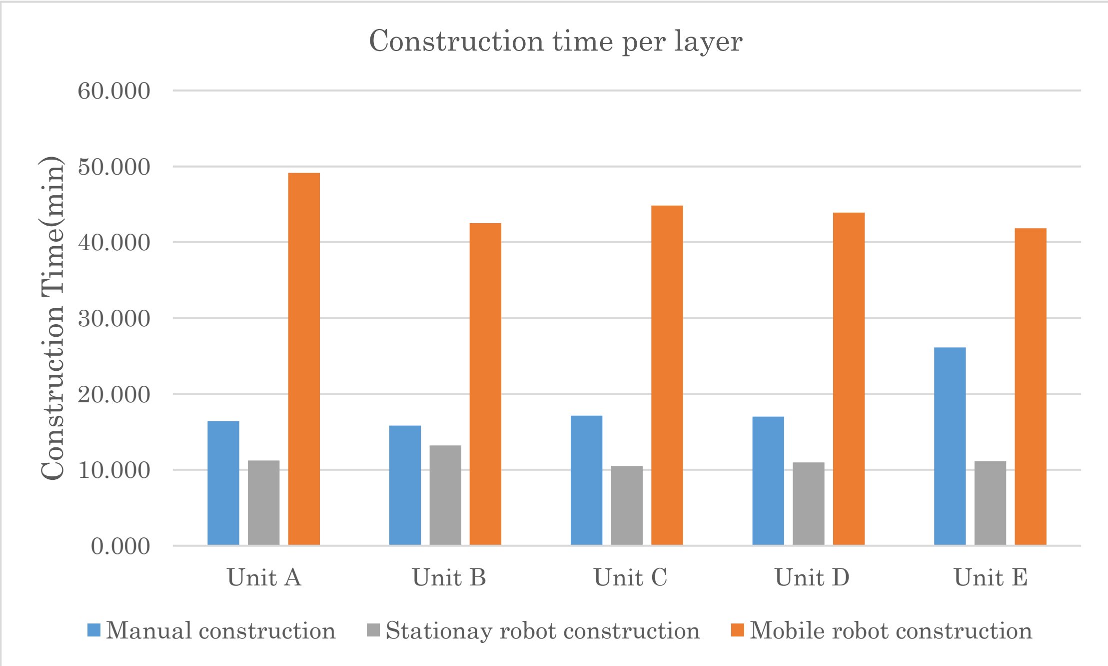



**Fig. 6-8 The comparison of construction time per layer.**

The Table 6-4 shows the total construction time, the number of unit construction layers, the average construction time of each unit and other relevant data of the three different construction methods, and visually presents the different construction time efficiency caused by different construction methods.

Table 6-4. Table of data related to different construction methods.

| Construction Method | | Unit A | Unit B | Unit C | Unit D | Unit E |
|---|---|---|---|---|---|---|
| Manual Construction | Total Time (min) | 115 | 111 | 137 | 153 | 183 |
| | Layer | 7 | 7 | 8 | 9 | 7 |
| | Construction time per layer | 16.43 | 15.86 | 17.13 | 17.00 | 26.14 |
| | Average unit | 18.51 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | construction time | | | | | |
| Stationary Robot Construction | Total Time (min) | 89.78 | 105.85 | 94.83 | 87.78 | 67.02 |
| | Layer | 8 | 8 | 9 | 8 | 6 |
| | Construction time per layer | 11.22 | 13.23 | 10.54 | 10.97 | 11.17 |
| | Average unit construction time | 11.43 | | | | |
| Mobile Robot Construction | Total Time (min) | 393.10 | 382.70 | 358.54 | 351.09 | 334.62 |
| | Layer | 8 | 9 | 8 | 8 | 8 |
| | Construction time per layer | 49.14 | 42.52 | 44.82 | 43.89 | 41.83 |
| | Average unit construction time | 44.44 | | | | |

The time efficiency of construction does not only depend on its absolute construction time, but should also include the overall time efficiency considering the number of builders. Here, the number of people involved in the construction differs significantly between manual and robotic construction, as manual construction requires more builders and the number of builders per unit varies and is unstable because it is done by students. In contrast, robotic construction requires a steady and smaller number of builders per unit. Mobile robot construction requires only one stocker and one robot operator for a total of two builders. The stationary robot uses long timbers and requires two stockers to place the timbers, plus the robot operator, for a total of three builders, as shown in Table 6-5 and Figure 6-9.

Table 6-5. Table of data related to different construction methods.

| Construction Method | | Unit A | Unit B | Unit C | Unit D | Unit E |
|---|---|---|---|---|---|---|
| Manual Construction | Construction time per layer | 16.43 | 15.86 | 17.13 | 17.00 | 26.14 |
| | People | 13 | 8 | 9 | 8 | 4 |
| | Construction time per layer × People | 213.57 | 126.86 | 154.13 | 136.00 | 104.57 |
| | Average unit construction time × People | 147.03 | | | | |
| Stationary Robot Construction | Construction time per layer | 11.22 | 13.23 | 10.54 | 10.97 | 11.17 |
| | People | 3 | 3 | 3 | 3 | 3 |
| | Construction time per layer × People | 33.66 | 39.69 | 31.62 | 32.91 | 33.51 |
| | Average unit construction | 34.28 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | time × People | | | | | |
| Mobile Robot Construction | Construction time per layer | 49.14 | 42.52 | 44.82 | 43.89 | 41.83 |
| | People | 2 | 2 | 2 | 2 | 2 |
| | Construction time per layer × People | 98.28 | 85.04 | 89.64 | 87.78 | 53.66 |
| | Average unit construction time × People | 88.88 | | | | |

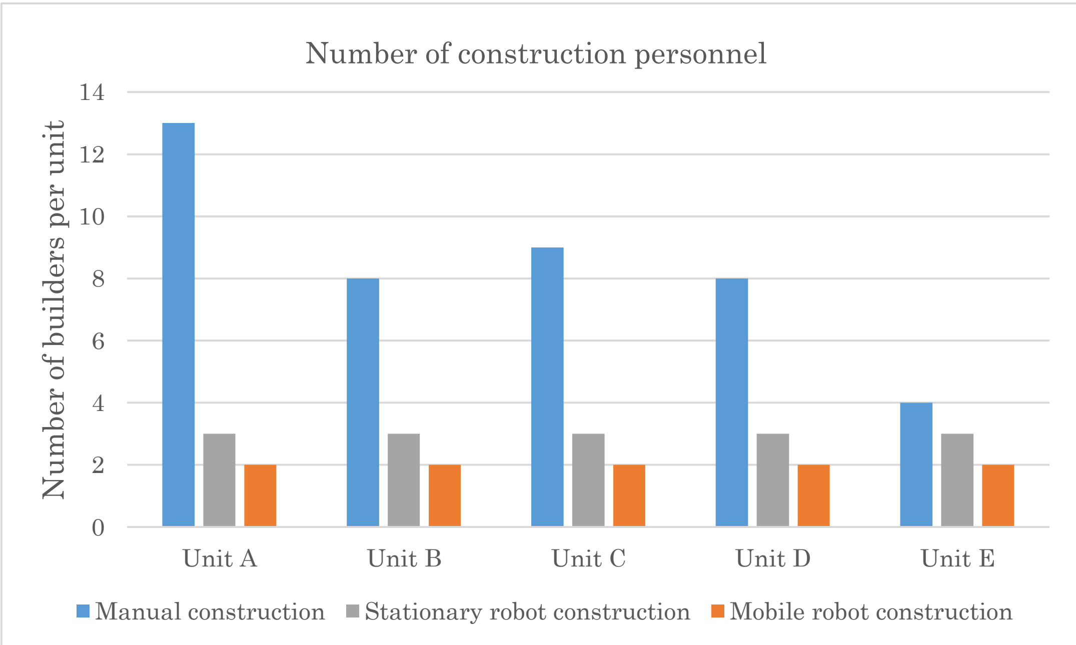



**Fig. 6-9 The comparison about number of construction personnel.**

the number of operators required for the whole construction process is smaller, and the total labor time is reduced as shown in Figure 6-10. Therefore, robotic construction is useful for reducing the use of labor and increasing the overall construction efficiency including the labor factor.

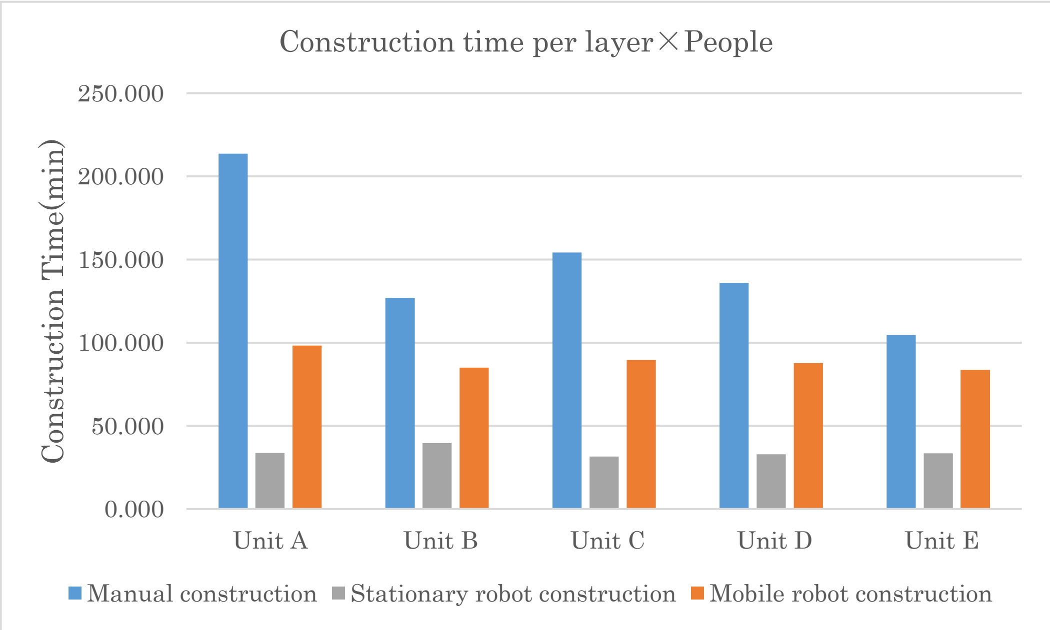



**Fig. 6-10 The comparison of construction time per layer×people.**

The comparison shows that the robot construction time is shorter than the manual construction time, more efficient and stable, and the efficiency of the robot in its normal construction state is not affected by the number of construction workers. Therefore, robot construction has an important impact on improving the efficiency of construction time.

### 6.3. Construction Quality Evaluation

Construction quality evaluation is equally important for construction projects. In addition to high construction efficiency, construction accuracy is also the key to measuring the merits of a project.

#### 6.3.1. Manual Construction

Due to the level of construction workers, the current state of the construction site, the precision of construction tools, and other aspects of the impact of on-site construction, there will be a certain degree of construction errors, the accumulation of errors layer by layer will cause some interference with the overall construction quality, reducing the accuracy of construction. In the case of manually constructed buildings, errors may exist in every step from timber cutting, timber building, and timber joining.

The chainsaw gears used to cut the timber are very thick and manually operated, so the cutting results will deviate from the required dimensions. As shown in Figure 6-11 shows the measurement of the timber after cutting, the actual cut size of the timber with the design size of 2900mm is

2896mm and the error has started to appear.


**Fig. 6-11 Manual construction site photos.**

There are also deviations in the process of erection and connection of timber, as shown in Figure 6-12, and the connection gaps tend to appear in the articulated part of the building facade and roof.

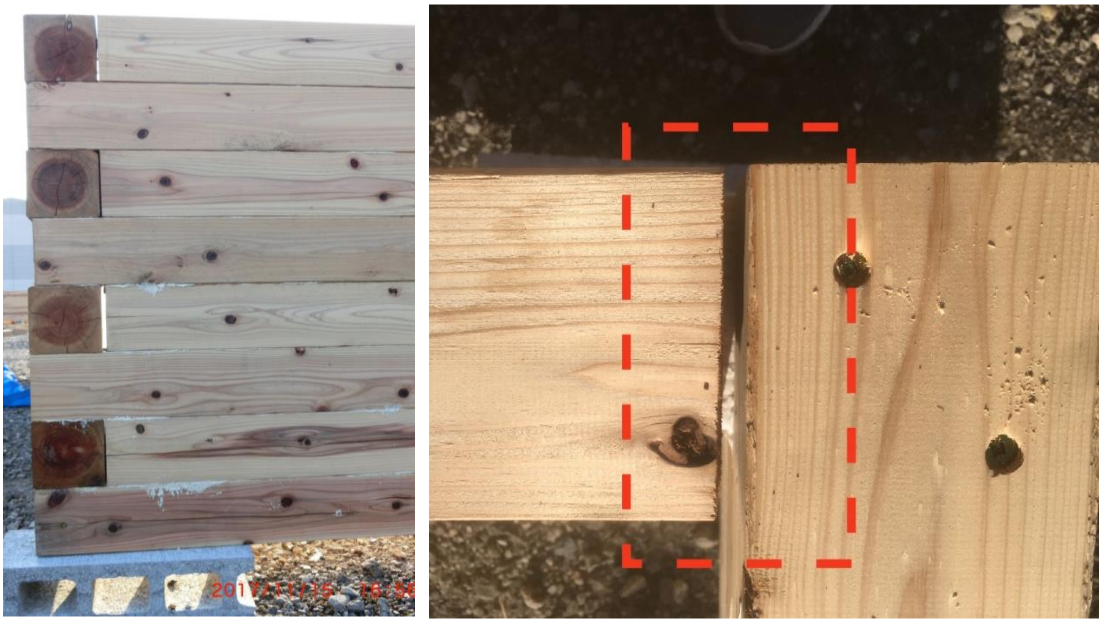


**Fig. 6-12 Manual construction site photos.**

As shown in Figure 6-13, the facade is displaced during the erection process, making the wall surface not flat enough.

**Fig. 6-13 Manual construction site photos.**

The stacked members also have an offset in the longitudinal direction. As shown in the Figure 6-14 is the part of the stair installation. When the stairs and the wall are fixed, the wood on the wall is pulled and affected by the stair wood and displaced.

**Fig. 6-14 Manual construction site photos.**

The construction process of gluing by hand may result in insufficient glue application in some places and too much glue application in others, or even overflow after being squeezed, as shown in the Figure 6-15.


**Fig. 6-15 Manual construction site photos.**

Manual construction, there are errors caused by unprofessional construction personnel or human error in construction. All the above reasons caused the reduction of building construction accuracy.

### 6.3.2. Robot Construction

Design methods and design tools have become increasingly complex and variable and data-dependent in the pursuit of architectural design accuracy, and this accuracy is often not fully implemented in the process of translation and construction because the construction tools do not dovetail with this data-based mode of operation, and the robotics platform makes up for this aspect of lack, making the design and high-precision construction of buildings truly a set of the continuous and complete model.

The accuracy of robot construction is not only improved by the parametric design, but also can be corrected immediately in the construction program when construction errors are found during construction, as shown in the Figure 6-16 and Figure 6-17.

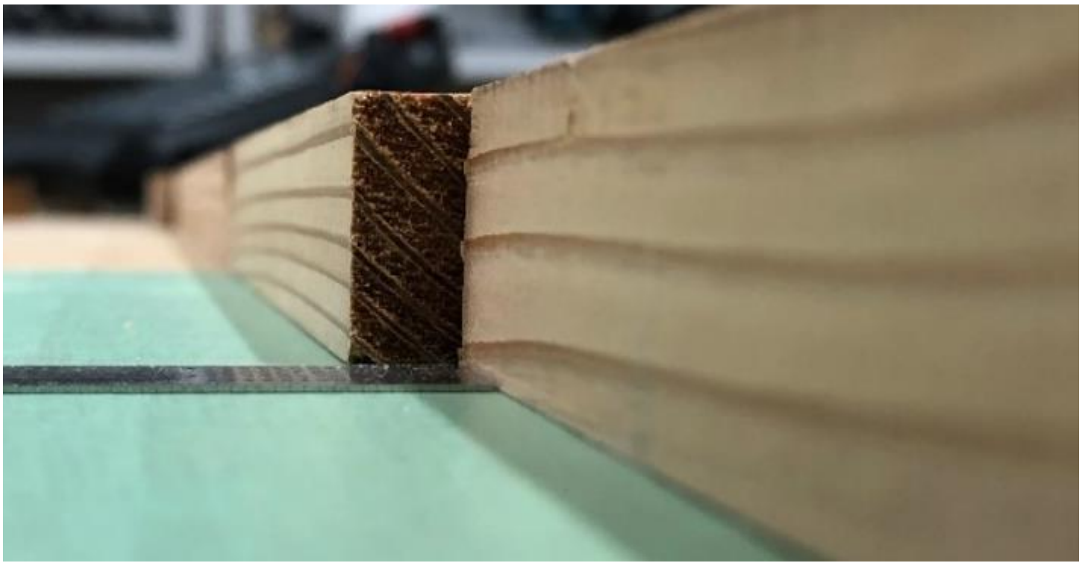


**Fig. 6-16 Errors in the construction process.**

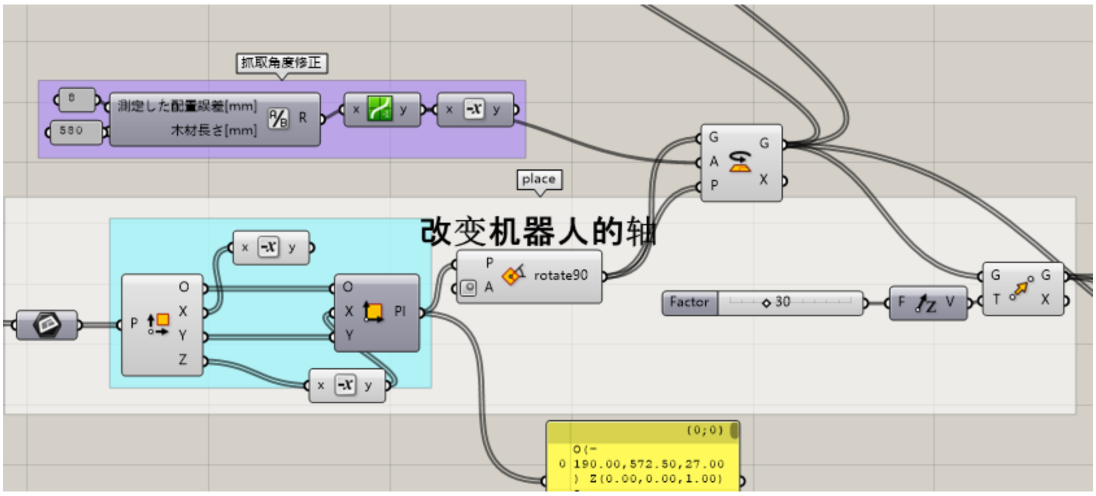



**Fig. 6-17 Procedure for correction of errors in grasshopper.**

The pictures shown in Figure 6-18 and Figure 6-19 are robot construction site, you can see that the quality of the whole construction process operated by robots is higher.


**Fig. 6-18 Robot construction site photo.**


**Fig. 6-19 Robot construction site photo.**

Not only is the robot more accurate in the construction process, but the sensing system that provides feedback during the construction process can constantly correct the errors that occur during the construction process, sensing and correcting the robot's own position and the construction target in time.

Comprehensive comparison of manual construction and robot construction in time efficiency evaluation, construction quality evaluation two aspects, it can be seen that the robot construction is better than manual construction in all aspects, which is also the motivation to study the robot to replace the manpower at the construction site.

*Chapter 7*

# *CONCLUSION AND PROSPECT*

**CHAPTER 7: CONCLUSION AND PROSPECT**

## 7.1 Summary of experiments

Through the implementation of two continuity case studies, the results of the study show that robots can build full-scale wooden buildings at scale directly on the construction site. The first experiment used a stationary robot to construct a wooden building. A multidisciplinary approach combining robotics and building construction has made it possible to conduct experiments using arm robots for the construction of target buildings. The successful implementation of the experiment marks the possibility of integrating parametric design and robotic manufacturing processes into building construction projects (1). And by comparing manual construction with the experimental process and experimental results, it is verified that robotic construction contributes to the improvement of construction efficiency, the reduction of labor use and material waste, thus improving the environmental and economic benefits of the whole construction process and achieving sustainability of construction. The accomplishments of the experiment can be summarized as follows: First, multiple construction steps of the building can be accomplished by parametric design operating the end-effector of the robot. Repeated construction steps of individual timbers are completely built by the robot. Second, it is verified that robotic construction highlights its high efficiency, stability, and accuracy compared to manual construction. Third, it is demonstrated that the logical workflow of parametric design can easily combine interdisciplinary design and construction techniques for testing, generation, and analysis in a digital environment.

The second study case is a continuation of the first study case in depth, with the same wooden building as the target of the study. Based on the experiment, it is clear that an integrated multi-science application approach combining mobile robotics, laser scanning and positioning technology with building construction makes robotic on-site construction possible and marks the possibility of integrating parametric design and robotic manufacturing processes into building construction projects. The results of this experiment can be summarized as follows: First, the results of the experiment confirm that robotic construction contributes to the reduction of labor use and material waste, thus improving the energy environment and economic environmental benefits. Second, it developed a mobile building unit construction and assembly strategy that allows the building units to be assembled continuously at different robot construction origins with a minimum number of robot relocations through overlapping staggered construction. Third, the interaction between the laser scanning software, the robot software and the modeling software allows the building site to be mapped and the CAD model of the building to be adapted to the true dimensions of the site scan, while also allowing the robot to localize itself with sufficient accuracy to complete its building construction tasks. Fourth, the parametric design of the robot's arm and end-effector allows it to automate multiple construction steps of building construction.

## 7.2. Strategies for robotic in situ fabrication

This thesis develops and experimentally validates strategies and techniques to overcome two major on-site fabrication challenges: the first involves large-scale assembly on the construction site and the second involves the accuracy required in building construction. The following conclusions can be drawn from the applied strategies(2).

### 7.2.1. Architectural scale

Many established robotic prefabrication methods rely on splitting architectural-scale components into subassemblies so that these subassemblies can be brought into the static workspace of a fixed robotic system for fabrication. Later in the process, these prefabricated components are transported to the construction site, where they are manually joined into a larger structure. During robotic site fabrication, the spatial relationship between the components and the robotic system is reversed. Such an assembly can no longer be divided into smaller parts, but it must be robotically assembled into a continuous, monolithic building structure at its final location. Thus, the robotic system must move and reach the final location and fabricate the still existing structure there. This study demonstrates two different approaches to address the challenges of manufacturing building-scale components in situ:

Stationary robotic construction: Study case 1 demonstrates stationary robotic construction with a Y-axis slide to extend the static workspace of the robot. Although the robotic system is small-scale and stationary, it still enables on-site construction of limited-scale buildings.

Mobile robotic construction: Study case 2 demonstrates the implementation of building-scale assembly at a construction site by mobile fabrication beyond the static workspace of the robot. In the experiment, a mobile robotic system assembled these large assemblies from multiple locations.

### 7.2.2. Accuracy

Many consolidation processes in robot prefabrication rely on perfect knowledge of the factory environment and perfect control of the stationary robot system. However, robotic on-site manufacturing processes lack a perfectly structured environment and well-controlled robotic systems. Moreover, they are characterized by an incomplete knowledge of the construction site surroundings.

Nevertheless, the experiments in this thesis show that by using sensors, robotic systems can complement this incomplete knowledge at different levels through: mapping-the geometry of the building site, localizing-the robot origin within it, surveying-the fabrication process (2).

As a result, the robotic system can maintain constant interaction with the environment and fabricate components directly at the construction site with the required precision.

## 7.3. Discussion

These two study cases demonstrate the far-reaching potential of implementing robotic construction directly on the building site, and the current limitations and future directions of the two study cases are discussed below.

Stationary robotic construction: For the future of robotic wood construction, it is also clear from the experiments that: first, the specifications of the stationary robot determine the size of the building that can be constructed, so Study Case 2 uses a mobile robot just to expand the static work space of the stationary robot. Second, the connection mode of wood is not only glue and nail, but also different connection modes for different structural types of wood buildings, so the adaptability between different connection modes and robot operation needs to be considered. Third, the research object of this experiment is a wooden structure building, the robot operating system and its end-effector can complete its nailing and glue application connection method, but different building structures have different construction methods, so it is necessary to consider the adaptability between robot operation and robot end-effector under different construction methods, which means that the exploitation of end-effector is equally important for the future development of robot building.

Mobile robotic construction: For the future of robotic wood construction on site, it is also clear from the experiments: first, the experimental simulation of the construction site environment is relatively simple, the real construction environment will be more complex and need to deal with uncertainty of the unexpected situation, so that the robot has the ability to deal with the complex situation of the construction site is the focus of subsequent research. Secondly, for the positioning method using LIDAR, the errors do not accumulate because the obtained point clouds are matched in relation to the reference point clouds obtained from the same initially values, however, this location method requires the surroundings to remain largely unchanged and does not exactly match the changing environment of the construction site (3). Therefore, an attempt can be made to scan only the building components, instead of scanning the environment. However, its ability to provide the desired accuracy is debatable. Third, considering the further optimization of mobile robots in terms of different characteristics, future research must focus on real-time sensing and complex dynamic whole-body control methods (2).

## 7.4. Conclusion

The involvement of robots in building construction is already a global trend. Compared with the current stage of construction in which a large number of people are involved, the stability of the robot construction process will greatly affect the construction efficiency and construction accuracy, thus 1) reducing the impact on the environment, saving natural resources and other obvious advantages of natural environmental benefits and 2) reducing construction costs, reducing the economic and environmental benefits of artificial use.

In this thesis, we propose a robotic construction method for wooden buildings, and discuss the robotic construction strategy and the construction method of continuous building components that break through the static workspace through the reconstruction of wooden buildings by fixed and mobile robots and complete the construction experiments of wooden buildings using this construction method.

The main works and results can be summarized as follows:

In Chapter 1, RESEARCH BACKGROUND AND PURPOSE OF THE STUDY. The research backgrounds of robotic construction are introduced in Chapter1, which is including the current status of robotic in architecture. And introduced several representative robot types in the construction robot industry. As well as the advantages of robotic construction, its obvious advantages over traditional construction manufacturing in terms of natural, economic, and social environments. Then, the introduction to Japanese wooden building. At last, the research purpose and logical framework is shown.

In Chapter 2, LITERATURE REVIEW OF ROBOTIC CONSTRUCTION. The purpose of this chapter is to place the research in this thesis in the context of historical and state-of-the-art examples and to summarize the areas of focus of this research. The main research background of this paper is the digitization process of construction manufacturing and the current status of robotics in construction manufacturing, especially the development history and research focus of in-situ robotic construction. The premise of the study is that robotics is clearly superior to traditional construction manufacturing in terms of energy environment, socio-economics and labor market.

In Chapter 3, METHODOLOGY. This thesis addresses the research objectives and designs two experimental study cases. The two experiments explored the construction of wooden buildings by two types of robots described in Chapter 2, respectively. The objects of the two experiments are wooden buildings with the same design drawings, and the experimental objectives are accomplished using a stationary robot and a mobile robot.

In Chapter 4, CASE STUDY 2: MOBILE ROBOT CONSTRUCTION. The case study in this chapter is the reconstruction process of a wooden building by a stationary robot and explores digital construction strategies and processes. The accomplishments of the experiment can be summarized as follows: First, to design the digital construction parameters for the complete construction steps, optimize the movement of the robot arm to avoid collisions at the construction site, and enable the robot to complete the construction of wooden buildings independently, and verify the feasibility and applicability of robotic construction of wooden buildings through experiments. Secondly, actual robotic construction was completed to verify the possibility of integrating parametric design and robotic manufacturing processes into building construction projects. Finally, it provides the program and experimental basis for the next mobile robot research.

In Chapter 5, CASE STUDY 2: MOBILE ROBOT CONSTRUCTION. In this chapter, we will take the in-situ construction simulation experiment of a complete wooden building as an example to explore the possibilities and challenges of continuous building construction that exceed the static workspace of robots. in this study, an integrated multi-science application approach combining robotics, laser scanning and positioning technology with building construction makes robotic on-site construction possible and marks the possibility of integrating parametric design and robotic manufacturing processes into building construction projects. The high efficiency and stability of this technology in the construction process will greatly influence the construction efficiency and construction accuracy, thus bringing obvious benefits to the natural and economic environment.

In Chapter 6, CONSTRUCTION EVALUATION. Construction evaluation is one of the main focuses of this experiment. The comparison between manual construction and robotic on-site construction experiments allows the advantages and disadvantages of two different construction methods for the same timber building to be identified. This chapter shows the advantages of robotic construction in terms of natural and economic environment, and the reasons for choosing robotic construction in terms of quantitative data. The manual construction building and the robotic construction building in our thesis have the same building plan, but due to the different construction methods, the building structure and construction process are different, and have a greater impact on the final construction efficiency. In this chapter, the efficiency of both sides is evaluated mainly in terms of time efficiency evaluation and construction quality evaluation.

In Chapter 7, CONCLUSION AND PROSPECT. A summarized of each Chapter is concluded.

Therefore, the conclusion of this paper can be concluded as Fig. 8-1. For improving the penetration of renewable energy in Japan power grid, the fourth fold including, supply side, demand side, power grid, and storage system was combined to analyzed.

**7.5. Prospect**

Research in robotic on-site construction, especially for whole buildings, is still in its infancy, and future actual construction is needed to support the conclusions of simulation experiments and present many theoretical, practical, and methodological challenges. The integration of digital design and automated construction is at the core for automated building fabrication and robotic construction, which fundamentally expands the scope of traditional building construction and introduces an assembly logic for robotic automated construction to the industry. Research in robotic on-site construction, especially for whole buildings, is still in its infancy, and future actual construction is needed to support the conclusions of simulation experiments and present many theoretical, practical, and methodological challenges. The integration of digital design and automated construction is at the core for automated building construction and robotic construction, which fundamentally expands the scope of traditional building construction and introduces an assembly logic for robotic automated construction to the industry (4). While robotic on-site construction across the construction industry is still in its infancy and there are many challenges required for the future, research in this highly interdisciplinary field is making progress and attempting to find solutions for robotic participation in building on-site construction (5).

**Reference**

1. Wang L, Zhang T, Fukuda H, Leng Y. Research on the Application of Mobile Robot in Timber Structure Architecture. Sustainability. 2022;14(8):4681.

2. Dörfler K. Strategies for robotic in situ fabrication: ETH Zurich; 2018.

3. Sandy T, Giftthaler M, Dörfler K, Kohler M, Buchli J, editors. Autonomous repositioning and localization of an in situ fabricator. 2016 IEEE International Conference on Robotics and Automation (ICRA); 2016: IEEE.

4. Furet B, Poullain P, Garnier S. 3D printing for construction based on a complex wall of polymer-foam and concrete. Additive Manufacturing. 2019;28:58-64.

5. Ardiny H, Witwicki S, Mondada F. Are autonomous mobile robots able to take over construction? A review. 2015.

# *Appendix*

**Unit A KUKA prc data output of the stationary robot construction process**

```
&ACCESS RVP

&REL 1

&PARAM TEMPLATE = C:¥KRC¥Roboter¥Template¥vorgabe

&PARAM EDITMASK = *

DEF timber_house ( )



;FOLD INI

;FOLD BASISTECH INI

GLOBAL INTERRUPT DECL 3 WHEN $STOPMESS==TRUE DO IR_STOPM ( )

INTERRUPT ON 3

BAS (#INITMOV,0 )

;ENDFOLD (BASISTECH INI)

;ENDFOLD (INI)


;FOLD STARTPOSITION - BASE IS 0, TOOL IS 4, SPEED IS 15%, POSITION IS A1 5,A2 -
90,A3 100,A4 5,A5 10,A6 -5,E1 0,E2 0,E3 0,E4 0

$BWDSTART = FALSE

PDAT_ACT = {VEL 15,ACC 100,APO_DIST 50}

FDAT_ACT = {TOOL_NO 4,BASE_NO 0,IPO_FRAME #BASE}

BAS (#PTP_PARAMS,15)

PTP    {A1 5,A2 -90,A3 100,A4 5,A5 10,A6 -5,E1 0,E2 0,E3 0,E4 0}

;ENDFOLD
```

```
;FOLD LIN SPEED IS 0.25 m/sec, INTERPOLATION SETTINGS IN FOLD

$VEL.CP=0.25

$ADVANCE=3

;ENDFOLD


;FOLD COMMANDS IN FOLD. SELECT EDIT/FOLDS/OPEN ALL FOLDS TO DISPLAY

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

BAS(#VEL_PTP,10)

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1268, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1268, Z -537, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1268, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1434, Y -668, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
```

```
LIN {E6POS: X 1434, Y -668, Z -537, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -668, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1434, Y -68, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -68, Z -537, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -68, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1434, Y 532, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 532, Z -537, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 532, Z -507, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1084, Y 1182, Z -507, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X 1084, Y 1182, Z -537, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X 1084, Y 1182, Z -507, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 484, Y 1182, Z -507, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 484, Y 1182, Z -537, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 484, Y 1182, Z -507, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X -116, Y 1182, Z -507, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -116, Y 1182, Z -537, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -116, Y 1182, Z -507, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1568, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1568, Z -437, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1568, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -1568, Z -277, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -1568, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -1568, Z -437, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1568, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -968, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -968, Z -437, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1
```

```
$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -968, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -968, Z -277, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -968, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -968, Z -437, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -968, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -368, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -368, Z -437, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X 1434, Y -368, Z -277, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -368, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -368, Z -437, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 232, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 232, Z -437, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z -277, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 232, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z -437, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 832, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 832, Z -437, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z -407, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 832, Z -277, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 832, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 832, Z -437, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE
```

```
$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1184, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X 1184, Y 1182, Z -437, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1184, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z -437, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 584, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 584, Y 1182, Z -437, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 584, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 584, Y 1182, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 584, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 584, Y 1182, Z -437, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X 584, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -16, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -16, Y 1182, Z -437, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -16, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -16, Y 1182, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -16, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -16, Y 1182, Z -437, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -16, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -616, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -616, Y 1182, Z -437, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1
```

```
$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z -407, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z -277, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -616, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z -437, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z -277, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1268, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1268, Z -337, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1268, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

LIN {E6POS: X 1434, Y -1268, Z -177, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -1268, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -1268, Z -337, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1268, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

```
WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -668, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -668, Z -337, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -668, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -668, Z -177, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -668, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -668, Z -337, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -668, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -68, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -68, Z -337, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -68, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -68, Z -177, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -68, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -68, Z -337, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE
```

```
$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -68, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 532, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 532, Z -337, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 532, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 532, Z -177, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 532, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 532, Z -337, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE
```

```
WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 532, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1132, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1132, Z -337, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y 1132, Z -307, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 1132, Z -177, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y 1132, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 1132, Z -337, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
```

```
LIN {E6POS: X 1434, Y 1132, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1084, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X 1084, Y 1182, Z -337, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1084, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1084, Y 1182, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1084, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1084, Y 1182, Z -337, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1084, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 484, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 484, Y 1182, Z -337, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X 484, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 484, Y 1182, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 484, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 484, Y 1182, Z -337, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 484, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -116, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -116, Y 1182, Z -337, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -116, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -116, Y 1182, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5
```

```
LIN {E6POS: X -116, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -116, Y 1182, Z -337, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -116, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -716, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -716, Y 1182, Z -337, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -716, Y 1182, Z -307, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -716, Y 1182, Z -177, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -716, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -716, Y 1182, Z -337, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE
```

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -716, Y 1182, Z -177, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1568, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1568, Z -237, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1568, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -1568, Z -77, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -1568, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -1568, Z -237, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1568, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -968, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
```

```
LIN {E6POS: X 1434, Y -968, Z -237, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -968, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -968, Z -77, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -968, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -968, Z -237, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
```

```
$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -968, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -368, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -368, Z -237, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE
```

```
WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -368, Z -77, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -368, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -368, Z -237, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 232, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 232, Z -237, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1
```

```
$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z -77, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 232, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z -237, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 832, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 832, Z -237, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X 1434, Y 832, Z -77, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 832, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 832, Z -237, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1532, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1532, Z -237, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1532, Z -207, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1532, Z -77, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 1532, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1532, Z -237, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y 1532, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
$VEL.CP=0.3
LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1184, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X 1184, Y 1182, Z -237, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1184, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z -237, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1
```

```
$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 584, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 584, Y 1182, Z -237, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 584, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 584, Y 1182, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 584, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 584, Y 1182, Z -237, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 584, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -16, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -16, Y 1182, Z -237, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -16, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -16, Y 1182, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X -16, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -16, Y 1182, Z -237, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X -16, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -616, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -616, Y 1182, Z -237, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -616, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z -237, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1216, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1216, Y 1182, Z -237, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1
```

```
$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1216, Y 1182, Z -207, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1216, Y 1182, Z -77, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -1216, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1216, Y 1182, Z -237, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1216, Y 1182, Z -77, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1268, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1268, Z -137, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -1268, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X 1434, Y -1268, Z 23, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -1268, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -1268, Z -137, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -1268, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
$VEL.CP=0.3
LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[204]=FALSE
$OUT[203]=TRUE
```

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -668, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -668, Z -137, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -668, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -668, Z 23, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -668, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -668, Z -137, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -668, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X 1434, Y -68, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
LIN {E6POS: X 1434, Y -68, Z -137, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -68, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -68, Z 23, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -68, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -68, Z -137, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
```

```
$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -68, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 532, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 532, Z -137, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 532, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 532, Z 23, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 532, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 532, Z -137, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE
```

```
WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 532, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1132, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1132, Z -137, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y 1132, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 1132, Z 23, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y 1132, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 1132, Z -137, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
```

```
LIN {E6POS: X 1434, Y 1132, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1732, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1732, Z -137, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1732, Z -107, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1732, Z 23, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 1732, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1732, Z -137, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1732, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1084, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X 1084, Y 1182, Z -137, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE
```

```
$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1084, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1084, Y 1182, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1084, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1084, Y 1182, Z -137, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1084, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 484, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 484, Y 1182, Z -137, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 484, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 484, Y 1182, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
$VEL.CP=0.5

LIN {E6POS: X 484, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 484, Y 1182, Z -137, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 484, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1
```

```
LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -116, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -116, Y 1182, Z -137, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -116, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -116, Y 1182, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -116, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -116, Y 1182, Z -137, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE
```

```
$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -116, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1
```

```
LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -716, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
LIN {E6POS: X -716, Y 1182, Z -137, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -716, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -716, Y 1182, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X -716, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -716, Y 1182, Z -137, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
```

```
WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -716, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1316, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1316, Y 1182, Z -137, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1316, Y 1182, Z -107, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1316, Y 1182, Z 23, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -1316, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1316, Y 1182, Z -137, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE
```

```
WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1316, Y 1182, Z 23, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1568, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1568, Z -37, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -1568, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -1568, Z 123, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -1568, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -1568, Z -37, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
```

```
LIN {E6POS: X 1434, Y -1568, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -968, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -968, Z -37, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -968, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -968, Z 123, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -968, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -968, Z -37, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -968, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -368, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -368, Z -37, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -368, Z 123, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -368, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -368, Z -37, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 232, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 232, Z -37, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z 123, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5
```

```
LIN {E6POS: X 1434, Y 232, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z -37, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 832, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 832, Z -37, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 832, Z 123, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 832, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 832, Z -37, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1532, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1532, Z -37, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1532, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1532, Z 123, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 1532, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1532, Z -37, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1532, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 2132, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
```

```
LIN {E6POS: X 1434, Y 2132, Z -37, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y 2132, Z -7, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 2132, Z 123, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y 2132, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 2132, Z -37, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
```

```
$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 2132, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1184, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1184, Y 1182, Z -37, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE
```

```
WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1184, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z -37, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 584, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 584, Y 1182, Z -37, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1
```

```
$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 584, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 584, Y 1182, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 584, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 584, Y 1182, Z -37, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 584, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -16, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -16, Y 1182, Z -37, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -16, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

```
LIN {E6POS: X -16, Y 1182, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -16, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -16, Y 1182, Z -37, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -16, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -616, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -616, Y 1182, Z -37, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -616, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z -37, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

```
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1216, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
LIN {E6POS: X -1216, Y 1182, Z -37, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -1216, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1216, Y 1182, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X -1216, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1216, Y 1182, Z -37, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
```

```
$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1216, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1816, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
LIN {E6POS: X -1816, Y 1182, Z -37, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -1816, Y 1182, Z -7, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1816, Y 1182, Z 123, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X -1816, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1816, Y 1182, Z -37, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
```

```
WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1816, Y 1182, Z 123, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1268, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1268, Z 63, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -1268, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -1268, Z 223, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -1268, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -1268, Z 63, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
```

```
LIN {E6POS: X 1434, Y -1268, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -668, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -668, Z 63, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -668, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -668, Z 223, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -668, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -668, Z 63, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -668, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
$VEL.CP=0.3
LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X 1434, Y -68, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
LIN {E6POS: X 1434, Y -68, Z 63, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X 1434, Y -68, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -68, Z 223, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -68, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -68, Z 63, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -68, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 532, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 532, Z 63, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 532, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 532, Z 223, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5
```

```
LIN {E6POS: X 1434, Y 532, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 532, Z 63, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 532, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1132, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1132, Z 63, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1132, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1132, Z 223, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 1132, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1132, Z 63, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1132, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1732, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1732, Z 63, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1732, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1732, Z 223, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 1732, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1732, Z 63, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1732, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 2332, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
```

```
LIN {E6POS: X 1434, Y 2332, Z 63, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 2332, Z 93, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 2332, Z 223, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 2332, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 2332, Z 63, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE
```

```
$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 2332, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1084, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1084, Y 1182, Z 63, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE
```

```
WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1084, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1084, Y 1182, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1084, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1084, Y 1182, Z 63, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1084, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 484, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 484, Y 1182, Z 63, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1
```

```
$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 484, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 484, Y 1182, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 484, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 484, Y 1182, Z 63, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 484, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -116, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -116, Y 1182, Z 63, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -116, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -116, Y 1182, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -116, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -116, Y 1182, Z 63, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -116, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -716, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -716, Y 1182, Z 63, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -716, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -716, Y 1182, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -716, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -716, Y 1182, Z 63, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -716, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1316, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
LIN {E6POS: X -1316, Y 1182, Z 63, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -1316, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1316, Y 1182, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X -1316, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1316, Y 1182, Z 63, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
```

```
$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1316, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1916, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -1916, Y 1182, Z 63, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1916, Y 1182, Z 93, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1916, Y 1182, Z 223, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -1916, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1916, Y 1182, Z 63, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE
```

```
WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1916, Y 1182, Z 223, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -1568, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -1568, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -1568, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -1568, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -1568, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -1568, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
```

```
LIN {E6POS: X 1434, Y -1568, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -968, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -968, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -968, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -968, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y -968, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y -968, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y -968, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y -368, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y -368, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -368, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y -368, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y -368, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y -368, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1
```

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 232, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 232, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5
```

```
LIN {E6POS: X 1434, Y 232, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 232, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 232, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 832, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 832, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 832, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 832, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 832, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE
```

```
WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 832, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 1532, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 1532, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1532, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1532, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 1532, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 1532, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 1532, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 2132, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP
```

```
LIN {E6POS: X 1434, Y 2132, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X 1434, Y 2132, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 2132, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X 1434, Y 2132, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X 1434, Y 2132, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
```

```
$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 2132, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1434, Y 2732, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1434, Y 2732, Z 163, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE
```

```
WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 2732, Z 193, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 2732, Z 323, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1434, Y 2732, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1434, Y 2732, Z 163, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1434, Y 2732, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
```

```
PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 1184, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 1184, Y 1182, Z 163, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1
```

```
$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 1184, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 1184, Y 1182, Z 163, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 1184, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X 584, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X 584, Y 1182, Z 163, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 584, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
LIN {E6POS: X 584, Y 1182, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X 584, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X 584, Y 1182, Z 163, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X 584, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE
```

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -16, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -16, Y 1182, Z 163, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -16, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -16, Y 1182, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -16, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -16, Y 1182, Z 163, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

```
$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -16, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP
```

```
WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -616, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'} C_PTP

LIN {E6POS: X -616, Y 1182, Z 163, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -616, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -616, Y 1182, Z 163, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE
```

```
$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -616, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1216, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1216, Y 1182, Z 163, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE

$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1216, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1216, Y 1182, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS

$VEL.CP=0.5

LIN {E6POS: X -1216, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1216, Y 1182, Z 163, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1

$OUT[201]=FALSE
```

```
$OUT[200]=TRUE

WAIT SEC 1

$OUT[204]=TRUE

$OUT[203]=FALSE

WAIT SEC 1

LIN {E6POS: X -1216, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1816, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -1816, Y 1182, Z 163, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
```

```
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -1816, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1816, Y 1182, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X -1816, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -1816, Y 1182, Z 163, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
```

```
WAIT SEC 1

LIN {E6POS: X -1816, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -1008, Y 412.871, Z 246, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

$VEL.CP=0.3

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

LIN {E6POS: X -1008, Y 412.871, Z -14, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[204]=FALSE

$OUT[203]=TRUE

WAIT SEC 1

LIN {E6POS: X -1008, Y 412.871, Z 46, A 0, B 90, C 0, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6POS: X 1082.116, Y -60, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 206.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

LIN {E6POS: X 1082.116, Y -560, Z 256.212, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

PTP {E6POS: X -2416, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 010'}
C_PTP

LIN {E6POS: X -2416, Y 1182, Z 163, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS

WAIT SEC 1

$OUT[201]=TRUE

$OUT[200]=FALSE

WAIT SEC 1
```

```
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -2416, Y 1182, Z 193, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -2416, Y 1182, Z 323, A 0, B 90, C -180, E1 0, E2 0, E3 0, E4 0} C_DIS
$VEL.CP=0.5
LIN {E6POS: X -2416, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -2416, Y 1182, Z 163, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
$OUT[204]=FALSE
$OUT[203]=TRUE
WAIT SEC 1
$OUT[201]=TRUE
$OUT[200]=FALSE
WAIT SEC 1
$OUT[201]=FALSE
$OUT[200]=TRUE
WAIT SEC 1
$OUT[204]=TRUE
$OUT[203]=FALSE
WAIT SEC 1
LIN {E6POS: X -2416, Y 1182, Z 323, A 0, B 90, C 90, E1 0, E2 0, E3 0, E4 0} C_DIS
PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 90, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP
$OUT[200]=FALSE
```

```
$OUT[201]=FALSE

$OUT[203]=FALSE

$OUT[204]=FALSE

PTP {E6AXIS: A1 5, A2 -90, A3 100, A4 5, A5 10, A6 -5, E1 0, E2 0, E3 0, E4 0} C_PTP

;ENDFOLD


END
```