Carbon Negative 3D Printing

Shinichi Miyazato (Kanazawa Institute of Technology)
Satoru Kobayashi (Kajima corporation)

1. Background

In recent years, 3D printing has made significant advancements. Research and development primarily conducted overseas in the construction industry, and cement-based 3D printing has been used for the construction of houses and pedestrian bridges. In Japan, multiple companies have also started research and development in this field. Cement-based 3D printing involves using a robotic arm to extrude cement material and adding it layer by layer to create members. By directly importing 3D data into a 3D printer, the entire process from design to construction can be completed digitally, resulting in labor and time savings compared to traditional methods that require manual labor, such as formwork assembly and pouring concrete. As a result, it is expected to address the urgent challenges of the construction industry such as a shortage of skilled workers and the improvement of productivity.

On the other hand, reducing CO_2 emissions, which is considered one of the causes of global warming, is also an urgent issue in the construction industry. Cement emits a large amount of CO_2 during the manufacturing process of its main component. Therefore, various organizations are actively developing environmentally friendly concrete that can reduce CO_2 emissions.

In other words, in addition to the mechanization and automation of construction work recommended by "i-Construction" that is advocated by the Ministry of Land, Infrastructure, Transport and Tourism, the construction industry also requires technological development from the new perspective of reducing environmental impact.

2. Purpose of the Joint Research

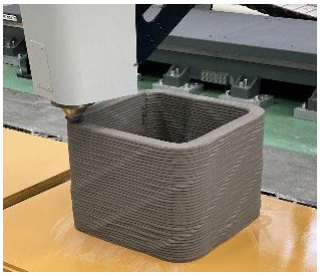
Researching 3D printing includes a lot of elements such as selecting the optimal materials, controlling robots, conducting structural calculations including the installation of reinforcement materials, and simulations through analysis.

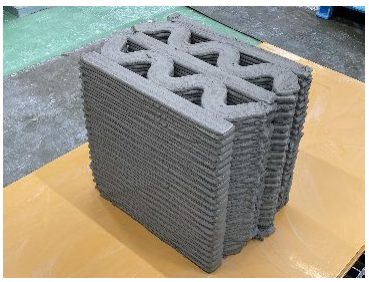
To address these elements, the Kanazawa Institute of Technology, which has extensive knowledge in various fields such as civil engineering, architecture, and mechanical engineering, and Kajima Corporation, which has expertise in design and construction techniques for civil engineering and architecture, as well as mechanization and automation using robots, have decided to conduct joint research on cement-based 3D printing by utilizing their respective

knowledge and technologies. Furthermore, they will apply CO_2-SUICOM, an environmentally friendly concrete developed by Kajima, as the material for 3D printing. CO_2-SUICOM is the world's first technology that can absorb and fix a large amount of CO_2 during the concrete manufacturing process, resulting in negative CO_2 emissions.
The "KIT × KAJIMA 3D Printing Lab" was established at Kanazawa Institute of Technology's "Yatsukaho Research Campus," where a robot arm-based 3D printer equipped with specially developed nozzles was installed. Research and development for achieving "Carbon Negative 3D Printing" has begun.

Robotic arm 3D printer

Through repeated research on the blending of CO_2-SUICOM suitable for 3D printing and the control method of the 3D printer, it has become possible to fabricate members with complex shapes.

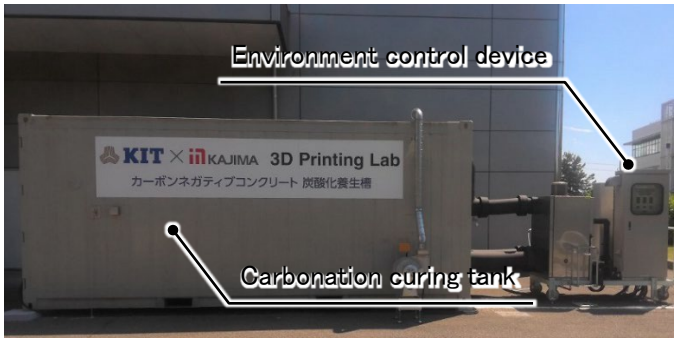

Printing situation


Member with complex shape

3. Overview of Carbonation Curing Equipment

As mentioned earlier, CO_2-SUICOM has the characteristic of absorbing and fixing a large amount of CO_2 during the manufacturing process. Therefore, the "carbonation curing" process is required to be absorbed CO_2 into the members formed by 3D printing. The carbonation curing equipment has been installed in the Lab to achieve this.

This carbonation curing equipment is used for the "carbonation curing" process to absorb CO_2 into the members formed by 3D printing. The equipment consists of a "carbonation curing tank" measuring 6m in length, 2.5m in height, and 2.4m in width, and an "environment control device" that creates air which adjusts the appropriate temperature, humidity, and CO_2 concentration and circulates this kind of appropriate air through the curing tank and the environment control device. By properly managing the environment inside the curing tank, CO_2 can be efficiently absorbed into the members. The curing tank is equipped with slide rails, allowing long members to be accommodated. The members that have completed carbonation curing absorb more CO_2 than the amount emitted during the manufacturing process, thus achieving carbon-negative 3D printing.



Carbonation curing equipment

Carbonation curing status

4. Future Goals

Kanazawa Institute of Technology and Kajima aim to realize the social implementation of innovative construction technology that achieves carbon negative using CO_2-SUICOM, in addition to improving productivity through 3D printing. To popularize and expand the use of 3D printing in the construction industry, it is necessary to install 3D printed products in public spaces and raise awareness. Therefore, they will continue research and development in collaboration with local governments, industry, and academia. Our goal is to install 3D printed products in public spaces of local governments in the Hokuriku region by the fiscal year 2023.