A Case Study of Polyuse's 3D Printer in Japanese Civil Engineering Projects

Hiroharu Kamada (Polyuse Inc., Japan)

This article introduces a domestically produced 3D printer for construction and an example of construction projects in Japan that utilize the printer.

Polyuse, a start-up company founded in 2019, is Japan's only construction 3D printer manufacturer engaged in research and development, commercialization, and dissemination of 3D printers for construction use. The Polyuse team develops 3D printable premix mortars, 3D printer systems, and software platforms that control the printing process from data design to printing. The 3D printer system is designed to be easy to transport and install in Japan's narrow and mountainous regions and is steadily gaining a growing track record in domestic construction. Fig. 1 is the Polyuse Zero 3D printer system for construction, a gantry-type system with the material extrusion laminating method.

As an example of construction using a 3D printer in Japan, the gravity-type retaining wall construction in Yamagata Prefecture in the Tohoku region is described. This civil engineering project was to install a 44.7-meter-long, 2-meter-high rockfall protection fence on top of a 43.7-meter gravity retaining wall (1.3~2 meters high), which was expected to take 83 days for ordinary concrete casting construction. Construction took place in Kaneyama-machi, Mogami County, in

Fig. 1 Polyuse Zero

a) The prefabricated members

b) Transportation of printed members

Fig. 2 The prefabricated formwork parts

Fig. 3 Installation of the prefabricated formwork members

Yamagata Prefecture, an area famous for its heavy snowfall in winter because it faces the Sea of Japan, and the originally planned construction plan called for work in deep snow.

To shorten the construction period, we planned to use a 3D printer. The construction method used was the residual formwork method, in which the 3D printer was temporarily installed in the fabrication yard, the gravity retaining wall formwork prefabricated there was installed at the construction site, and concrete was cast inside the formwork to integrate it into a single structure.

A total of 54 members were printed for the residual formwork of the 43.7-meter-long gravity retaining wall, divided from a min. of 1.5 meters to a max. of 2.0 meters in the longitudinal direction and from a min. of 1.3 meters to a max. of 2.0 meters in the vertical direction (Fig. 2a). After all components were printed, they were delivered to the construction site (Fig. 2b), the formwork was installed, and the concrete was cast (Fig. 3). The construction period of the residual formwork method using the 3D printer for construction was completed in 44 days, and the effect of reducing the construction period to about 53% of the 83 days expected for typical construction was confirmed.

In this way, cases in which construction productivity is greatly improved by applying construction 3D printers to residual formwork construction methods have become apparent. In the future, it is important to establish guidelines for design and construction so that constructors can confidently introduce 3D printers for construction, and it is essential for the diffusion of 3D printers for construction in Japan.