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3D PRINTING FOR A NEW CONSTRUCTION PROCESS ENTITLED "EGG SHELL"

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Problem statement. Currently, methods of manufacturing building structures and products using a 3D printer becoming more and more popular. Such a technology for manufacturing structures consists in principe that a building or its individual structural elements can be constructed by layer-by-layer application of a concrete mixture using special computer programs [1]. Using of 3D printing allows you to reach a new level of creating objects of complex configuration using the necessary materials. With the help of construction 3D printers, you can create high-strength structures in shortest possible time, and reduce labor costs and production waste to a minimum [4].

Purpose of the study. Consists in a combination of large-scale robotic FDM printing with simultaneous pouring of fast-setting concrete.

Main results. Using this technique, the Zurich researchers, together with the German engineering firm Basler & Hofmann, planted a "tree of the future" in the courtyard of the company's headquarters. This model, in addition to others produced by the researchers, could well demonstrate the potential of the process for mass customization and optimization of structures within concrete architecture. (Fig. 1)

Fig. 1. Tree of the future, printed on a 3D printer

Concrete is the most widely used building material in the world. However, in order to be printable, it must be supported by formwork during solidification, which can be quite expensive, up to 50 percent of the material cost, or even more for non-standard elements [2; 3].

As a result, while concrete can theoretically be formed into almost any shape, standard, orthogonal structures remain the norm. And while 3D printing has shown promise for use in construction, the method's speed, limited scope, difficulty with reinforcement, and the inability

to produce thin printed structures that act as formwork to hold fresh concrete are hindering widespread adoption.

The early Smart Dynamic Casting (SDC) method, developed by a team of researchers in Zurich in 2014, assumed a different approach. Through using of a digital pouring process and concrete hydration control, the material that exit the moving formwork was able to bear the load of the overlying material. Although this process was faster than previous methods, the range of geometries it could produce also remained limited due to the complex mechanical controls required for dynamic movable formwork.

In an effort to leverage the advantages of the SDC process while eliminating its disadvantages, the Zurich-based research team developed the "eggshell" concept. The new technology combines large-scale robotic FDM 3D printing with an SDC-developed digital injection molding system. This allows for more complex structures with using a thin single-layer shell as formwork (Fig. 2).

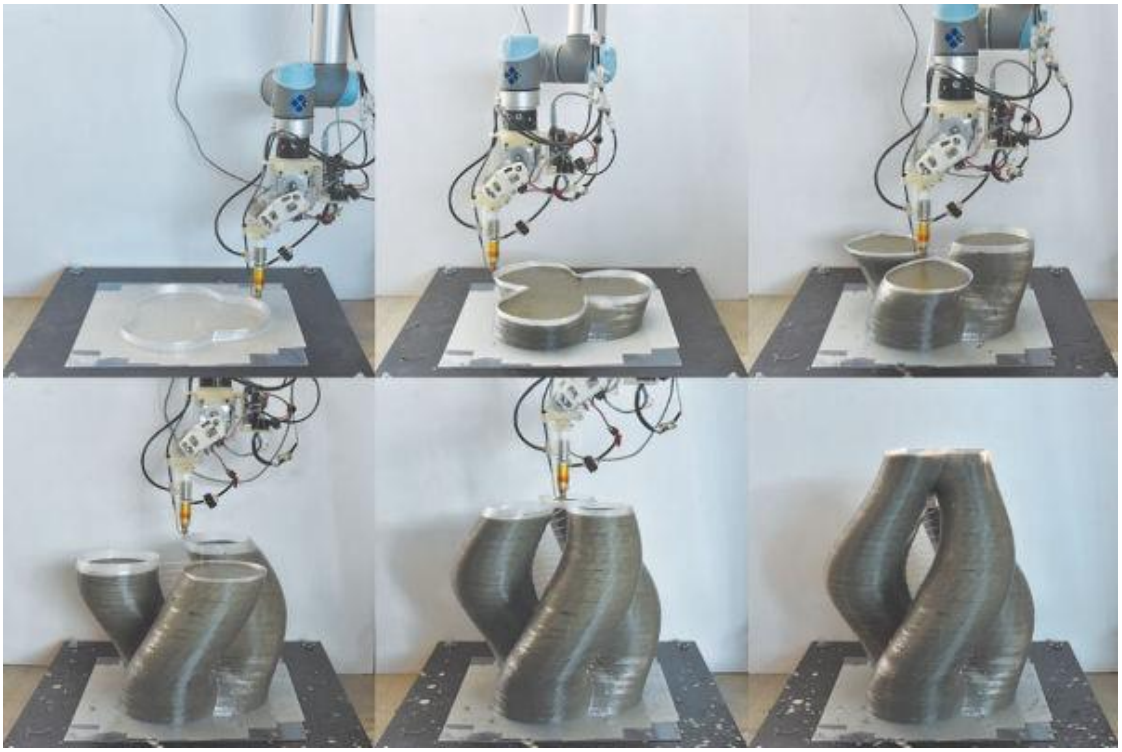

Fig. 2. SDC digital casting system

In order to try out the new technology, the Zurich-based researchers developed the concepts of "branching column", "twisted column" and "tree of the future". To create these concrete structures, the team used a robotic arm, controlled by specially designed Python software, which gave arm ability of printing out the formwork using a homemade extruder.

Conclusions. Researchers are now working to automate the process and strive to make the method more sustainable and financially viable. In addition, they came to the conclusion that it was necessary to develop a faster version of the method, which would prevent the joints of the created structures from drying out.

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