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PROSPECTS FOR THE APPLICATION OF ADDITIVE TECHNOLOGIES IN THE CONSTRUCTION INDUSTRY

Additive manufacturing is emerging as one of the most promising technological directions in the modern construction sector. Its principal advantages include high efficiency, reduced labor intensity, and significantly accelerated project timelines. Traditional construction methods often require substantial human and financial resources, whereas 3D printing enables the rapid fabrication of structural components tailored precisely to project specifications.

In 2018, France witnessed the completion of the first 3D-printed residential house occupied by a family of five. The 95 m² structure required only 54 hours to print its load-bearing walls, and the total construction cost was approximately 20% lower compared with conventional building methods.

Ukraine is also actively adopting these innovations. The first construction project using 3D printing has been launched in Lviv—a new building for first-grade students at School No. 23. The structure was erected in only 48 hours using large-format 3D printing technology [1].

Additive manufacturing in construction can be implemented in two principal ways:

1. on-site printing of full-scale structural elements, and
2. printing of individual components followed by assembly.

In the first case, printing occurs directly on the construction site. This approach, however, imposes notable constraints. The printer's working volume must exceed the dimensions of the building being constructed, requiring the entire structure to fit within the printer's operational envelope. Furthermore, the printing process must account for the relationship between deposition speed and material setting time, as well as such material properties as abrasiveness, chemical resistance, UV stability, and overall environmental durability.

In the second case, the printer may be considerably smaller. Provided that the printing material maintains stable physical and mechanical properties, high dimensional accuracy can be ensured. This enables the subdivision of building elements into smaller components suitable for modular assembly.

At the construction scale, the principal additive manufacturing methods include extrusion (using concrete/cement, wax, foam, polymers), powder-based bonding (polymer binding, reactive binding, sintering), and additive welding. The dominant technology employs a large-format extruder that deposits a fast-setting cementitious mixture with specialized additives. The layered deposition process allows not only the fabrication of wall structures but also more complex architectural forms. The layers bond and compact effectively, enabling the printed components to withstand both self-weight and external loads. When necessary, horizontal and vertical reinforcement can be incorporated between layers or through post-printing insertion into designated channels.

The entire printing process typically requires only two operators: one monitors the printer's parameters, while the second performs auxiliary tasks such as placing horizontal reinforcement or installing ties connecting the main structural wall to the façade system.

The main advantages of construction 3D printers include drastically reduced construction durations, optimized logistics, and highly efficient material utilization.

The principal limitations involve the difficulty of integrating 3D printing into comprehensive construction, reconstruction, and repair processes, as well as the high cost of modern large-format printing systems.

As noted earlier, the printer's working volume must exceed the size of the printed structure. Maintaining this condition is crucial for maximizing printing efficiency, as it allows the uninterrupted fabrication of entire buildings without relocating equipment. However, traditional mechanical configurations—portal, frame (Fig. 1), or cantilever—impose restrictions on the maximum printable size. Scaling up the working volume leads to disproportionate increases in structural mass, equipment cost, and reductions in positional accuracy due to increased inertial forces. [2].

A major breakthrough occurred in 2017 with the development of a fundamentally new mechanical design that significantly expands the potential of additive manufacturing in construction.

Swedish engineer Torbjörn Ludvigsen introduced the Hangprinter, an innovative suspended FDM-type 3D printer (Fig. 2). The device is mounted to the ceiling and anchored to walls using tensioned cables, while computer-controlled pulleys provide movement. The print head moves along the X/Y/Z axes by coordinated tensioning and releasing of cables. Four versions of the Hangprinter have been released to date. The first version featured a standard FDM extruder but achieved a print area of approximately 4 meters—ten times that of typical consumer printers.

The Hangprinter's documentation is distributed under the GNU license, allowing any user to access, build, modify, and improve the device.

The system provides sufficient precision to fabricate large-scale objects without compromising structural integrity. In its most recent iteration, the drive mechanisms responsible for cable control are positioned at the anchor points, substantially reducing the mass of the print head assembly [3].

A network of suspension points placed on masts around a construction site could enable the printing of elongated or large structures. In such a configuration, the scalability of the printing volume is limited primarily by cable mass and mast height.

Fig. 1. The COBOD BOD2 printer. Printing is performed using a cementitious mixture.

Fig. 2. The Hangprinter 3D printing system.

Therefore, the application of additive technologies in construction offers significant potential for sustainable and innovative industry development. Their successful integration requires interdisciplinary collaboration, yet their benefits—accelerated construction, reduced waste, and expanded design capabilities—position additive manufacturing as a transformative force capable of reshaping the future of construction.

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