MODERN 3D TECHNOLOGIES IN ARCHITECTURE AND CONSTRUCTION

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ABSTRACT

The article discusses the main trends that are combined with modern technologies in architecture, which also have a great influence on its formation, the conditions in which 3D-technological processes are being rapidly introduced. The general advantages and disadvantages of using 3D-technologies are analyzed, examples of building objects and modifications using information technologies are given. In addition, various stages and nuances of working with the use of 3D-technologies are also touched upon.

One of the technological breakthroughs of our time is innovative digital technologies, particularly 3D printing. Since their inception, over a period of approximately half a century, digital 3D technologies have reached a colossal level of development. Today, they are advancing rapidly and are permeating virtually all areas of human activity [1–6].

Today, the use of 3D technology is the most effective method for improving design quality. The active implementation of 3D technology in project design and implementation has a number of advantages and disadvantages.

The main positive aspects include the following: 1) Wide range of applications; 2) Cost savings in the construction process; 3) Possibility of collaboration with related specialists; 4) High accuracy and speed in both design and construction; 5) Possibility of laying utilities during construction; 6) Working with these technologies does not require a large number of highly qualified specialists, since all work is maximally automated; 7) The 3D technology industry is currently promising. In this regard, it can be assumed that as they become popular, equipment and resources will become cheaper, and greater availability will appear on the market.

On the other hand, the use of 3D technologies also has its downsides. The main one is their low adoption rate. Furthermore, operating these types of equipment requires personnel knowledgeable in the technology, necessitating specialized training institutions.

The following disadvantages related to construction processes should be highlighted: 1) Special requirements for the construction site related to its preparation; 2) Low mobility and, as a result, special requirements for the objects under construction (size, shape). The inability to construct high-rise and large-scale structures; 3) The need for additional specialists for

finishing work; 4) High construction costs for individual house-building companies; 5) A limited selection of equipment on the current market.

Today, half of the world's architectural firms use digital 3D modeling (BIM), and few dispute the fact that the advent of BIM has brought about a true revolution. Architects finally have a reliable way to quickly, clearly, visually, and accurately communicate their ideas to clients.

Let's take a look at some areas of architecture and design where the use of 3D technology has proven to be most effective and helped to reach a new, higher level of quality.

1. Modeling. 3D technologies are used in many areas of design. One of them is modeling. High-quality visualization of a project in a visual model helps obtain more complete information about the properties of the designed object. A model allows us to judge the object's structure, size, proportions and scale, surface flexibility, spatial arrangement, color scheme, and much more. The quality of a model directly depends on the quality of the materials and tools used, as well as the time spent on the work.

2. Restoration. The restoration process involves a range of measures aimed at preventing deterioration and ensuring the preservation of the monument. Based on this, two main principles of restoration can be identified: 1) restoring the work to its original appearance; 2) preserving the object as intact as possible.

3. Construction. The use of 3D printing in construction has developed in several directions, differing in the type of printing tool used. One such approach is the use of mobile robots [2, 5]. A group of mini-robots moves around a site, gradually constructing the object.

The first stage of such construction is the creation of the outline, the "footprint," of the future building. Robots move along a predetermined path, connected to a delivery robot that supplies the printed material. After the foundation is laid, the walls and ceilings are erected on top, after which reinforcement is an important step to ensure greater strength.

The second direction is printing with industrial manipulators [2]. A distinctive feature of this direction is that printing occurs not layer by layer, but directly onto a structure resembling a frame. The shell can be filled with mortar and plastered, which increases the strength of the structure, and can also be used without filling. Branch Technology specializes in printing in this area. They were the ones who submitted a patent for printing using C-FAB technology, which allows the material to harden in air and take any desired shape.

The third approach is the use of gantry printers [2]. This technology is similar in principle to stationary 3D printers. A distinctive feature is that the object being built must always be smaller than the printer itself, as the print head moves along massive guides. This is not always convenient, so a workaround is to assemble the object piece by piece on the construction site.

The author of the concept is Malaysian architect Hasif Rafiei envisioned a skyscraper whose construction would never stop—as soon as a new tenant moves in, a new 3D-printed residential module would be integrated into the structure. The building's design consists of a frame with empty cells, each containing a residential module. The printing press would be located on the upper floors, and as the building grows, the printing system would rise higher and higher. Once a module is ready, a crane would install it in the empty cell. Residents would be able to choose the module configuration and design, and dull or damaged units could be replaced or repaired.

Italian 3D printing developer WASP has built a house demonstrating Crane's ability Wasp (modular 3D printer) creates houses from biodegradable materials of various formats and sizes.

Gaia measures 30 square meters and was printed using a mixture of soil taken from the surrounding area and rice production waste—chopped straw and husks. Gaia is the result of limited and optimized use of agricultural resources, which, thanks to technology, were transformed into a biodegradable residential building with minimal environmental impact. Please note that if the building is not properly maintained, it may degrade into soil.

Immediately after the tragedy that befell Notre Dame Cathedral in Paris, numerous restoration projects began to emerge. The authors of one of the ideas (the Dutch company Concr3De) commented on their project: "We saw the spire collapse and thought we could offer a way to combine old materials with new technologies." Concr3De, founded by architects Erik Geboers and Matteo Baldassari has already created a 3D model of Strix , one of Notre Dame's most famous gargoyles , which appeared on the roof of the cathedral during its 19th-century restoration. The statue is made from a mixture of materials taken from the cathedral's ashes, lending it an authentic appearance. The process of creating the Strix replica took less than a day.

This is a compelling argument against employing artisans and sculptors who would use the same methods and materials as in the 13th century. Therefore, Concr3De proposes to 3D print all of the cathedral's lost stone elements. 3D-printed 3D-printed 3D-printed 3D-printed sculpted elements will be indistinguishable from the originals and will withstand any climatic conditions. Concr3De's proposal would allow the original material of the damaged building to be used during its reconstruction. Even limestone, which is susceptible to the high temperatures of flames, could be used in this process. This method could also be used to print stone vaults to replace those damaged by the collapse of the spire. The Concr3De architects are confident that their proposal will help "expedite the reconstruction and create a cathedral that is not simply a copy of the original, but rather one that proudly displays its multilayered history."

Today, the use of 3D technology is the most effective method for improving design quality. Although these technologies are still in their infancy, it's safe to say they will play a key role in design in the near future. Thanks to 3D printing and scanning, architects can realize and create the highest quality, most ambitious creative ideas with minimal resources and less time. Due to the unique requirements and specifics of 3D technology, approaches to the design process will be reimagined, and the style of objects and details will change. These technologies will simultaneously take technical, engineering, structural, and visual solutions to a new level, leveraging cutting-edge solutions

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