UDC 666.972

NANOCOMPOSITES FOR 3D PRINTING TECHNOLOGY IN CONSTRUCTION

Author − Oleksandr Vatazhyshyn[1], Postgrad. Stud. of gr. RIC-22a
Scientific supervisor − Derevianko V.M.[2], Dr. Sc. (Tech.), Prof.
Language consultant − Shashkina N.I.[3], Cand. Sc. (Philol.), Assoc. Prof.
[1]avvtzh@gmail.com derevianko, [2]viktor@365.pdaba.edu.ua,
[3]natashashkina2018@gmail.com
Prydniprovska State Academy of Civil Engineering and Architecture

The construction industry is developing dynamically, but it is characterized by a high level of costs, energy intensity and resource intensity. Therefore, in order to increase the economic, social and environmental effectiveness and efficiency of construction processes, the industry is constantly improving construction technologies, as well as improving the qualifications of personnel.

One existing technology that has potential for applications in the construction process and is rapidly developing and improving.

Additive technologies have expanded the horizons for many areas of production. 3D printing has allowed technologies recently developed in laboratory conditions to reach a new level. Additive technologies (from the English Additive manufacturing) is a generalized name of technologies that involves the production of a product according to a digital model (or CAD model) by the method of adding material. 3D printing technology began to gain popularity at a frantic pace in various fields of activity, such as medicine, food industry, mechanical engineering, military affairs, construction, etc. The reason for such a rapid increase in the popularity of 3D printing is mobility and, most importantly, the unlimited possibility of printing objects of various shapes [1].

For most developers, this technology is a revolutionary new method of quick and cheap construction of buildings. However, despite the existing advantages of 3D printing technology in construction, its widespread use is restrained by a number of factors, such as:

- the relatively high cost of modern models of construction 3D printers;
- problematic implementation of 3D technologies in the complex process of construction, repair and reconstruction;
- lack of regulatory and legal acts, standards and developed unified terminology for 3D printing of buildings and infrastructure elements;
- construction objects do not have effective thermal insulation and have high energy consumption;

Also, the development and creation of new materials used for 3D printing, as well as the improvement of technical designs and software of 3D printers, are

also required for the application and development of the use of additive technologies in construction.

3D printing of construction objects is a new technology for the construction of buildings and structures, which allows to build housing or an infrastructure object according to an individual project in the shortest possible time using various materials. The construction 3D printer uses extrusion technology, in which each new layer of construction material is squeezed out of the printer on top of the previous one, and in this regard, the solution must have special properties: high mobility, and after leaving the nozzle and applying it to the structure, a high hardening speed. The use of printers for printing individual elements of constructions in production conditions allows to eliminate the seasonality of construction, that is, to print parts of buildings, keep them in warehouses until the strength of concrete is set, and then collect them in the building on the construction site. Gypsum-based construction mixtures are used to print building models. The process of horizontal and vertical reinforcement, installation of frames inside wall cavities, laying of communications is practiced on the models [1; 3].

Currently, the existing types of binders have exhausted themselves in terms of physical and mechanical characteristics, since modern requirements for building materials require a multiple increase in physical and mechanical characteristics. One of these directions of modification of mineral binders can be nanomodification using nanotubes, nanoparticles, and nanofullerenes.

There are several different nanocomposites that can be used for 3D printing in construction. Here are some examples:

1. Nanocomposites taking into account carbon. They consist of carbon nanotubes or graphene that are added to 3D printing materials such as concrete or polymers to improve their properties. For example, carbon nanotubes can increase the strength and stiffness of the material, and graphene can improve its thermal and electrical conductivity.

2. Nanocomposites taking into account aluminum oxide. They can be used to improve concrete properties such as strength, stiffness and corrosion resistance. Aluminum oxide is added to concrete mixtures in the form of nanoparticles, which increases their density and improves mechanical properties.

3. Nanocomposites based on nanosilica. They can be used to improve polymer properties such as strength and stiffness, as well as to improve thermal and sound insulation. Nanosilica is added to polymer mixtures in the form of nanoparticles, which improves their mechanical properties and increases their resistance to the influence of external factors [2; 3].

These are just a few examples of nanocomposites that can be used for 3D printing in construction. Depending on the specific application, other nanocomposites can be developed that have the necessary properties to create stronger, more stable and durable structures.

Currently, scientists from many countries around the world are looking for solutions to improve existing and develop new materials to improve 3D printing technology in construction.

Here are a few scientific articles on the topic of using nanocomposites in 3D printing in construction:

1. In the article "Development of a 3D Printer for Concrete Structures: Laboratory Testing of Cementitious Materials. 2020" which was published in the "International Journal of Concrete Structures and Materials", the authors demonstrate the potential of using 3D printing of concrete structures in construction, and also show the importance of further research in this area of technology development [1].

2. In the article "Developments and Applications of Carbon Nanotube Reinforced Cement-Based Composites as Functional Building Materials" published in the journal "Frontiers in Materials", the authors provide an overview of research conducted in the field of using carbon nanotubes to strengthen the cement-sand composition. The influence of various factors on the mechanical properties of such materials, such as the concentration of carbon nanotubes, their diameter and length, composite manufacturing technology, etc., is considered [2].

3. The article "The effects of nano- and micro-sized additives on 3D printable cementitious and alkali-activated composites" examines the effect of the addition of nano- and micro-sized additives on the properties of cementitious and alkali-activated composites that can be used for 3D printing. Different types of particles and different concentrations to evaluate their effect on the strength, plasticity and other properties of materials have been used. The article was published in Materials and Structures in 2021 [3].

Nanocomposites for 3D printers in construction are relatively new materials, and developers are constantly working on creating new formulas. Also, new nanocomposites for 3D printing in construction are being developed by companies engaged in the construction and production of 3D printers, such as Winsun Global, Mighty Buildings, ICON, COBOD and others.

All of these companies continue to research and develop new formulations of nanocomposites for 3D printing in construction to improve material performance and reduce costs. Thus, the use of 3D printing technology in construction has great potential and will continue to develop.

REFERENCES

1. Jun Ho Jo, Byung Wan Jo, Woohyun Cho, Jung-Hoon Kim. Development of a 3D Printer for Concrete Structures: Laboratory Testing of Cementitious Materials. 2020.