ABSTRACT

The development of concrete technology in recent years has gained extraordinary momentum. This is due to the introduction of widely understood elements of automation to both the processes of material production and execution of construction. One of the fastest growing technologies in recent years is additive manufacturing technology, commonly known as 3D printing. The technology of additive manufacturing with cementitious mixtures does not require the use of formwork. Specially prepared cementitious composites are extruded with the use of a pumping device into the indicated place through a hose ended with a head/nozzle. The whole construction - the robot - is controlled from a computer, which reads pre-programmed sequences of movements.

One of the main disadvantages of this technology is the lack of appropriate methods of reinforcement of elements. In traditional construction, steel and composite bars are a natural part of the concreting process. Due to 3D printing technology's use of pumping equipment to directly extrude the mix at the printing location, the use of traditional methods of reinforcing elements is limited. One method of reinforcing the concrete mix is the use of dispersed reinforcement. There are many types of dispersed reinforcement available in the market including polymer, glass, steel or carbon fiber reinforcement.

The development of 3D printing technology has forced the development of new ways of reinforcement and expanded the research on currently available traditional methods of reinforcing elements. The analysis of the literature on the reinforcement in 3D printing, led the author to address the issue of using fibers to produce mixtures meeting the requirements of this technology and to conduct a number of studies and analyses on their influence on the rheological and strength properties.

The study part of the thesis describes the basic information related to the use of fibers in concrete technology. Methods of producing elements in 3D printing technology were defined and properties of mixtures suitable for this technology were described. A literature review on the use of fibers in 3D printing technology is also presented.

The research was divided into two main stages. The first stage consisted of preliminary research consisting in determining the effect of four types of fibers: basalt, glass, carbon and polymer fibers of different lengths, added in different amounts to a mixture with a high content of reactive binder. The effects of the fibers used on the slump flow, shear strength, and stress-strain curve were determined. Compressive and

flexural tensile strength tests were performed for three periods of 1, 3, and 7 days. The results presented here showed that the use of fibres in cementitious composites with such a large amount of binder not only does not result in an improvement, but also causes a deterioration of the rheological properties and, in some, of the strength.

The second stage of the research, began with the design and determination of the properties of a new mixture that meets the requirements of 3D printing technology with a reduced amount of binder. The place of the binder was partly taken by non-reactive limestone powder. As in the preliminary study, the effects of four types, five different lengths and six fibre quantities on the rheological and mechanical properties of the cement composite were again determined.

Determination of the influence of sample preparation method on the strength of composites was performed. For this purpose a method was developed to produce the specimens for strength tests using 3D printing technology based on placing the mixture by means of a Cartesian robot in specially prepared forms.

The tests made it possible to identify the mixes that had the best strength gain, with the least possible deterioration in rheological properties. Verification tests were carried out for the selected mixes. Rheological and strength properties were determined. The microstructure of samples was also evaluated The results obtained allowed comparative analyses to be carried out and conclusions to be drawn about fibre reinforcement of mixtures using 3D printing technology.