The project concerns the development of a new generation of hybrid materials, a combination of cement composites obtained using classic molding techniques and multifunctional intelligent cement composites obtained using 3D printing techniques. The project involves developing a technique for obtaining printable cement composites with electrically conductive and photocatalytic additives, developing a method for determining their printability, and developing hybrid solutions with optimal geometry of printing paths made of multifunctional intelligent materials. Cement-based composites with conductive additives can be used in various ways, including: for monitoring the temperature of concrete elements, including in heat pumps, and for measuring the temperature of facades. A signal proportional to the temperature difference can be used to control heating, blinds, or ventilation in buildings or proportional to the load of elements. Reaching the percolation threshold is necessary to create a continuous network of the additive, which carries the risk of deterioration of the strength and durability of the composite. This reduction in the basic properties of composites with electrically conductive additives was the premise for the design and production of hybrid materials in which the multifunctional cement composite constitutes only a small part of the element's volume, in the form of a printed spatial path, so it will have a small impact on the strength of the entire composite. This approach assumes the use of 3D printing technology to create a path from a material with active additives, and the remaining part of the volume of the hybrid element is filled by casting or pressing. Cement composites with the addition of TiO_2 intended for photocatalytic air purification will also be obtained in a hybrid form with a printed mesh on the cement mortar. The project assumed the hypothesis that the amount of active TiO_2 on the surface of the cement composite in the hybrid system, depending on the geometric parameters of the printed path, will affect the efficiency of removing contaminants by the composite. The 3D printing technique has many advantages, but it places very high demands on the rheological properties of printing mixtures. The project involves developing a technique for forming active hybrid composites and examining the relationships that determine their effectiveness depending on the type of active filler.

The project also assumes that the use of 3D structural modeling and the creation of spatial or surface conductive paths in the volume of the composite will largely eliminate the unfavorable decrease in strength. When powering conductive paths printed in the volume of the material, a volumetric heating element can be obtained. The hypothesis assumes that it is possible to design a hybrid system with similar heat generation efficiency compared to the material with a conductive filler evenly dispersed in the volume but with a much smaller amount of conductive additive. The 3D printing technique allows you to fill the surface of the hybrid composite with virtually any shape made of a cement-based active material. As part of the project, the so-called "wet on wet" forming technique, i.e. printing with a mixture with an active additive on a fresh cement mixture without additives.

The results obtained in the project expand knowledge about the relationship between the microstructure of hybrid composites the properties of various active additives and the geometry of printed paths on the volume of composites. The results of this project will be a bridge to the design of intelligent hybrid cement-based composites obtained using 3D printing.