Popular science summary

Project goal

The aim of the project is to develop an innovative low-processed construction composite based on clay, sand and hemp shives, to determine the impact of the admixture of a protein-based biopolymer on its selected properties, and to propose tools for testing the hygro-thermal behavior of the developed material. The biopolymer used is acid casein, which is a technical substance obtained from cow's milk and dissolves in alkaline solutions. Due to its adhesive properties and water resistance, it is used, for example, in the production of wood glues.

Issues and reasons for taking up the topic

Building materials based on unfired clay (plasters, mortars, bricks, insulating mixtures) are mainly used in ecological construction due to the low carbon footprint of such materials. They have a beneficial effect on the microclimate due to their ability to regulate relative air humidity and the ability to accumulate heat, and by binding dusty pollutants, they can alleviate allergy symptoms. Clay-based materials are characterized by low strength and lack of resistance to water, which is why they are mainly used inside buildings. Due to the density of clay, these materials are characterized by a high thermal conductivity coefficient. It is reasonable to look for modification methods that improve the properties, thus enabling the expansion of the use of unfired clay in construction. The use of hemp shives will improve the ability to provide thermal insulation. Casein dissolved in an alkaline solution has binding properties that can improve the strength of the developed composites and at the same time improve their water resistance. The use of this biopolymer in construction is an issue that has been little researched. There is information in the practical literature on the modification of lime plasters with casein, but there is no detailed research, especially on the modification of clay with casein. Based on own previous research, a beneficial effect of casein in selected amounts on the mechanical strength of the lime-hemp composite was found. The ability of the composite to absorb water has also been limited, without negatively affecting the flow of water vapor. Taking into account the positive effect of the use of casein in the modification of lime-hemp composites, it is reasonable to investigate the possibility of improving the key parameters of clay-based composites, also containing shives. It is also important to check how the proposed modifications will affect the hygro-thermal behavior of clay-based materials, and to propose tools for predicting heat and moisture transport in wall elements based on the developed material. Such tools may later be of practical importance at the possible stage of introducing the developed material to the market.

Description of research

A series of composite recipes will be developed, differing in the amount of biopolymer used. A methodology for preparing mixtures and processing casein will be proposed. First, the working properties of fresh mixtures will be examined, such as consistency, viscosity, air content and water retention capacity. After the period of ripening, drying and seasoning, the mechanical properties of the hardened mortars will be tested, such as bending and compressive strength (with different moisture content), as well as physical properties such as drying shrinkage, density, vapor permeability, capillary rise, resistance to washing out by water, humidity. sorption, specific heat and thermal conductivity. Durability related to resistance to UV radiation will be determined. The microstructure of the composites will be examined using mercury porosimetry, X-ray diffraction and scanning electron microscopy. The adhesion of plaster mortars to the substrate made of the developed composite will also be determined. An original computational tool and an experimental method will be proposed for examining the transport of heat and moisture in the developed composites and wall elements made of them. Based on the tests performed using them, the thermal and humidity behavior of the developed material will be assessed, which is of fundamental importance related to the subsequent practical applications of this material.

The most important expected effects and the importance of the research

Based on our own previous research, it can be assumed that admixtures used in specific amounts will improve mechanical strength and reduce water absorption, while having no negative impact on other parameters. Hemp shives can improve thermal insulation and increase vapor permeability and sorption. Recommendations will be developed for the use of casein in optimal amounts, bringing positive effects related to better strength of the developed material and favorable hygro-thermal behavior. If benefits are demonstrated in the practical use of composites, it will be possible to cooperate with the industry to implement the developed solutions. It is planned to publish the research results in prestigious journals with a high impact factor.