

Abstract of the doctoral dissertation: “Aspects of use of hemp-lime composites in the construction of individual residential houses in pro-ecological architecture”

Over the last few decades, the need to manage the Earth’s resources more rationally has been observed; which has had an increasing impact on modern architecture. Pro-ecological solutions in architectonic design are economically, socially, and legally motivated.

The increasing use of plant-based materials can be seen in many areas of the economy. In construction, which generates a large burden for the environment, plant-based materials have been used since the very beginning. At present, in the post-industrial revolution era, their application gains new importance; a significant factor being the decrease of the negative impact of the technical cycle on the environment through the introduction of sustainable industrial processes.

This study deals with problems in application of mineral and plant (hemp-lime) composite materials in the design of individual residential buildings. Such technological and material solutions were first introduced at the end of the 20th century, though in Poland this took place only in the second decade of the 21st century, therefore these methods are still not well recognized.

The background research of this paper outlines the importance of ecology in modern architecture, the technology of so-called natural construction, the development of composite materials, as well as solutions for external walls currently dominating general construction. Based on global publications and supported by our own observations and experience, the technology of hemp-lime composites is characterized within this paper. Also, applications of *hemcrete* in both global and Polish architecture are analyzed, from renovations of historical buildings to construction of new ones, documenting the variety of technical solutions applied and their architectonic effects. Particular attention is paid to individual residential buildings, where *hemcrete* technology is used most often. Aspects of application of this technology which hold significant potential for development of structures more friendly to humans and the environment are analyzed. They include both the minor negative impact of the material on the environment at the production stage and characteristics of the composite, which allow for limited energy consumption during the building’s use and creation of a natural, comfortable microclimate of interiors. The research and analyses conducted have confirmed these concerning the ecological value introduced to construction through the technology of hemp-lime composites as well as its broader potential as an alternative for use in general single-family

housing through differentiation of architectonic possibilities offered by technical solutions currently available.

The research and analysis part of the paper emphasizes the usability of the technology described in Polish conditions, indicating the possibility of meeting the minimum binding requirements in terms of thermal protection of partitions and limiting the risk of interstitial condensation for all climate zones by applying suitable materials and construction solutions. Research has been conducted assuming characteristics of the composite based on our own laboratory analyses, the results of which have proven generally consistent with results obtained in global research. The following tests have been conducted: compressive strength, thermal conductivity, water vapor transmission, and specific heat of composites of various composition made using the tamping method (from ingredients available in Poland). Analyses of parameters refer to the function of volume density, which is the result of various compression levels of the material during application, since that aspect has practical importance in the application of the *hemcrete* construction technique currently most popular in Poland and can be useful in the design process. Main tests have been conducted on 59 material samples in total (with many more developed for the purposes of preliminary tests). Furthermore, a comparative analysis of the thermal capacity of partitions made with the use of the composite and other selected materials has been conducted. Also, the thermal capacity of the building with the application of various material and construction solutions has been tested. It has been proven that the composite ensures sufficient thermal capacity of the structure, although not as large as in the case of building designs based on traditional masonry technologies. The results obtained indicate the possibility of eliminating some limitations in selection of a light skeletal structure for single-family houses in Poland, and can contribute to making rational design decisions in the construction of such structures with *hemcrete* infill, simultaneously pointing out the need of further research in this area, using more advanced and sophisticated research methods.

This study contains 258 photos, 183 drawings, and 57 tables. The bibliography includes 166 literature publications, 25 legal acts and standards, as well as 118 Internet sources.

Keywords: hemp-lime composites, *hemcrete*, pro-ecological architecture, natural construction technologies, natural building materials.

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