Analysis of material properties of industrial waste-based geopolymers for assessment of their usability in construction

SUMMARY

The research presented in Thesis has been performed as an answer to serious environmental problems: huge emission of CO_2, the enlarging consumption of water and the significant quantity of discarded CRT glass. Geopolymer is considered as an environmental friendly alternative for a concrete, which consumes less water during production and is responsible for smaller emission of CO_2. The geopolymer described within this Thesis contains discarded CRT glass as an aggregate what, additionally, gives an opportunity for safe recycling of this dangerous waste. The main goal of the Thesis, was presentation and description of the metakaolin-based geopolymer with CRT glass as potential building material together with proposition of the new way of CRT glass recycling. The extensive study on one type of geopolymer, containing CRT glass in form of an aggregate is also an answer to deficiencies defined by an Author in existing publications.

The research has been divided into three main parts: the initial research, main research and complementary research. The initial research contains description of all used materials and research methods, the determination of optimal CRT glass content, determination of the optimal curing temperature, the measurement of temperature changes inside the cured geopolymer and change of the strength over time. In all tests, both the flexural and compressive strength have been examined. The density of each geopolymer has been measured as well. As the result of the initial tests, the one optimal mixture, containing CRT glass to metakaolin in mass ratio 1:1 has been chosen for the next part of the research.

The main part focuses on the influence of different factors on geopolymer's mechanical behavior. The change of the strength over time of samples cured at different temperatures has been compared. Then, the influence of the activator concentration and the CRT glass particle size have been determined. Finally, the long-term strength has been tested.

The last part presents the complementary tests and contains the determination of the porosity of geopolymer and its physicochemical characteristics. The examination of leachate from geopolymer incorporating CRT glass has been compared with leachate from not-stabilized CRT glass. Mainly, the amount of chosen elements has been tested.

The following main conclusions has been drawn from the research part: metakaolin-based geopolymer with CRT glass has good mechanical characteristics; the CRT glass content does not influence significantly the mechanical behavior of geopolymer; elevated curing temperature provides higher early strength and ability of quicker demolding than curing at the ambient temperature,although, long-term strength of geopolymer cured at ambient temperature surpasses strength of geopolymer cured at elevated temperature; the increase of an activator concentration leads to the increase of strength; the change of CRT glass particles does not influence significantly the strength; the temperature inside the geopolimer during the curing process increases along with the increase of metakaolin content; addition of CRT glass to metakaolin-based geopolymer helps in immobilization of heavy metals in comparison to not-stabilized CRT glass.

The research directions planned for the future includes: determination of changes of the geopolymer strength over years; the influence of humidity and freeze and thaw cycles on the mechanical behavior; determination of material's rheology; the influence on the living organisms, human's health and on the reinforcement; big-scale tests and determination of the boundary surface of the material.

12.06.2023.