At macroscale, concrete is a well-researched material. Specialists can predict its behavior during long-term exposure to various, often harmful, conditions. However, there are many issues that still need to be addressed by both the scientists and the industry, especially to design the composites which are more ecological, according to assumptions of sustainable development and circular engineering. Over the last few decades, the attention of scientists and manufacturers has shifted towards the climate change. In the field of cement and concrete research, calcium sulfoaluminate (CSA) and belite-ye'elemite-ferrite (BYF) cements have gained particular attention as they seem to be a promising, eco-friendly alternative to Portland cements due to their low carbon footprint. Moreover, literature reports that CSA/BYF cements can be synthesized from various waste materials. However, many questions related to their manufacturing and hydration remain unanswered. A comprehensive analysis of the possible changes that could be introduced to the BYF binders would allow to develop cements with a better composition, understand the balance between the hydration substrates and products and determine the corrosion mechanisms in BYF-containing concretes, since the hydrates are significantly different from those found in the ordinary Portland cement paste. The main goals of the project are the synthesis of individual BYF clinker phases – ye'elemite, belite, calcium aluminate and calcium aluminoferrite, both with and without selected stabilizers, and the characterization of their structure and hydration rate, followed by the investigation of the hydration process and rheological properties of model BYF cements prepared from these pure phases. Additionally, the structural and microstructural characterization of the BYF cements hydration products and the controlled synthesis of pure hydrates (ettringite, monosulfate, C-A-S-H, $Al(OH)_3$) will be carried out to better observe various hydration-related structural changes and evaluate the durability of hydrates in corrosive environments. The main hypothesis of the project is: "Changes in the chemical and phase compositions of BYF cements significantly affect their properties such as: consistency, setting time, compressive strength and corrosion resistance, because the physicochemical nature of the hydration products and therefore, their individual contribution to the properties of the composites is different". **The search for new ye'elemite and belite stabilizers, as well as additives that would allow to decrease their sintering temperature, is an ongoing issue. The project aims at developing synthetic BYF cement clinkers, containing carefully selected amounts of components and previously unstudied ye'elemite and belite stabilizers. The hydration of BYF cements is controversial due to the difficulties in describing the amorphous-crystalline balance of the reaction products and the effect of external ions on the process.**

The research program will consist of two main stages. **Stage I** will focus on the synthesis of BYF clinker phases, both with and without the stabilizers. Next, their activity and hydration will be studied. Model mixtures of pure phases will be developed, corresponding to BYF cements with various chemical and phase compositions. The reactivity of such model cements will be evaluated by monitoring their hydration progress with instrumental methods. Moreover, the rheology of cement paste will be measured, as it is a crucial factor determining the workability of fresh mortars and concretes. **Stage II** will focus on determining the differences in the phase composition, structure and microstructure of the hydration products of cements obtained in stage I. This step will lead to the synthesis of model hydrates with a controlled chemical composition, which will allow to explain the differences in the structural stability of ettringite and C-A-S-H under the conditions simulating the real BYF cement hydration process and the related ionic equilibrium of the liquid phase. Finally, a detailed physicochemical analysis of the hydrates and their corrosion resistance will be carried out. Salt solutions will be prepared that correspond to real corrosive environments. All synthesized phases will be treated with the solutions at specially designed laboratory stations. The research will lead to the physicochemical characterization of the structure and microstructure of BYF clinker phases and their hydration products.

Describing the mutual interactions between the model phases and their individual corrosive resistance is a very important aspect, as the they translate into the overall properties of the composites at macroscale. Therefore, the topic has a cognitive potential and will contribute to the development of new materials.