

1. Objective of the project

Cement chemistry has been developed intensively for recent years. A special impact has been put to the mechanism of cement hydration. The implementation of supplementary cementing materials by the so-called pozzolanic additives (it means the materials which reveal hydraulic activity in alkaline environment of cement paste) is very important from many points of view; this has been the subject of numerous intensive studies. The presence of vitreous or amorphous component with high SiO_2 and Al_2O_3 content is the main feature of active additives. The active pozzolanic components of cement paste modify the kinetics and mechanism of hydration at the same beginning of reaction. The idea of the project proposal consists in the studies of the hydration mechanism in model systems in which the reaction of particular clinker minerals and their assemblages with water will be investigated separately. Moreover, the pozzolanic additive will be synthesized from pure initial components too as a model substance. The fineness and chemical composition, reflecting the data typical for the real systems, will be thus under control.

This project will put a new light on some controversial findings as the so-called induction period and additional „aluminate” effect on the calorimetric curve of hydrating cement is concerned. The experiments intensively carried out on a large scale are needed in order to elucidate some aspects of physical and chemical phenomena.

The elucidation of the mechanism of hydration in the cement – active pozzolanic material system through the studies in model systems composed of cement clinker together with silica and aluminosilica glass with various alkali content is the main goal of the project. The two hypotheses have been formulated:

- a) The activity of vitreous component is affected by the presence of alkalis present in the structure and by the alkali/ Al_2O_3 molar ratio.
- b) Alkaline component and aluminium in the structure of vitreous substance have an impact on the microstructure and durability of hydration, it means C-S-H and C-A-S-H.

2. Basic research in project

The project will be divided into four main stages where basic research will be carried out in order to clarify certain physico-chemical phenomena accompanying the process of cement hydration.

Stage I – The synthesis of silica and aluminosilica glass with and without alkaline component; the physical and chemical investigation to obtain comprehensive characteristics of materials.

Stage II – Synthesis of the most important cement clinker minerals alite (solid solution of calcium oxyorthosilicate C_3S ($3\text{CaO}\cdot\text{SiO}_2$)) and tricalcium aluminate C_3A ($3\text{CaO}\cdot\text{Al}_2\text{O}_3$); the physical and chemical investigation to obtain comprehensive characteristics of materials.

Stage III – Main experimental part consisting in the hydration of relevant mixtures (simulating the real systems) at variable water to solid ratios and set controlling agent content. The continuous monitoring of liquid and solid state phenomena will be provided (chemical composition of liquid phase, heat evolution process and other experiments).

Stage IV – Identification of phenomena responsible for modification of hydration kinetics/setting and hardening (quantification of bound water, the physical and chemical composition of products: C-S-H, C-A-S-H, N-A-S-H, ettringite).

3. Reasons for choosing the research topic

This project will give further details about the role of the following factors dealing with the application of supplementary pozzolanic cementing materials. The structural effect aluminum and alkalis in the vitreous material structure both from the vitrification process and further hydration reactions point of view. The activation/accelerating effect of “internal” alkalis built up in the vitreous materials structure, in comparison with the effect of “external” alkali activators derived from the presence of alkaline compounds or calcium hydroxide. From the other side the verification of positive, important from the practical point of view features as the durability and strength of material is concerned resulted from the modification of setting, hardening and microstructure

The project thus proposed will contribute to the development of the supplementary cementing materials application. Nowadays this is a very important task – the limitation of carbon dioxide emission, a serious problem for cement industry - is possible only when the active, supplementary cementing materials will be introduced as a part of binder. The Portland cement clinker must be very economically disposed. Fortunately, the standards allow to take into account various material defined as “pozzolanas”; there is only the question how to find them and how to assess their applicability. It seems that this project will be a “milestone” in doing it.