The alkali-silica reaction (ASR) occurs between the reactive form of silica in the aggregate and the sodium and potassium hydroxides present in the pore water in the cement matrix composites. The dissolution of silica in the presence of a highly alkaline solution forms an expansive gel. Cracking of both, the aggregate grains and the cement matrix is a result, which significantly reduces the durability of the material. Due to climatic conditions prevailing in Poland, in winter, on road surfaces (including more and more commonly built from cement based materials), deicer in the form of sodium chloride (NaCl), potassium formate (HCOOK) and sodium formate (HCOONa) are used, which may be an additional source of alkalies and contribute to increasing the intensity and severity of the alkali-silica reaction.

The aim of the Project is to investigate the impact of deicing agents solution on the chemical composition, microstructure and mechanical properties of ASR products formed in cement matrix composites.

The research program includes the triggering and production of alkali-silica reaction products in cement matrix composites by appropriate selection of aggregate susceptible to ASR. Detailed assessment of the mineral composition of aggregates due to the content of reactive minerals (such as opal, chalcedony, cristobalite, micro- and crypto-crystalline quartz, stress quartz) and minerals that are the source of alkali will be carried out using petrographic analysis. The alkali-silica reaction will be developed using standard methods for testing aggregate reactivity (accelerated method at 1 M NaOH, 80 °C; long-term method at 38ºC). Observations of the microstructure of the ASR gel will be conducted using optical microscopy, scanning electron microscopy (SEM) and transmission electron microscopy (TEM). EDS (Energy Dispersive X-ray Spectroscopy) and XRD (X-Ray Diffraction) will be used to assess the chemical and mineralogical composition of the reaction products. The impact of deicing agents at different concentrations on the potential for alkalies reaction in cement matrix composites will be considered. To this aim, in the accelerated method, the sodium hydroxide solution will be replaced by a variable concentration of the deicing agents. For this purpose, in the accelerated mortar-bar test, sodium hydroxide will be replaced with a variable concentration of deicing agents.

The combination of FIB (Focused Ion Beam) with a scanning electron microscope, as well as nanoindentation will provide advanced mechanical characteristics of the ASR gel at previously unavailable resolution. The data obtained will include compressive strength, modulus of elasticity and microhardness distribution in the ASR gel as a function of distance from the interface between the aggregate grain/cement matrix and the external border constituting the source of external alkalies. Complemented with macro-expansion data collected for changing environmental conditions (humidity, temperature), the approach will provide more accurate characteristics of the alkali-silica reaction products.

In the available literature there is a lack of data on the simultaneous impact of the chemical composition and microstructure of the alkali-silica reaction products on their mechanical properties in the presence of deicing agents. Implementation of such research subject is due to the proposer's interest in supplementing information on the recognition of the phenomenon of alkali-silica reaction in cement matrix composites. The detailed characteristics of ASR products will contribute to the deepening of knowledge towards the creation of high durability constructions with cement matrix materials.

The results of the proposed basic research will serve to inference about the relationship between the chemical composition and microstructure of the alkali-silica reaction products and their mechanical properties. Research hypotheses assume that variable concentrations of the deicing agents affect the diversity of the chemical composition of the ASR gel, which significantly affects its mechanical properties. Humidity conditions also affect the mechanical properties of the ASR gel. In turn, the alkali released from the mineral aggregate affect the mechanical properties of the ASR gel by changing its chemical composition..

The planned research aims to deepen the knowledge of the mechanism of formation and expansion of alkali-silica reaction products and the impact of sodium chloride on the potential and intensity of this phenomenon, as yet, not fully explained. Understanding these relationships will contribute to broadening the scope of knowledge regarding the durability of cement matrix composites.