ABSTRACT

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Title: Study of Sulfate Attack Resistance of Carbonated Low-Lime Calcium Silicate Systems

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Due to ecological issues and the limitations of the resources, study and creation of construction materials responsible for savings on energy and resources as well as facilitation for solution of ecological problems are of big interest. One of such research directions is based on study of construction materials produced by carbonation of low-lime calcium silicate minerals. As laboratory investigations and their industrial applications (e.g. Solidia Technologies^{TM}) showed, concrete can be made by carbonation of calcium silicate minerals. However, in order to determine to what extent such material can serve as a replacement for concrete based on the ordinary portland cement (OPC), a comparative study of durability of the low-lime carbonated calcium silicate systems (CCS) is needed.

Among all types of durability issues uncovered and investigated to date, the external sulfate attack taking place in concrete elements exposed to sulfate-rich environment (sulfate-rich soil, sea water, drainage or ground water, etc.) might cause significant damage. As a result of continuous exposure to sulfates, such processes as leaching/dissolution of specific elements, softening of the CSH gel, formation of new reaction products, precipitation and growth of expansive crystallo-hydrates of sulfate salts in free space of the matrix contribute to concrete matrix disintegration. Due to predominantly chemical nature of the sulfate attack, focus on the mineralogical and chemical composition of the CCS system is important in comparative study. In other words, revealing the key features in CCS microstructural composition which make it different (stronger or weaker) from hydrated OPC system with respect to sulfate resistance constitutes a central research problem. This gives rise to the need for the independent study of CCS system in contact with the sulfate-rich media to understand the process of interaction with sulfates, to determine the compositional alterations, if any, and to evaluate possible consequences resulting in the damage of the concrete. These issues motivated the research work presented in this PhD thesis.

Despite sizeable amount of work on the carbonation of calcium silicates, little can be found in the literature regarding the potential performance issues associated with the CCS systems. Therefore, another more specific motivation of this work was to contribute to the body of knowledge on the sulfate resistance of the CCS materials by considering the effects of variety of the (low-lime) calcium silicates, types of sulfate solutions and temperature of exposure.

The specific topics explored as a part of the work leading to this dissertation included: chemical interactions and kinetic of reactions between CCS and sulfates, the role of the types of calcium silicates, response of the CCS system with respect to the type of the sulfates, verification of the possibility of thaumasite sulfate attack (TSA) in CCS systems, and compositional alterations and damage processes in the CCS matrix resulting from the sulfate attack.