学 位 論 文 内 容 の 要 旨

DISSERTATION ABSTRACT

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Characterization and Modeling of Alkali-Silica Reaction of Reactive Siliceous Materials in Conducting Model and Mortar Experiments

(モデルおよびモルタル実験によるアルカリシリカ反応のキャラクラリゼーションおよびモデル化)

The use of certain aggregate in harden concrete may cause in a particular chemical process in which various silica forms of aggregate react with alkali hydroxides dissolved in the pore solution of concrete, attributing to the alkali silica reaction (ASR). This so-called ASR gel absorbs water and the resulting swelling expansion, leading to loss of strength and reductions in the elastic modulus and durability of the concrete. Therefore, ASR is a major liability for the durability of concrete structures. The main objective of this dissertation is to clearly understanding the ASR mechanism as a cause of damage. One way to approach the mechanism is to analyze the chemical compositions and structure of ASR products. A chemical model is presented here to simulate the ASR formation volume in deteriorated concrete due to ASR. The ASR formation was studied with experiments involving siliceous materials (Yoro-chert, Seto- chert, Silica sand, and Pyrex glass) and Ca(OH)2 with alkalinity under accelerated conditions at different temperatures (60, 70, and 80C). The dissertation is organized into seven chapters with the references. The contents of each chapter are presented as follows.

In Chapter 1, the study context and motivation, the significance for practice, the objectives of the study and the research methodology are viewed. Attention in Chapter 2 had been paid to the basic chemical reaction, the model description of ASR expansion, the identification of ASR in deteriorated structures, the laboratory identification of ASR products and the examination of quality of aggregates. In Chapter 3, the materials and experiments carried out in this investigation are revealed. The results and discussion of model system are described in

Chapter 4. With the dissolution rate of soluble silica determined by ICP-AES analysis, the increasing temperature increases in the contents of soluble silica. For investigation of insoluble products, the C-S-H formed in model system can be attributed to the ASR occurring between the available SiO2 and Ca ions. The XRD and 29Si Nuclear Magnetic Resonance (29Si-NMR) spectra indicated a more reasonable relationship between ASR gel and C-S-H when Ca ions are present in particular. The sequence in the simulated process of ASR can be divided into 4 steps (more detailed in Chapter 5) and the simulation model tends to give predictions of C-S-H, C–Na–S–H, and Na-S-H that are in a good agreement with the experimental data from the corresponding tests in the XRD and 29Si-NMR results. Hence our simulation strongly confirms that sequence of the ASR of Pyrex glass is the same as those of both cherts (Yoro and Seto). The expansion measurement made at constant temperatures of 40C, using two alkali contents, allow the ASR reactivity of Pyrex glass to be investigated in this research (shown in Chapter 6).

One of the important constituents of this study is to associate the dissolution rate of soluble silica with mortar expansion due to ASR. Based on Arrhenius law, three parameters including the constant rate of dissolution at 40C, the dissolution rate of soluble silica at 40C and the activation energy (Ea) could be determined by considering the dissolution rate of soluble silica at different temperatures (60, 70, and 80C) in model system. The results showed a strong relationship between the rate of dissolution of Si from aggregate in the model and its contribution to ASR-induced expansion of mortar under temperature of 40C. Ultimately, the activation energy of dissolution of reactive silica can also be used to evaluate the reactivity of ASR, suggesting that aggregate with activation energies below 95 kJ/mol may be sensitive to ASR. The summary of results is revealed and contributed to the recommendations for future works in Chapter 7.