# SUMMARY


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Thesis title: Long-term Alternation of Material Properties in a Thick Concrete Wall

Title translation: 厚いコンクリート壁内の経年による材料物性変化


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Ensuring long service-life of concrete structures is one of the means for mitigation of the negative environmental impact of the concrete industry. Furthermore, as for 2019, nuclear energy remains in the long-term energy plan of Japan while the safety of the operation is given the top priority. To assure the integrity of nuclear facilities from the structural point of view, among other things, it is necessary to evaluate material performance characteristics of concrete elements and predict processes which may affect them in the future. Aiming to contribute to the long and safe service-life of concrete structures, this thesis provides insights into the fundamental phenomena affecting concrete.

First, a broad set of experimental data obtained from a massive, shear, concrete wall of Unit 1 of the Hamaoka nuclear power plant is presented. A variation of material properties with the depth is observed 45 years after the construction. The highest compressive strength is obtained in the centre of the element and gradually decrease towards both surfaces, while still well-exceeding the design strength value. Other material properties characteristics follow a similar trend. Microstructural and chemical analyses reveal that the underlying mechanism is the reaction of the feldspar rock-forming minerals contained in the aggregate batch with the hardened cement paste. The mechanism of the reaction is similar to the reaction of supplementary cementitious materials. The feldspar minerals release silica and alumina oxides which subsequently react with the calcium provided by portlandite to form additional amorphous phase. Furthermore, the Ca/Si ratio of the amorphous phase decreases owing to this reaction. It is found that this reaction increases the material properties in the long-term. The observed distribution of the material properties throughout the depth of the wall originates from a different degree of the reaction since it gradually terminates from the surfaces as the concrete dries.

Further, a numerical model for the evaluation of concrete drying is presented later in the thesis. The numerical approach is based on the evaluation of a multiphase flow inside of a porous body while the liquid and gas phases are linked through a desorption isotherm. Through a comparison of different desorption isotherm data, it is found that the water content is not only a function of relative humidity but also a function of the drying-induced microstructural rearrangement which causes a continuous decrease of the water content at constant relative humidity. This time-dependent behaviour is implemented into the numerical code through a semi-experimental desorption isotherm model for hardened cement paste. A good agreement with the experimental data both for small-scale, rapidly-drying samples and for larger elements with slower drying kinetics supports the capability of the code to evaluate the drying of cementitious materials. Finally, the numerical results for the drying of the massive concrete wall of Unit 1 of the Hamaoka nuclear power plant are presented.