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主　論　文　の　要　旨

論文題目　Long-term Alternation of Material Properties in a Thick Concrete Wall
（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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論　文　内　容　の　要　旨

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 plan of Japan while the top priority is given to its safety. To assure the integrity of nuclear facilities from the structural point of view, it is necessary to evaluate material performance characteristics of concrete elements.

First, a broad set of experimental data obtained from a massive 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 and it gradually decrease towards both surfaces. 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 feldspar minerals release silica and alumina oxides which subsequently react with the calcium provided by portlandite to form amorphous phase. It is found that this reaction increases the material properties. 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 as the concrete dries.

Further, a numerical model of concrete drying is presented. The model 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 long-term decrease of the water content. 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, numerical results for the drying of the concrete wall of Unit 1 of the Hamaoka nuclear power plant are presented.