Development of centrifuge model test for evaluation of long term geomechanical behavior in HLW near field

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Studies of a prototype test and a numerical simulation relevant to evaluation of the long term behavior between the engineered barrier and host rock surrounding the high radioactive waste disposal repository (called the "near-field") are being conducted. In order to verify the results of the numerical analysis, it is one of the effective method for the accuracy of the numerical model to compare the results of prototype test with the numerical analytic results. However, the period that can be carried out prototype test in practice is about a dozen years at the longest, and it is extremely difficult to verify the numerical analytic results in units of several hundred years.
Based on centrifugal scaling laws for thermal-hydraulic-mechanical (T-H-M) behavior, any two investigations of the same conditions using a centrifuge model test and a prototype are similar and related. And, the centrifuge model test has the advantage that it can greatly shorten the long time needed to see behavior resulting from the typically slow flow of groundwater that satisfies Darcy’s law. Therefore, it is possible to estimate in part the long-term mechanical behavior in practice. Focusing on the point in CRIEPI, we developed the geotechnical centrifuge which can be operated up to 6 months continuously and mounted a model of maximum payload of 1.5 ton, and are developing a method of the long-term geomechanical behavior evaluation experiment of the near-field using the centrifuge. In this development, our target is the geomechanical interaction between the buffer material and the surrounding rock, and we carried out the long term centrifuge model test in order to measure the behavior in the near-felid.
First, we made the reduced model of the near-field consisting of a single model-overpack, ring- and cylinder-shaped buffers, and a cylindrical rock mass. The model-overpack is a stainless steel adjusted to a predetermined weight, the buffer is a compacted Na-bentonite (Kunigel-V1 of 100%), and the rock mass is a Tage tuff. Tests were conducted with a centrifugal force field of 30 G under isotropic stress-constrain conditions with confining pressures of 5 to 10 MPa and injection of pore water up through a time period equivalent to about 165 yr in the field. The temperature condition of the model and boundary is constantly 25 °C (called the "normal temperature test"). We measured the vertical displacement of the overpack, the bentonite pressure, and the strain of the rock mass. Our results showed that the measured values and the temporal changes in the displacement of the overpack, the bentonite pressure, and the strain of the rock mass were clearly dependent on the confining pressure. These data were not convergent during the test. Our data experimentally revealed that long-term behavior in the near-field was changed by the geomechanical interaction between the deformation stress of the bedrock/disposal hole and the swelling behavior of the bentonite buffer.
Next, we developed the “heating-type overpack” enclosing a compact electrical heater in a stainless steel. Using the equivalent rock mass, compacted bentonite and the heating-type overpack, the tests were conducted under isotropic stress-constrain conditions. The temperature of the overpack was constantly 95°C. As the result, the values showed similar behaviors to that of the normal temperature tests partially. However, the different behaviors were measured compared with normal temperature tests. In addition, the flow rate of the injection pore water suddenly changed after hundreds of hours. Furthermore, the density of the buffer was lower than that of the normal temperature tests by X-ray CT imaging in the post-tests. We infer that the high temperature

overpack influenced the stiffness and the pore water distribution of the buffer, and the density and the soil pressure of the buffer decreased.

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