4-11 Water Behavior in Concrete Observed Using Neutrons
—Application to Deterioration Diagnostics of Concrete Structures—

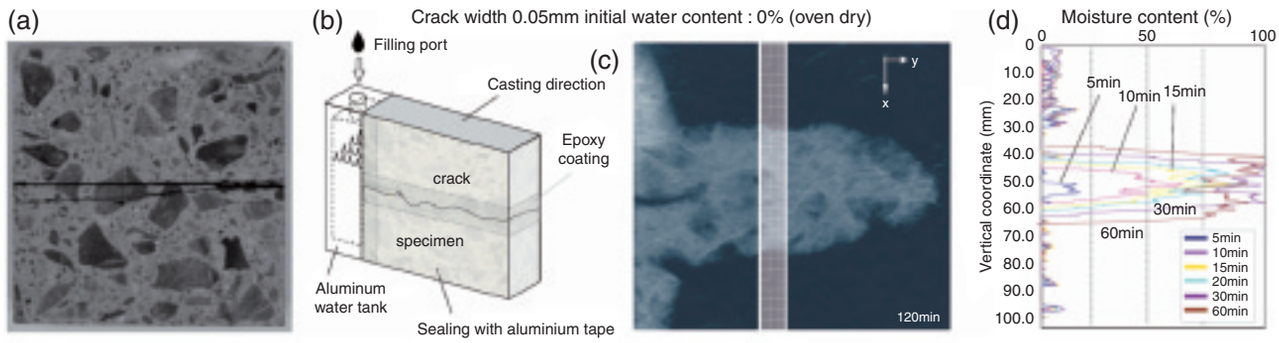

Fig.4-25 Quantification of moisture content of concrete
(a) Cutting plane of concrete specimen. (b) Specimen specifications. (c) Extracted image of moisture content only.
(d) Change of the moisture concentration of the area sandwiched by the white lines along the vertical direction.

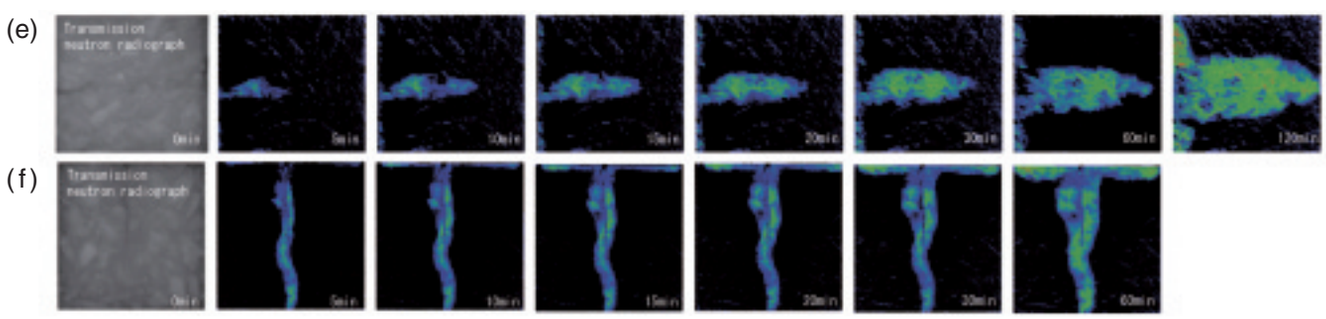

Fig.4-26 Visualization of water behavior in a crack (e) horizontal crack (f) vertical crack
With these images, moisture behavior in concrete can be obtained dynamically that was difficult to detect by existing method.

In Japan, improving the durability of concrete structures is one way to contribute to sustainable development of society, and it has also become a crucial issue from an environmental viewpoint. It is well known that moisture behavior in reinforced concrete is linked to phenomena such as cement hydration, volume change and cracking caused by drying shrinkage, reinforcing bar corrosion, and water leakage that affect the durability of concrete. Moisture content is commonly detected by using a humidity sensor of such material as ceramic or polymer. However, these techniques make measurements at discrete intervals with low resolution capability, and the devices are difficult to install without influencing the concrete or cement matrix system.

Fig.4-25 and Fig.4-26 show a typical image of water penetration behavior through the crack into a cementitious matrix that is successfully obtained by using the thermal neutron radiography facility (TNRF) of "JRR-3". From these images, it is clearly confirmed that TNR can make visible the water behavior in/near the horizontal crack and can quantify the rate of diffusion and concentration distribution of moisture with high spatial and time resolution. And, by making a detailed analysis it is observed that water penetrates through the crack immediately after pouring and its migration speed and distribution depends on the moisture condition in the concrete.

Furthermore, a lot of specialized information was obtained by using TNRF, such as moisture behavior during the cement hydration, water penetration into other building materials, and water retainment of recycled aggregate.

Thermal neutron radiography is expected to be useful as a method to detect phenomena related to building materials that cannot be grasped by the existing techniques. Also, it will contribute to more reliable design methods of newly constructed buildings and improved deterioration diagnosis techniques of existing buildings which were built during the high economic growth period.

Research into this theme has been started as one of the promotion programs of the Ministry of Education, Culture, Sports, Science and Technology in 2006, and this research was continued under the general facility research program of JAEA in 2007.

Reference

Kanematsu, M., Iikura, H. et al., Visualization and Quantification of Water Behavior around Cracks by Neutron Radiography, Proceedings of the Japan Concrete Institute, vol.29, no.1, 2007, p.981-986 (in Japanese).