Diagnosis and Repair of Concrete Reinforcing Bar

Sasaki, Takahiko
Senior Researcher, Laboratory Head, Concrete Materials, Materials Technology Division

Reinforced concrete is used in quantities for viaducts and other structures installed on Japan Railway lines. Reinforcing bars do not corrode even in strong base concrete since they are protected by passive films, but are subjected to corrosion in the structures located in coastal areas or when sea sand is used without adequately desalted. This is because the passive film is decomposed by chloride ion. Corrosion of reinforcing bars causes falling-off of concrete debris or cracking and loosening of cover due to the expansion resulted from rusting, which compromise the safety of pedestrians passing under viaducts.

To repair concrete structures with corroded reinforcing bars, it is important to grasp information on the location of corroded reinforcing bars and the degree of its corrosion. As a means to detect the corrosion of reinforcing bars, the self-potential method is widely adopted with a simple and convenient device. However, the self-potential on the concrete surface is higher at lower levels of water contents than those measured near a reinforcing bar (see Fig. 1).

Railway Technical Research Institute (RTRI) has proposed a self-potential method newly developed to determine the degree of the reinforcing bar corrosion by applying the criterion given in Table 1 to the evaluation of the self-potential corrected for the variation over the difference in cover properties. Since reinforcing bars corroded by chloride ion require rust-preventive care, the local repair method is mainly adopted for the reason of economy. RTRI developed a salt adsorbent releasing nitrite ion that is known to have the effect to suppress the corrosion when the adsorbent absorbs, fixes, and detoxifies salt accelerating reinforcing bar corrosion. The adsorbent has been put into practical use as a technique for local repair named Suppressing Salt Injury Method (SSI Method) to utilize the salt adsorbent. See Fig. 2.

To confirm the long-term durability of the rust-preventive effect provided by the SSI Method, we exposed a specimen containing chloride ion more than the critical amount for rusting to a sea-salt-rich environment with a high-temperature high-humidity for seven years. After this trial, no corrosion was observed on the part applied with the repairing material blended with the chloride-ion adsorbent. At the position of reinforcing bars, the amount of chloride ion was smaller when repaired by the SSI Method than with mortar that contains no chloride-ion adsorbent (Fig 3), and the mole ratio of nitrite ion to chloride ion, which is an index of the corrosion suppressing effect by nitrite ion, was 0.6 or over (Fig. 4).

These facts clarify that the vicinity of reinforcing bars is maintained in a sufficiently high rust-preventive environment even after a seven-year exposure to an pessimum environment and guarantee the long-term rust-preventive effect of the SSI Method adopted with the salt adsorbent. About 50,000 m^2 of concrete sectional areas, which have been repaired by the SSI Method, have remained quite normal so far. RTRI will apply this method to the diagnosis and repair of all concrete structures, naturally including those of railway, and will improve their durability with corroded reinforcing bars. Moreover, the method will also contribute to their maintenance and management.

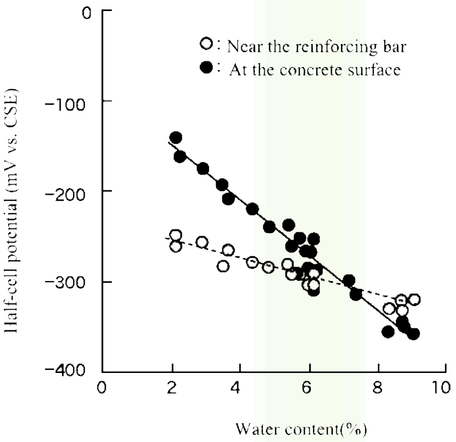

Figure 1. Relationship between the water content and the half-cell potential.

Table 1. Criteria of Reinforcing Bar Corrosion

Corrected half-cell potential	Degree of reinforcing bar corrosion
E>-250 mV	I: No corrosion
-250 mV>E>-350 mV	II: Slight spot rust on the surface
-350 mV>E>-450 mV	III: Slightly lifted rust on the surface and rust adhered to the concrete
-450 mV>E	IV: Expansive rust partial deficit or more deteriorated

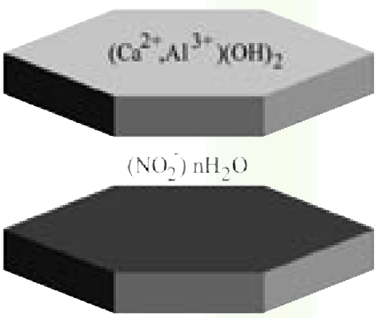

Figure 2. Schematic structure of the salt adsorbent.

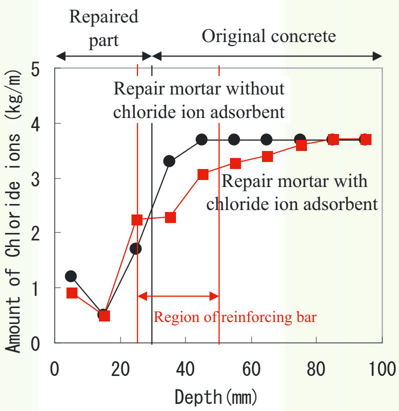

Figure 3. Profile of chloride ion across the interface.

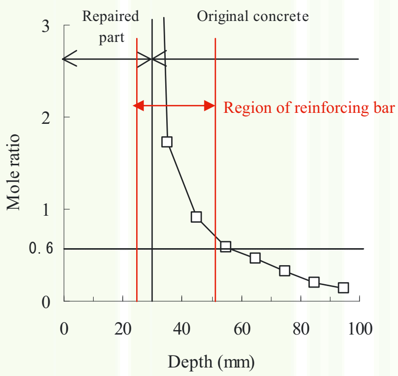

Figure 4. Profile of mole ratio (nitrite ion/soluble chloride ion) across the interface.