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Corrosion Tests of Steel Bar in Concrete under High Temperature by Salt Solution

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1. Introduction

The saturation of South Korea's at-reactor (AR) spent fuel storage pools has created necessity for additional spent fuel storage capacity [1]. The utility company (Korea Hydro & Nuclear Power Company) is planning to construct a dry storage facility, which offers advantages such as no generation of second time radioactive waste, relatively low operational cost, and a short construction period [2]. Spent nuclear fuel from CANDU will be stored in MACSTOR-400. MACSTOR-400 developed by KHNP and AECL is a new dry storage module to replace Korea's existing concrete silo. This module composed of reinforced concrete has a capacity of 446MgU, twice the MACSTOR 200. Concrete has been used in the construction of nuclear facilities because of two primary properties, its structural strength and its ability to shield radiation. The use of concrete in nuclear facilities for containment and shielding of radiation and radioactive materials has made its performance crucial for the safe operation of the facility.

Corrosion of reinforcing bars deteriorates the concrete structures and reduces their service life. Because spent fuel dry storage will be constructed near seashore, the reinforced concrete components and structures must withstand the damage due to salt attack under high temperature that is emitted by spent fuel. It can be noted that the temperature considerably affects degradation of reinforced concrete structure. However, there are very few examination examples to make clear the influence of the temperature[3]. To obtain the basic material properties at high temperature and evaluate life time of spent fuel dry storage facility, the following test is now in progress.

2. Experiment

2.1. Corrosion process

Corrosion of steel in concrete is an electrochemical process. The corroding system consist of an anode in which steel is corroded, a cathode, an electrical conductor, and an electrolyte (concrete pore solution). The potential difference between anode and cathode is driving electrical force for steel corrosion. Usually, the process can be divided into primary electrochemical processes and secondary processes.

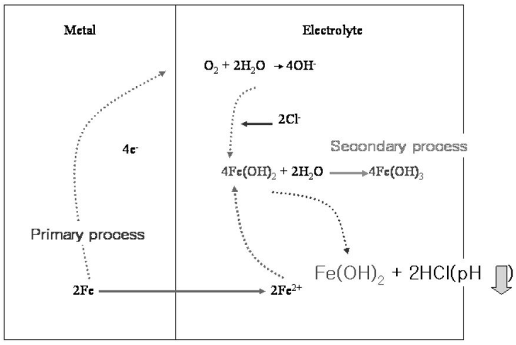


Fig. 1. Corrosion mechanism in concrete structure

As shown in Fig.1, chloride ion diffusion makes decrease the pH in media and makes condition that corrosion is occurred easily.

2.2 .Experimental system

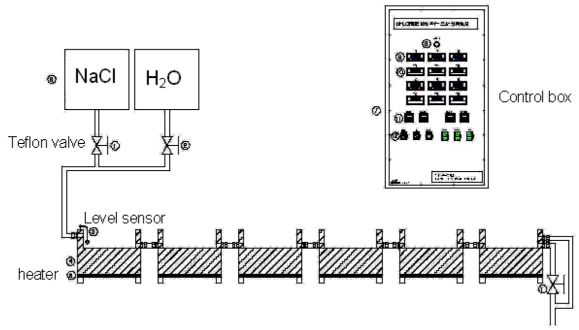


Fig. 2. Experimental system for corrosion of steel bar in concrete structure under the high temp.

In order to carry out the corrosion test, experimental system as shown in Fig. 2 is evaluated in this study. This system consist : concrete samples, heater, control box, tank for NaCl solution and Water, and pipe line for supplying concrete sample with NaCl solution and Water.

2.2.1. Concrete samples

Type 1 ordinary portland cement(OPC) is used for concrete samples. For experiment, three kinds of concrete samples are used according the ratio of

Water/Cement. Table 1 shows the composition of concrete samples[4].

Table 1. Composition of concrete sample

w/c	45%	50%	55%
Coarse aggregate	11.35	11.58	11.77
Fine aggregate	8.01	8.16	8.30
Cement	4.66	4.20	3.81
Water	2.10	2.10	2.10

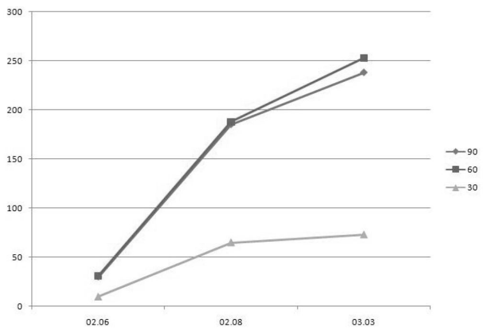
Three steel rebars are inserted and three cover thicknesses were used 1cm, 2cm and 4cm in one concrete sample. Concrete samples were cured for 28days, according to the guidelines from the concrete institute.

2.2.2. Half-Cell

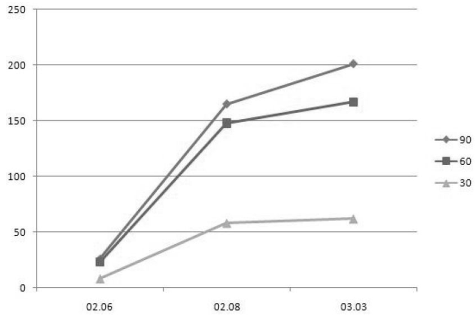
To detect the corrosion of steel rebar in concrete sample, this study uses the half cell potential technique that has been used to locate corroding reinforcement without disrupting the concrete cover to the reinforcing steel. In essence a standard reference electrode (a saturated copper/copper sulphate electrode) is connected to the reinforcement through a high impedance voltmeter. Electrical continuity through the electrolyte (the concrete and the copper sulphate solution) is achieved by a conductive bridge (a sponge soaked in detergent solution) between the concrete and the copper sulphate solution in the reference electrode. The voltmeter records the potential difference between the half-cells comprising the steel-concrete interface and reference electrode[5].

3. Experimental result

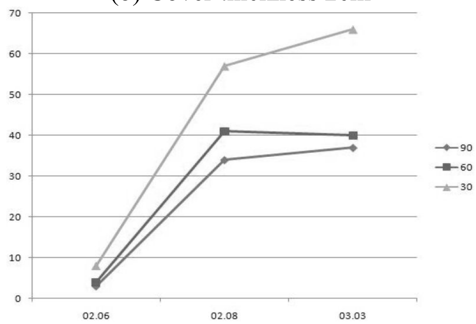
The result of detection using half – cell for three samples each of 1cm, 2cm, and 4cm cover thickness concrete samples are shown in Fig. 3. The experiment was carried out under 30℃, 60℃, and 90℃ conditions. As increase the temperature, detection value was increased. Detection value means the potential difference and degree of corroding reinforcement rebar.



(a) Cover thickness 1cm



(b) Cover thickness 2cm



(c) Cover thickness 4cm

Fig. 3. Detection result according to cover thickness

4. Conclusion

The corrosion initiation time of steel bar in concrete sample was changed according to the difference of temperature. It is estimated that this changes are due to differences of chloride ion diffusion rate according to the temperature.

If this experiment is completed, it will helpful to estimate the life time of spent fuel dry storage facility, especially for PWR

Acknowledgements

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