

## Principal Research Results

# Development of Evaluation Method of Salt-induced Deterioration of Reinforced Concrete Casks under High Temperature

### Background

Studies are advancing on concrete casks using economic material reinforced concrete as storage facilities for spent nuclear fuel of nuclear power plants. In order to operate concrete casks in Japan, an evaluation method of salt-induced deterioration of reinforced concrete under high temperatures is needed, because the casks will be located in the vicinity of the coast, and the concrete is heated to about 60°C by heat of spent nuclear fuel. But the present evaluation method of salt-induced deterioration of reinforced concrete cannot evaluate effect of temperature.

### Objectives

To develop an evaluation method of salt-induced deterioration of reinforced concrete under high temperatures by extending the present method \* 1, to make clear the effect of temperature on chloride ion diffusion in concrete and on corrosion of reinforced concrete by experiments.

### Principal Results

#### 1. Effect of temperature on diffusion coefficient of chloride ion in concrete

The value of diffusion coefficient of chloride ion in concrete became larger with the increase of temperature. It shows that the possibility of salt-induced deterioration becomes larger with temperature. Moreover, concrete with a larger water cement ratio has a tendency of having a larger diffusion coefficient. The diffusion coefficient evaluation equation by which the temperature and the water cement ratio could be considered was proposed based on the test results.

#### 2. Effect of temperature on threshold chloride ion concentration for initiation of steel corrosion

Threshold chloride ion concentration for initiation of steel corrosion stays almost unchanged even in high temperatures. Therefore, the value of threshold chloride ion concentration at normal temperature can be used at the high temperature as for the design value of chloride ion concentration of corrosion initiation.

#### 3. Development of evaluation method of salt-induced deterioration

A method to evaluate chloride effect on reinforced concrete structures was developed by incorporating the above test results into current design practice under normal temperatures. It can be applied to the reinforced concrete structure of water cement ratio 40%-60% used in temperature up to 90°C.

This study was entrusted with the Ministry of Economy, Trade and Industry.

### Future Developments

Effects of long-term heat on concrete, and of carbonation of concrete on diffusion coefficient of chloride ion, will be clarified, and an evaluation method of salt-induced deterioration linked to them, will be developed.

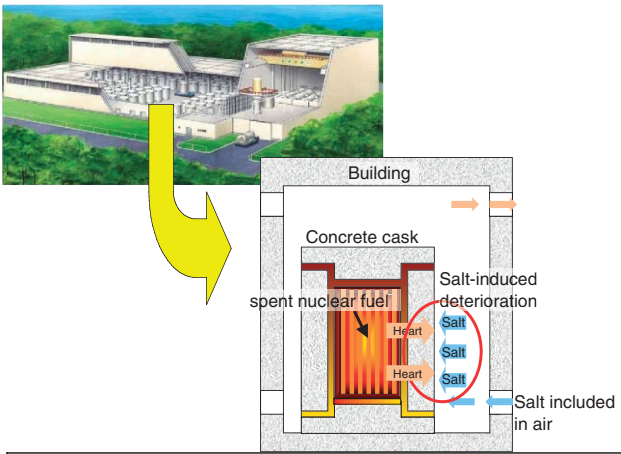
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### Reference

T. Matsumura, et.al., 2005, "Study on concrete cask for practical use - Development of evaluation method of salt-induced deterioration of reinforced concrete -", Technical Report N04032 (in Japanese)

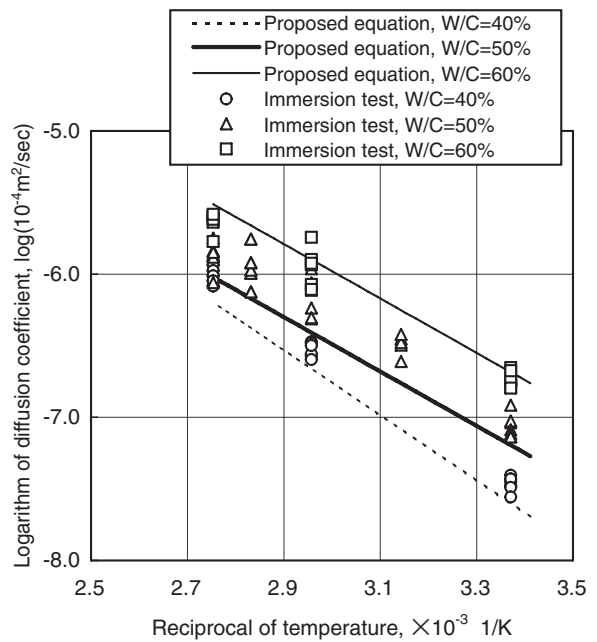
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\* 1 : The method of Concrete Standard Specifications "Chapter of construction" Japan Society of Civil Engineering, 1999



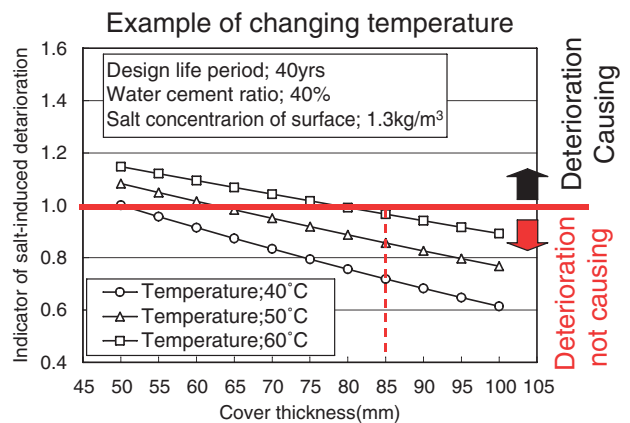
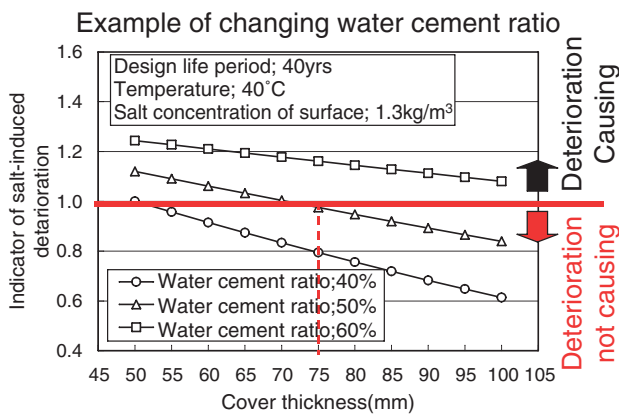
**Fig.1** Salt-induced deterioration of storage facilities, which are located in the vicinity of the coast

Although concrete casks are set indoor facilities, salt-induced deterioration under high temperatures is a primary factor of design, because salt included in air reaches the concrete casks from open windows.



**Fig.2** Chloride ion diffusion coefficient in concrete

From the results of immersion tests of specimens in NaCl water solution, we found almost a linear relationship between reciprocal of temperature and logarithm of chloride ion diffusion coefficient.



**Fig.3** Examples of results of evaluations of salt-induced deterioration

Right figure; In the case of chloride ion concentration of concrete surface being 1.3kg/m<sup>3</sup>, if concrete of water cement ratio 40% is used, and cover thickness is 85mm, salt-induced deterioration will not be caused for 40 years, when temperature of concrete is 60°C.

Left figure ; In the case of chloride ion concentration of concrete surface being 1.3kg/m<sup>3</sup>, if concrete of water cement ratio 50% is used, and cover thickness is 75mm, salt-induced deterioration will not be caused for 40 years, when temperature of concrete is 40°C.