105. Permeability of an Inorganic Corrosion Inhibitor for Concrete by Bruch Application

Takayuki HIRAI*, Kiyoshi MURAKAMI** and Takehisa KAI***

1. PURPOSE

The writers studied the method of brush applying corrosion inhibitor on concrete surface to permeate it into the concrete as a method to control corrosion of reinforcing steel in reinforced concrete structures containing salt. To control corrosion of reinforcing steel with this method, the applied corrosion inhibitor should permeate to the place where the reinforcing steel exists and the concentration effective for corrosion control should be maintained. The purpose here is to test with the passing of time the process of permeation of corrosion inhibitor into concrete when it is applied on an existing reinforced concrete wall.

2. TEST METHOD

2.1 SUBJECT OF TEST

The test was conducted with a sidewall of exposed concrete of about 1.5m high facing NNW, forming a part of a reinforced concrete swimming pool of a high school in Oita Prefecture. The period between concrete placing and beginning of the test was approximately 13 years. As subject of the test, a flat and smooth surface, without cracus or pores, was selected. The compressive strength, as conversion of the column specimen, measured with a Schmidt hammer at the beginning of the test on dry concrete surface layer averaged 282kgf/cm^2.

The depth of carbonation measured on the core extracted from the concrete averaged about 17mm and the salt content analyzed on the test material obtained by crushing the core into fine pieces is shown in Fig.1. The peak of salt content is seen at the depth of about 30mm from the concrete surface, and the overall concentration of salt is around 0.1%. It is assumed that in the concrete, sea sand containing salt concentration exceeding 0.3% was used without removing its salt content.

2.2 MATERIAL AND ITS SPECIFICATION

The materials used are shown in Fig.1. The corrosion inhibitor used has good permeability into concrete.

Specifications of applied corrosion inhibitor are shown in Table 2. There are four types of specifications and they are the combination of a process in which alkalinity is given to the base concrete prior to the application of corrosion inhibitor and a process to cover the surface with rustproof paste containing corrosion inhibitor. These specifications are

* Oita University
** Kumamoto University
*** Oita Structure & Maintenance Planning Office

represented as E, F, G and H.

2.3 APPLICATION

The tested concrete wall was layed out in areas of 90x10cm in the horizontal direction. The surface was rubbed hard with dry clothes to remove stains, then waterwashed. Applications were performed according to specifications in Table 2. In the case for applying alkalinity to the base concrete, five hours were left after the alkalizing agent was applied. The applied amount are shown in Fig.2. In the case to cover the surface with rustproof paste, the paste was trowel-applied twice to achieve a final thickness of 1.5 - 2.0mm.

2.4 TEST

Two concrete cores of 65mm in diameter from each type were extracted from the four types of specifications at a period of 7 days, one month, three months, six months and one year from the date of corrosion inhibitor application. To prepare specimens, they were crushed to fine pieces passing a sieve of 149μm. Four specimens were made from each core, three of them were taken from three layers each one centimeter deeper from the concrete surface and another was 5-6cm from the surface. To estimate the content rate of the corrosion inhibitor quantitative analysis on nitrite ion, the main ingredient of the corrosion inhibitor, was conducted by naphtylamine absorptiometric method.

3. RESULT AND OBSERVATIONS

3.1 CONCENTRATION OF THE CORROSION INHIBITOR

Figs. 4 to 7 show the analyzed result of specimens prepared from concrete cores extracted from the concrete wall which used the four specifications shown in Table 2. The concentration of NO_2 ion is taken on the vertical axis and the age on the horizontal axis, showing concentration and age for each depth from the surface of the material. Those of the depth of 0-1cm from the surface show very high concentration just after the application of the corrosion inhibitor, thereafter with the lapse of time, the concentration of corrosion inhibitor decreases.
Those from the depth of 1-2cm and 2-3cm from the surface show that concentration of corrosion inhibitor increased with the lapse of time. Those from the depth of 5-6cm from the surface the concentration of corrosion inhibitor, though slightly, increases with the age. From these, it can be observed that the corrosion inhibitor which was put on the surface diffuses and permeates into the concrete.

Figs.4 and 6 show the case in which rustproof paste was not applied after the application of corrosion inhibitor. There the concentration of corrosion inhibitor decreases overall as the age grows. This is because the corrosion inhibitor put on the concrete surface are emitted and lost from the concrete surface to the environment.

Figs.5 and 7 show cases in which the rustproof paste was put on the surface after application of corrosion inhibitor. In these cases the concentration of corrosion inhibitor is kept high overall even after age grows and the quantity of the corrosion inhibitor which is emitted and lost from the concrete surface to the environment is small. This applies to both cases whether or not the alkalizing agent was first applied to the concrete surface. This method to cover the surface with rustproof paste after ap-

plication of corrosion inhibitor is effective in reducing the emittance and loss of corrosion inhibitor from the concrete surface and therefore in preventing the decrease in concentration of corrosion inhibitor which permeated into the concrete.

In specifications F and H in which the surface was treated with corrosion inhibitor, as shown in Figs.5 and 7 the corrosion inhibitor of a considerable concentration permeated to the depth of 1-3cm already at the age of 30 days. The concentration of the corrosion inhibitor in this case is 0.05 to 0.2%, indicated by the concentration of NO_2 ion. After age grew, the concentration of corrosion inhibitor at the depth of 1-3cm from the concrete surface maintains much the same value of around 0.1%, indicated by the concentration of NO_2 ion.
And at the depth of 5-6cm from the concrete surface, while age is young, the concentration of corrosion inhibitor is low, however, as the age grows, it becomes around 0.01%, indicated by NO_2 ion.

In the meantime, the test result of concentration of NO_2 ion in the case of nontreatment where no corrosion inhibitor was applied was 3 decimal places by percentage.

4. CONCLUSION

The corrosion inhibitor applied on the concrete surface permeates inside or is emitted and lost from the surface to the environment. To prevent rust inhibitor from being emitted and lost from the surface, a method to apply rustproof paste is effective. With this method, corrosion inhibitor permeated into concrete shows a considerable concentration until the depth of several centimeters from the concrete surface and throughout the test period which lasted for one year it kept high concentration and showed no tendency of decreasing concentration. Its concentration, indicated by NO_2 ion is 0.05 to 0.2%. This is higher than the concentration required of corrosion inhibitor to prevent corrosion of reinforcing steel. The method of applying a corrosion inhibitor onto the surface of concrete is considered to be effective and powerful to improve the durability of existing reinforced concrete which contains salt.

In the meantime, if an alkalizing agent is applied onto the concrete surface before applying the corrosion inhibitor, the surface strength of the concrete deteriorated by aging can be improved.

Table 1 Materials
(All made by 'O' company)

Materials	Main Ingredients
Corrosion Inhibitor (for brush application)	Calcium Nitrate
Rustproof Paste (for surface covering)	Normal Portland Cement Synthetic Rubber Latex Calcium Nitrate
Alkalizing Agent (for brush application)	Alkali Silicate

Table 2 Specifications

Type	Specification
E	Alkalizing Agent + Corrosion Inhibitor
F	Alkalizing Agent + Corrosion Inhibitor + Rustproof Paste
G	Corrosion Inhibitor
H	Corrosion Inhibitor + Rustproof Paste

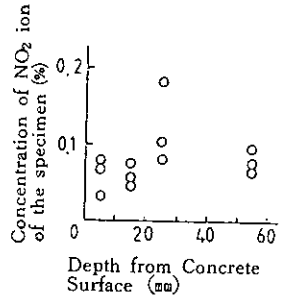

Fig. 1

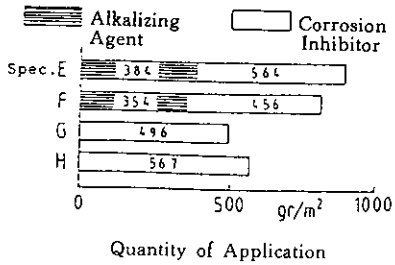

Fig. 2

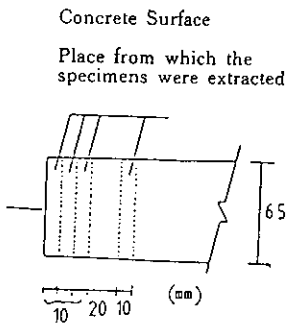

Fig. 3

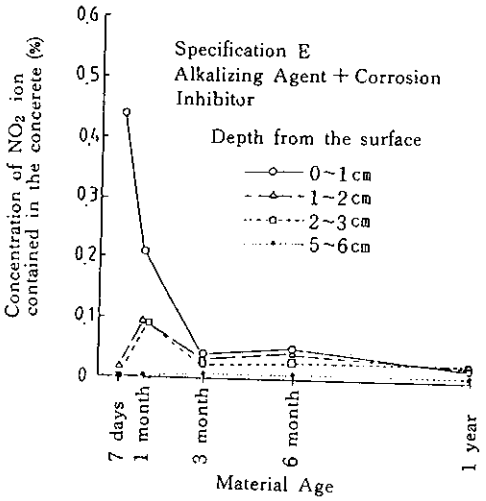

Fig. 4

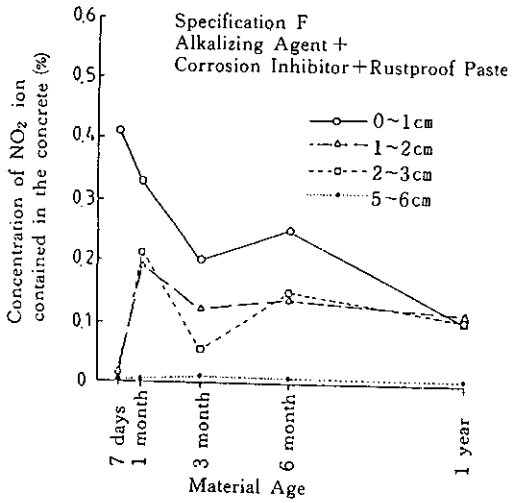

Fig. 5

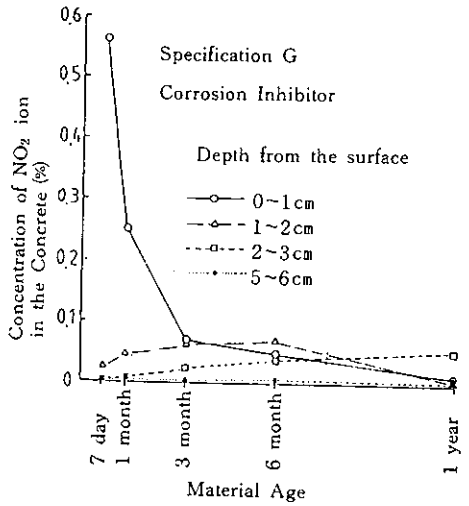

Fig. 6

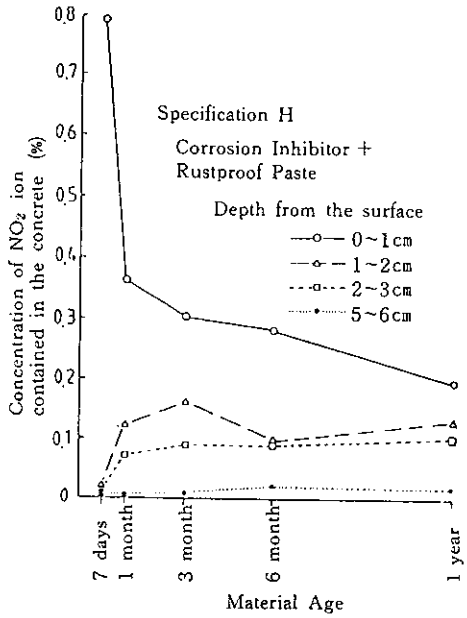

Fig. 7