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The status after 10 years of exposures of the PC beam specimen received damage from salt water which repaired by the desalination construction method and the re-alkalization construction method

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ABSTRACT

The desalination construction method and the re-alkalization construction method were applied to the prestressed concrete (PC) beam logged from the actual bridges which received salt water, and it was exposed to it for 10 years at the coast areas. Concrete place status after exposure was carried out for the natural potential of steel materials and polarization resistance, etc., and comparison examination of the degraded condition was carried out on various sides. Consequently, it was presumed that corrosion of steel will not harch by the desalination methods 10 years after exposure, but it is in sound state. On the other hand, by the re-alkalization construction method, a result presumed to be in a corrosion conditions was brought. By a re-alkalization construction method, it thinks because desalination effect is not expectable.

Keywords. chloride induced deterioration, PC beam, The desalination construction method, the re-alkalization construction method

INTRODUCTION

In recent years, many maintenance managements of new concrete structures and repair technology are developed, and have been put in practical use. The electrochemical anti-corrosion method of construction is the one and the effect and coverage are shown by Japan Society of Civil Engineering and so on. The desalination construction method and the re-alkalization construction method are one of the electrochemical anti-corrosion methods of construction.

The desalination construction method makes a direct-current electricity discharge chloride ion in concrete outside by pouring during the reinforcing rod and the outside electrode in concrete. The re-alkalization construction method makes a neutralization part recover in the same way at making alkaline solution penetrate inside concrete by pouring in the direct-current electricity, being alkaline. There is some report in the durability of the concrete structure which applied both methods of construction therefore but little report about the pre-stressed concrete (PC) beam occurs.

Therefore, in this report, analysis examination detailed about what exposed to along the seashore what was repaired by desalination and a re-alkalization construction method for this PC beam for ten years was performed employing PC beam actually used with coast highway bridge.

THE CONDITION OF THE PC BEAM BEFORE THE EXPOSURE

The PC beam to have made a subject of study was used for the highway bridge which was constructed to the position which left Sea of Japan at the Hokuriku district by about 70 m and was composed by 15 pretension PC beams of the about 14 m length as shown in Figure 1. The standard section of the PC beam is shown in Figure 2. This bridge was under the severe environment, the spray band, because the bridge-site was low, after completed in February, 1972, a repair with several times was done and was removed in the step which was passed in 25 years after construction. This time, it used the PC beam of G14 which is shown in Figure 1.

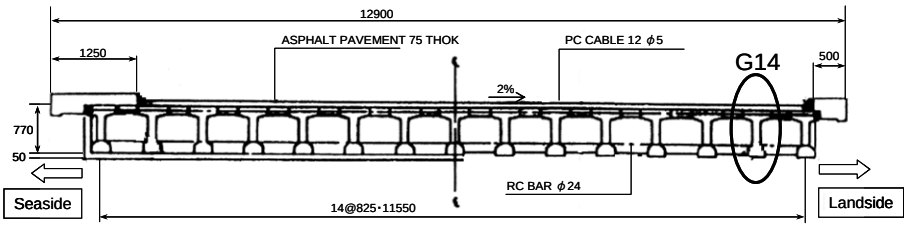

Figure 1. Outline of Removed Road Bridge (Unit : mm)

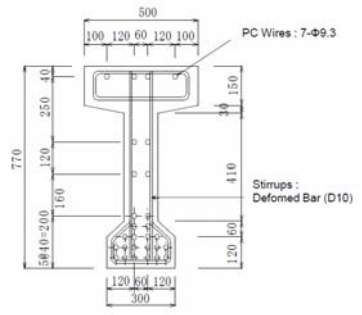

Figure 2. Cross-Section of PC beam (Unit : mm)

A surface coating was given by the PC beam before the exposure but a trace of some repairs was confirmed when removing this. As for the degradation of the exterior of the PC beam, the exposure of the binder was only confirmed in the side with being on the oceanside near the midspan and the rust, the float, the delamination that the corrosion of steel became cause weren't confirmed. By the analysis of the chloride ion, about maximum 3.0 kg/m^3 chloride ion penetrated in the reinforcing rod position. The average with neutralization depth was 1.6 mm and wasn't very deep. There was one which is made the condition as the thin rust is spreading to the surface though the head is about 40 mm in the binder which is on the oceanside in the investigation of the corrosion status of the reinforcing rod.

THE INSTLATION OF DESALINATION AND RE-ALKALIZATION COMSTRUCTION METHOD AND THE EXPOSURE ENVIROMENT

These methods of construction are the one which gets a repair effect by pouring in the direct-current electricity between the reinforcing rod and the anode by to make the electrolyte solution which put an anode in the concrete surface. The difference of the desalination construction method and the re- alkalization construction method is electrolyte

solution and a turning on period and besides, similar construction technique is therefore caught. The basic concept of the method of construction of both is shown in Figure 3.

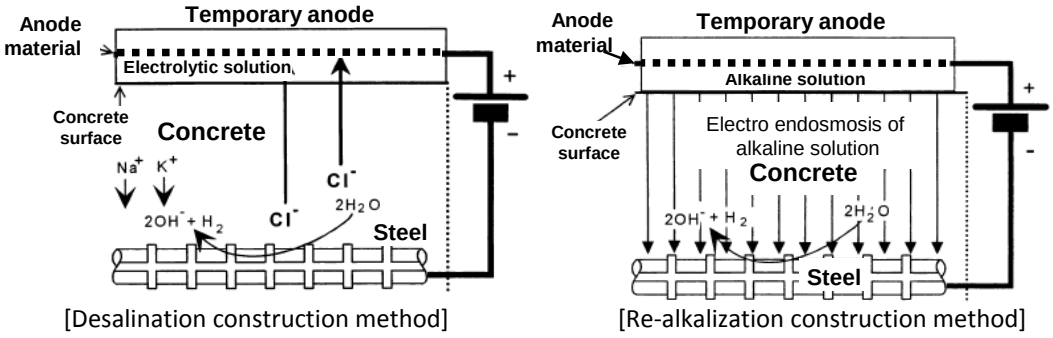

Figure 3. Schematic system diagram of desalination and re-alkalization construction method

In the desalination construction method, it used the lithium hydroxide and the boric acid for electrolytic solution. In the re-alkalization construction method, it used the sodium carbonate solution. The electric current passed an electric current with the current densities of 1.0A/m^2. In the turning on period, the desalination construction method was for 56 days and the re-alkalization construction method was for 10 days. Incidentally, after a required turning on period is ended, it doesn't apply a surface coating and so on. It installed a PC beam after installation in the place which is located in 30m from the coastline at the Sea of Japan side to be disclosed to the severe damage from salt water environment for 10 years.

THE SITUATION STUDY OF THE PC BEAM BEHIND 10 YEARS OF EXPOSURES

The natural-potential and the polarization resistance of steel. The natural-potential distribution before the exposure beginning and behind 10 years of exposures is shown in Figure 4. The result of measurement of the polarization resistance of the steel which was measured by the AC impedance method (the measuring specification: 10 Hz of high frequencies, low frequency 20mHz (the sine wave), ±10 mV of applied electromotive force) behind 10 years of exposures is shown in Figure 5. Incidentally, the natural-potential used a lead electrode and it converted the value which could be gotten to the saturated copper sulfate electrode standard.

As seen Figure 4, the area of the natural-potential -300~-200mV vs CSE and - 200~-100mV vs CSE of the part of the installation of a desalination construction method at 10 years of exposures accounts for most of the whole installation parts. In the standard of ASTM, it is in "the indefiniteness" and the area which is classified into "equal to or more than 90 % of corrosion pears". The natural-potential of the part of the installation of a re-alkalization construction method the area of -400~-300mV vs CSE account for 80 percent of the whole installation part in the same way and in the standard of ASTM, the possibility of the reinforced corrosion is in "the indefiniteness" or the area which is classified into "equal to or more than 90 % of corrosion".

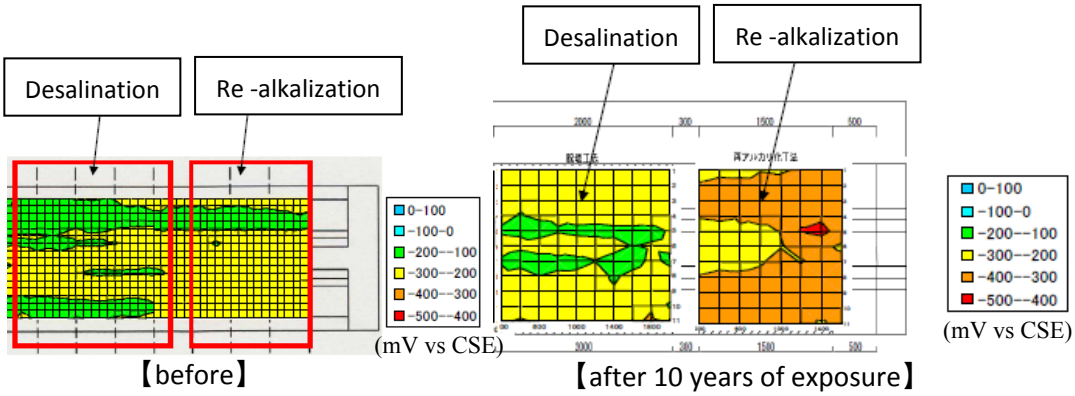

Figure 4. The natural-potential distribution before exposure and after 10 years of exposures

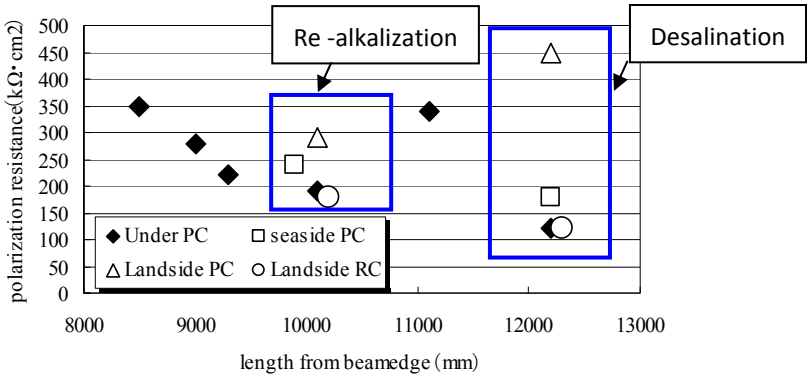

Figure 5. The polarization resistance value after 10 years of exposures

The polarization resistance value of the part of the installation of a desalination construction method is 190-460kΩ・cm^2 and in the acceptance standard of CEB, it is classified into "the

passive-state condition (the corrosion pear)" from Figure 5. On the other hand, in the part of the installation of a re-alkalization construction method, in 103-138kΩ･cm^2, in the whole measuring point, it often becomes a small value and there are many parts which become the value that an acceptance standard by CEB is classified into "the corrosion-rate of low-the medium degree".

A part of the installation of a desalination construction method is judged able to maintain the environment that the reinforcing rod doesn't corrode for the most part from above thing when 10 years lapses after installation, too. On the other hand, that there was possibility not to lead by the time the corrosive-atmosphere can be improved in the re-alkalization construction method because it was in the condition with high salinity even if the pH was keeping, that it was alkaline distinguished between the part of the installation of a re-alkalization construction method.

The chloride ion concentration. The distribution of all the chloride ion concentrations over the part to have built a desalination construction method is shown in Figure 6 than the distribution before installation. It pulled out a concrete core to pierce a PC beam and the measurement implemented the analysis of all the chloride contents according to JCI-SC4. Incidentally, in case of core pulling-out, it measured the position of the reinforcing rod beforehand with the RC radar and it pulled out core in the reinforcing rod near position. A result at the part to have installed a re-alkalization construction method in the same way is shown in Figure 7.

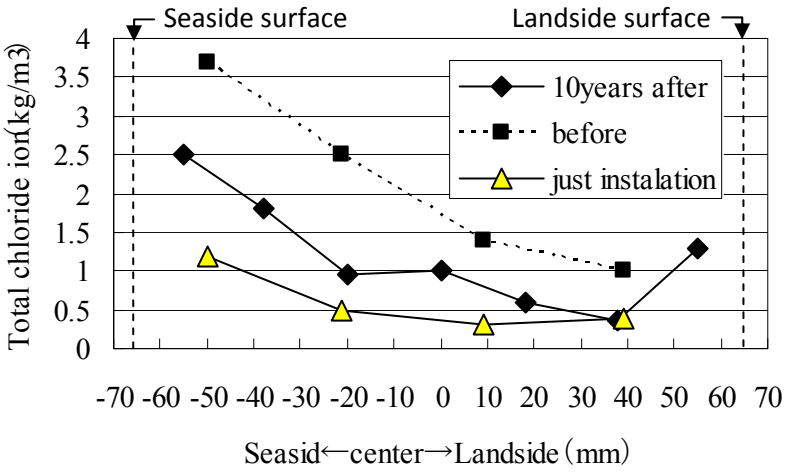

Figure 6. Total chloride ion concentration distribution of the desalination part

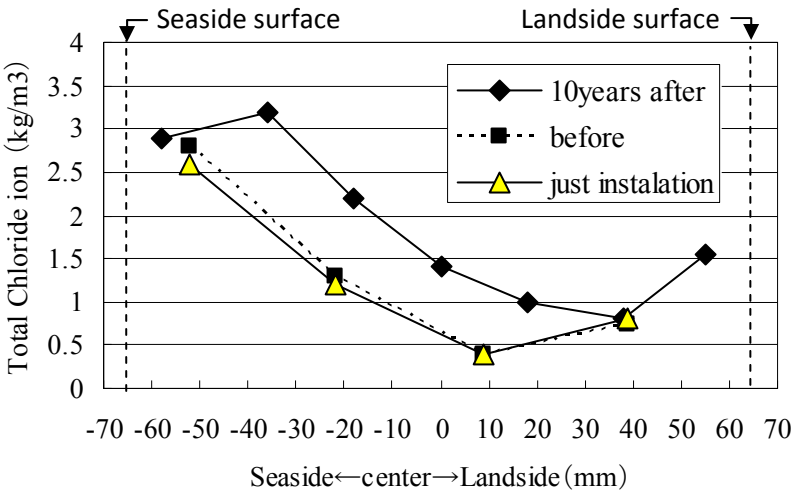

Figure 7 Total chloride ion concentration distribution of the re-alkalization part

As seen Figure 6, values of seaward is high, the chloride ions concentration distribution before desalting methods and construction is 3.6kg/m^3, and chloride ion concentrations declines and has become 1.0kg/m^3 as it is on a land side.

From the centre, to the seaward, immediately after that whose chloride ion concentration before desalination construction method construction in a 50mm portion was 3.6kg/m^3 constructs, it is falling to about 30% of all the salinity before about 1.2kg/m^3 and construction.

About all the salinity, it is before and after construction of desalting methods similarly, and it was accepted that salinity declines greatly.

About the result of measurement after 10 years of exposures of the part of the installation of a desalination construction method, the chloride ion concentration in the 50-mm part increased and from 2.5kg/m^3 in all the salinity the value immediately after installation and became about 70% of all the salinity before installation from the center to being on the seaside. It thinks that this is one by the salinity supply from the sea. Generally, all the salinity behind 10 years of exposures is increasing from all the salinity immediately after application but is staying in about 40-70% of all the salinity before application.

It found that the chloride ion concentration in the part of the installation of a desalination construction method was changing at the value which is lower than in the chloride ion concentration before building behind 10 years of exposures, too.

On the other hand, since an increase is looked at from the concentration immediately after construction by the salt supply from the surface, in order to maintain durable by it at a long terms, it is thought that it is necessary to suppress increase in salinity by re-supply of salts.

As seen Figure 7, as for the chloride ion concentration distribution before installation of a re-alkalization construction method, the value which is on the seaside is high and in 2.8kg/m^3, the specimen central part becomes 0.8kg/m^3 lowest in the part on 40 mm of the sides of the land from the next of 0.4kg/m^3, the center. There was little change of the chloride ion concentration before and after installation of a re-alkalization construction method.

As for the result of measurement after 10 years of exposures of the part of the installation of a re-alkalization construction method, penetration by the inner diffusion of salinity from being on the seaside to the landside is seen and the chloride ion concentration is increasing generally. It becomes the increment of about 0.5-1.0kg/m^2 generally.

The above things showed that a re-alkalization method of construction could hardly expect benefits of desalination.

CONCLUSIONS

The installation part of desalination construction method is judged to be what can be maintaining the environment which a reinforcing rod does not corrode in general also in ten years after exposure. Otherwise, it was judged that the construction portion of a re-alkalization construction method will have steel in corrosive environments ten years after exposure. By a re-alkalization construction method, desalination effect is not expectable. Therefore, it is thought that the re-alkalization method has not improved the corrosion environments of reinforcing rod.

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