Effectiveness of Joint Treatment on Corrosion of Steel Bar in Prestressed Concrete Beams
-- Observation of Severely Damaged Specimens under Marine Conditions for More than 30 years --

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1. Introduction

It is well known that “joints” are unavoidable in construction due to various reasons, namely the size of the construction and limitations in the realization of the work. However, the presence of joints often hinders the durability of concrete [1]. For instance, it promotes the ingress of harmful agents in the vicinity of the rebar, which leads to the corrosion of the latter. As a result, a better understanding of the effect of joints on the corrosion of reinforcing steel is crucial for a better handling of the issue. In this paper, the electrochemical aspect of the effect of joint on severely damaged beams is assessed.

2. Methodology

2.1 Specimen outline

In this study, 6 specimens (120 x 150 x 1200 mm) were used with a concrete cover of 30 mm as shown in **Figure1**. Initial bending cracks were applied to the specimens and 2 types of joint treatment were chosen for the study. The specimens were cast around 1982 and put in the marine splashing exposure site of the Port and Airport Research Institute (PARI) for about 30 years under a continuous bending load. Then, they were moved to the experimental laboratory in Kyushu University 8 years ago. Two specimens were treated with the same cement mortar used for the concrete (M1, M2) and two specimens were treated using epoxy resin 5 mm in thickness, Sika No.31 (E1, E2). **Table 1** summarizes the different treatments and bending crack width applied to each specimen.

2.2 Measurements

Electrochemical measurements were performed to investigate the condition of the rebars. First, Half-cell potential was measured for each specimen. ASTM C 876 criteria were used to evaluate the corrosion probability [2]. Second, anodic-cathodic polarization curve measurement was done in order to assess the grade of passivity of the steel bar based on the current density [3]. Potentiostat, Function generator and Data logger were used in this test. Third, potential step method (contact method) was attempted. The same apparatus used in the polarization curve method was employed in this measurement and the oxygen permeability was monitored for 4 hours on each point. Polarization curve and potential step measurement were performed directly on the top of the joints.

Table 1: Treatment and crack width outline

Type	Joint	Treatment	Crack*(mm)
N1	Without	-	0.1
J1	With		0.1
M1	With	Cement Mortar	0.1
M2	With		0.2
E1	With	Epoxy Resin	0.1
E2	With		0.2

*Targeted cracks under continuous bending loads.

3. Results and Discussions

3.1 Visual observation

Figure 2 illustrates the actual state of the specimen without

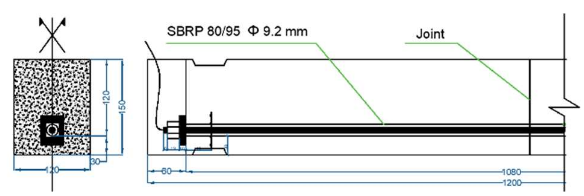

Figure1. Design drawing of the specimen


Figure2. Specimen with joint but no treatment condition (J1)


Figure 3. Specimen with joint treatment condition

treatment at the joint (J1). Several years after being brought to Kyushu University, one section from the joint of the specimen completely fell apart. While in the other section, very large

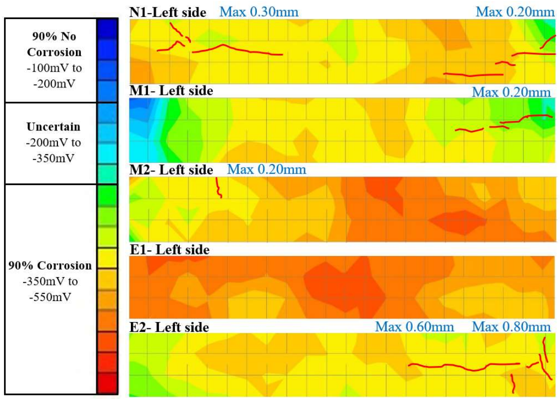

Figure 4. Half-cell potential and crack mapping

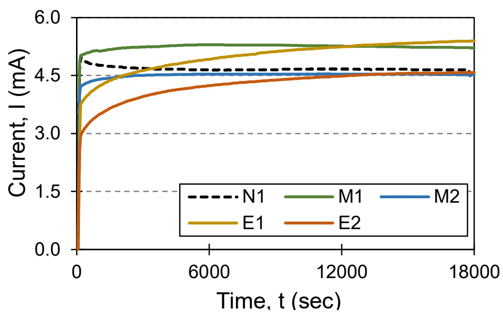

Figure 6. Potential step test result at the joint

cracks could be observed; with a maximal crack width of 10mm. However, the failure point of the steel bar was not located in the joint section. This might be to the fact that the joint area became the cathode where oxygen and water are supplied and the other section of the steel bar became the anode. Whereas, the specimens with joint treatment were found in a better condition even with a maximal crack width of 0.55mm (**Figure 3**).

3.2 Half-cell potential

Figure 4 shows the results of the half-cell potential mapping. Large areas of the 5 specimens are in the 90% corrosion zone (-350 mV to -550 mV). Moreover, the formation of macro-cell corrosion is a common trend observed in all the specimens. The beam E1 is found to be in the worst condition of corrosion. However, the mortar (M1) and the Epoxy (E2) treatment specimens appear to be on the similar state as the specimen without joint (N1); which justifies the effectiveness of the use of treatment even after 38 years.

3.2 Anodic cathodic polarization curve.

As shown in **Figure 5**, the result suggests that the specimen N1, M1, M2 have a grade of passivity 3 and a grade of passivity 4 for the E1 and E2. These results infer that the joint with treatments keep the passivity state on the steel surface.

3.3 Oxygen permeability

Figure 6 illustrates the results from the potential step test. It could be observed that the difference in oxygen diffusion

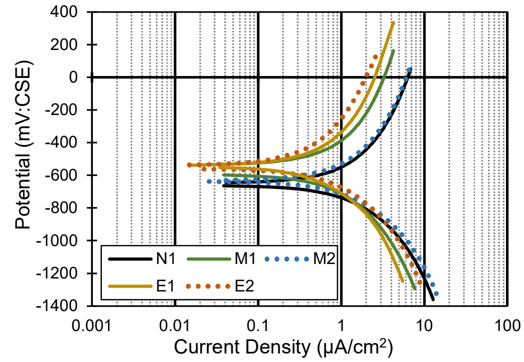

Figure 5. Anodic-cathodic polarization curve at the joint

between the treated specimen and the specimen without join is minor (4.65 mA). From this, it can be implied that the joint treatments are effective to limit the oxygen diffusion in the joint area for treated specimen.

4. Conclusion

In this study, the effectiveness of different joint treatments is investigated using electrochemical measurements. The results suggest that:

1. The application of joint treatment is essential to ensure the durability of beams since the specimen with no treatment in the joint reached the failure state before other specimens
2. The half-cell potential results proved that the mortar treatment M1 is in the best condition and the specimen E1 is in the most corroded condition. However, the effect of the two types of treatment could not be differentiated.
3. The use of joint treatment is as performant as the specimen without joint to limit the diffusion of oxygen in the concrete and to keep the passivity condition on the steel surface at the joint location.

In future work, visual observation is still required to confirm the actual corrosion conditions of each steel bar. In addition, further research is needed to confirm the effectiveness of each type of treatment.

Reference

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[3] N. Otsuki: A study of effectiveness of chloride on Corrosion of Steel in Concrete. Report of Port and Harbour Research Institute 127-134,185