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Corrosion Protection Effect with Sacrificial Anode for Corroded Steel Members using Al-Zn Casting Alloy and Fiber Sheet

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ABSTRACT

In this study, the electrochemical tests were conducted on corroded steel plates to obtain the time-dependent of protective current by sacrificial anode protection using the casting alloy. The properties of sacrificial anode for the corrosion protection were examined using an anode material and fiber sheet expected the high anti-corrosion. Thus, effect of sacrificial anode for the corrosion protection and the protective current characteristics by the reduction reaction of corrosion products for the Al-Zn casting alloy were examined. As a result, the anti-corrosion effect of the corroded steel plate was determined by using sacrificial anode corrosion of an alloy cast material. In case of the remained corrosion product on steel surface, the reduction reaction of the corrosion product was shown while protective current flows.

1. INTRODUCTION

The corrosion problem has been generally considered as repainting periods until now. In Japan, repainting on steel structure was generally applied every ten-odd years after investigation of deteriorated paint thickness and visual inspection. However, the durability of the paint coating were decreased by corrosion products and chloride after the inadequate surface treatment such as blast and water jet etc,. Therefore, (Kainuma 2011, 2013 Ishihara 2014) have developed anti-corrosion technology for the steel base material remained corrosion products and chloride using porous sintered anode material and water retaining fiber sheet which can be able to expect high anti-corrosion performance. Also, the current behavior and the reduction mechanism of corrosion products under the sacrificial anode, it was clarified by applying technique for the corrosion steel plate.

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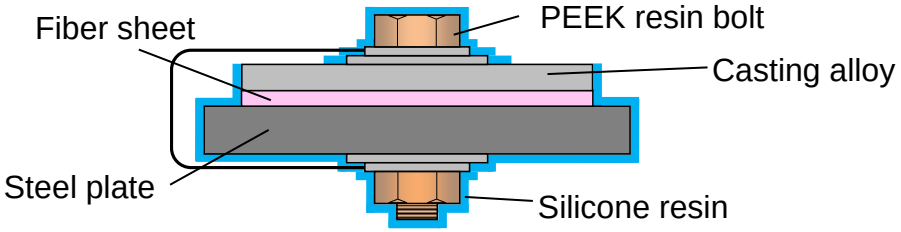


Fig.1 Structure of the Specimen

Table 1 Test condition

Specimens	Steel type	Electrolyte of fiber absorbent	Test environment	
			Temperature T (°C)	Relative humidity RH (%)
C-1	Carbon	26.4wt%NaClaq	30	100
C-2				
W-1	Weathering			
W-2				

In this study, the Al-Zn casting alloy was selected as a sacrificial anode materials, also it was examined in effect on the sacrificial anode corrosion protection of corroded steel plates and characteristics of anti-corrosion current by reduction of corrosion products. To obtain the time-dependent of corrosion current, the electrochemical tests on corroded carbon and weathering steel plates were conducted. The properties of sacrificial anode for the corrosion protection were examined by using an anode material and fiber sheet. Thus, effect of sacrificial anode for the corrosion protection and the characteristics of the protective current by the reduction reaction of corrosion products for the Al-Zn casting alloy were examined.

2. SPECIMENS AND METHOD

Fig.1 shows structure of the specimen, which was composed of corrosion steel plate, casting alloy, fiber sheet and PEEK resin bolt. Uncoated carbon steel plates and weathering steel plates were used, which are specified in JIS G 3106 SM490A and JIS G SMA490AW, respectively. The uniform corrosion were occurred in the steel plates of the bridge girder which is located at lat.33°35'N and long.130°21'E, it could be not affected wash-off by rainfall for about five years during August 2008 to July 2013.

Sacrificial anode material was used the casting alloy (66×66×5mm), its component ratio of Al and Zn was 4 to1. Eight holes with diameter φ of 6.5 mm were drilled at the casting alloy in order to maintain the wet environment of fiber sheet through external moisture. The fiber sheets on the capability of water retaining and absorbing were used a cross-linked acrylate fiber of about thickness of 3mm and basis weight of 300g/m^2. The corrosion products of steel plate in outside area where the sacrificial anode material contact were removed completely by blast treatment. Sacrificial anode materials and steel plates were electrically connected between the lower surface of the steel plate and upper surface of the sacrificial anode material. The moisture was supplied only through

the sacrificial anode material, it was coated with a non-anodic material surface with silicone sealant. In Table.1, the fiber sheet was allowed absorb an electrolyte solution of 26.4wt% NaCl aq under corrosion environment, it was easily to express the effect of a sacrificial anode corrosion. To examine the corrosion protection effect with sacrificial anode, the test was used by thermo-hygrostat. The temperature and relative humidity of tested corrosion environment were kept constantly at 30C° and 100% and anti-corrosion current was measured every 10 minutes using a zero resistance ammeter.

3. RESULTS AND DISCUSSIONS

Fig.2 shows the time-dependence of current density for the specimens. With the exception of the specimen W-2 using a weathering steel plate, anti-corrosion current of C-1, C-2(Carbon steel) and W-1(Weathering steel) remains constant from the tests start. Protective current of each specimens are rapidly reduced, and has remained at 0, but this is design of the ammeter, it has been confirmed that it was negative current in fact. The specimen C-2, W-1 and W-2 were terminated at test, respectively at 700hrs., 640hrs. and 760hrs. in order to check the internal state of the specimens. Fig.3 shows the state of the specimens C-2, W-1 and W-2 surface of the steel plate after the end of tests.

In case of an electric circuit of the anti-corrosion current in the respective specimens, it was considered on the initial corrosion products FeOOH which generated on the steel plate surface was reduced to Fe_3O_4 in Ishihara (2014). However, measurement value of the protective current was less than 0, as shown in Fig. 2, it was shown to be have been formed by new corrosion products according to the oxidation reaction on Fe_3O_4.(Ishihara 2014).

Fig.3 (a) shows the steel plate surface of C-2 after the end of test. The steel plate surface before the test was totally brown. However, it was investigated on present corrosion product with black and brown. The corrosion product of black was affected by Fe_3O_4, it was reduced from FeOOH by sacrificial anode corrosion protection of anode material, and those of brown is a new corrosion product by the oxidation reaction on Fe_3O_4 when the anti-corrosion current was less than 0. In Fig.3 (b), the corrosion

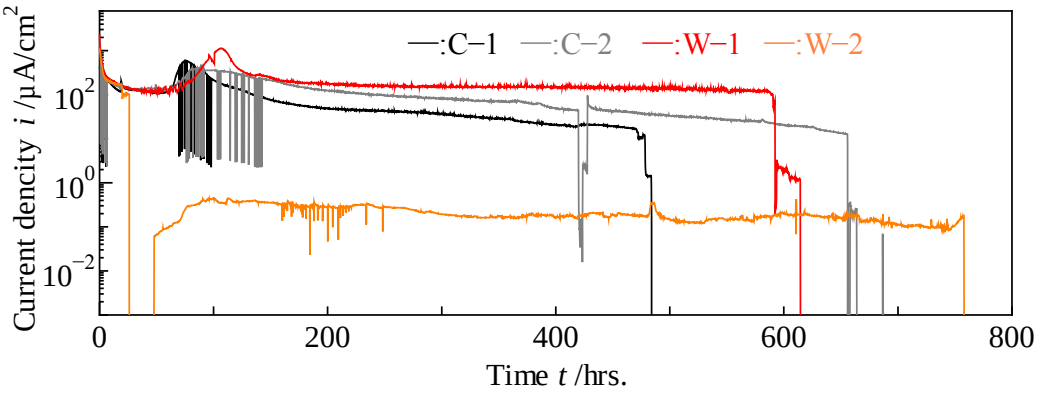
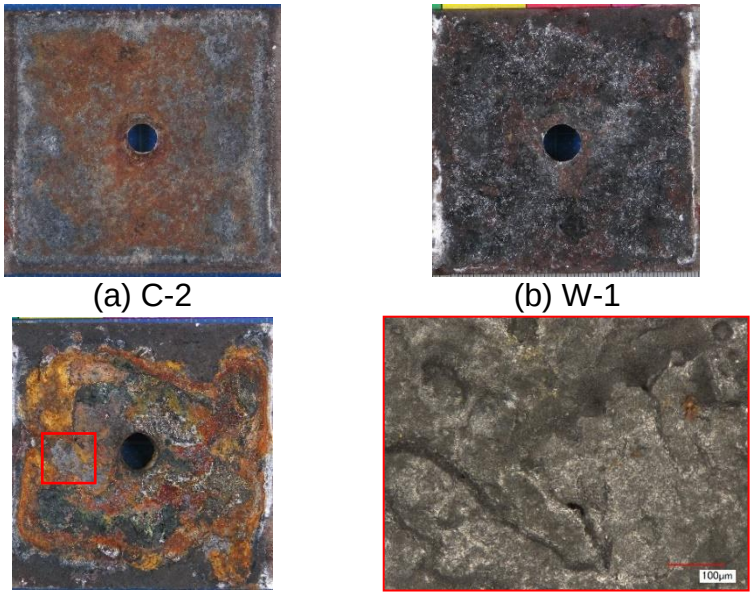


Fig.2 Time-dependence of current density



(a) C-2 (b) W-1

(c) W-2 (d) Peeling part of rust (×500)

Fig.3 Steel plate surfaces of tested each specimen

product was seems to be totally black, it was influenced by the sacrificial anode corrosion protection effect of the anode material. And the white sludge on the steel plate surface was formed and separated by the fiber sheet. W-2 specimen was similar tendency of C-1 specimens surface of the steel plate after the end of test, as shown in Fig.3 (c) and (d). Steel plate surface of the specimen W-2 after the end of test was present corrosion product of black and brown. It is considered brown corrosion products generated on Fe_3O_4 as new corrosion product by an oxidation reaction during a few hours after the initial corrosion products has been reduced to Fe_3O_4 by sacrificial anode corrosion protection. Also, a portion indicated by a solid red line of the steel plate surface is a part where rust peeled and the steel basis material was exposed.

Fig.3 (d) shows the separated portion of the rust using the microscope. (Ishihara 2014) has been explained on the mechanism, its corrosion products occurred by reducing adhesion of Fe_3O_4 layer and the steel base material when the formed initial corrosion products was reduced to Fe_3O_4. (Ishihara 2014)

4. SUMMARY OF FINDINGS

In this study, characteristics of protective current due to the reduction reaction of corrosion products and the sacrificial anode corrosion protection examined using the Al-Zn casting alloy for the corroded carbon and corroded weathering steel plate. The main results obtained in following.

1) Initial corrosion product was reduced to Fe_3O_4 on the surface of the corrosion steel plate when the electric circuit of protective current was formed on the corrosion steel plate to the Al-Zn casting alloy.
2) An adhesion performance was decreased between Fe_3O_4 layer and the steel surface because of the initial corrosion products with Fe_3O_4. It should be occur the desquamation of corrosion products for weathering steel.

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