The Tenth East Asia-Pacific Conference on Structural Engineering and Construction
August 3-5, 2006, Bangkok, Thailand

INFLUENCE OF EDGE GEOMETRY OF BASE STEEL PLATE ON CORROSION RESISTANCE OF COATED STEELS

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ABSTRACT: In steel bridges, the corrosion damages occur easily at sharp free edge of bottom flange, bolts and nuts, because securing desired thickness of coating films is difficult at such locations. This study examined an accelerated exposure test and measured the thickness of the coating to investigate corrosion resistant at different types of edge geometry. Test specimens were exposed to the accelerated corrosion environment conforming to Japanese Industrial Standards K5621 for 200 days for metallic coating and 300 days for painting coating. From the corrosion occurred at edge and thickness of coating, anticorrosive performance of the coating systems was discussed. The coating system at the round edge had good performance.

KEYWORDS: steel bridge coating system, edge geometry, accelerated exposure test, thickness of coating film

1. INTRODUCTION

Painting coating systems are widely used to prevent corrosion damage on steel bridges. However the anticorrosive performance of coating films decreases gradually. Corrosion damages occur easily at sharp free edge of bottom flange, bolts and nuts, because securing desired thickness of coating films is difficult at such locations. Occurred corrosion is expanded and affects aesthetic and performance of steel bridges. Sharp free edge is often produced as beveled edge or rounded edge in real steel bridges. But the effect of edge treatment has not been cleared. Corrosion occurred from edge affect the remaining life of coating systems. Therefore, it is necessary to examine the anticorrosive performance at edge.

This study performed accelerated corrosion test to examine corrosion characteristics at different types of edge geometry. The three types of edge geometry for specimen were prepared in 3 types, square edge without edge-treatment, beveled edge with 1 mm long and 45 degree, and rounded edge with a radius of 2mm. Then 4 types of painting systems, A-painting systems for a mild corrosion environment, B- and I-painting systems for a little severe corrosion environment and C-painting systems for a severe corrosion environment in Japan, and 2 types of metallic coating systems (zinc hot-dip galvanizing, zinc-aluminum alloy thermal sprayed coating) were applied. The specimens were made by 4 pieces in each group; one of them was cut, and the thickness of coating of the sections was measured by a microscope with a magnification of ×100. The others were exposed to an environment chamber controlled by S6-cycle corrosion condition, conforming to Japanese Standard Industrials (JIS) K 5621, for 200 days for metallic coating systems and 300 days for painting coating systems. Based on the

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occurred corrosion along the edge and the thickness of the coating, anticorrosive performance at the edge of the coating systems was discussed.

2. EXPERIMENTAL PROCEDURE

2.1 TEST SPECIMENS

Substrate steel plates of 150×32×12 mm were made of structural steels SM490A (JSA.1999). Edge prepared in 3 types of edge geometry, square edge without edge-treatment (C0), beveled edge with 1 mm long and 45 degree (C1), and rounded edge with a radius of 2mm (R2). Then specimens ware coated with 4 types of painting systems, A-painting systems for a mild corrosion environment, B- and I-painting systems for a little severe corrosion environment and C-painting systems for a severe corrosion environment in Japan, and 2 types of metallic coating systems, zinc hot-dip galvanizing, zinc-aluminum alloy thermal sprayed coating. Coating details, configuration of test specimen and edge geometry are shown in Table 1, Figures 1 and 2.

Table 1. Coating systems used in this study

Coating systems	Coating process	Treatment	Designed thickness (μm)
A-painting systems	Surface preparation Undercoat Undercoat Intermediate coat Top coat	Blast, SIS Sa2 1/2 Class Lead anticorrosive paint Lead anticorrosive paint Alkyd resin Alkyd resin	- 35 35 30 25
B-painting systems	Surface preparation Undercoat Undercoat Intermediate coat Intermediate coat Top coat	Blast, SIS Sa2 1/2 Class Lead anticorrosive paint Lead anticorrosive paint Phenolic resin Alkyd resin Alkyd resin	- 35 35 45 35 30
C-painting systems	Surface preparation Undercoat (Mist coat) Under coat Under coat Intermediate coat Top coat	Blast, SIS Sa2 1/2 Class Inorganic zinc-rich paint Epoxy resin Epoxy resin Epoxy resin Polyurethane resin Polyurethane resin	- 75 - 60 60 30 25
I-painting systems	Surface preparation Undercoat Intermediate coat Top coat	Blast, SIS Sa2 1/2 Class Organic zinc-rich paint Polyurethane resin Polyurethane resin	- 75 30 25
Zinc-aluminum alloy thermal spraying	Surface preparation Metal spraying Sealing treatment	Blast, SIS Sa2 1/2 Class Zinc-aluminum alloy coating Epoxy resin sealing coating	- 100 -
Zinc hot dip galvanizing	Surface preparation Metal plating	acid pickling Zinc hot dip galvanizing (JIS H9124)	- (550g/m^2)

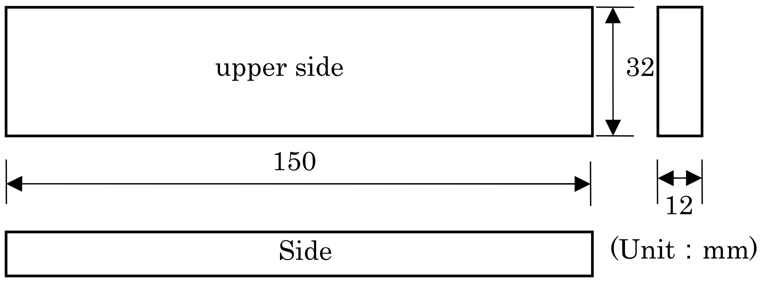


Figure 1. Test Specimen

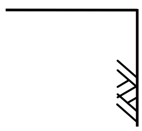
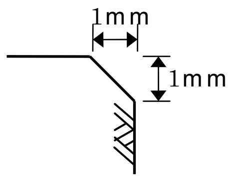
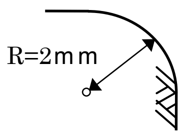
Type	C0	C1	R2
Processed geometry	no edge-treatment	beveled edge with 1 mm long and 45 degree	rounded edge with radius of 2mm
Section geometry			

Figure 2. Edge geometry

2.2 MEASURING THICKNESS OF COATING FILMS

Three specimens of each group were used for accelerated exposure test and the other one was cut for measuring the thickness of the coating. Each specimen for measuring thickness of coating was cut into four to investigate the film thickness. Photographs of coating films were taken at regular intervals (1mm) using microscope. Then the thickness of coating films was measured by using the photographs, as shown in Figure 3.

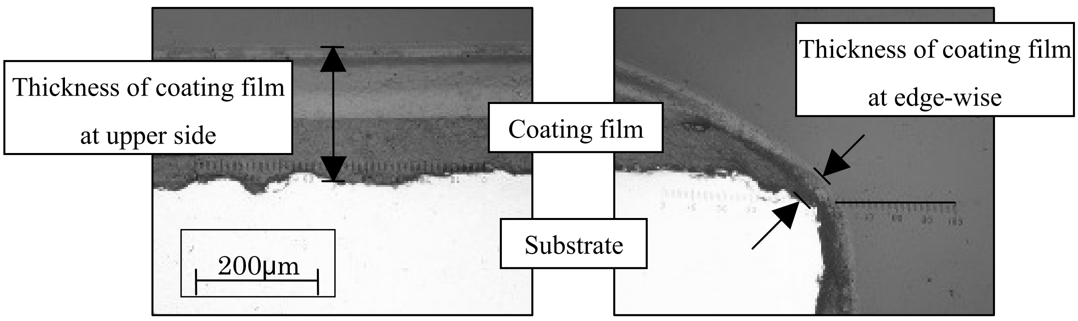


Figure 3. Photographs on section (A-painting system; C0)

2.3 ACCELERATED EXPOSURE TEST

2.3.1 Condition of Accelerated Exposure Test

A Combined Cyclic Corrosion Test Instrument (SUGA Test Instruments Co., Ltd.) was used to simulate the cyclic corrosion environments. This equipment can operate automatically the conditions of atomizing of salt water, temperature, and humidity in arbitrary order and combination. The environment in the chamber was controlled conforming to the S6-cycle test condition specified in JIS

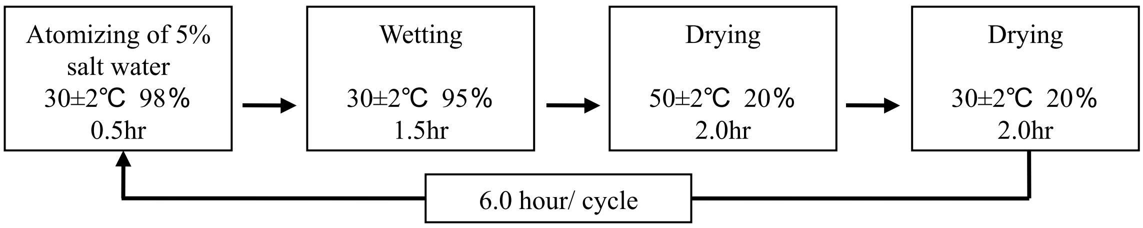


Figure 4. Accelerated exposure test condition (S6-cycle)

K5621, as shown in Figure 4.]

2.3.2 Measuring Progress of Corrosion

The specimens of painting coating systems were taken pictures every 25 days. They were used to measure the appearance change with passage of testing time. The proportion of corrosion length along the edge to the total length (150mm), so called rust rate, was used to represent the corrosion progress. Metallic coating systems differ from painting coating systems in anticorrosive mechanics. Therefore to evaluate anticorrosive performance is necessary in a different way from painting systems. After exposure corrosion test for 200 days, the specimen were cut and remade for measuring thickness of coating like measuring the initial thickness of the coating film, and measured thickness of coating films.

3. EXPERIMENTAL RESULTS

3.1 MEASURING THICKNESS OF COATING FILMS

The proportion of the upper (under) side thickness of coating films to the edge one was used to evaluate the influence of the edgewise for thickness of coating films. As shown in Figure 5, the thickness of all painting coating films was C0<C1<R2 and C0, C1, and R2 were 21-33%, 41-77% and over 79%, respectively. Metallic coating systems seem to have similar tendency with painting systems. The differences in thickness of coating with edge geometry on metallic coating system are smaller than the one on painting coating systems. The edge geometry effect on thickness of metallic coating is smaller than painting coatings.

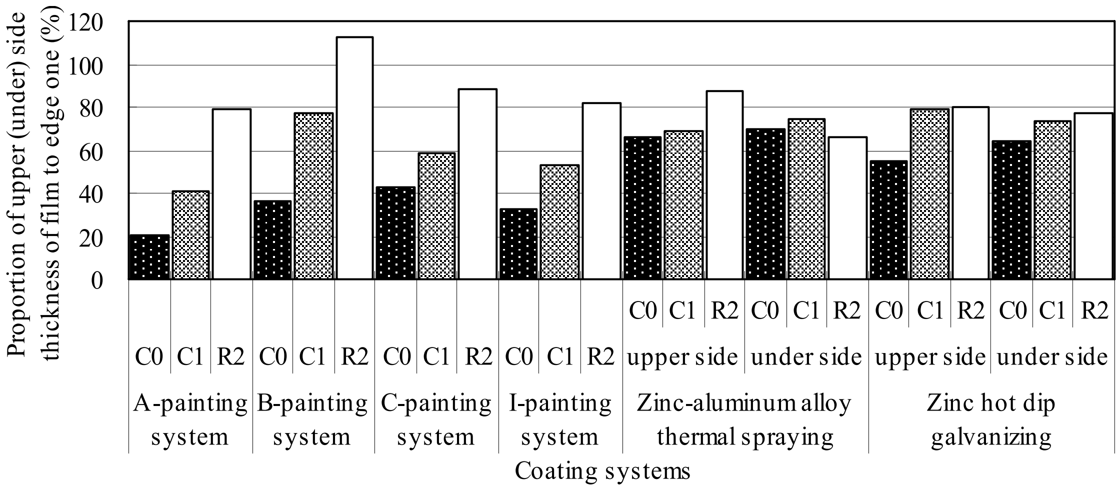


Figure 5. Thickness of coating films

3.2 ACCELERATED EXPOSURE TEST

3.2.1 Painting coating systems

(1) Visual observation

The test specimens exposed in S6-cycle corrosion test for 300 days. But corrosion occurred so far only on specimens with A-painting systems. Therefore an A-painting system was taken as an object of this paper about progress of corrosion. As shown in Figure 6, corrosion occurred on some of the specimens of C0 for all length along the edge at the exposure time of 150 days. On some of C1 and R2 corrosion occurred at the exposure time of 300 days. There is a dispersion in each specimen. Then from now on the rust rate was examined summed up of the same kind of specimen.

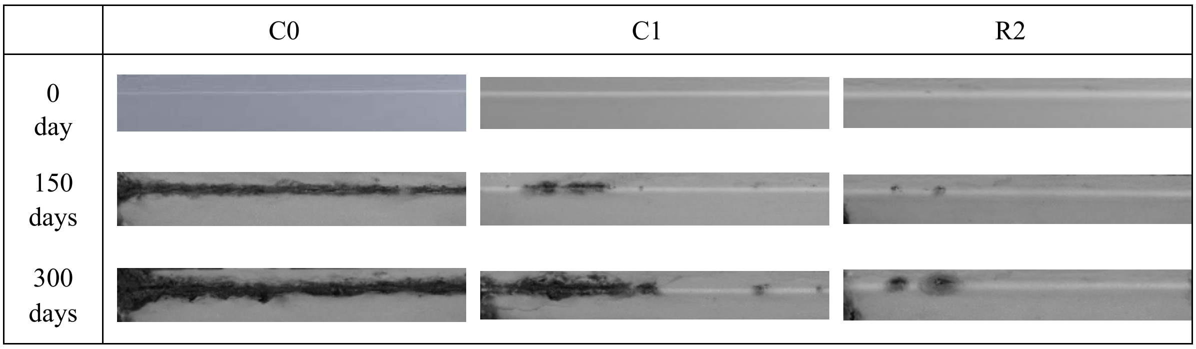


Figure 6. Corrosion progress (A-painting system)

(2) Progress of rust rate

The average rust rate of each type of edgewise is plotted against the testing time in Figure 7. C0 increases linearly until the testing time reaches 150 days, and its increase speed decreases gradually. Around 300 days, rust rate is almost zero. There is possibility that the area occurred no corrosion has thick coating compare with the area of corrosion occurred. C1 and R2 increase slowly, and C1 and R2 reach about 20% and 5% while C0 reaches about 90% at exposure times of 300 days. It is clarified that preparing edge geometry like C1 and R2 can decrease the occurrence of corrosion greatly.

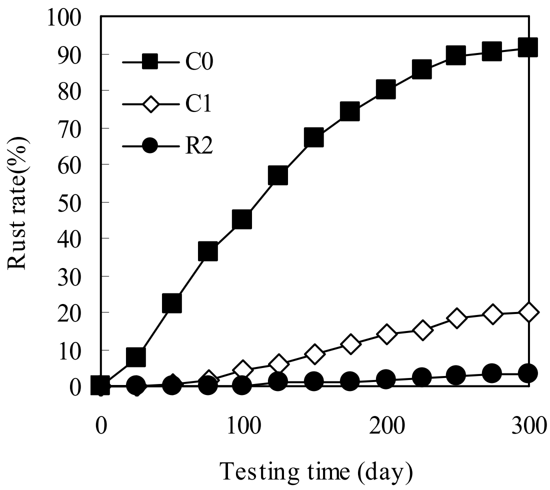
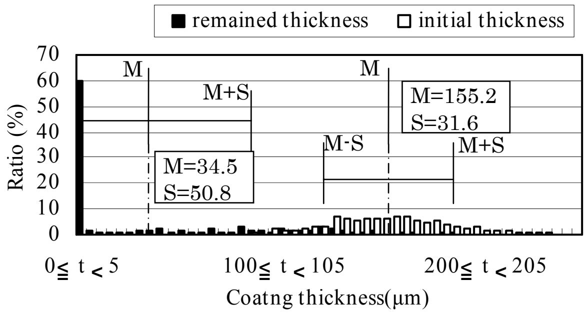


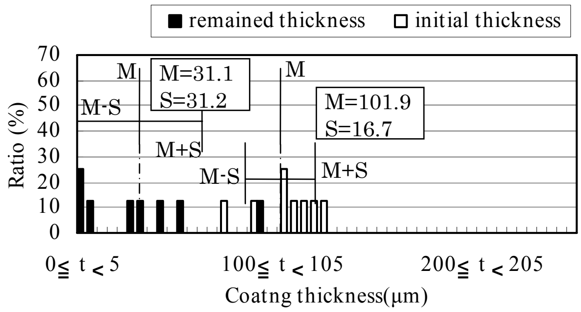
Figure 7. Rust rate

3.2.2 Metallic coating systems

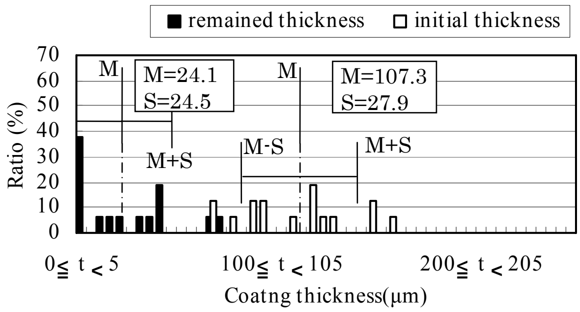
The distribution of the initial and the remained thickness of metallic coating are shown in Figure 8. Referring the thickness of coating films, the edge geometry effect on the thickness of metallic coating was not clear. Edge geometry slightly affects anticorrosive performance. The thickness loss of the upper side for exposing salt spray directly is larger than under side which is not showed in here.



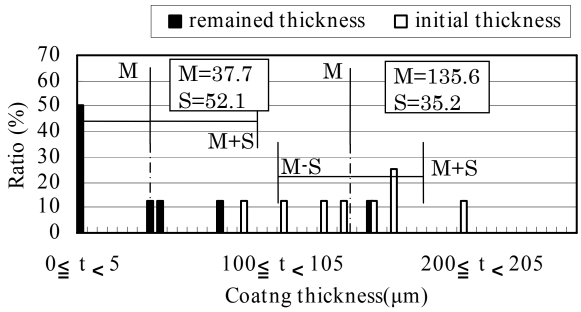
(a)Upper side



(b) C0



(c)C1



(d)R2

Figure 8. Distributions of coating thickness (zinc-aluminum alloy thermal sprayed coating)

Zinc-aluminum alloy thermal spraying and Zinc hot dip galvanizing were showed in similar result.

4. SUMMARY

This study performed accelerated cyclic corrosion tests to examine the influence of the edge geometry on the anticorrosion performance at edge-wise. Edge-wise of steel plate where prepared in 3 types of edge geometry, square edge without edge-treatment (C0), beveled edge with 1 mm long and 45 degrees (C1), and rounded edge with radius of 2mm (R2), and then coated with 4 types of painting coating systems and 2 types of metallic coating systems. They were corroded under S6-cycle corrosion environmental condition for 200 days for metallic coating systems and 300 days for painting coating systems. Based on the test results of visual inspection and thickness measurement of coating films, anticorrosive performance of painting coating systems are affected by edge geometry, while metallic coating systems are slightly affected edge by geometry. In order to apply the present result to corrosive field environments, further study is necessary.

5. REFERENCES

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