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Investigation on correlation and acceleration coefficients of accelerated corrosion tests to atmospheric exposure tests

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ABSTRACT

In previous study, to obtain the foundational data for the corrosion phenomenon of steel, many atmospheric exposure tests and accelerated corrosion tests have been conducted. However, the correlation analysis between atmospheric exposure test and accelerated corrosion test have been unclear. In order to clarify their correlation and acceleration coefficients, accelerated corrosion tests were carried out using cycle D specified in JIS(Japanese Industrial Standard) K5600-7-9 and the results of accelerated corrosion tests were compared with atmospheric exposure tests. From the result comparison, the accelerated corrosion tests were shown to be unsuitable and be dissimilar with exposure tests. However, the corrosivity of uncoated plate under atmospheric environment can be easily calculated using the acceleration coefficients of mean corrosion depth according to accelerated corrosion test.

1. INTRODUCTION

In order to properly maintain steel structures, it is very important to recognize the time-dependent corrosion behavior and the corrosion phenomenon of individual parts of members in steel structures. In previous study, to obtain the foundational data for the corrosion behavior of steel, many atmospheric exposure tests and accelerated corrosion tests have been conducted. However, it was not evaluated of the correlation analysis between atmospheric exposure test and accelerated corrosion test because corrosivity is ambiguous and unclear. In this study, in order to clarify the correlation and acceleration coefficients, accelerated corrosion tests were carried out using cycle D specified in JIS K5600-7-9 and the results of accelerated corrosion tests were compared with atmospheric exposure tests.(Kainuma 2012)

2. Accelerated corrosion tests and atmospheric exposure tests

The specimens were 150 × 70 × 6-mm Japanese Industrial Standard (JIS) G 3106 SM490A structural steel plate. Table 1 shows the chemical composition of the test specimens. The surface treatment of the specimens were blasted (ISO 8503 Sa2.5)on focus surface (Kainuma 2013) and another side were coated with silicon component for

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Table 1 Chemical compositions of material used in specimen (mass%)

C	Si	Mn	P	S
0.12	0.26	1.15	0.016	0.004

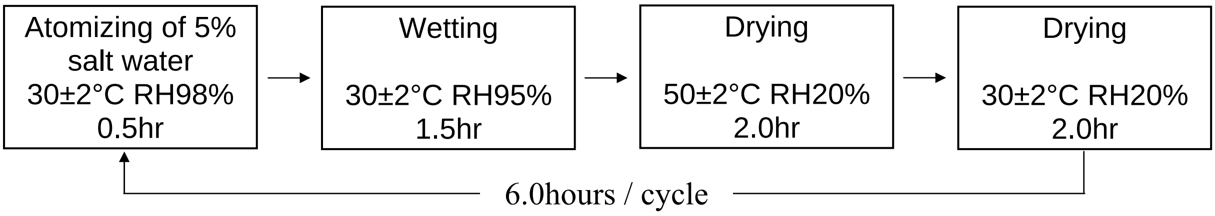


Fig. 1 Corrosion cycle applied during the accelerated exposure tests

anti-corrosion. Accelerated corrosion tests (JIS K5600-7-9 Cycle D) were conducted on uncoated steel plates. Fig. 1 shows the corrosion cycle applied during the accelerated exposure tests. It was performed for 600, 1,200, 1,800, 2,400 and 3,600 cycles. The mean corrosion depth were calculated using the weight loss method and the corroded surface of the specimens were measured with a laser-focus measuring system (spot diameter : 30μm, resolution : 0.05μm) according to the 0.2 mm (Kainuma 2013) after removal of the rust for each specimen.

In this study, results of accelerated corrosion test were compared with atmospheric exposure tests. (Kainuma 2012) Atmospheric exposure tests were conducted in 2 exposure fields, which was important factor in corrosion environment such as airborne salt and the wash-away effect by exposed to rainfall. Test condition of each test field is explained as follows.

1) A test field was under Okinawa Highway at 30m away from the west coastline, Kyoda, Okinawa Island (Lat.26°32’N, Long.127°57’E). This test field can be expected high airborne sea salt without rainfall.

2) A test field was on the Campus of the University of the Ryukyus (Lat.26°15’N, Long.127°46’E) with 2.3km away from east coastline and 4.4km away from the west coastline in Okinawa Island. This test field can be considered high rainfall and airborne sea salt. In order to consider the various corrosion conditions based on detail and installation of steel structural members, it is installed at angle of 0° and 45° to the horizontal. Atmospheric exposure tests were conducted for period of 1, 2, 3 and 4 years.

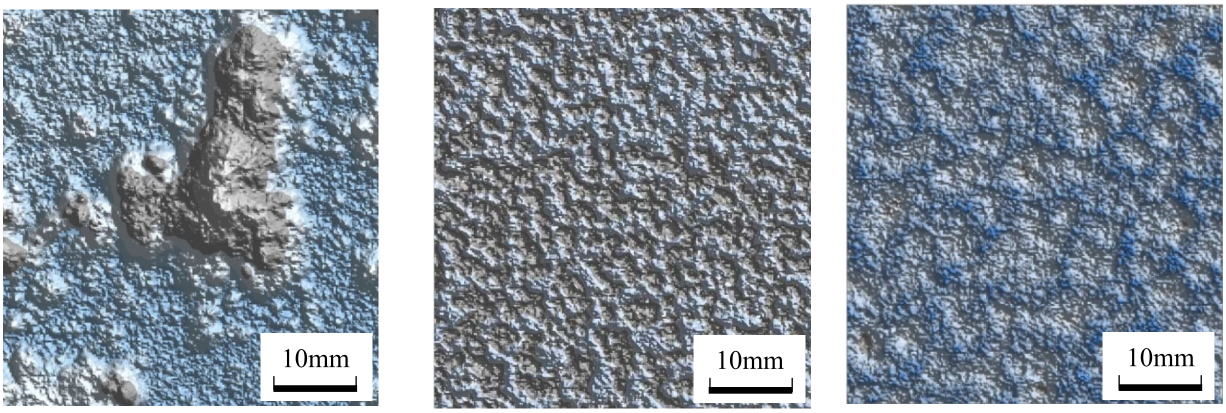
3. RESULTS AND DISCUSSIONS

3.1 Correlation between accelerated corrosion test and atmospheric exposure tests

Corroded specimens after accelerated corrosion test are shown in Fig.2. In case of the 600 cycles, corrosion products were formed on the entire surface. The corrosion product layer of the specimen was fragile and porous state regardless of the number of cycles. Fig.3 shows the surface image of the specimens after rust removal. In case the atmospheric exposure tests, although the surface roughness appearances seem to vary slightly depending on the exposure field, the corrosion morphology was appeared to be all classified as uniform corrosion. However, accelerated corrosion tests were occurred at local corrosion. The surface roughness profiles of the atmospheric exposure tests and accelerated corrosion tests were different, because anode portions were locally fixed. It was accelerated and concentrated by spray salt on accelerated corrosion tests.

(a) 600cycles (b) 1,200cycles (c) 1,800cycles (d) 2,400cycles (e) 3,800cycles

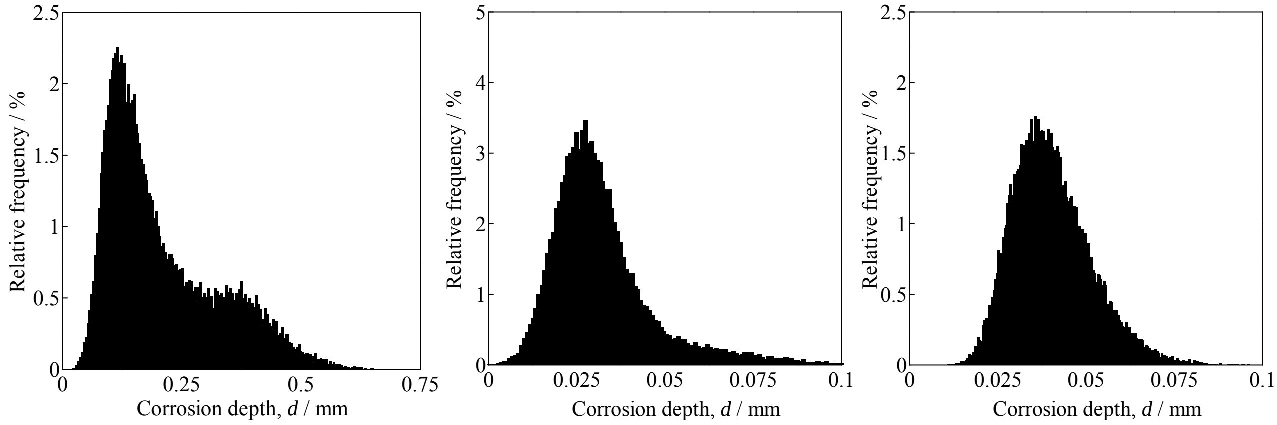
Fig. 2 Corroded specimens after accelerated corrosion test



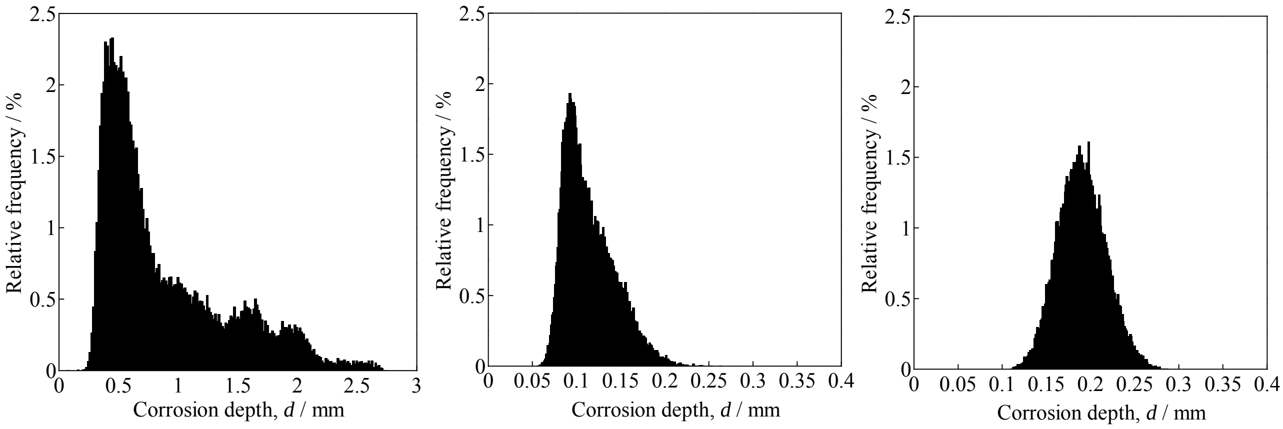
(a) Accelerated (3,800cycles) (b) University of the Ryukyus (4yrs) (c) Kyoda (4yrs)

Fig. 3 Surface image of the specimens after rust removal

Fig.4 shows the histograms of corrosion depth on each test specimen and Table 2 shows the coefficients of histogram shown in Fig.4. The absolute value of the skewness S_k and kurtosis K_u on the exposure tests were decreased with the increaseing the test period, because the specimen surface will be uniformly corroded depending on test period. The histogram can be expressed by a single probability density function regardless of the test period. However, those of accelerated corrosion test were increased with the increase of the test cycles. It should thought to be accelerated by chloride and pollutant at the corroded pitting developed by the corrosion. It cannot evaluate the histogram of atmospheric exposure test, because the accelerated corrosion test specimens were composed uniform corrosion and local corrosion. (Kainuma 2009) Thus, the coefficient of variation on the accelerated corrosion test specimens was larger than the exposure specimens. It was attributed to the formed local corrosion on accelerated corrosion test as shown in Fig.3 (a). From the results, the corrosion roughness and corrosion phenomenon will be not similar between the accelerated corrosion test and atmospheric exposure.



(a) Accelerated (600cycles) (b) University of the Ryukyus (1yrs) (c) Kyoda (1yrs)



(d) Accelerated (3,800cycles) (e) University of the Ryukyus (4yrs) (f) Kyoda (4yrs)

Fig. 4 Histograms of corrosion surface of each test specimen

Table 2 Coefficients of the histogram

	Accelerated		University of the Ryukyus		Kyoda	
Test period	600cycles	3,800cycles	1yrs	4yrs	1yrs	4yrs
Coefficient of variation	0.57	0.61	0.48	0.25	0.28	0.14
Skewness	0.95	1.1	1.7	0.85	0.70	0.16
Kurtosis	0.072	0.35	4.3	0.36	0.73	-0.12

3.2 Acceleration coefficients of JIS cycle D accelerated corrosion test with respect to the atmospheric exposure tests

Fig.5 shows the mean corrosion depth d_{mean} of each tested surface depending on test period t. Relationship with t and d_{mean} of accelerated corrosion test was a linear relationship, because the corrosion product layer was generated by the accelerated corrosion test (JIS K5600 Cycle D) which spray salt was accumulated and concentrated

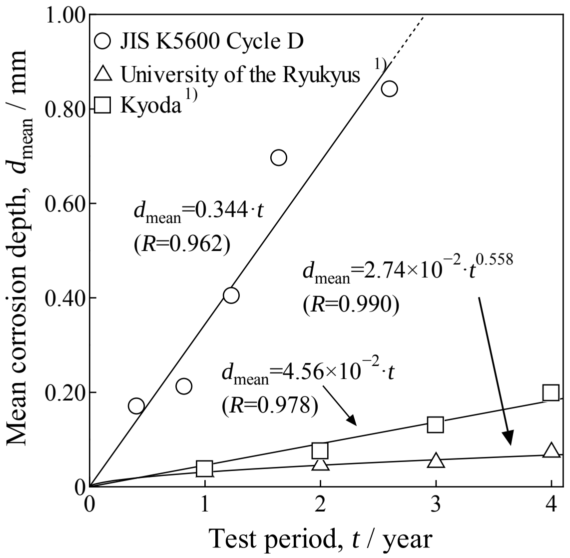


Fig.5 Mean corrosion depth d_{mean} - test period t relationship

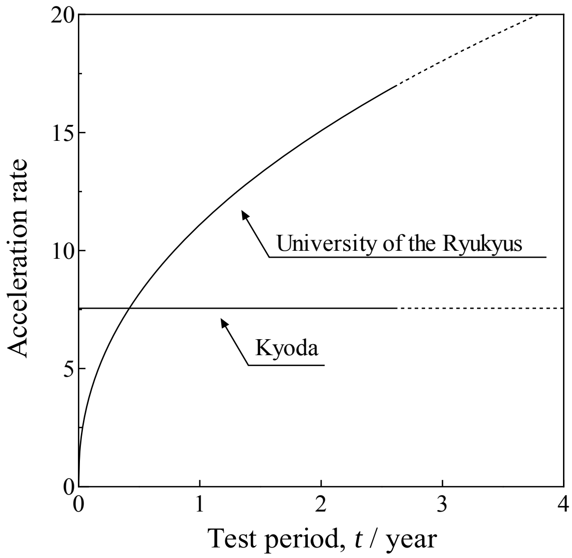


Fig.6 Acceleration coefficients of accelerated corrosion tests

didn't have protection against corrosion factors. Kyoda shows that mean corrosion depth have a linear relationship with exposure period because their corrosion product layers could be not to have a role to protect additional corrosion on the corroded surface from porous in the corrosion product layers affected without wash-away effect and accumulation of airborne sea salt. However, relationship of University of the Ryukyus was affected on wash-away effect by exposed to rainfall. Fig.6 shows the acceleration coefficients of accelerated corrosion tests. They were calculated by equation as shown in Fig.5. The acceleration coefficients of Kyoda are constant value regardless of the test period, but those of University of the Ryukyus shows non-linear function. Although these corrosion value and tendency was different, the acceleration coefficients with respect of the real environment on the accelerated corrosion test can be simply calculated using the relationship with atmospheric exposure test. In addition, the time dependent corrosion depth can be estimated by using the thickness of the corrosion-product layer on steel monitoring plates[1]. However, as described above, since the corrosion properties of steel in the accelerated corrosion tests and atmospheric exposure tests differ greatly, the acceleration coefficients for atmospheric environment, it can be said that it is desirable to consider based on the d_{mean}.

4. CONCLUSIONS

In this study, corrosion phenomenon of steel plate were examined to quantifiably investigate and clarification. Accelerated corrosion tests (cycle D specified in JIS K5600-7-9) were carried out in order to clarify the correlation and acceleration coefficients. The main results obtained in this study are shown follows.

1) Corrosion surface roughness of the steel plate on accelerated corrosion test were significantly different as compared with atmosphere exposure test.

2) Relationship with test period and mean corrosion depth of accelerated corrosion test was a linear, because the corrosion product layer was generated by the accelerated corrosion test (JIS K5600 Cycle D) which spray salt was accumulated and concentrated.

3) The acceleration coefficients of accelerated corrosion tests for atmospheric environment were evaluated based on the mean corrosion depth.

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