Study on Influence of Surface Treatment on Fasteners and Members of Aluminium Alloy to Galvanic Corrosion by Accelerated Exposure Test

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1. INTRODUCTION

There has been an increasing demand to construct massive steel structures which are durable, but corrosion of steel has been the most challenging aspect. Paint coating systems are widely used to prevent corrosion damages, but their anticorrosive performance decreases gradually with time[1]. Researchers and designers have been assessing the possibility of using aluminium alloy to supplement the use of steel due to its considerable light weight and high corrosion resistance compared to steel[2]. Currently, aluminium alloy is used only for light duty components of structures and some products due to limited mechanical strength, low Young's modulus and high cost.

Due to limited strength of aluminium alloy, fastening of aluminium alloy members requires fasteners which are made up of other strong materials different from aluminium alloy. However, the different material of fasteners such as stainless steel bolts render galvanic corrosion of aluminium alloy members.

The research was carried out to investigate the influence of fasteners' surface condition, aluminium alloy members' surface condition and alloy type to galvanic corrosion by a salt water spray experiment.

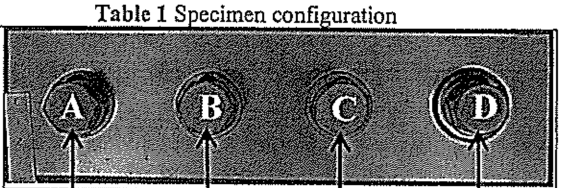
2. EXPERIMENT AND DATA ANALYSIS

A 1000 hours salt water spray test was carried out on specimens described on Table 1 according to Japan Industrial Standard (JIS Z 2371). The exposure environment was accelerated in order to realize the effect of corrosion faster than on actual site. Salt water spraying was automatically done by a special spraying machine[3]. After the test, corrosion measurement was done by laser displacement meter (KEYENCE, LE-4010) with vertical measuring range of ±5mm, diameter of laser-spot of 30μm and accuracy of 0.1μm. The measurement was carried out to determine the magnitude of corrosion depth (CD), corrosion area (CA) and corrosion volume (CV) at intervals of 200μm on 45mmx45mm areas around each bolt hole on both side of specimens.

Corrosion depth was measured from multi section profiles drawn on 2D maps of each 45mmx45mm area as shown in Fig. 1. Maximum corrosion depth (CDmax) was measured from profiles with outstanding trough. The magnitudes of corrosion area (CA) and corrosion volume (CV) were calculated automatically from the measurement results by laser displacement meter.

Table 1 Specimen configuration

Specimen Configuration



SUS 304 Bolt, Untreated	SUS 304 Bolt, GEOMET Treated	SUS 304 Bolt, Painted Washer Only	SUS 304 Bolt, Insulation Bush Only

Specimen	Alloy Type	Treatment
01	A6061S-T6	Both sides:A2 silver color
02	A6061S-T6	Top: A2 silver color Bottom: untreated
03	A6061S-T6	Top: untreated Bottom: A2 silver color
04	A6N01S-T5	Untreated
05	A5083P-O	Untreated
06	A3004P-H32	Untreated
11	A6063S-T5	Both sides: A2 Sutenkara color (KCS)
12	A6063S-T5	Both sides A2 Brown color (KOB)
13	A6063S-T5	Both sides A2 Dark brown color (KSB)

A2: The type of combined coating of anodic oxide and organic film (JIS H 8602)

3. EXPERIMENTAL RESULTS

3.1 Influence of Fasteners Surface Condition

The influence of fasteners surface condition to galvanic corrosion is assessed with reference to Figs. 2, 3 and 4. Untreated fasteners at hole 'A' caused the highest effects of galvanic corrosion on both sides of specimens. Zinc flake (GEOMET) treated fasteners at hole 'B' did not show any signs of causing galvanic corrosion on both sides of specimens. Untreated fasteners with only painted washers at hole 'C' caused less severe galvanic corrosion on both sides of specimens compared to untreated fasteners. Untreated fasteners with insulation bush at hole 'D' caused much less galvanic corrosion only on top side of specimens compared to untreated and painted washer only fasteners.

3.2 Influence of Specimens Surface Condition

The influence of specimen surface condition to galvanic corrosion is compared between specimens of same alloy types and a holistic assessment is made by studying Figs. 2, 3 and 4.

It is obvious that, untreated SP04, SP05 and SP06 suffered severe galvanic corrosion due to bare contact with dissimilar metal. Alternating surface condition and orientation of fasteners does not inhibit galvanic corrosion as was expected on SP02 and SP03 configuration. Untreated top side of SP03 which was covered by treated splice plate was not protected from galvanic corrosion. The colour of surface treatment has no significant influence to galvanic corrosion. SP11, SP12 and SP13 whose surfaces were treated with different colours of combined anodic oxide and organic film coating did not show any potential resistance to galvanic corrosion.

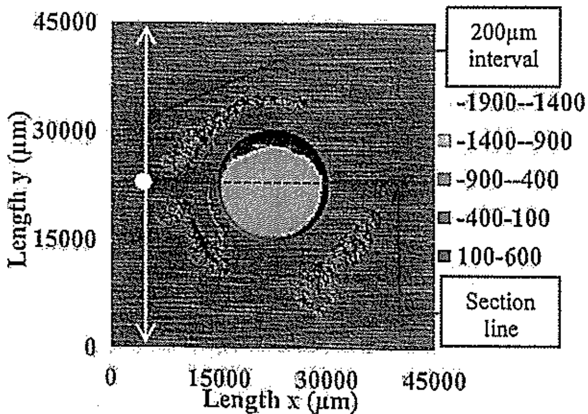
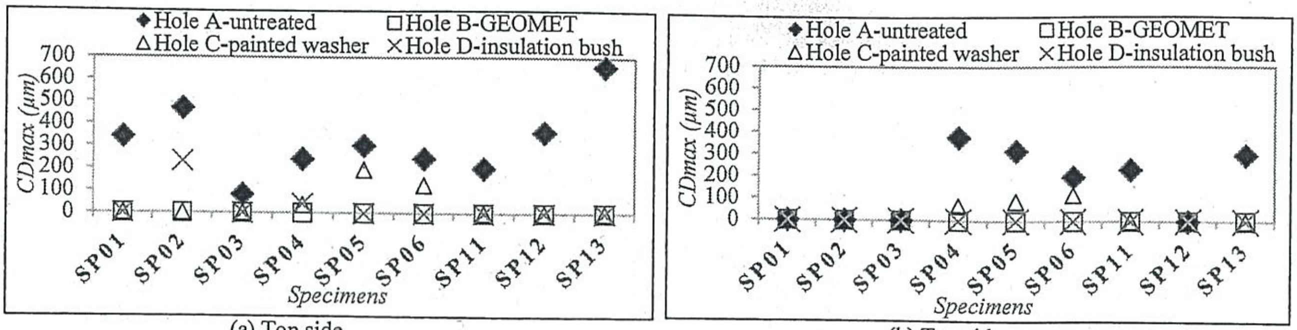
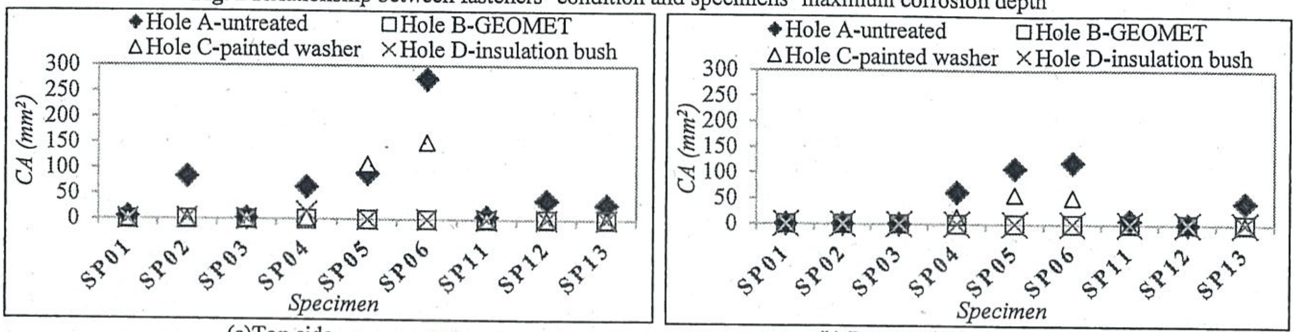


Fig. 1 Example of 2D map around bolt holes and sections line



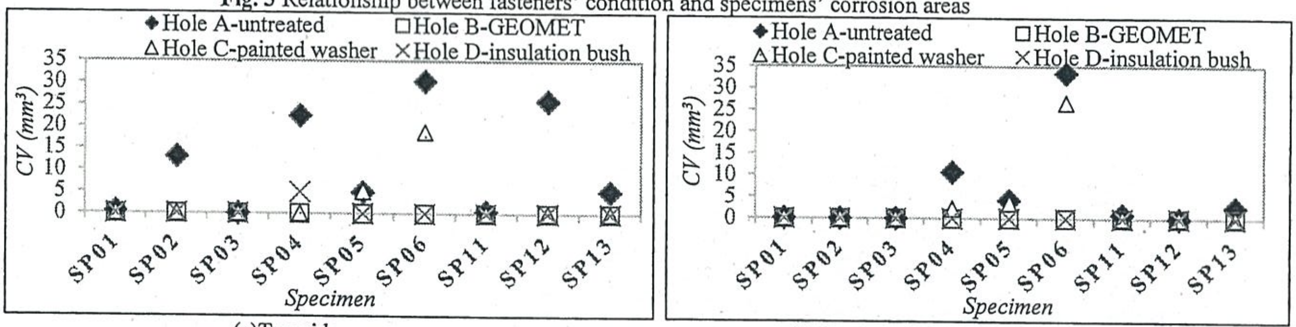
(a) Top side (b) Top side

Fig. 2 Relationship between fasteners' condition and specimens' maximum corrosion depth



(a)Top side (b) Bottom side

Fig. 3 Relationship between fasteners' condition and specimens' corrosion areas



(a)Top side (b) Bottom side

Fig. 4 Relationship between fasteners' condition and specimens' corrosion volume

3.3 Influence of Alloy Type

The influence of aluminium alloy type to galvanic corrosion is assessed on specimens with different alloy types but with same surface condition which are SP04, SP05 and SP06. The corrosion resistance of SP05 drawn from alloy type A5083P-O is observed to be stronger as shown in Figs.4 (a) and (b). Generally, aluminium alloy series 5000 have the best inherent corrosion resistance due to high content of magnesium[4]. It also have lower copper content which makes it less corrosive. SP04 of alloy type A6N01S-T5 and SP06 of alloy type A3004P-H32 exhibited relatively high corrosion due to lower contents of magnesium and higher contents of copper compared to A5083P-O.

4. CONCLUSION

1) Zinc flake coating treatment (GEOMET) for stainless steel bolts is an effective treatment to prevent galvanic corrosion of aluminium alloy even in a severe corrosive environment.
2) Vinyl chloride insulation bush is also found to be the effective treatment for untreated stainless steel bolts to prevent galvanic corrosion.
3) Aluminium alloy type A5083P-O is found to have a better chemical composition to resist galvanic corrosion and general corrosion compared to types A3004P-H32 and A6N01S-T5 in untreated surface condition.
4) Covering untreated surface with treated cover plate does not prevent galvanic corrosion as observed on SP02 and SP03.
5) SP04, SP05 and SP06 of different alloy types are found to be the most corroded specimens in this study. Because they displayed the highest values of corrosion volume. From this observation, it is evident that aluminium alloy members require treatment regardless of their alloy type.

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