Fundamental study on stress concentration factors on atmospheric corroded steel plate

Kyushu University Student member ○Y. S. Jeong
Kyushu University Regular member _S. Kainuma

1. Introduction Long-term durability of steel structures is mainly related to deterioration caused by corrosion and fatigue. The occurrence of fatigue damage by corrosion is concerned. However, it is difficult to definitely evaluate stress concentration factor in corroded steel surface. Therefore, numerical analyses were conducted to quantitatively evaluate the spatial statistics data-stress relationship of the corroded surface, because fatigue can be developed by the stress concentration of the corroded surface. The stress concentration factors on corroded surface were examined by numerical analysis and finite element analysis based on the tested corroded surface data from atmospheric exposure test. From the FE analysis of test specimens and simulation, correlation with the stress concentration factors and corrosion characteristics was established.

2. FE model In this study, the spatial statistical simulation on corroded surface were performed based on atmospheric exposure test results using semi-variogram and generation of corroded surface was modeled using the test specimens and simulation results. It is to obtain the maximum stress and location of corrosion pit at each specimen. Figure 1 shows the boundary region and dimension of FE model. Figure 2 show the concept of nominal stress and maximum stress considering corroded surface. The model is meshed using solid element and minimum size determines 0.2×0.2×0.2mm based on the range of the corroded surface. In these analyses were used for MARC 2008.

3. FE analysis result The stress value at corroded surface is influenced by the corrosion pit according to the thickness reduction. These values are related to a nominal stress through the following stress concentration factor.

$$K_t = \frac{\sigma_{\max}}{\sigma_n} \tag{1}$$

where, K_t is normal stress concentration factor, σ_{max} is maximum principal stress, σ_n is normal stress.

Figure 3 shows the corroded surface images for corrosion depth and FE analysis result. When corrosion depth less than mean corrosion depth, stress concentration factor appeared less than 1, because nominal-section is defined as residual depth. Figure 4 shows the stress concentration factor-mean corrosion depth relationship on corroded surface. The correlation coefficient of test specimen is smaller simulation result, because it was variation in the primary stage of corrosion. The relationship between the stress concentration factor and mean corrosion depth can be expressed as Eq. (2)

$$K_t = 2.66 \cdot d_{mean}^{\ 0.59} + 1 \tag{2}$$

The occurred maximum stress at corroded surface was affected by aspect ratio a/b (width: 2b, depth: a(mm)) of corrosion pit. In general, aspect ratio a/b was increased in corrosion pit, stress concentration factor is larger. And stress concentration factor of corroded surface were compared with the spatial statistical values. The stress concentration factor-spatial statistical values(range and sill) relationship on corroded surface is shown in Fig. 5. From the Fig. 5, the stress concentration factor is increasing according to the increasing spatial statistical values. It can know that the stress concentration factor of corroded surface is expected based spatial statistical values(range and sill).

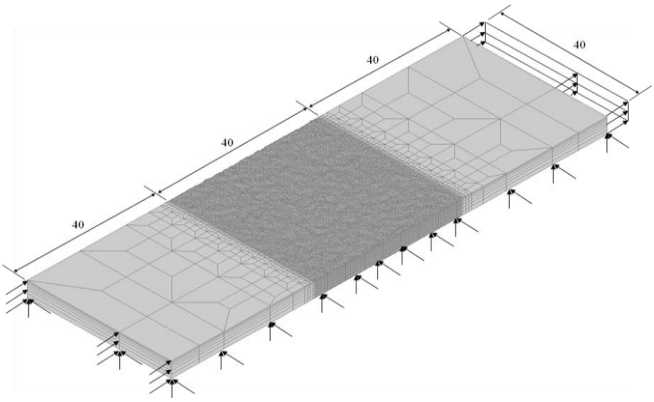


Fig.1 Boundary region and dimension of FE model (mm)

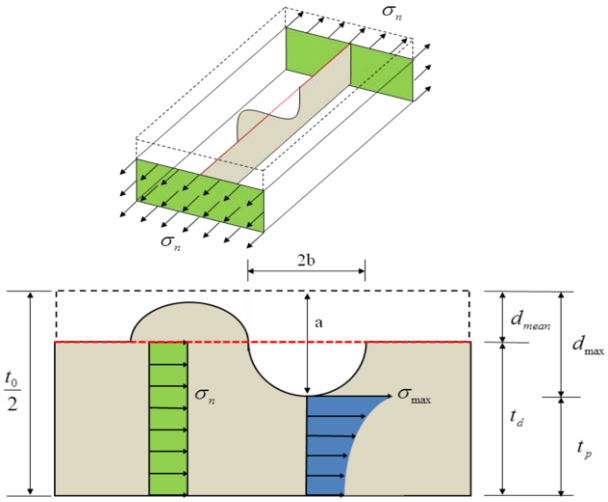
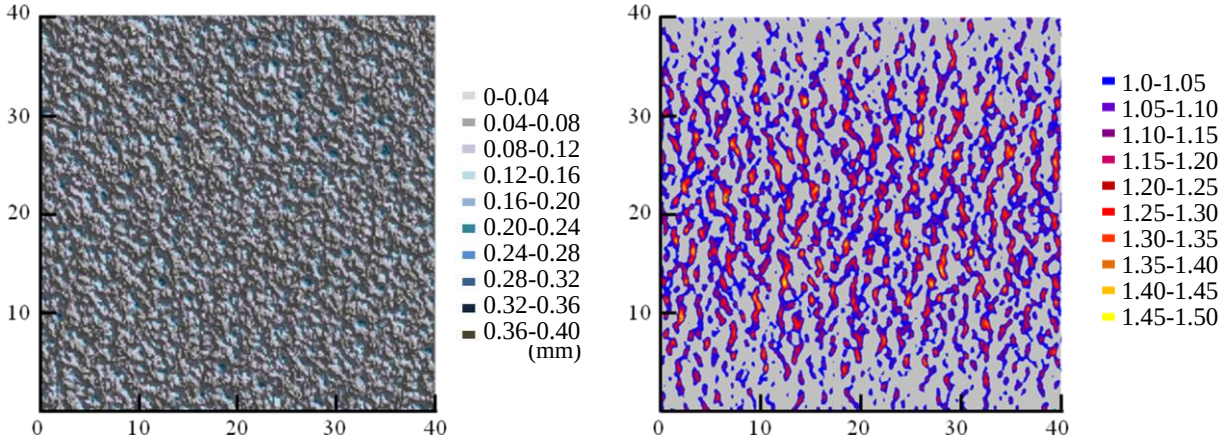


Fig.2 Concept of nominal stress and maximum stress

Keywords: stress concentration, corrosion, FE analysis, spatial statistics
744, Motooka, Nishi-ku, Fukuoka 819-0395 Kyushu University



(a) Corrosion depth of specimen (b) Stress concentration factor

Fig.3 Corroded surface of specimen and stress distribution specimen

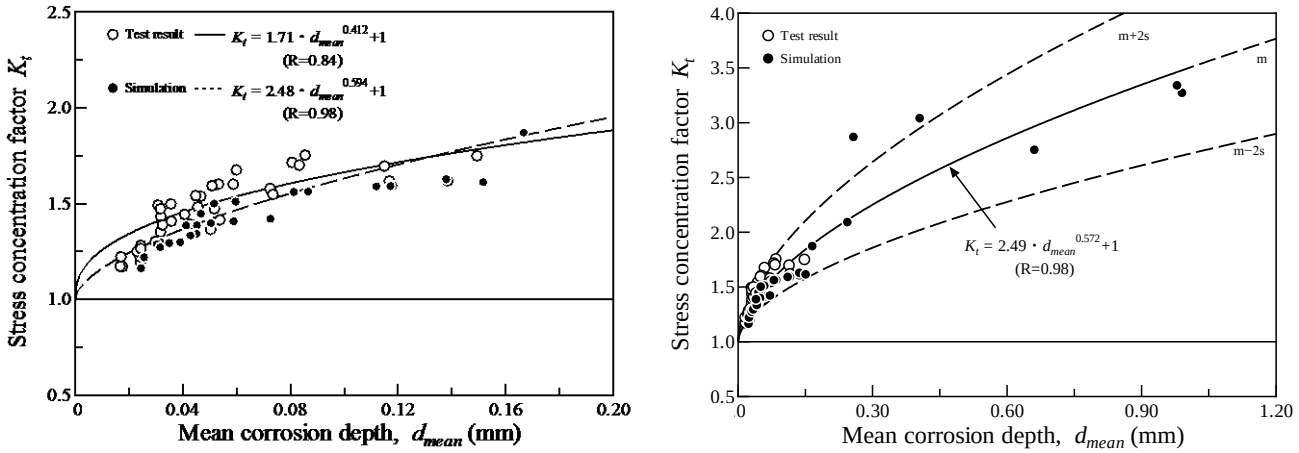
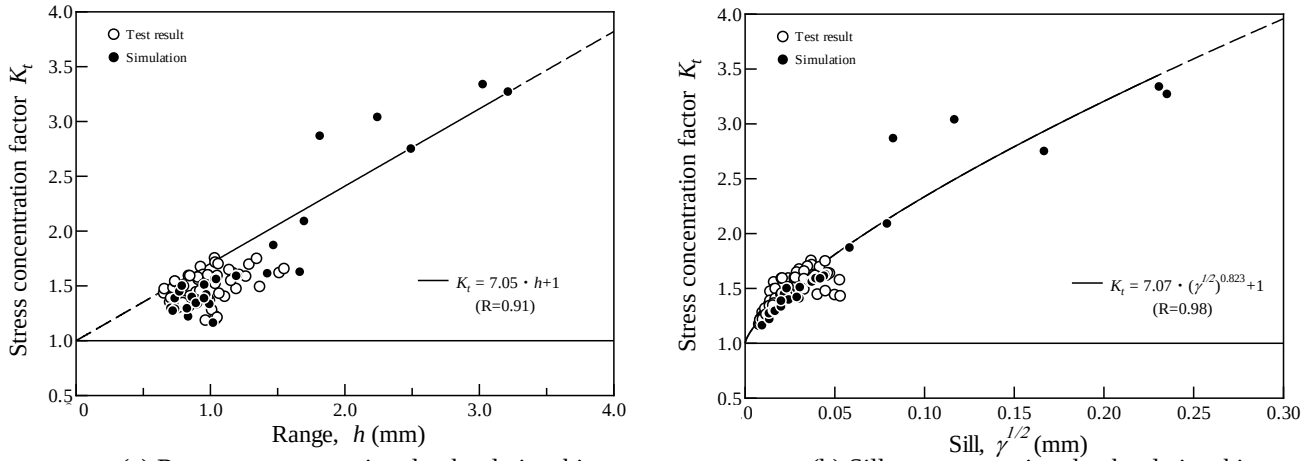


Fig.4 Relationship between nominal stress concentration factor and mean corrosion



(a) Range-mean corrosion depth relationship (b) Sill-mean corrosion depth relationship

Fig.5 Relationship between nominal stress concentration factor and spatial statistical values of corroded surface

4. Summary of findings In this study, numerical analyses, atmospheric exposure tests and simulations of corroded surfaces were conducted to examine the stress concentration factors. From stress analysis results on corroded surfaces, the stress concentration factor can be suggested based corroded surface information and spatial statistical simulated surface of corroded steels.

References

1) Cressie. N : Spatial prediction and ordinary kriging, Mathematical geology, Vol.20, No.4, pp.405-402, 1988.

2) S. Kainuma, N. Hosomi, Fatigue life evaluation of corroded structural steel members in boundary with concrete, Fracture mechanics, Vol.157, No.1-2, pp.149-158, 2009

3) N. Hosomi, S. Kainuma, Evaluation of stress concentration factor for corroded structural steel members in boundary with concrete, JSCE, Vol. 66, No.4, 613-630, 2010