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土木・建築

Digital Image Correlation Method for Strain Measurement of Corroded Weathering Steel

■ Introduction

The non-uniform stress distribution induced by surface roughness of corroded steel members in civil infrastructure present a critical concern for both structural safety and the long-term serviceability. A localized strain at peak point of roughness cannot be effectively detected using conventional physical strain gauges. In this study, Digital Image Correlation (DIC) method; a widely adopted non-destructive technique for strain measurement, was adopted for strain detection in corrosion induced rough surface. The outcomes of this research provide essential baseline data demonstrating the effectiveness of the DIC method for strain detection on corroded steel, supporting its application to real steel bridge structures with corroded members.

■ The experimental details

Corroded samples of weathering steel after exposure period of 4 months, 7 months and 12 months in Okinawa are used in this experiment. The surface conditions and roughness after exposure are shown in Fig. 1 and Table 1.

(a) (b)

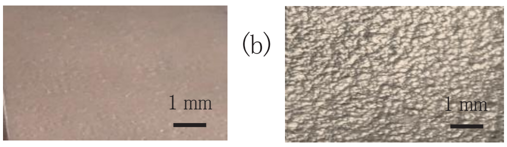


Fig. 1 Corroded steel of 4 months (a), 12 months (b)

Table 1. Surface roughness

Corrosion period	Rust thk., μm	Roughness (μ m) Ra	Rz	Ry
0 m	0	6.9	36.5	34.1
7 m	68.7	23.2	133.0	108.6
12 m	102.7	25.4	183.1	131.2

The uniaxial tensile test with loading ranges was raised up to 1 MPa in elastic state and 0.1 MPa in plastic state manually. Stain distribution on steel surfaces were identified from images of rough surface during application of tensile loading. An open source 2-dimentional DIC MATLAB program call “Ncorr” is adopted for an identification of strain distribution on rough steel surface. As for comparative study, physical strain gauges were also installed during the tensile test.

■ Results and discussion

A stress-strain diagram from physical gauge measurement describes that strength of steel specimen decreases with increasing roughness, especially in yielding state as shown in Fig. 2. On the other hand, the DIC measurement results are capable of obtaining the strain distribution map and showing localized strain concentrations, as illustrated in Fig. 3.

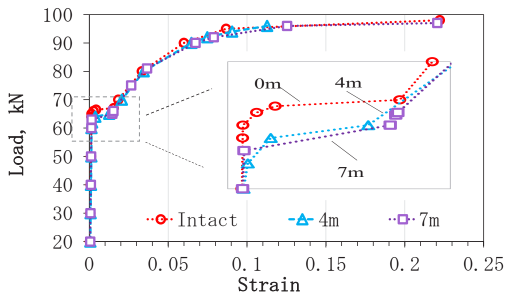
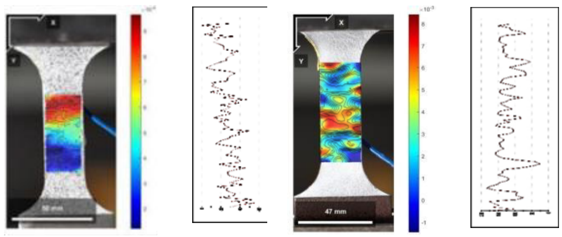


Fig. 2 Load vs. strain curve from strain gauge



(a) Intact steel (b) Corroded steel

Fig. 3 Full-field DIC strain and relative roughness

The DIC analysis result indicates that localized stress concentrations were observed at the peak points of surface roughness during tensile loading. The result of full-field strain maps from DIC analysis is also capable to identify that the localized stress concentration reduces the load-bearing capacity of steel and serve as initiation sites for crack formation and propagation. A strong correlation is observed between the physical strain gauge and the DIC method, with an R^2 value of 0.92 in the roughness range of 150-200 μm. This study observes that full-field strain distribution map by DIC method allows to identify local strain concentration on uneven steel surface and predict failure point by corrosion.

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■キーワード： (1) Corroded steel
(2) The DIC method
(3) Strain distribution

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