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Detection of back-surface crack based on temperature gap measurement

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Abstract

For large-scale steel structures such as orthotropic steel decks in highway bridges, nondestructive inspection of deteriorations and fatigue damages are indispensable for securing their safety and for estimating their remaining strength. As conventional NDT techniques for steel bridges, visual testing, magnetic-particle testing and ultrasonic testing have been commonly employed. However, these techniques are time- and labor- consuming inspections, because special equipment is required for inspection, such as scaffolding or a truck mount aerial work platform. The present authors developed a new thermography NDT technique for crack detection, which is based on temperature gap appeared on the surface of structural members due to thermal insulation effect of the crack. The practicability of the developed technique to through crack was demonstrated by the field experiments for highway steel bridges in service. In this paper, the applicability of the inspection technique based on temperature gap measurement to back-surface crack detection is investigated by the laboratory testing. The testing was conducted for several specimens. A fatigue crack was introduced in a back surface of each specimen by 4 point bending fatigue test. This investigation has revealed that back surface fatigue crack can be detected by the proposed technique.

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Keywords: Infrared thermography, remote nondestructive testing, back surface crack, steel structure ;

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1. Introduction

In recent years, fatigue crack initiations and propagations in aged steel bridge which may lead to catastrophic structural failures have become a serious problem. For large-scale steel structures such as orthotropic steel decks in highway bridges, nondestructive inspection of deteriorations and fatigue damages are indispensable for securing their safety and for estimating their remaining strength. As conventional NDT techniques for steel bridges, visual testing, magnetic particle testing and ultrasonic testing have been commonly employed. However, these techniques are time- and labor- consuming inspections, because special equipment is required for inspection, such as scaffolding or a truck mount aerial work platform.

The present authors developed a new thermography NDT technique for crack detection, which is based on temperature gap appeared on the surface of structural members due to thermal insulation effect of the crack. The practicability of the developed technique to through crack was demonstrated by the field experiments for highway steel bridges in service by Mizokami et al. (2015). The applicability of the developed technique to semi-elliptical internal slit of 1.0 mm width introduced by wire electrical discharge machining (EDM) was investigated by Izumi et al. (2016), and it was found that internal slit can be detected by the proposed technique. In this paper, the applicability of the inspection technique based on temperature gap measurement to back-surface fatigue crack detection is investigated considering the crack shape and the crack width. The testing is conducted for several specimens with fatigue crack introduced by 4 point bending fatigue test.

2. Experimental setup

2.1. Specimen

The testing was conducted for several specimens. A fatigue crack was introduced in a back surface of each specimen by 4 point bending fatigue test. The specimen material was carbon steel, JIS SS400, and the dimensions of the specimen were 300 mm in length, 60 mm in width and 10 mm in thickness. At the center of the specimen, drilled hole were introduced. A fatigue crack was propagated from the drilled hole by 4 point bending fatigue test. Fig. 1 and Fig. 2 shows the schematic illustration of 4 point bending fatigue test and crack shape, respectively. The maximum loading was 7.8 kN, the stress ratio was 0.1 and the loading frequency was 5 Hz. The crack size of each specimen was shown in Table 1. Crack depth was measured by crack depth gage (RMG 4015, Nihon Matech Co.). The distributions of the crack depth and the crack width was shown in Fig. 3(a) and Fig. 3(b), respectively.

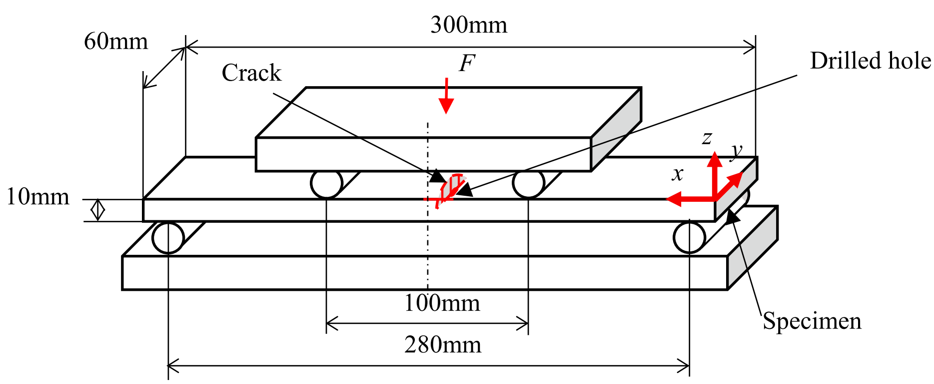

Fig. 1. Schematic illustration of 4-point bending fatigue test.