Fatigue Performance of Pre-Corroded Bridge Wires

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Summary

Corroded high-strength bridge wires on three corrosion levels were produced from the accelerated corrosion experiment. The uniform corrosion depth was calculated and the zinc coating was totally consumed for all the specimens. Three-dimensional (3D) profile measurements of the wires without destruction were conducted after the corrosion products were removed by the chemical cleaning. Based on the 3D coordinates of the points on the surface, it was found that the pitting depth followed the normal distribution. The corrosion depth contours and the maximum pitting depth of each specimen were also obtained from the data.

Fatigue tests were conducted to investigate the fatigue properties of the corroded wire specimens and significant decrease in fatigue life of corroded wires was observed. A modified fatigue crack growth model considering the fatigue threshold was used for fatigue life prediction of the wire specimens. The material constants used in the model were fitted according to the most relevant tests. The results showed that fatigue lives predicted by the model were compared well against the experimental results as the largest error of the life predictions is within 36% of the experimental lives. The life prediction method based on the model and 3D profile is a valuable tool for assessing remaining fatigue life of corroded bridge wires without destruction and expensive fatigue tests.

Keywords: Fatigue performance; Bridge wires; corrosion; 3D profile; Fatigue life prediction

1. Introduction

Stay cables, which serve as a major structural component in the long-span bridges, are extremely vulnerable to the environmental corrosion. In recent 20 years, more than fifteen bridges have replaced the cables in China due to the severe corrosion[1]. The high-strength bridge wires that make up the cable start to deteriorate when the cable corrosion occurs[2]. In order to evaluate the operation life of corroded stay cables, the degradation of the mechanical properties of the bridge wires should be researched on.

In the past decades, the static properties of corroded wires have been widely studied. The static properties, including elastic modulus, ultimate stress, ultimate strain, yield stress and yield strain, are measured using corroded wire specimens by the uniaxial tensile test [3, 4] and the degradation model is established [5]. However, the research on the fatigue properties of corroded wires is limited compared with the static properties.

Nakamura and Suzumura investigated the fatigue strength of corroded galvanized steel wires and the fatigue strength was found to decrease with the increase of the corrosion level [6]. A dramatic degradation in fatigue life was also observed by Lan and the pit was considered to be the fatigue initiation zone [7]. The fatigue tests are conducted by Zheng with two types of corroded wires and the fatigue performance of wires made by artificial accelerate corrosion test was better than the wires taken from the bridges [8]. The standard deviation of fatigue life was found to increase with the pit size and the stress ratio had little impact on the fatigue life of corroded wires [9]. However, the investigation of fatigue life prediction of corroded wires has been very insufficient.

In this study, corroded bridge wires on three corrosion levels were produced from the accelerated corrosion experiment. 3D profile measurements of the wires without destruction were conducted after the corrosion products are removed by cleaning. The distributions and characterizations of pitting corrosion were obtained and then the fatigue tests were conducted with the wire specimens. Finally, the fatigue life of corroded wires was predicted using the crack propagation model

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