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Experimental and analytical study on stress concentration of corroded bridge wires

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Abstract

The wire specimens with artificial pits whose sizes were decided by the measured corrosion pit data. Three different pit shapes were assumed: round, triangle and triangle with a notch. Stress concentration factor at the sharp edge of pits were obtained by strain gauge measurement and 3D FEM analysis. Both methods showed that strain was almost same value and stress concentration is larger for sharper pit shapes.

Keywords: Corrosion; corroded bridge wire; 3D FEM analysis; stress concentration

1 Introduction

Bridge cables consist of high tensile galvanized steel wires. Many old suspension bridges suffer from deteriorated cables all over the world. Some of the steel wires of the main-cables are heavily corroded and fractured [1] [3]. When water enters a suspension bridge cable, the wires that make up the cable start to deteriorate. The protective zinc coating is the first element that is damaged, followed by corrosion of the steel itself. Hanger ropes of suspension bridges and stays of cable-stayed bridges have also been severely corroded on many bridges.

The authors carried out tension tests for corroded galvanized wires and found that the actual tensile strength, breakage load divided by reduced cross sectional area, does not decrease with the corrosion level [6]. On the other hand, although elongation does not change when only the galvanized layer is corroded, it decreases when the steel part starts to corrode.

Mechanism of fracture of corroded wires has been widely studied in the past. Although many studies have been conducted to clarify the mechanism to cause wire breakage, discussions are still in progress. Some researchers find that the wires suffer high tensile stresses and bending stresses and residual stresses, along with the corrosive environment, which lead to stress corrosion cracking or hydrogen-assisted cracking [5]. The authors find that the amount of hydrogen absorbed in the steel layer does not reach the level to cause hydrogen embrittlement and corrosion fatigue is more susceptible for wire breakage [4].

The authors investigated the broken wires of an old suspension bridge. The fracture surface was similar to that caused by fatigue rather than by hydrogen embrittlement [4]. It was estimated that the wires were fractured by the mixed effects of corrosion, cyclic stresses and hydrogen. Hanger ropes have high stress fluctuation which increases risks of wire breakage due to corrosion.

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