Noncontact NDE technique for Main Cables of Suspension Bridges integrating Direct Current Magnetization with a Searching Coil-based Total Flux Measurement

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Summary

Current inspection methods for main cables of suspension bridges are mainly carried out by visually inspecting the exterior covering of the cable periodically. In spite of necessity of non-destructive examination (NDE) to detect the inner cross-sectional damage of the main cable, a suitable NDE technique for the main cable has not been existed due to its large diameter. In this study, a cross-sectional loss monitoring system that can detect the external and internal damages of main cables has been developed for the safety of long span bridges in future city This main cable NDE technique was based on the direct current (DC) magnetization technique and a searching coil-based total flux measurement. A total flux sensor head prototype was fabricated that was consisted by a magnetization part to magnetize the specimen and a sensing part to measure the total magnetic flux. The magnetic field for magnetizing the main cable was generated by applying the low frequency DC voltage to the winded coil. The sensing part was configured by two semi-circular search coils, and it measures the electromotive force that pass through the search coil by using the faraday's law of induction. Total flux was calculated by integrating the measured magnetic flux. Then, B-H curve was extracted using the total flux, and cross-sectional loss can be detected using variation of features from the B-H curve.

Keywords: Cable NDE; Search coil; Total flux; DC magnetization; Damage quantification.

1. Introduction

In a steel cable, cross-sectional damage can occur due to corrosion and fracture, which can lead to stress concentrations. Furthermore, the cross-sectional damage can be a direct cause of structural failure. Therefore, non-destructive examination (NDE) to detect the initial stages of cross-sectional damage in a cable is strongly required for the safety of long span bridges in future city.

However, it is difficult to monitor the condition of most cables, as the damage can be invisible and inaccessibly located. In particular, in case of main cables of suspension bridges, there have been no research and development activities yet other than direct visual inspections.

To overcome this limitation, this study proposes a noncontact cable inspection system incorporating the magnetic sensor by using the cable's ferromagnetic characteristic. Magnetic sensors are widely used to monitor structures, including aircrafts and ships, due to their excellent reliability and reproducibility [1-3]. Various kinds of magnetic sensors exist, and optimal magnetic properties can be utilized according to the kind of target structure [4-7]. However, it has been not widely applied to monitor the large scale civil infrastructures. Application of the magnetic sensor technique for infrastructure, such as suspension bridge, has been researched recently [8-10].

The magnetic flux leakage (MFL) method is most suitable for continuous structures which have constant cross-sections such as cables and pipes, and has been applied for the inspection of steel cables for ski lifts, elevators, and for other applications [11-14]. However, MFL method can only detect the local fault near the surface. So, hidden damages at the inside of large cable could not be detected.

To supplement the limitation, this study proposes a new methodology incorporating the direct current (DC) magnetization with a search coil-based total flux measurement to investigate the loss of the cross section of the main cable due to corrosion damage. From the hysteresis curve of the magnetized main cable measured at the search coil of the proposed NDE equipment, a

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