Deflection estimation of a steel box girder bridge using multi-channel acceleration measurement

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Abstract

The deflection of a bridge is an important physical quantity, which is usually specified in design. The deflection can also be utilized in the estimation of traffic load. However, the measurement is oftentimes not practical. Reference points for displacement sensor are usually not available. While deflection estimation by double-integration of acceleration measurement provides a simple and inexpensive deflection estimation, this approach suffers from large integration errors. In this study, deflection estimation without the integration errors only using accelerometers is proposed. The acceleration signals are used to estimate girder inclination. By combining this inclination and the vertical acceleration through a Kalman filter, the bridge deflection is evaluated. A steel box girder bridge is instrumented with wireless tri-axial accelerometers. The deflection estimated through the Kalman filtering is compared with references.

Keywords: bridge deflection; inclination; acceleration; Kalman filter; field measurement

1 Introduction

Deflection is important in bridge design and assessment because it is directly related to bridge stiffness, integrality, and serviceability. Deflection can also be utilized in roughly estimating the moving traffic loads on bridge. However, displacement measurement is oftentimes not practical.

Bridge deflection estimation methods can be generally categorized into two groups: contact and non-contact estimation methods in terms of instrumentation. Displacement sensors such as linear differential transducers and dial gauge are used in contact measurement. This kind of measurement needs a reference point under bridge, which is not always available, in particular, when bridges are over rivers or deep valleys. Another contact method is the use of strain data obtained by stain gauge installed on bridge girder to calculate displacement [1]. However, this method is not only time-consuming for installation but also sensitive to noise.

To overcome the difficulties in contact measurement, various non-contact measurement methods have been proposed. Laser Doppler vibrometer can measure bridge deflection and vibration simultaneously based on the Doppler shift of laser light [2]. Image processing techniques are also utilized to obtain the dynamic deflection by tracking target points on bridges. However, these non-contact measurement methods require a static reference point and the associate cost can be high. GPS system can provide the location of the measuring points in real-time without reference

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