# Development of Stay Cable Measurement System using Wireless Sensors

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## Abstract

Acceleration measurement is widely employed in various engineering field, because acceleration sensors generally have low noise and cost effective. Recently, FFT analysis of measured acceleration data is widely used to determine cable tension. This study proposes a stay cable measurement system using acceleration data to determine the cable tension and vibration amplitude. Real vibration amplitude can be estimated with this system by taking the vector summation of the plane (2-axis) displacements measured simultaneously. A small light-weight wireless sensor and cable climbing robot are also proposed to increase the applicability.

**Keywords:** cable-stayed bridge; cable measurement system; wireless sensor; acceleration displacement reconstruction.

## 1 Introduction

Many design guides and recommendations suggest the limitation of cable tension, vibration amplitude and deflection angle as the stay cable design criteria. However, practical field-measuring methods to determine cable characteristic during the construction stage or after completion are absence. Recently, the vibration method, which uses FFT analysis of measured acceleration data to determine cable tension, is widely used. The vibration method is able to relatively accurately determine the cable tension, but a practical method to determine vibration amplitude and damping ratio of the cable is absence. This study proposes a bridge vibration measurement system that determines the cable tension and vibration amplitude from acceleration data measured with a small light-weight wireless sensor.

Multimode-based evaluation method from taut cable theory and ambient vibration data, without artificial impact or forced vibration, are used for estimating cable tension, and measurement time is optimized based on comparison of FFT analysis with different data lengths. The accuracy of the estimated cable tension has been verified by field test from a cable stay bridge under construction.

The system implements a FIR-filter type displacement estimation algorithm to determine the vibration amplitude and to remove low frequency drift. Near-real time displacement reconstruction is possible with the algorithm, and laboratory tests are carried out to verify the feasibility and accuracy.

Generally, cables do not vibrate in a straight line but elliptically in the transverse plane of the cable. Since most devices measure projection length of the cable vibration, the measured vibration amplitude shall differ according to the direction of the measurement, which will result in a smaller measured vibration amplitude than the actual amplitude. The proposed system measures the



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