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Structural response reconstruction using inclinometer and velocimeter

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1 Abstract

This paper proposes a structural dynamic response reconstruction algorithm using inclinometer and velocimeter, combining in-situ measured data with finite element model. Using a small number of inclination and velocity data, the dynamic deflection, rotation, and strain at any position of a structure can be estimated. Firstly, static structural deformation estimation method is introduced as the base. The key content is to solve an underdetermined static equation using partial least square regression and calculate equivalent nodal force. By rewriting dynamic balance equation into state space, an equivalent static balance equation is obtained. Use partial least square regression to solve this equation and compute time histogram of equivalent nodal force, in which dynamic distortion exists. Accordingly, a frequency response-based time interval correction method is proposed to correct the dynamic distortion and is validated to be effective. Finally, numerical simulation is adopted to validate accuracy and robustness of the algorithm through changing parameters including sampling time interval, input frequency components, model parameters and introducing measurement noise. All results have demonstrated that the algorithm is of good adaptability to various changes and maintains high accuracy.

Keywords: State Space; Underdetermined Equation; Partial Least Square Regression; Dynamic Inclination, Velocity.

2 Introduction

Measurement incompleteness is an important problem for structural health monitoring[1] (SHM), because of financial constraint or inaccessibility. Data like structural deflection or strain is always in incomplete condition. However, immeasurable, especially deflection, is important for bridge assessment and other important works for SHM[2]. To overcome this problem, researchers have devoted to transferring other kinds of measurements to the required type of data.

Deflection curve estimation methods based on structure strain[3-6] and inclination[7-10] is proposed, because both strain and inclination are easier to obtain and free of reference point[11]. But the limitation of this group of methods is that only deflection curve of simple deformation form (simple-supported beam) can be estimated.

Another way to estimate structural deformation curve is by estimating the external load[12], with external load and finite element model (FEM), any required response like strain or deflection can be calculated[13, 14]. This research scope is named as input estimation. External inputs mainly include vehicle loads and wind loads for short-time input estimation work[15-18].

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