Compatible Deformation in the Condition Assessment of Beam Structures

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Abstract

The structural deformations should satisfy some geometric relations. However, this might not hold when the measured deformations are contaminated by measurement errors. In order to filter out the incompatibility in the measured deformation due to errors, the mathematical relation among the displacements within the structure are derived by the structural system identification by observability method. Namely, checking the observability of the parameters and obtaining the symbolical solution of those observable variables in the observability equations. Rearranging the associated solution leads to the geometrical equations that some displacements should satisfy, which is referred as the compatibility conditions. Among all compatible deformations satisfying these conditions, the one closest to the measured deformation is found by an optimization procedure. Finally, the structural parameters are estimated based on the optimal deformation shape. This method can smooth away the incompatibility due to errors and is validated by a simply supported beam and a two-span continuous beam.

Keywords: compatibility conditions; optimization; structural system identification; measurement errors; observability method; compatibility conditions; optimization; structural system identification; measurement errors; observability method;

1 Introduction

Due to the aging, the environmental erosion, the increasing traffic loads, the performance of in-service bridges are continuously deteriorating. It is of primary importance to assess their current conditions. Structure system identification (SSI) has been popular in the condition assessment of structures for decades. The SSI methods can be categorized as static ones and dynamic ones depending on the characteristic of the external loads during the non-destructive tests. Extensive research has been focused on the dynamic SSI methods. However, compared to the dynamic methods, much less attentions has been paid to those static ones. This paper is going to focus on static methods due to the following reasons: (1) In the static methods, the equilibrium equations are only associated with the structural stiffness, external forces and the structural response. In the case of those dynamic methods, the information of the mass and the damping is also required, apart from those physical quantities used in static SSI. Consequently, static SSI are simpler than dynamic SSI. (2) It is common to assume that the mass of the structure is independent of the damage of structure. Also the damping of the structure is

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