An approach to monitor bolt faults in two-dimensional structures without reference

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Abstract. Monitoring potential bolt faults is very necessary and meaningful to keep structures' healthy operation. For this purpose, an improved approach to monitor bolt faults in two-dimensional structures without reference is proposed. In the new method, nonlinear dynamic behaviours of the structure to be monitored are studied by a general multi-degree-of-freedom (MDOF) mode with nonlinear elements. By exciting the structure many times with the same excitation and the local structural modification method, nonlinear features from the structure to be monitored only are defined. Based on these features, a novel fault index and corresponding improved approach are proposed and explained. With some numerical examples on a two-dimensional structure, the effectiveness and reliability of the method are verified fully.

Introduction

For various two-dimensional engineering structures, bolts are widely applied to clamp different structural components together and to bear external loads. However, bolt connections easily encounter faults since these two-dimensional engineering structures often work with dynamic environments and operations. Bolt faults not only cause decrease of clamping force but also lead to serious slip or separation between structural components [1]. As a result, monitoring potential bolt faults as early as possible is very important and meaningful to keep the normal and smooth operation of these two-dimensional engineering structures. For this objective, a host of output spectrum-based methods have been presented [2]. The fundamental principle of these methods is that output spectrum-based features depend on structural physical properties solely. Thus, any variation in properties caused by bolt faults could be monitored by monitoring changes in output spectrum-based indexes [3-4]. Existing nonlinear output spectrum-based methods provide much more information of two-dimensional structures with potential bolt faults. However, one obvious limitation is that fault data from basement structures are required during the diagnosis of faults. This condition would affect these methods' effectiveness if states of health structures are not known. To overcome this limitation, an improve approach to monitor bolt faults in two-dimensional structures without reference is proposed in this paper. The main contributions and novelties of this paper are, (1) Using nonlinear output spectra of local and damaged two-dimensional engineering structures only and the local structural modification method, local damage features are derived and analysed; (2) With damage features, an improved method with sensitive damage indexes is proposed, and its effectiveness and availability are illustrated through simulation cases on a MDOF model of two-dimensional engineering structures.

Results and discussion

By considering impact of faults as nonlinear forces, two-dimensional discrete MDOF model with nonlinear components could be built for the dynamic analysis of two-dimensional structures.

With the local structural modification method, similar equations from the structure to be monitored could be used to form one matrix, whose rank could be a sensitive index for inspection.

Results from simulation studies on a two-dimensional model with multiple faults show that the proposed method could give precise sates of bolt faults in numerical structures.

References

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