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Forced Time-transient Response Analysis of Acoustic Emission Signals in Bridge Cables Based on Semi-Analytic Finite Element Method

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Abstract

Cable damage is one of the typical diseases of cable supported bridges. Acoustic emission (AE) technique, as a dynamic and non-destructive technique, can be applied to the health monitoring of bridge cables, while the propagation characteristics of AE signals in bridge cables is the key problem. The goal of this paper is to theoretically investigate the time-transient responses of single wire waveguide under excitation. Firstly, a formulation based on semi-analytic finite element (SAFE) method was proposed to calculate the time-transient response in cylindrical waveguides. Next a high tensile strength steel wire with 5mm diameter was used as an example to calculate its displacement responses under narrowband excitation and broadband excitation respectively, with damping effect considered. The results illustrated the propagation characteristics of AE signals in single wire waveguide.

Keywords: Time-transient response; Acoustic emission (AE); Semi-Analytical Finite Element (SAFE) method; bridge cables; single wire waveguide.

1. Introduction

Cables are important structural components of cable bridges and the cost proportion is about 25%-30% of the whole bridge. The safety and durability of cables is a significant guarantee of the whole performance of cable-supported bridges. The steel wires in the cables, however, may crack due to long-term effect of high stress, corrosion and fatigue, which will diminish the stress area and accelerate the damage growth, eventually threaten the safety of the whole bridge.

Acoustic emission (AE) technique, as a dynamic and non-destructive technique, can be applied to the real-time monitoring of damage occurrence and development, and predict damage location and property. The signal processing has two methods: parameter analysis and waveform analysis. The parameter analysis method, used widely in the past few decades, picks some simplified characteristic parameters from the waveform to represent the signal characteristics. In comparison, the waveform analysis analyzes the full waveform of the signal, which concludes the whole information of the emission source. Thus, it is more accurate to represent the signal characteristics, leading to broad application prospect with promotion of equipment performance.

The propagation characteristics of AE signals in bridge cables is the key problem of the application of waveform analysis in AE monitoring of cables. A necessary simplification of the waveguide is to firstly study AE signals in the single steel wire, before more complicated waveguides like multi-wire strands and cables. Friedrich Moser [1] used

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