# Research on the Damping Ratio Variation of Vehicle Bridge Interaction System Based on the Complex Mode Method

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## Abstract

Vehicle-bridge interaction (VBI) is a classical problem in bridge structural health monitoring (SHM), and there are many studies on this problem. However, most of the studies have focused on the frequency of VBI systems and neglected the damping. In this paper, the effects of vehicle parameters on the damping ratio of VBI systems are investigated. First, the equations of motion (EOM) of the VBI system are given. Then the damping ratios of the VBI system are solved by the complex mode method, and the results are verified by numerical simulation. Finally, the effects of vehicle parameters on the damping ratio of the bridge are analyzed. The results show that the speed, position, mass, frequency, and damping ratio of the vehicle will affect the damping ratio of the VBI system. When the vehicle frequency is close to the resonance condition, the change of damping ratio of the bridge is not negligible.

**Keywords:** Vehicle-Bridge Interaction; Damping Ratio; Complex Mode Method; Vehicle parameters.

## 1 Introduction

The frequencies and damping ratios of bridges are important indicators in the bridge structural health monitoring (SHM), as the dynamic characteristics of bridges contains information on structural damage. Traffic loads also have an impact on the dynamic characteristics of bridges[1], therefore it is important to explore this issue in order to assess the condition of bridges.

Many studies have shown that the natural frequencies, damping ratios and vibration modes of bridges will change due to the vehicle-bridge interaction (VBI) effect. Yang[2] studied the variation of vehicle and bridge frequencies when a vehicle acts on a simply supported beam and gave a closed form solution considering only the first order vibration mode without damping. The results show that the effect of the VBI effect on the inherent frequency of the bridge cannot be ignored, when the vehicle mass is large or the frequency is close to the resonance condition. Yang[3] proposed an indirect method based on S-transformation to identify the bridge frequency when a vehicle passes over a bridge. From the identification results it can be seen that the bridge natural frequency varies with the vehicle position and vehicle mass. Cantero[4] conducted an experiment to measure bridge frequencies and modes for vehicles in different positions and used a simplified numerical model to analyse the results. The results show that the bridge frequency varies with the vehicle position. Stoura[5] and Yau[6] studied the additional damping effect of bridges caused by the VBI effect. They also gave separate simplified formulas for additional damping applicable to railroad bridges. From the above studies it can be found that the position, speed, mass and dynamic characteristics of the vehicle have an effect on the frequency and damping ratio of the bridge. However, there are few studies that discuss the

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