Vibration analysis of a steel truss bridge with random track irregularities under a moving train load

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Summary

This paper deals with the dynamic response of a truss bridge under a single moving train. A planar finite element model of a train-bridge system is used. The train is divided into one-foot sprung masses. The bridge is modelled as frame and truss elements. Vertical random track irregularities are generated by power spectrum density functions. The dynamic equations of motion of the train and the bridge are coupled by the shape constraints and contact forces. The interaction dynamic equation of motion is solved by the Newmark-beta and Newton-Raphson method. The dynamic response of a steel truss bridge with track irregularities under a KTX train is calculated as an example. The dynamic impact factors for different bridge nodes are evaluated and compared with different train speeds and track irregularities conditions.

Keywords: Truss bridge; Train-bridge interaction; Dynamic impact; Finite element method.

1. Introduction

The steel truss bridges are easy to design, manufacture, and construct, thus they are popular among bridge engineers. Due to their light self-weight and high stiffness, steel truss bridges are more sensitive to the vibration caused by high speed trains. In addition, the existing track irregularities will cause larger bridge vibrations. So the initial dynamic analysis for the steel truss bridge under a high speed train is necessary to guarantee the train running safety and bridge stability.

This paper addresses a planar finite element model of train-bridge system. The bridge trusses are modelled as truss elements, while the stringers are modelled as frame elements. Track irregularities are generated by the empirical power spectrum density formula. The train is modelled as a series of one-foot sprung masses located at the positions of its wheel sets. A steel truss bridge under a moving KTX train is taken as an example to analyse the dynamic impact for the truss bridge. The vibration of the bridge is evaluated at three points on the stringers, and the dynamic impact of the bridge with different levels of track irregularities are plotted and discussed.

2. Model of the train

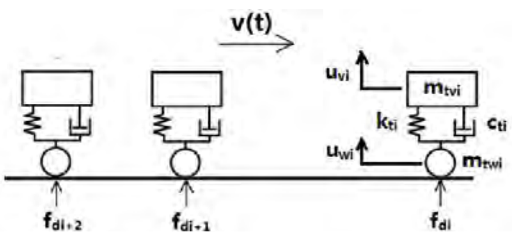

Fig. 1: One-foot spurng mass model of the train

In this study, the train is divided into a series of two dimensional one-foot sprung masses located at the positions of wheel sets, shown in Figure 1. The train moves with speed $v(t)$. Each one-foot sprung mass has two vertical degrees of freedom u_w and u_v, which represent for the displacements of wheel and car body, respectively. The upper sprung mass m_{tv} which stands for the part of the car body and bogie is connected with the lower sprung mass m_{tw} which stands for the wheel

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