Modelling and Performance Analysis of Rail Vibration Absorber by FE and BE Methods

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Summary

A finite element model of the railway track with a rail absorber is proposed for investigating the effects of the absorber’s multiple motions on the dynamic behavior of the track. The rail vibration and radiation due to a roughness excitation are calculated with the use of the absorber. The calculation results are compared with those of the beam-spring model. The results show that the radiation efficiency of the rail with the absorber is significantly reduced in the frequency range 300-1000 Hz. The noise reduction calculated by the finite element model is less than that of the beam-spring model in the frequency region of 400—1000 Hz due to the transversal rotation of the absorber. The rail-radiated noise can be reduced by about 7.1 dB(A) using the rail absorber.

1 Introduction

A two-frequency tuned rail absorber can increase the rail vibration decay rate along the track, so it can effectively reduce the railway rolling noise. Field tests [1] showed that the rail noise could be decreased by up to 6 dB(A) using a rail absorber on a track with the rail pads of medium stiffness. Researchers have developed some theoretical models [1-4] for investigating the dynamic behavior of the rail with absorber. Compound track models with continuous or discrete rail absorber were developed in Ref. [2] to study the mechanism of rail absorber, where the absorber was represented by a damped two-degree-of-freedom mass-spring system and the rail was modeled as an infinite Timoshenko beam. With the influences of the rail absorber’s bending modes taken into consideration, Ref. [3] proposed a combined model of the railway track with rail absorber, which was treated as a beam-spring system.

In practice, the vibration modes of the absorber are composed of both elastic deformation and rigid body motion. The mass-spring model only considers the
absorber’s translational motion in the vertical direction, and the beam-spring model considers both the bending modes and the translational motion of the absorber in the vertical direction. However, the vibration motion of an absorber also includes the transversal rotation of the mass bar, which was not taken into consideration in the above models. In addition, the structural shape of the rail changes due to the absorbers glued to the rail. Consequently, when the rail vibrates, the vibration phase difference between the rail and the mass-bar of the absorber causes changes in the sound radiation behavior.

In this study, first, a finite element model of the railway track with a rail absorber is developed to investigate the effects of the absorber’s multiple motions on the dynamic behavior of the track. Then, a boundary element model is developed for the rail with the absorber to calculate its radiation efficiency. Finally, the wheel—rail interaction excited by a roughness input is calculated, in addition to the sound radiation power from the rail according to its vibration energy. The results are compared between the finite element and the beam-spring models.

### 2 Finite Element Model and Vibration Behavior

A quarter of the railway track with rail absorber is modeled by the element SOLID 95 in ANSYS codes due to symmetry, as shown in Fig. 1. The track model considered is 78 and 31-m-long for the untreated rail and treated rail, respectively, and only vertical vibration is taken into account. The length of the absorber, which is attached one by one along the rail, is 0.6 m. The first and second resonance frequencies of rigid body motion of the absorber are designed to be about 400 Hz and 700 Hz, respectively, as shown in Fig. 2. In the first mode of rigid body motion the upper mass-bar oscillates up and down, while in the second one the bottom mass-bar oscillates. The rail supports are discrete and consist of the rail pad, the sleeper, and the ballast. The rail pad and the ballast are modelled by element COMBIN 14, and the sleeper by element MASS 21.

![Fig. 1. Mesh of the finite element model for a rail section with absorber.](image)

The parameters of the track absorber used in this paper are listed in Table 1, and they are used to represent a track with UIC 60 rails, stiff rail pads, and concrete