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Numerical and experimental study on noise reduction of concrete LRT bridges

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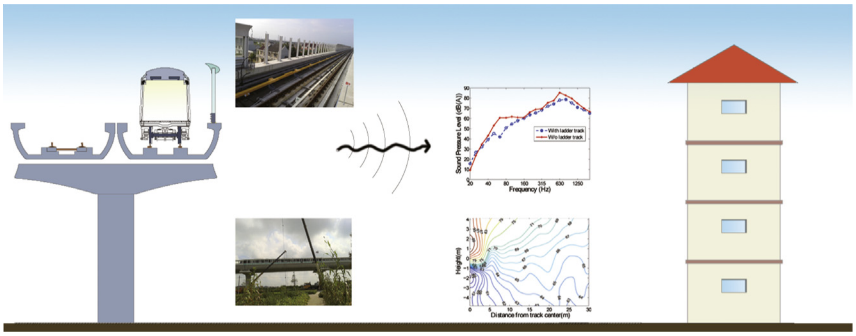
HIGHLIGHTS

- A refined dynamic interaction model and an efficient acoustic model were used for numerical simulation.
- The effect of three noise mitigation measures on the noise reduction of rail, track structure and bridge was studied.
- The noise reduction is evaluated by installation and removing a noise barrier and sound absorbing panel in a field test.

GRAPHICAL ABSTRACT



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ABSTRACT

Rolling noise and structure-borne noise radiating from the bridge are two major sources of noise in light rapid transit (LRT) bridges. To control the noise radiation from LRT bridges, an efficient numerical method for noise prediction is needed. In this study, a combined three-dimensional dynamic model and 2.5-dimensional acoustic model were used to investigate noise reduction in a rail and in a U-shaped girder bridge. The effects of three noise mitigation measures on noise control were then compared: installation of a noise barrier, use of a rail pad with a lower stiffness, and use of a floating ladder track. The corresponding noise reduction was investigated using the numerical method. A field test was conducted to validate the noise reduction effects. It was found that the noise barrier was more effective in reducing the rail noise, and the soft rail pad is more effective to control the bridge noise. The floating ladder track can significantly reduce bridge vibration, but the excessive vibration of the ladder track itself became another major noise source. The findings should guide the selection of appropriate mitigation measures for noise reduction in LRT bridges.

1. Introduction

Rolling noise and structure-borne noise radiating from bridges caused by passing trains are major sources of sound in urban rail transit elevated structures in the low and medium frequency range (20 to 1000 Hz). The noise radiating from urban rail transit lines is causing increasing complaints from the community as rapid urbanization and transport infrastructure development progress (Xie et al., 2016). Thus, effective mitigation measures should be applied to reduce the noise levels of light rapid transit (LRT) systems.

Experimental methods are widely used to investigate noise radiation, as they can directly evaluate noise reduction effects. Venghaus

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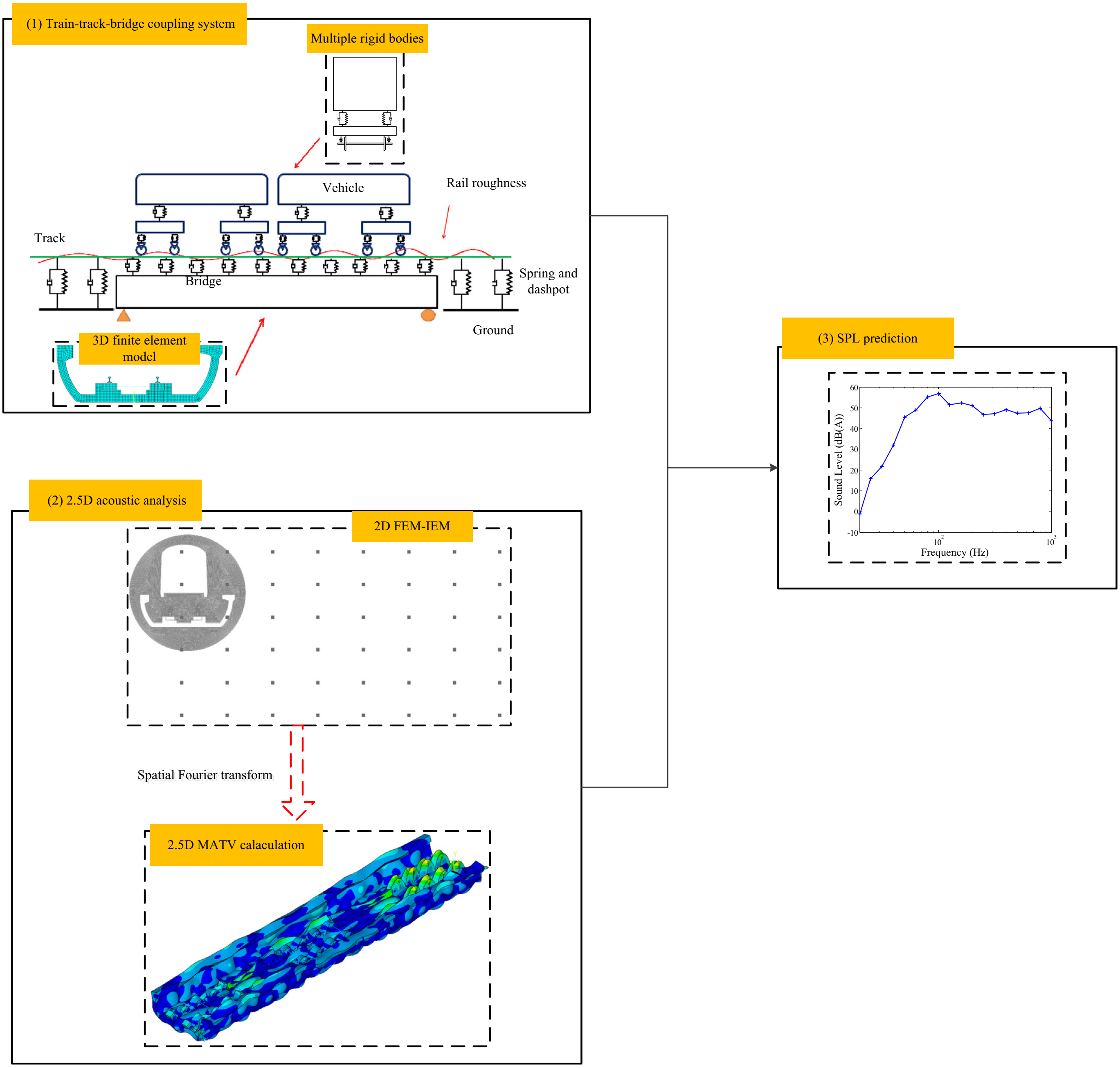

Fig. 1. Schematic model of the numerical procedure.

et al. (2012) conducted field tests to study noise reduction in four steel bridges fitted with different noise mitigation systems, including rail absorbers, bridge absorbers, a soft rail fastening system, and soft elastomeric pads. Related technologies were also used to reduce the noise radiating from steel railway bridges in Germany (Stiebel et al., 2015) and Sydney (Wang et al., 2000). The effects of three mitigation measures on the noise radiating from light rail transit networks were investigated through field tests (Vogiatzis and Vanhonacker, 2016). A full-scale bridge model was used to investigate noise reduction in a bridge with a floating ladder track and floating concrete deck (Watanabe et al., 2012). Lin et al. (2013) used glass fiber reinforced polymer (GFRP) plates and rapid hardening concrete to reduce the structure-borne noise of steel bridges, and showed that the noise could be reduced by 5 to 15 dB after strengthening. Saito et al. (2015) conducted an impact hammer test to compare the vibration and noise radiation of a steel girder bridge with wooden sleepers and a steel girder bridge with a concrete deck. Ngai et al. (2006) used a floating honeycomb panel to control the structure-borne noise from a viaduct under impulsive force excitation. High-performance damping material was used to reduce railway noise in Austria, and tests showed that a reduction of 2 to 4 dB could be achieved for ballast tracks (Koller et al., 2012). Vogiatzis (2011) investigated the effect of a floating slab on ground-borne noise and vibration attenuation through extensive field tests.

However, in experimental methods parameters such as the combined rail-wheel roughness and rail pad stiffness can differ over multiple comparison tests, which may influence the conclusions about