Vibration reduction performance of floating slab track with fractional derivative model for rubber bearings

†*Shengyang Zhu, and Wanming Zhai

State Key Laboratory of Traction Power, Southwest Jiaotong University, China.

*Presenting author: syzhu@swjtu.edu.cn
†Corresponding author: syzhu@swjtu.edu.cn

Abstract

With the rapid development of the urban rail transit, low-frequency vibrations of underground railway induced by the wheel–rail interaction have become important environmental issues. In this study, a fractional derivative model is used to capture the complex behavior of rubber bearings of floating slab track, which is implemented into the coupled dynamic model of vehicle–floating slab track systems. The vehicle is treated as a multi-body system with 10 degrees of freedom, and the slab track is represented by a three layer Bernoulli–Euler beam model. The model for the rubber bearing is one dimensional, and the force–displacement relation is based on a superposition of elastic, friction, and fractional derivative forces. This model takes into account the influences of the excitation frequency and of the displacement amplitude through a fractional derivative element, and a nonlinear friction element, respectively. The Grünwald representation of the fractional derivatives is employed to numerically solve the fractional and nonlinear equations of motion of the coupled system by means of an explicit integration algorithm. Dynamic response of the coupled system obtained by the proposed model is compared and validated with filed experimental data. Further, comparisons between the proposed model and traditional model adopted for the coupled system are conducted in the time domain as well as in the frequency domain, demonstrating several modeling advantages over the traditional model. Finally, sensitive analyses of the model parameters on the vibration reduction performance of floating slab track subjected to vehicle dynamic loads are investigated induced by random track irregularities.

Keywords: **Fractional derivative, floating slab track, rubber bearing, vehicle-track coupled dynamics, vibration reduction**