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Train-induced vibration control of railway systems using particle damper

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ABSTRACT

From mass transit rail to high-speed rail and urban/suburban light rail transit, the train-induced vibration by intensive wheel-rail interactions has been a global concern for long time. However, up to now, currently in-use rail dampers function within a relatively limited frequency range, which is insufficient to deal with the broadband vibration (100–2000 Hz) generated from the variant rail operating environment.

Generally, railways are built in harsh environments that inefficiently affect the functionality of existing rail dampers and might be accompanied by material degradation issues. Particle damping technology can overcome the technical challenges of existing rail dampers. It is a form of an auxiliary passive type vibration absorber wherein granular materials are filled into the cavities of the container that is attached to a structure to reduce the vibration response of the system. In this study, a rail particle damper (RPD) is developed to mitigate the high-frequency rail vibration caused by the operation of railway systems.

In addition, the dynamic equations of motion of a rail coupled with particle damper under traffic loading is deduced. A new analytical model of a damped rail structure equipped with particle damper device is developed. Parametric analysis of RPD is performed and verified using the experimental data for subsequent experimental verifications. The analysis results show that the analytical model can reflect the vibration control performance and mechanism of the RPD. It is found that the proposed RPD system is effective in mitigating the displacement responses of the rail system which is essential for minimizing the excessive vibration caused by wheel-rail interactions.

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