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Time-domain model for wheel-rail noise analysis at high operation speed

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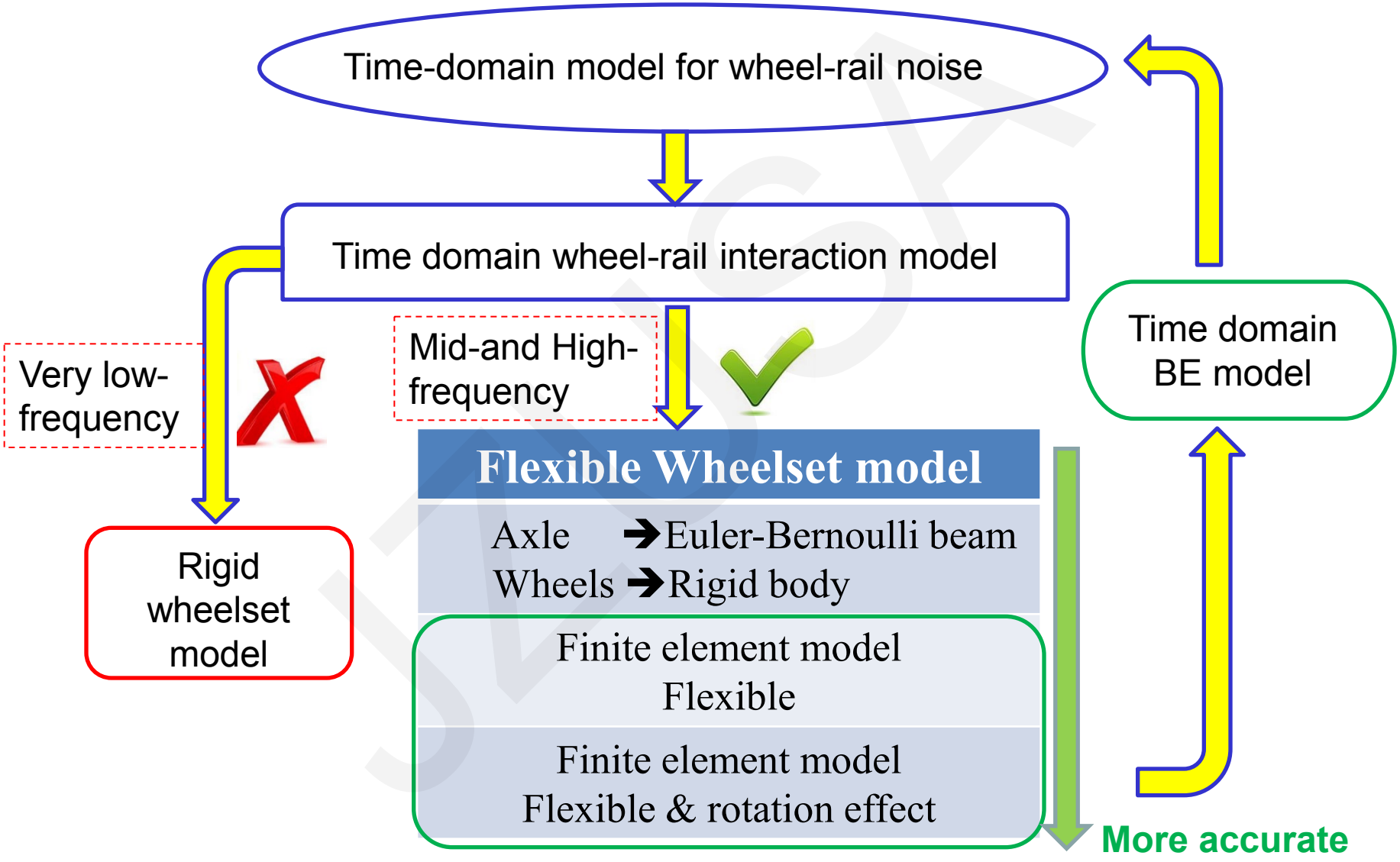
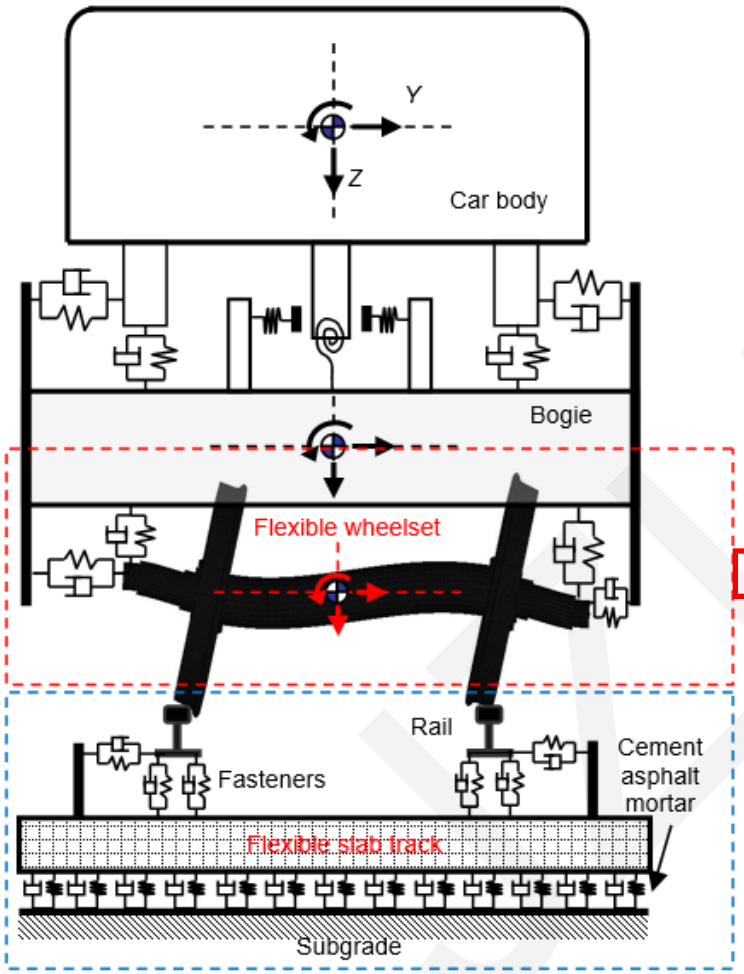
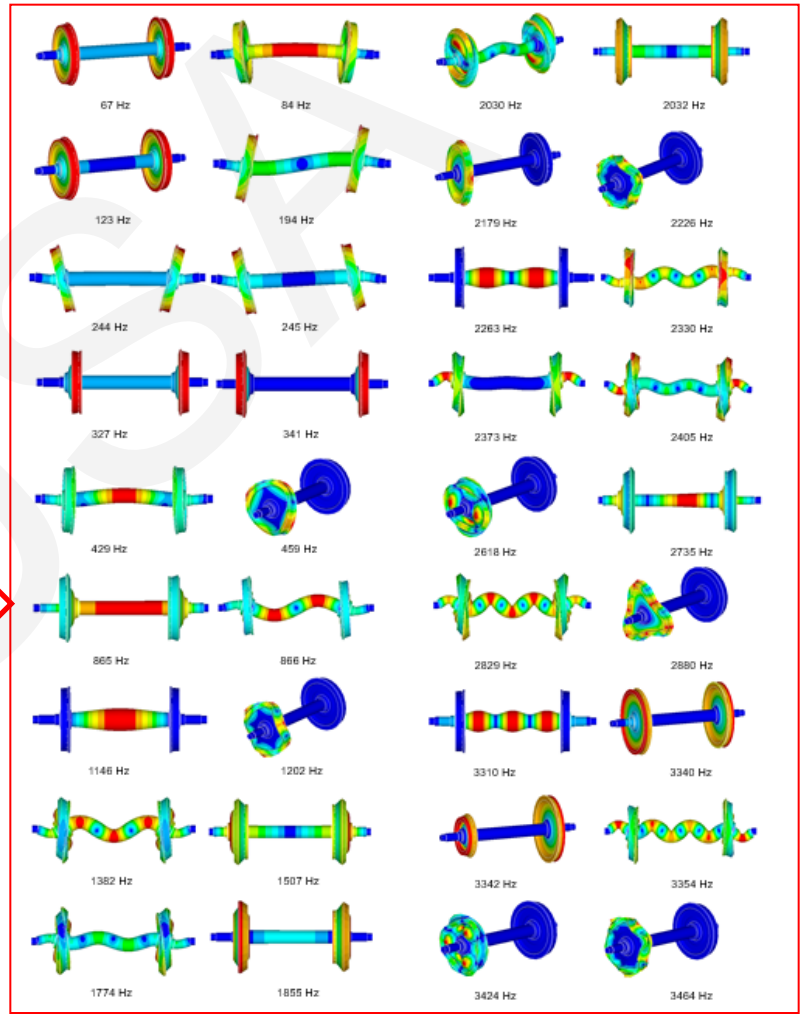
Research approach



Dynamic model

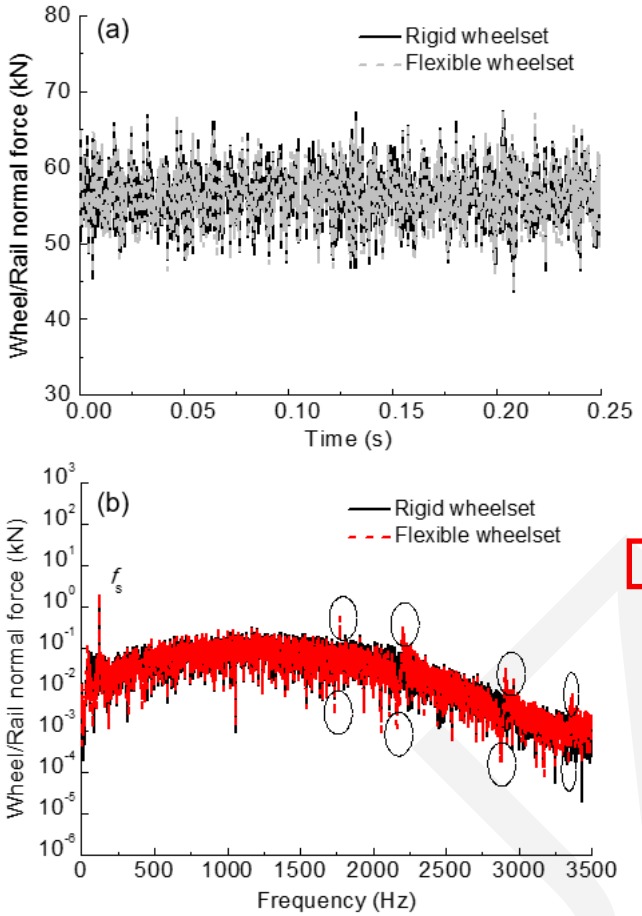


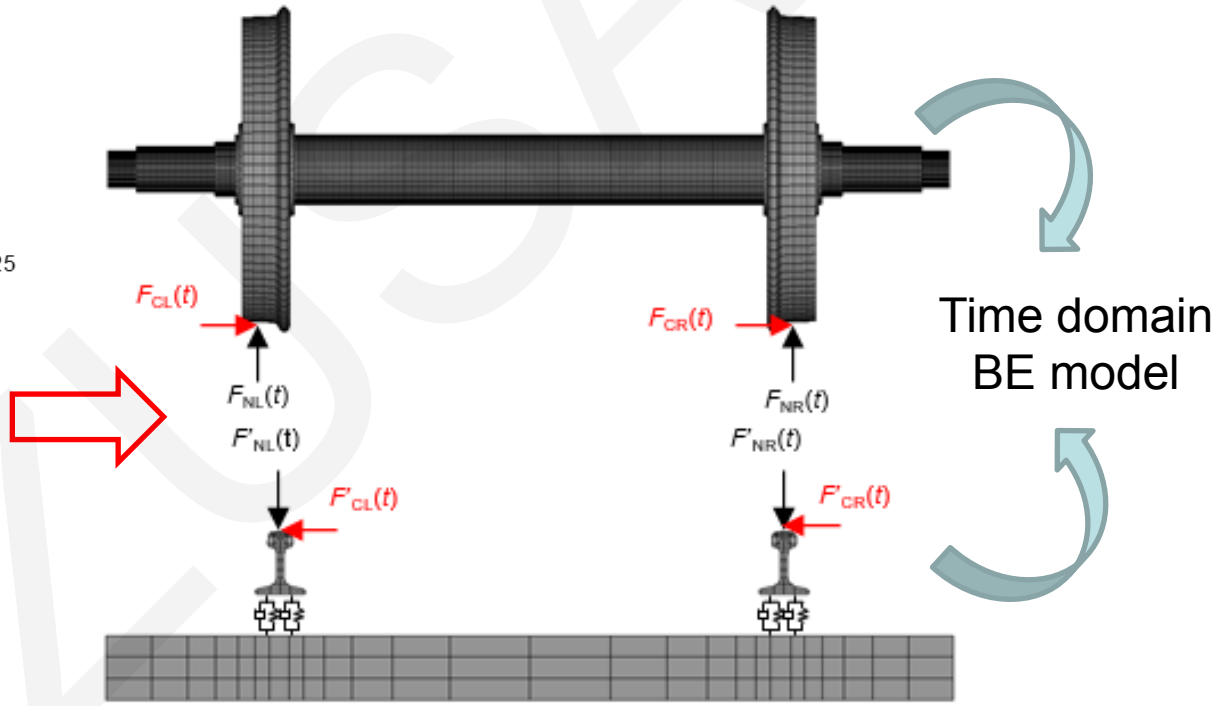
Rigid-flexible coupling dynamic model of vehicle and track



Mode shapes of high-speed wheelset

Model for wheel-rail vibration and sound

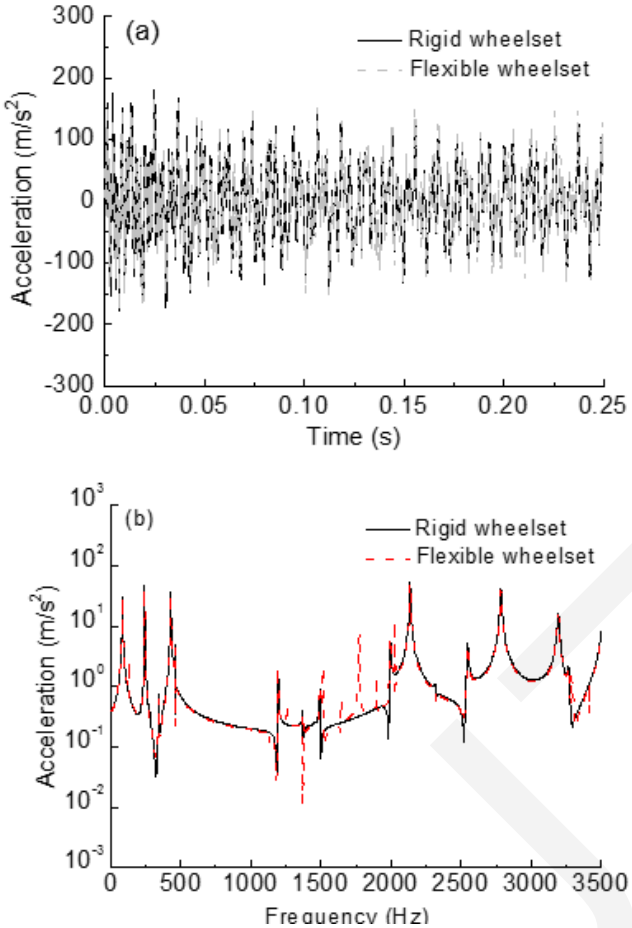




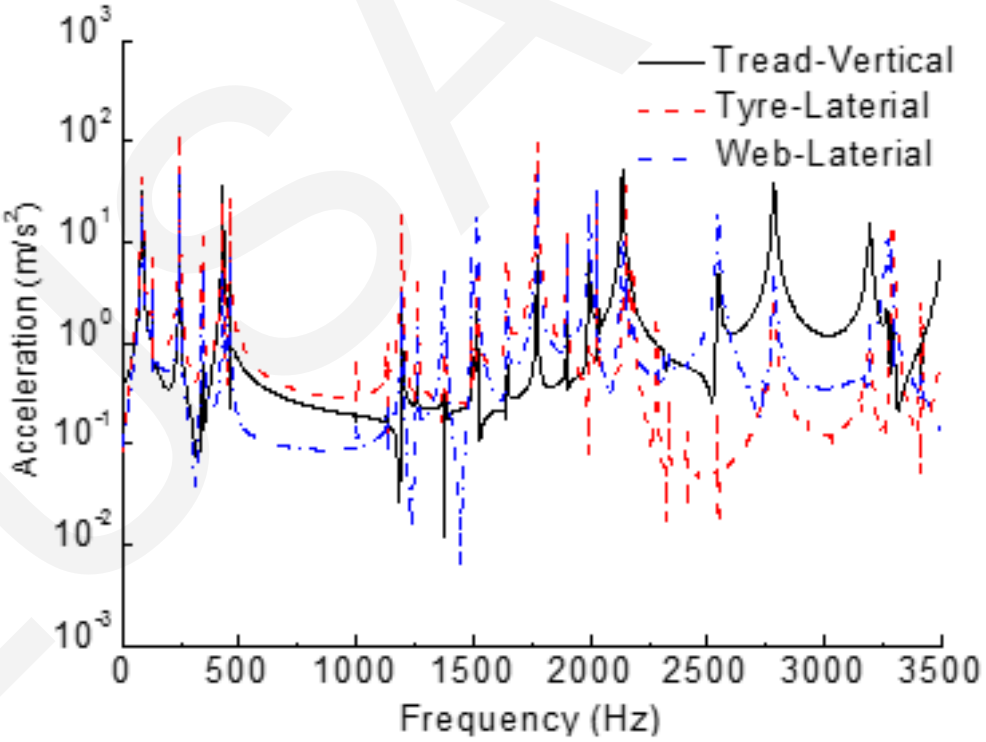
Wheel/rail contact force considering flexible wheelset and track

Wheel/rail vibration and sound model

Results for wheelset vibration



Acceleration of rigid wheelset and flexible wheelset on tread: (a) time domain; (b) frequency domain



Acceleration of a flexible wheelset in different locations

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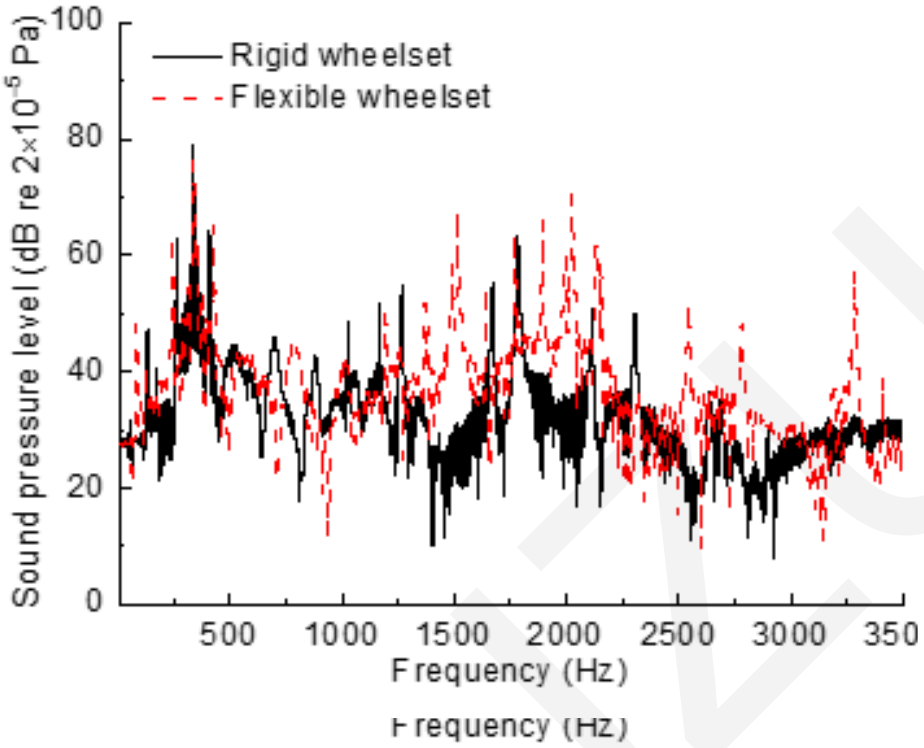
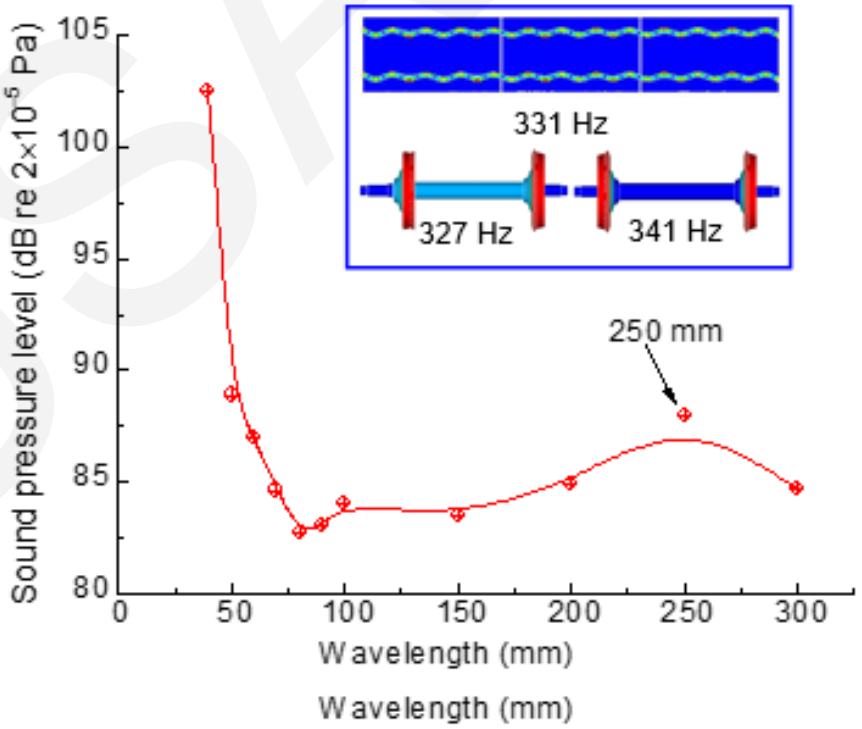
Results for wheel-rail sound radiation



Sound pressure level of rigid wheelset and flexible wheelset



Effect of rail corrugation on wheel/rail noise

Conclusions

In this paper, a numerical model of wheel-rail noise in the time-domain is developed based on vehicle-track coupling dynamics and considering flexible wheelsets and track, and the transient FE-BE wheel-rail noise prediction method. This time-domain model of wheel-rail noise can characterize noise components up to 5 kHz, and the present analysis frequency in this paper is up to 3.5 kHz. By using this model, the wheel-rail normal forces and the vibration and sound of rigid and flexible wheel-set are analyzed. The effect of rail corrugation on wheel-rail noise is also calculated. The following conclusions can be drawn:

- 1. The fluctuation of the wheel-rail contact force considering the effect of wheelset flexibility is similar to that with a rigid wheelset at low frequencies. The main difference occurs at higher frequencies. The wheel-rail contact forces considering wheelset flexibility are lower when wavelength roughness excites a natural frequency of the wheelset, and higher when wavelength roughness excites an anti-resonance frequency. The wheel-rail contact force fluctuates at high frequency due to wheelset flexibility and wheel-rail nonlinear contact relationship.
- 2. The vibration and sound of flexible wheelsets are similar to those of rigid wheelsets below 500 Hz. The vibration and sound in the mid-frequency and high-frequency ranges have more peaks and valleys. Moreover, the SPL can be underestimated when using the rigid wheelset model in predicting wheel-rail noise.
- 3. Wheel-rail noise decreases with the increase of the corrugation wavelength. The peaks of wheel/ rail noise appear at the corrugation wavelengths, where the wheelset modes are sensitive and excited.