Influence of track parameters on curve squeal

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Introduction

Curve squeal with large magnitude high-pitch tonal components generated during negotiation through tight curves is generally considered as the most disturbing noise emitted by rail traffic. It is commonly attributed to self-excited vibrations that develop due to large lateral creepage caused by imperfect curving of wheelsets. In the literature, curve squeal (from the inner wheel) and flange squeal (from the outer wheel) are typically distinguished by their respective frequency ranges separated by a cut-off frequency of approximately 5 kHz (Thompson et al., 2018). This abstract follows-up on recent field measurements on Stockholm's metro that indicate a different behaviour compared to this traditional separation between flange and curve squeal noise.

Analysis

The in-house code for time-domain simulation of high-frequency dynamic wheel–rail interaction WERAN (WhEel/RAil Noise) is applied to investigate the conditions of curve squeal at a 213 m radius curve on the Stockholm metro (Pieringer, 2014). WERAN combines pre-calculated impulse response functions (Green's functions) for track and wheel dynamics with Kalker's variational method for transient rolling contact. The structural flexibility of the wheel and the track model are calibrated with respect to track decay rates and mobilities measured in the studied curve and a wheel of the current rail vehicle, respectively. Low-frequency curving dynamics is accounted for using the commercial software SIMPACK.

Conclusions

The calibrated simulation model is applied to investigate the curve squeal generation in the studied curve. Varying wheel–rail contact conditions in the metro train are considered. Frequency characteristics of the simulated lateral wheel–rail creep force are compared and verified by comparison against pass-by noise measurements. Further, results from a parameter study that examines the importance of selected track parameters such as e.g. track gauge and rail pad stiffness on curve squeal generation are presented.

References

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Railway curve squeal field measurements and tonal analysis

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Introduction

Railway curve squeal, a loud tonal noise originating from self-induced vibrations in the wheel-rail contact during vehicle curving, poses noise challenges in urban environments. This noise typically contains distinct tonal components within the 1 to 10 kHz range, originating from acoustic radiation of specific wheel eigen modes (Thompson et al., 2018) and potentially the rails. Acoustic monitoring of curve squeal enables the spectro-temporal analysis of squealing sound, providing insights into curve noise characteristics and facilitating the identification of sound sources and their resonances during squealing.

Analysis

In this study, field measurements conducted on a 310-meter radius curve in Sweden are examined to gain insights of curve squeal sound levels and tonal characteristics. The measurements were carried out on two occasions, resulting in a total of 47 measured train passages, of which 34 contained curve squeal.

An algorithm, designed to detect tonal components from signal time-frequency representation, is proposed and applied to analyse the measured squeal events. The algorithm assumes tonal components to be sustained in time, constant in frequency, and show clear local maxima in the signal spectra.

Conclusions

The squeal measurements showed significant tonality and maximum sound levels generally exceeding 90 dBA at 7.5 meters distance from the track. During squealing, several distinct tonal components are observed in the signal. Statistical analysis of the identified components shows clear clustering on specific narrow frequency bands within the range 1 to 10 kHz.

References

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Inclusion of rail and wheel roughness in noise mapping calculations with Nord2000

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Introduction

Mapping of rail noise in Sweden is usually based on calculated noise levels that in theory can take into account the condition of wheel and rail with simple standard values. As relevant standard values historically have been difficult to determine, corrections for different rail and wheel conditions have very seldom been used. To not use the correction equals to an assumption of having an average rail and wheel wear.

Analysis

Results from a comprehensive measurement campaign comprising both noise and rail roughness show that the rail roughness has a major impact on noise levels and that there are large variations in the rail network. In one case, the northbound and southbound tracks at one measurement site exhibited a 9 dB noise level difference due to difference in rail roughness between the tracks. As a comparison, a 9 dB difference would correspond to an eightfold increase in traffic.

Preparations are underway for a transition to the more accurate Nord2000 noise calculation method. As part of that, an engineering method has been developed that can translate measured rail head roughness into a single-number noise correction term to be used in noise calculations.

Conclusions

The Nord2000 noise prediction method would benefit from being further developed to allow for noise level corrections in one-third octave bands based on measured roughness spectra. A corresponding standardised method for efficiently mapping the rail roughness for an entire rail network would also be needed to make use of rail roughness corrections in practise.

References

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Dynamic analysis of Swedish steel-post wood-panel noise barrier under aerodynamic load from high-speed train

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Introduction

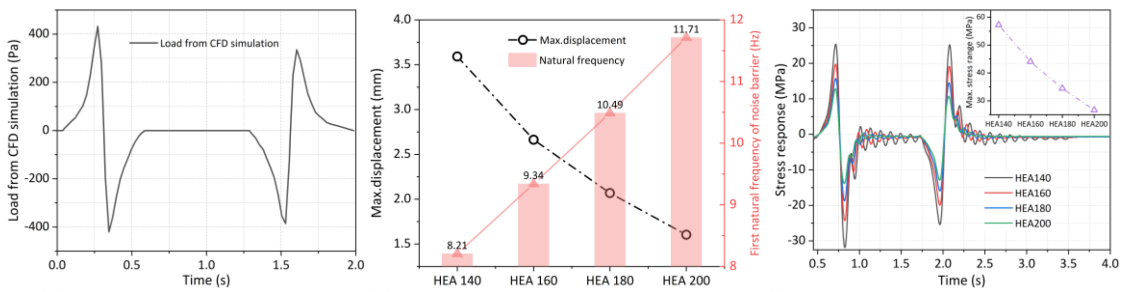
High-speed railway noise barriers are subjected to strong and transient aerodynamic loads from passing trains. The steel-post wood-panel noise barrier is a typical structural type in Sweden. In this study, a dynamic finite element analysis (FEA) of such a noise barrier under aerodynamic load was conducted using Abaqus® commercial software to analyse the effect of the profile of the steel column on its dynamic behaviours.

Analysis

As shown in Figure 1(b), when the cross-sectional area of the steel column decreases (e.g., from the larger HEA200 to the smaller HEA140), the first natural frequency of the noise barrier also decreases significantly from 11.71 Hz to 8.21 Hz. However, it remains higher than the excitation frequency of the aerodynamic load caused by the train (generally below 5 Hz), indicating a lower likelihood of resonance effects. When applying the classic time-varying train-induced aerodynamic load, as shown in Figure 1(a), the displacement and stress in the noise barrier vary over time in correspondence with the variation in aerodynamic load, as shown in Figure 1(b) – (c). As the natural frequency of the noise barrier decreases linearly, the maximum mid-span displacement of the barrier panel and the maximum stress range at the bottom of the steel column gradually increase, although these changes are not strictly linear.

Conclusions

The decrease in the natural frequency of the entire noise barrier structure due to the reduction in cross-section of the steel column leads to a non-linear rise in both the maximum displacement and stress range of the noise barrier.



(a) Time-varying aerodynamic load curve (b) Natural frequency and displacement of noise barrier (c) Stress response at the steel post of noise barrier

Figure 1. Dynamic response of noise barrier under train-induced aerodynamic load.

A ground-borne noise prediction model for railway traffic in tunnels in bedrock

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Introduction

Expanding railway lines has improved human life but introduced noise and vibration issues in residential areas. To reduce train-induced noise, efficient and accurate models for ground-borne noise prediction are required. Generally, there is a lack of published information about parameters for predicting ground-borne noise for Swedish conditions (Stenlund 2019). This study aims to create a ground-borne noise prediction model for underground tunnels, suitable for Swedish Transport Administration projects. It uses a three-stage methodology covering location, planning, and construction stages. The model, formulated for Swedish bedrock, considers various terms such as source term and corrections for train speed, distance attenuation, and building type. Moreover, uncertainties are estimated using the standard deviation of each term.

Analysis

The suggested model is formulated in 1/3-octave. The prediction of the vibration levels on the floor of a basement is generally formulated as

$$L_{\mathrm{VASmax}} = L_{\mathrm{eASmax}} + \Delta L_{\mathrm{S}} + \Delta L_{\mathrm{g}} + \Delta L_{\mathrm{f}} + \Delta L_{\mathrm{b}} + \Delta L_{\mathrm{corr}} \quad (1)$$

where $\boldsymbol{L_{\mathrm{VASmax}}}$ is the A-weighted maximum vibration level using time weighting Slow (dBA re 50 nm/s), $\boldsymbol{L_{\mathrm{eASmax}}}$ is the A-weighted maximum vibration level using time weight Slow in a reference position (dBA re 50 nm/s), $\Delta\boldsymbol{L_S}$ the train speed correction term (dB), $\Delta\boldsymbol{L_{\mathrm{g}}}$ the distance attenuation correction term (dB), $\Delta\boldsymbol{L_{\mathrm{f}}}$ the coupling loss correction term at the foundation (dB), $\Delta\boldsymbol{L_{\mathrm{b}}}$ the floor-to-floor attenuation correction term (dB), and $\Delta\boldsymbol{L_{\mathrm{corr}}}$ a correction term for other effects (dB). The sound pressure level in the room is given by

$$L_{\mathrm{pASmax}} = L_{\mathrm{VASmax}} + 10\log_{10}\sigma_S + 10\log_{10}\frac{4S}{A} \quad (2)$$

where $\boldsymbol{L_{\mathrm{pASmax}}}$ is the level of maximum sound pressure level for time-weighting slow (dBA re 20 µPa), $\boldsymbol{\sigma_S}$ is the radiation efficiency (-), $\boldsymbol{S}$ is the element surface area (m^2), and $\boldsymbol{A}$ is the equivalent absorption area of the room (m^2 Sabine).

Conclusions

As a result, a comprehensive model adapted to various planning stages is suggested for ground-borne noise prediction in Swedish Transport Administration projects. However, the model is still under development and may be improved.

References

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