Predicting the sound radiation from track vibrations for auralisation

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Introduction

Shifting transport from road to railway means that a rise in noise exposure attributed to railway activities can be anticipated. Utilizing auralization to simulate the noise becomes a useful tool for evaluating the perception beyond equivalent sound pressure levels. Exploring the correlation between factors such as track design parameters and the perceived sound quality allows for designing railway tracks with a focus on human noise perception. Developing a computationally efficient model becomes essential for accurately reproducing the sound field produced by track vibrations.

Analysis

A method is presented that uses simulated, time-domain surface velocities of a rail and sleepers as input. The software DIFF, developed at Chalmers (cf. Nielsen (2008)), is used to calculate the vertical vibration of a rail and sleepers in several positions along the track. The sound pressure signal in a position on the side of the track is efficiently predicted by convolving these velocities with precalculated acoustic transfer functions (cf. Theyssen et al. (2024)). For a typical ballasted track, the necessary spatial discretization along the track is determined in a convergence study, and the length of the finite section of the track to be included in the prediction is determined. Finally, pass-by signals generated by track vibration are demonstrated.

Conclusions

The presented method allows for an efficient prediction of the pass-by sound pressure signal with the potential application the auralisation of events in the rolling contact.

References

Nielsen, J. C. O. “High-frequency vertical wheel–rail contact forces—Validation of a prediction model by field testing”, *Wear*, *265*(9–10), 1465–1471, 2008

Theyssen, J., Pieringer, A., & Kropp, W. „Efficient calculation of the three-dimensional sound pressure field around a slab track“, Acta Acustica, 8, 4., 2024

Cost modelling-based railway decarbonization schemes applicability analysis: a case study of passenger rail in the United Kingdom

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Introduction

The UK government plans to phase out pure diesel trains by 2040 and fully decarbonize railways by 2050. Hydrogen fuel cell (HFC) trains, electrified trains using pantographs (Electrified Trains), and battery electric multiple unit (BEMU) trains are considered the main solutions for decarbonizing railways. However, the range of these decarbonization options' line upgrade cost advantages is unclear. This study through the construction of a novel energy train cost model, recommendations are made regarding the cost advantages ranges of HFC trains, Electrification trains and BEMU trains. This is achieved by calculating the average comprehensive cost per km under varying line conditions, including differing operating hours, traffic densities, and distances. The London St Pancras to Leicester line decarbonization plan was chosen as a case study.

Analysis

The cost of rail operations is one of the parameters that operators focus on. Two conditions are necessary to promote the decarbonization of rail systems. The first is government policy support, and the second is market demand. Rail operators may refuse or delay decarbonization upgrades if operating costs are too high. Vuuren (2002) et al have proposed some railway operating cost calculation methods, but the current research on cost estimation models for railway decarbonization upgrade programs is still limited. This study uses equation (1) to determine the average comprehensive cost per km of different types of railway decarbonization options, thereby finding which decarbonization option is more cost-effective under different traffic density conditions. Where $C_{Total/km}$ is the average integrated cost per km, S is the length of the line, T is the service year and D is the line traffic density.

$$C_{Total/km} = \frac{C_{Fixed}}{S * T * D} + \frac{C_{Operation}}{S} \tag{1}$$

Conclusions

When the traffic density exceeds 55 trips/day, electrified trains begin to have cost advantages. BEMU trains are suitable for the transitional stage of electrified lines. Due to the current high price of hydrogen, HFC trains currently only have advantages on routes with lower traffic density and longer distances. When hydrogen prices drop by 26%, HFC trains begin to have cost advantages for short-distance lines less than 100km.

References

Vuuren, D. V., “Optimal pricing in railway passenger transport theory and practice in The Netherlands”, Transport Policy, vol. 9, 2002.

A study on the metro train type influence on the particulate emissions and pollution cost on an underground platform

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Introduction and Analysis

Recent research has indicated that underground metro platforms are prone to the accumulation of airborne particulate matter. Drawing upon data from over two years of extensive field measurement, this study employs statistical modelling to examine the influence of three distinct metro train types (CX, C20, and C30) on PM10 levels at an underground platform in Stockholm by Tu and Olofsson (2023). Furthermore, to furnish recommendations on environmental impacts to relevant sectoral agencies, an annual pollution cost estimation for each train type has been conducted, leveraging model estimations and an ASEK report detailing the yearly costs of air pollution per individual by Trafikverket (2023).

Conclusions

The outcomes regarding the pollution cost associated with each train type are depicted in Figure 1. Reflecting the price levels of 2017, C20 trains incur the lowest cost. In comparison, C30 and CX trains exhibit pollution costs that are 1.3 and 3 times higher than those of C20 trains, respectively.

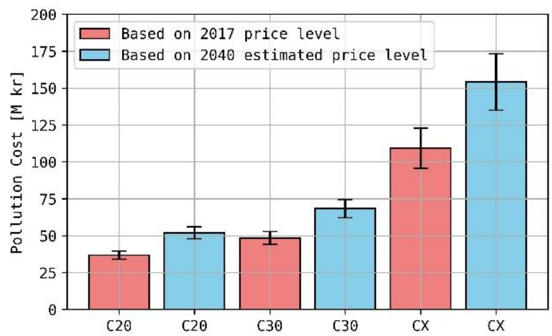

Figure 1. Estimation of pollution cost for each train type.

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References

Trafikverket, 2023. “Analysmetod och samhällsekonomiska kalkylvärden för transportsektorn: ASEK 7.1”. Trafikverket.

Tu, M., Olofsson, U., 2023. “Estimating PM Levels on an Underground Metro Platform by Exploring a New Model-Based Factor Research”.

Evaluation of low-cost air quality sensors at underground train platforms

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Introduction:

Exposure to particulate matter (PM) is linked to health issues affecting the heart and lungs, leading to illness and death. In comparison to above-ground stations, underground stations had higher concentrations of some metals like Fe, Cu, and Mn(Chang, Chong et al. 2021). Low-cost sensors (LCS) are relatively affordable and smaller, allowing the deployment of many network nodes in a small area(Rai, Kumar et al. 2017). Past assessments of various low-cost PM sensor models have shown encouraging outcomes when compared to Federal Equivalent Method (FEM) devices or high-quality research instruments(Zheng, Bergin et al. 2018). This study aims to check the quality, calibrate, and estimate the useful life of the LCS.

Analysis:

Calibration tests were performed using a reference device, Palas Fidas 200S, to evaluate the efficiency of LCS air quality sensors. Fidas 200S underwent gravimetric calibration using the Dekati PM10 Impactor following the ISO23210:2009 standard (ISO, 2009)(Tu and Olofsson 2021). The LCS Open Seneca, Tera NextPM st-urs, Sensirion Sen55, IQAir, and DB sensors were parallelly measured. Hourly average data was utilized for the data analysis, employing a no-intercept linear regression approach.

Conclusions:

The key findings of this study highlight the necessity for evaluating the quality of each type of LCS due to substantial differences observed in R-square values when compared to the reference instrument. Due to the considerable variation between instruments, we also need to calibrate each LCS individually. Additionally, differences in measurement values between two locations underscore the need to conduct thorough sensor calibration across multiple subway platforms, each characterized by humidity, particle size and concentration conditions.
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References:

Chang, L., W. T. Chong, X. Wang, F. Pei, X. Zhang, T. Wang, C. Wang and S. Pan (2021). "Recent progress in research on PM2.5 in subways." Environmental Science: Processes & Impacts 23(5): 642-663.

Rai, A. C., P. Kumar, F. Pilla, A. N. Skouloudis, S. Di Sabatino, C. Ratti, A. Yasar and D. Rickerby (2017). "End-user perspective of low-cost sensors for outdoor air pollution monitoring." Science of The Total Environment 607-608: 691-705.

Tu, M. and U. Olofsson (2021). "PM10 in underground stations from different types of trains." Transportation Research Part D: Transport and Environment 95: 102867.

Zheng, T., M. H. Bergin, K. K. Johnson, S. N. Tripathi, S. Shirodkar, M. S. Landis, R. Sutaria and D. E. Carlson (2018). "Field evaluation of low-cost particulate matter sensors in high- and low-concentration environments." Atmos. Meas. Tech. 11(8): 4823-4846.