

Subject

Determination of the vibro-acoustic behavior of a railway track using a WFE method

Recommended grade

Master (M2)
 Master (M1)
 Ingénieur
 Licence
 Bac + 2

Required skills

Vibration, Sound radiation, Numerical methods, Matlab, Actran

Description

Context. The subject is part of research focused on reducing noise emissions emitted by railway infrastructures. In a wide range of rolling speeds, the main contribution of rail-bound vehicles is due to rolling noise. This noise arises from vibrations initiated at wheel/rail contacts by wheel/rail surface irregularities. The track itself emits a significant proportion of the noise, due to the acoustic radiation of vibration waves propagating on either side of the excitations (cf. **Fig. 1**). Modeling the vibro-acoustic behavior of the track is thus necessary to estimate its noise contribution. Identifying and understanding the mechanisms responsible for noise can also help to propose mitigation solutions.

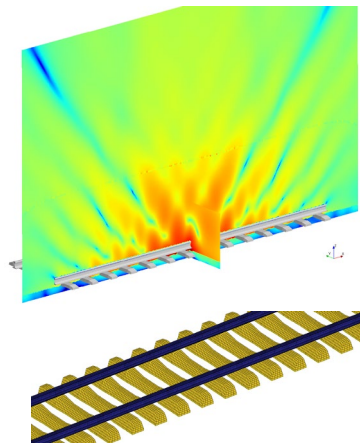


Fig. 1: Finite element model of railway track and radiated sound field

Scientific issues. At first approach, the track can be considered as an infinite structure, invariant in the longitudinal direction. Waveguide methods are therefore naturally suited to calculating its vibratory behavior. The SAFE¹ method, which combines a wave description in the longitudinal direction with a finite element discretization (FEM) of the cross-section, can be used to decompose vibrations on the basis of a sum of waves characterized by a frequency-dependent wavenumber and cross-sectional deformation that depend on frequency. However, this method requires a specific finite element formulation, which is rarely implemented in commercial codes. Furthermore, track structures are generally not invariant, but rather periodic. The WFE² method, based on Floquet's theory and finite element discretization of a complete cell (slice) of the periodic structure, seems more suitable. As regards acoustic radiation, the fluid medium

¹ Semi-Analytical Finite Element

² Wave Finite Element

being open, the BEM³ is very often used, but alternatives exist in the literature, such as infinite elements or PML⁴. In addition, a 2.5D approach, based on the wave decomposition of the exciting vibratory field, is often preferred, but always limited to a uniform, non-periodic geometry.

Objectives. The aim of the internship is to develop a frequency-domain vibro-acoustic model of railway track using a WFE method, including the calculation of acoustic radiation using PML. Unlike usual developments, the WFE will be implemented by directly searching for spatially periodic vibrational solutions for each wavenumber of the Floquet decomposition. One advantage of this approach is that it provides a clear truncation strategy, based on the range of excitation frequencies. Another advantage is that the method should make it possible to determine the acoustic radiation of the track while preserving the periodic geometry of the system. The vibration model will be implemented in Matlab using the SDT finite element toolbox. The acoustic radiation of a periodic slice will be calculated with Actran software at each wave number, then imported into Matlab for final recomposition. Validation by comparison with other methods will be proposed at each stage of development.

Location

- Uni Eiffel, Campus Lyon** (25, avenue François Mitterrand, Case24, Cité des mobilités, F-69675 Bron Cedex)
- Uni Eiffel, Campus Nantes** (route de Bouaye, CS4, F-44344 Bouguenais Cedex)
- Cerema – Strasbourg** (11, rue Jean Mentelin, Strasbourg-Koenigshoffen, F-67035 Strasbourg)

Duration (detailed dates have to be adapted)

Starting date:
End date:
Duration: 6 months

Contact

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Compensation

Indemnity equivalent to 15% of the (French) Social Security hourly maximum amount
<https://www.service-public.fr/simulateur/calcul/gratification-stagiaire>

³ Boundary Element Method

⁴ Perfectly Matched Layer