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Experimental characterization of the noise urban railway traffic in Porto metropolitan region

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Abstract

Exposure to transport noise is one of the greatest stress factors for populations living close to railway lines, affecting their health and well-being. The noise generated by rail traffic has several origins and the factors that influence it concern to the running speed, the track type and the track and rolling stock defects. This article aims to characterize the noise generated by light railway traffic in the Porto metropolitan region. Several measurements were performed in places with different track characteristics and traffic conditions. The final aim is to understand and characterize how the different types of track that make up the network contribute to this phenomenon.

Keywords: Railway noise, Noise characterization, Measurements, Different tracks.

1 Introduction

Rail transport is the most sustainable type of transportation, exhibiting the lowest energy consumption and lowest carbon footprint when compared to air and road transport. However, the noise generation can be faced as one of its major drawbacks, being imperative the development of innovative and efficient solutions for noise mitigation to ensure the environmental viability of expanding such mode of transportation.

The report “Railway Noise in Europe” [1] analyses the perception of population exposed to noise from different sources, as shown in Figure 1. Naturally, the vast majority of situations are associated with road noise but, as can be seen, railway noise does not play a negligible role (see Table *1*).

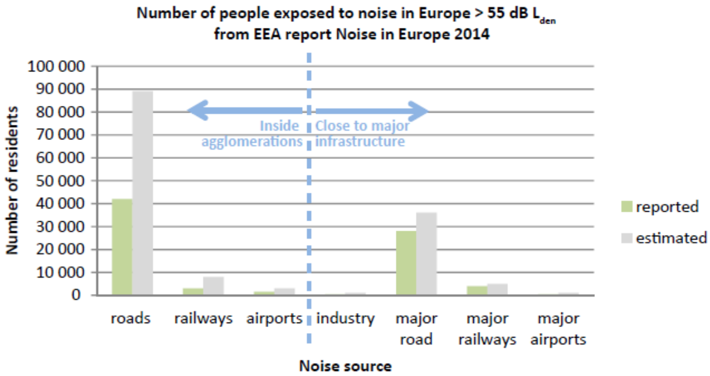


Figure 1 - Number of persons exposed to noise exceeding 55 dB - adapted from [1].

Noise exposure class L_{den}	Road noise	Railway noise
55-60 dB	46 %	46 %
61-65 dB	32 %	29 %
66-70 dB	16 %	18 %
> 70 dB	6 %	8 %

Table 1 - Percentage of population exposed to different noise levels - adapted from [1].

With regard to various noise levels, studies performed in the vicinity of European railway lines show that are a significant percentage of people living in regions with concerning noise levels. Noise above 55 dB is considered as noise pollution. If noise above this level lasts for an extended period of time, the efficiency and well-being of a person will be reduced. Noise in the range 65 to 75 dB causes stress to the body, which in limit situations can lead to arterial or cardiovascular disease and myocardial infarction [2].

In order to find railway noise mitigation measures it is necessary to characterize the noise produced by rail traffic in urban environment. In order to do this task realistically, it is imperative to perform experimental characterization of the noise levels generated by train passage.

This characterization allows the identification of the noise level and the frequency content, essential for the definition mitigation solutions such as noise barriers. Moreover, it allows a better understanding about the influence of the track type on the noise propagation. In this paper, the experimental characterization of the noise induced by train passage in different types of track is presented and discussed.

2 Methods

The experimental campaign was performed considering measuring places selected from the urban railway network of Metro do Porto. This railway infrastructure crosses densely urbanized regions, with potential impact on the living areas, on health facilities and on educational institutions.

The measurements were performed in different stretches of track: a) Type I, grass track; b) Type II, slab track; c) Type III – ballasted track; d) Type IV -Rail embedded in the pavement, as shown in Figure 2. The setup consists of four microphones. The closest microphone (M1) is placed at 0.8m from the outer rail, and the other microphones are placed at a distance of 1.5m from each other. Microphone M1 is placed at ground level, the height of the second microphone was set at 0.5m high, and the others placed at 1.5m high, as shown in Figure 3.

Type I Type II Type III Type IV

Figure 2 - Representation of the types of tracks and the setups in the field

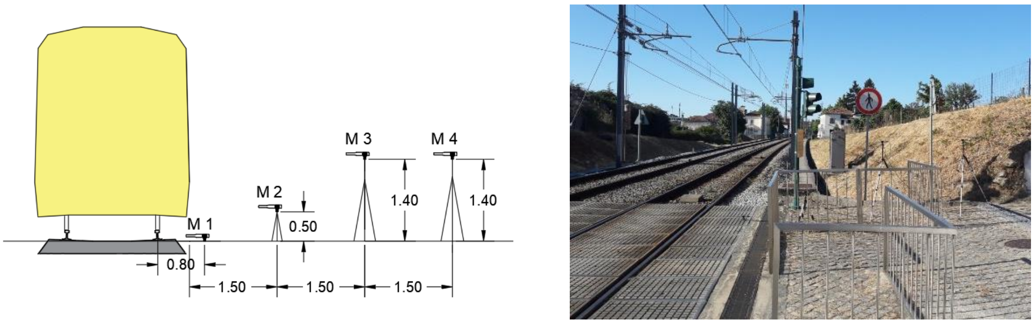
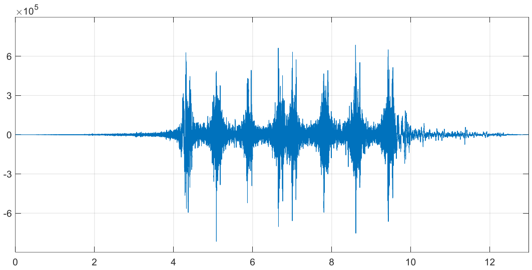


Figure 3 - Example of one of measurement sites

Figure 4 shows an example of the time record of sound pressure measured. The signal processing was performed with a matlab toolbox, ITA-Toolbox [3].

a) 

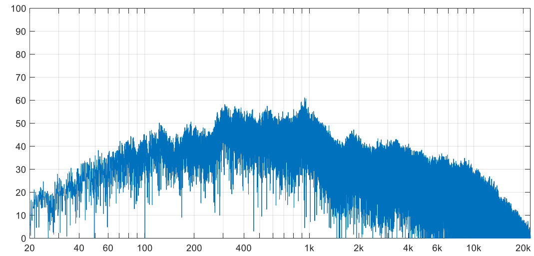
b) 

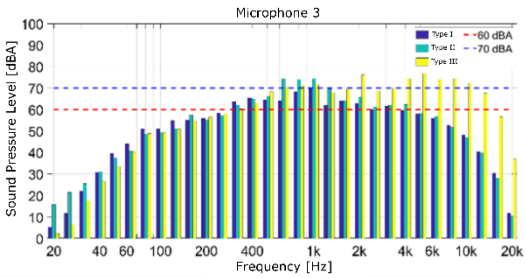
Figure 4 - a) - Example of a time domain registration for passing a vehicle; b) - Example of a record in the frequency domain, corrected by filter A.

3 Results

The results presented relate to the same type of vehicle with similar speed and although they have an influence on the measured noise level, the major difference is due to the type of track. In Type I, the rails embedded in the grass, part of the energy is absorbed by this material. In Type III, the slab track is essentially reflective, the material has no capacity to absorb energy and thus the noise level that achieves the receiver is larger. The results in the Figure 5 refer to a running velocity of about 42km/h.

When analyzing the SPL in one-third octave band frequencies, a A-weighting filter was applied to reflect the response of the human ear to noise. Observing the presented results, it is clear that the frequency content of the measured signals is most significant between 200 Hz and 4000 Hz. It is also clear that some differences are registered between the various routes for similar speeds, as a result of the energy being absorbed by the different materials. Particularly in Type II analysis, sound pressure values are lower compared to Type III, although there is a higher peak specifically in three frequency bands which can be explained by the dynamics of the track which amplifies the signal at these frequencies.

To further analyse the effect of different track types, it is clear that the Type II track leads to reduced SPL, due to the presence of the ballast. This effect is visible throughout the frequency range, but particularly significant above 3150 Hz, where a deep reduction of the sound pressure level is registered.

a) 

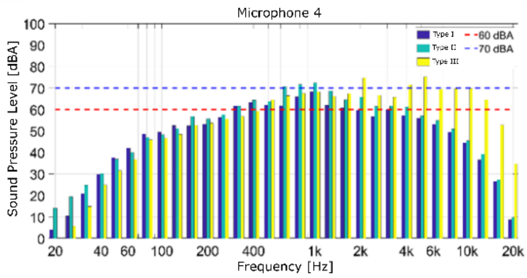
b) 

Figure 5 - Sound pressure level for different tracks.

The Figure 6 compares the SPL measured for the same track (Type II) and for different velocities. In this comparison, it can be noted that although an overall increase in the sound pressure levels occur throughout the analyzed range, this increase is more significant in the lower (up to 400 Hz) and higher (above 2kHz) frequency bands.

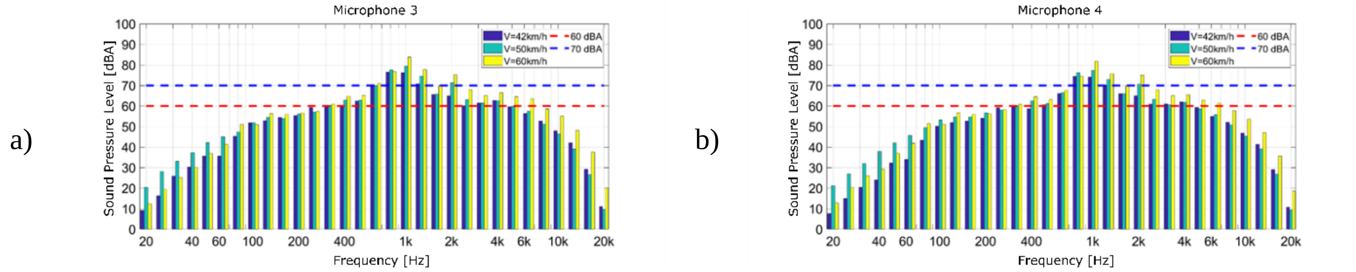


Figure 6 - Comparison of registered SPL for the same track and different velocity.

Figure 7 shows the SPL for the track Type IV, for similar running velocity (23km/h). In this case it can be observed that in the whole frequency range the SPL is up to 10dB higher in the case of the curved track compared to the straight track.

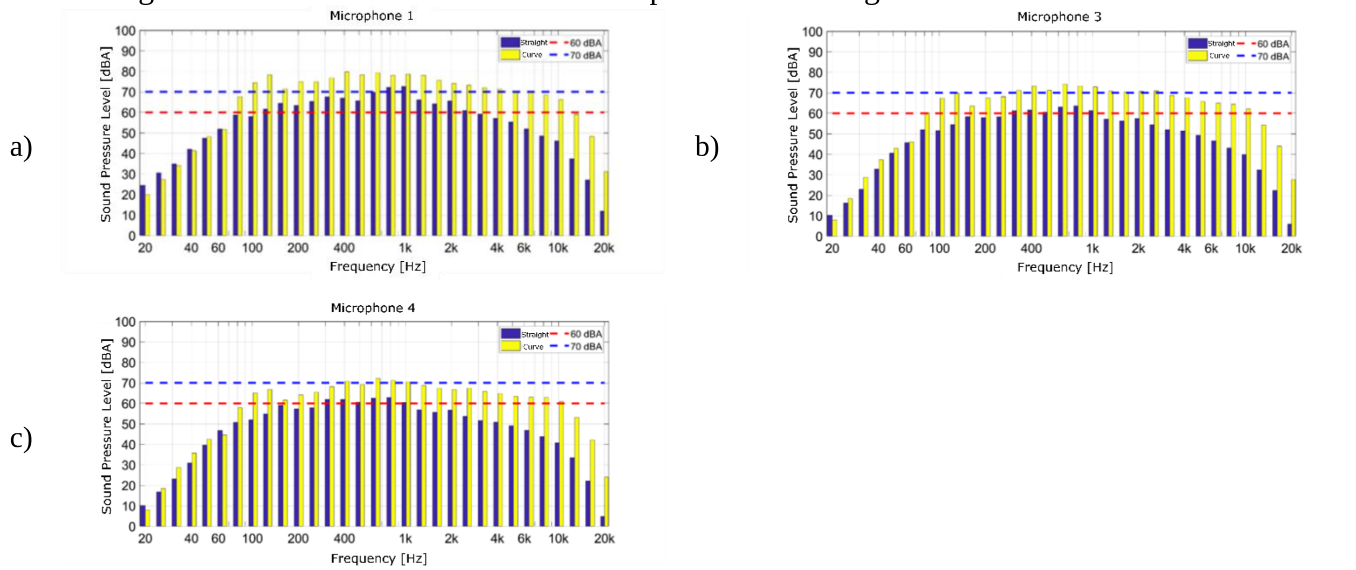


Figure 7 - Comparison of registered SPL for different track geometries.

4 Conclusions and Contributions

From the analysis of the results it is clear that, even slightly, the results exceed the values defined as tolerable to the human ear. However, this situation will be worse in places where the circulation speed is higher.

It can be seen that the noise emitted by circulating railway vehicles can be a problem for the population and should be treated with special attention, and the development of modern modes of rail transportation, which produce less noise impact on the urban environment must be a priority.

The present work aimed at contributing to the knowledge about the emitted noise by low speed railway vehicles by presenting a set of preliminary results about the experimental characterization of rolling noise in different environments. The

presented results, besides contributing to understand how the different types of tracks influence the final integrated solution, allow understanding the noise levels to which the resident population in areas close to railway tracks is subject.
It should be noted that this is also an essential step to validate the numerical models used simulate railway emitted noise, and also for the definition of possible mitigation measures, since understanding the frequency content is of utmost importance to correctly design these measures.

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FCT Fundação para a Ciência e a Tecnologia

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