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On railway noise modelling - an approach to the european interim method

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Railway noise results from a number of sources, with airborne and structure borne transmission mechanisms being responsible for the noise radiation and propagation. The European Directive 2002/49/EC requires the drawing of noise maps for areas near major transport infrastructures. The Portuguese Noise Act of 2007 further requires the drawing of noise maps for all transport infrastructures. This paper reports on our experience on noise mapping of the major Portuguese railway lines. The interim calculation model RMR96/SRMII, recommended in Directive 2002/49/EC, was adopted for the prediction of the railway noise, where a 1/1 octave band noise spectrum curve fitting approach was followed. Details on the implementation, adaptation and validation of the calculation procedure are reported. Emphasis on the required data such as train categories, superstructure, and speed profiles will be given. Examples and results for a number of major railway lines will be presented.

1 Introduction

The train has been part of the European landscape for many decades. Railway noise is, thus, a part of the soundscape in most countries.

Noise from railways can be particularly relevant in urban or suburban areas, especially near residential areas. Although there is a sympathetic view in the perception of train noise, when the noise levels are too high or have a narrow band contents, such as with freight or high speed trains, nuisance can be very important. With the development of railway transportation in the recent decades, railway noise became a serious issue.

Reliable railway noise prediction methods are then called for, to assess the impact of new lines, to develop new vehicles, and to study and develop noise abatement measures. They are also used in noise mapping to assess the noise situation in large areas.

The new European Noise Policy, following the publication of the 1996 Green Paper, led to the publication of the Environmental Noise Directive (END) 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise [1]. This is an instrument that requires agglomerations and large transport infrastructures to draw noise maps and action plans. This Directive has been transposed to all Member States. Some of these, such as Portugal, have passed legislation that requires that the noise mapping work applies to most urban areas and transport infrastructures [2]. The railway authorities are the bodies responsible for undertaking the noise mapping work. The Directive recommends what calculation methods should be used for each type of noise source, namely railway. The Dutch RMR method is recommended as an interim calculation method for those countries that have not adopted a national method. Studies are being developed, within the scope of the European Commission, to set up a harmonized calculation method for all major noise sources. This work is being overviewed by the EU Noise Policy Working Group Assessment of Exposure to Noise (WG-AEN).

The general use of the RMR method has proved difficult, since the railway vehicles, contrary to road vehicles, are usually quite different in every country and the RMR method includes a very specific database with a limited number of vehicle classes corresponding to the Dutch trains. New classes can be added, though, by means of noise measurements and appropriate procedures are included. The WG-AEN has issued a "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data" [3] that sheds some light on such issues, as well as on many others. However, the use of the method still offers a high complexity. Some countries, such as Spain, developed some work to show the difficulties of the necessary measurements to adapt the method. The Portuguese Environmental Agency, recognising the difficulty, requires that the END recommended interim methods are used, except for railway noise, where equivalent methods can be used. This is a provision also stated in the END, although no definition for equivalence is included. The WG-AEN work on this issue has not been conclusive.

2 Railway Noise Predictions

Railway noise results from a number of sources, the railway vehicle body itself, the rolling movement, the track and from interaction between the track and the vehicle body. The dynamics of the whole system determines the noise levels that are received. Airborne and structure borne noise transmission mechanisms are present.

A reliable and comprehensive prediction method must include all such factors.

Figure 1 shows a sketch of the typical dependence of the major sources of railway noise on the train speed.

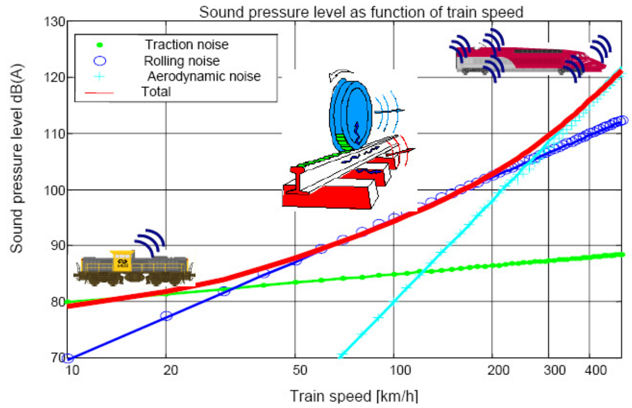

Fig. 1 Railway exterior sound sources and typical dependence on train speed [4]

The Acoustics and Noise Control Group at CAPS-IST, Lisbon Technical University, has been working on railway noise for some time. A railway noise prediction program, FERR, was developed from first principles, which contains data on all Portuguese railway vehicles and is adapted to the national railway situation. The latest version, FERR3, was updated during 2006, under contract with the national railway authority. A large number of measurements were conducted to determine emission reference values for all types of vehicles under different conditions of speed and number of wagons. Although the model accounts for ground and air absorption, it is not well suited, at the present stage, for noise mapping purposes.

The Group has been drawing noise maps for the Portuguese major railways. A new approach for the use and adaptation of the RMR method was attempted. The objective was to set up a relatively simple and inexpensive technique, if the RMR was to be followed. This method is interesting in the sense that the propagation algorithm is quite flexible, allowing for a vast number of corrections and adjustments to account for the different acoustical effects found in real situations. Other simpler prediction algorithms do not allow the specification of the propagation path with so much detail. Therefore, the resulting accuracy will suffer accordingly. This seemed an upfront advantage of using the RMR calculation method.

The first stage of the approach consisted on a programme of measurements of pass-by noise. These were carried out for each type of train vehicle and for different speeds. Recordings of L_{Aex}, of L_{max}, and of 1/3 octave band spectra were made. An averaging technique was followed, by using samples for different passages of the same type of vehicles, under similar conditions.

The 1/3 octave band reference spectra for the different vehicle classes in the RMR database were drawn, for the same conditions. These curves were calibrated for the measured overall noise values. A curve fitting procedure was then followed to find the curve (train class) that best fitted the measured one.

Figure 2 shows a curve fitting for a type of suburban train. The measured 1/3 octave spectrum is shown together with the curves corresponding to different RMR classes.

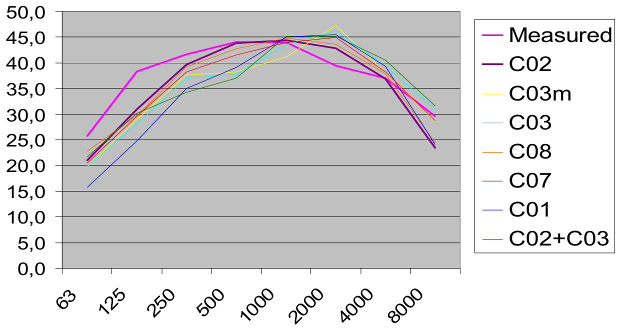

Fig. 2 Curve fitting for a type of suburban train

Figure 3 shows the measured curve for a type on intercity train, together with those of different RMR classes.

This curve fitting procedure was pursued for all types of trains and conditions, to determine the emission values.

Corrections were made, from visual inspection, for track types, namely long welded or with joints, and conditions, such as rail roughness.

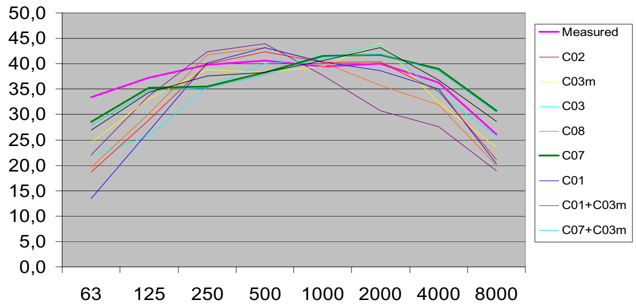

Fig. 3 Curve fitting for a type of intercity train

Further corrections and calculations included special conditions, such as curve noise. Situations of low frequency and squeal noise were identified in the noise measurements.

Figure 4 shows the noise spectra of similar sections of the same railway line with and without curve noise. A marked increase in energy in the lower and in the middle frequency bands can be observed. Overall, an increase between 4 and 5 dB could be measured.

Calculations were then performed using the method's SRMII algorithm.

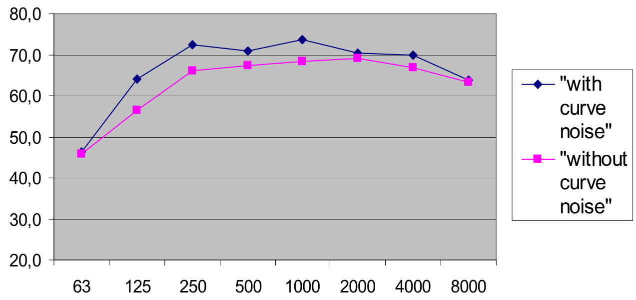

Fig. 4 Curve noise effects

3 Discussion

The 1/3 octave band spectrum curve fitting approach was followed, until now, for three major railway lines. In all cases, a very good agreement was found between measurement and calculations. Local deviations were rarely found to exceed 3 dB, with typical values observed well below 2 dB.

These results validate the procedure described, allowing the RMR to be used in most railway lines without following a complex and expensive measuring programme to determine emission values. This simple curve fitting approach does not preclude, however, the measurements recommended both in the method and in the Good Practice Guide. These should be followed if an accurate and detailed determination of the emission values of the different noise sources is required.

The approach described above is simple, accounts for the various intervening factors and mechanisms in noise radiation and propagation and can be adopted for strategic noise mapping purposes and for the studies necessary to develop noise abatement measures.

4 Acknowledgements

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References

[1] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, published 18.7.2002, L189/12-25 (2002).

[2] Portuguese Noise Act, Decree-Law 9/2007, of 17 January (2007); Noise Pollution Act, Decree-Law 292/2000 of 14 November (2000).

[3] Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure, version 2 (13 January 2006).

[4] Position Paper on the European strategies and priorities for railway noise abatement, Working Group Railway Noise, European Commission (2003).