Reduction of noise of railway steel bridges with tuned absorbers on rail

Franck POISSON[1], Olivier COSTE[2]

[1]*SNCF - Direction de la Recherche, 45 rue de Londres, 75379 PARIS cedex 08, email : franck.poisson@sncf.fr*
[2]*SIGNAL DEVELOPPEMENT, 17 rue Albin HALLER, 86000 POITIERS, email : olivier.coste@signal-dev.fr*

INTRODUCTION

Most of railway steel bridges produce much more noise than a ballasted track. Located in populated area, they may generate annoyance for the population. Specific noise reduction solutions must be developed. A research program has been started by the French railway company SNCF for Réseau Ferré de France to deal with this problem.
The aim of this project consists in develop a methodology based on measurements and/or simulations to choose the best solution to reduce the noise of a given steel bridge.

A GLOBAL APPROACH

The first step of the study concerns the selection of a test bridge. The Gavignot bridge in Enghien les Bains (see figure 1) is representative of the bridges of the French railway network and its structure is one of the noisiest [1,2].

Figure 1: steel bridge GAVIGNOT selected for the study

The rail fastening system is representative: rail is supported by wood sleepers (or longitudinal sleepers) directly fastened on the steel deck plate (see figure 2).

Figure 2: rail supported by sleepers or longitudinal sleepers

As a first step of the study, a measurement campaign is carried out to localize on the whole frequency band the sound pressure level (SPL) increase due to the bridge. Then, the noise radiated by several passengers trains is measured in front of the bridge and few hundred meters far from the bridge on a ballasted track. Differences between SPL are presented on figure 3.

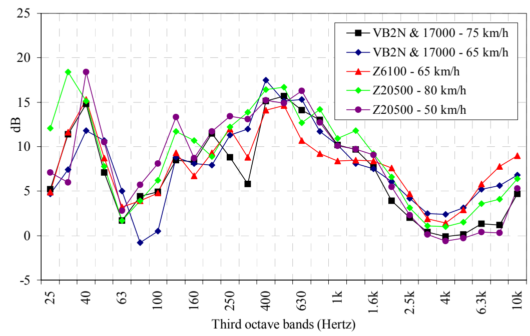

Figure 3: spectrum of the sound pressure level increase due to the train pass by on the test bridge GAVIGNOT

The SPL rises up around 40 Hz and 400 Hz. The sound pressure level increase in dB(A) is mainly due to the high frequency energy but the lower part generates annoyance too, by causing the windows to vibrate.
Then, the simulation of the vibroacoustic behavior of the bridge must be conducted on the whole frequency range. The finite element method is used below 200 Hz and the statistical energy analysis (SEA) in the higher frequency band.
The low frequency problem is presented in [3]. The deck plate radiates the main part of the acoustic energy around 40 Hz. Solutions exist and will be tested on the Gavignot bridge in 2004.

THE HIGH FREQUENCY PROBLEM

Up to 200 Hz, the SEA is used to predict the noise radiated by the bridge and identify parts of the structure which radiate the much more noise. The model is presented figure 4.

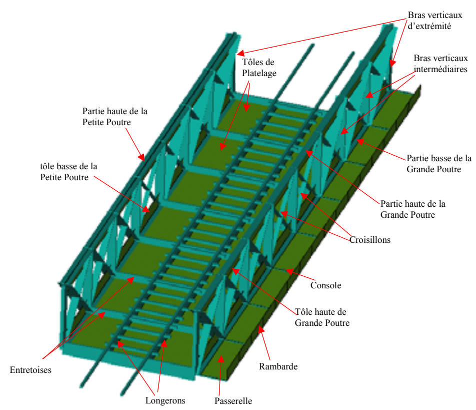

Figure 4: SEA model of the GAVIGNOT bridge

The bridge is built with plates and L corner beams. It is 18 meters long and 4 meters wide. Vibration and acoustic measurements have been used to optimise sub-systems parameters and simplify the model. The main parts of the structure used in the simplified model to simulate the pass-by noise radiation are the deck plate, the two longerons (longitudinal beams) and the cross beam.

The noise spectrum computed by the model is presented figure 5.

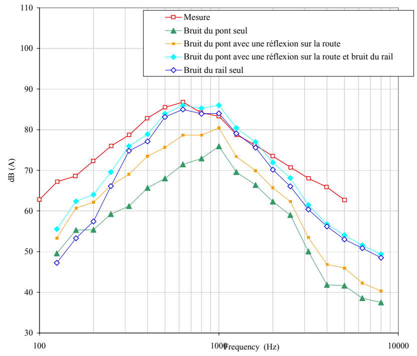

Figure 5: sound pressure level prediction for a Corail pass by (high frequency)

The noise predicted by the SEA approach (green line) is lower than the measured one (red line). Some measurements have been carried out to estimate the contribution of the site amplification (orange line). The rolling stock noise is much more difficult to estimate but the measurement of vibratory level of the rail during a train pass-by shows that the rail behavior is specific on the bridge. The decay rates of the energy in the rail on the bridge confirm this result. They are much lower than on a ballasted track (see figure 6).

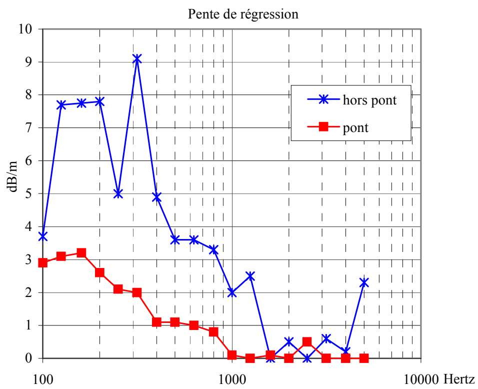

Figure 6: decay rates on the test bridge and on the track

If the rail is taken into account in the SEA model (figure 5, blue lines), it becomes the major source between 600 Hz and 1000 Hz which is responsible of the dB(A) sound pressure level. This result leads to dedicated noise reduction solutions like rail dampers.

THE TUNED ABSORBERS SOLUTION

Decay rates of the vibratory energy in the rail which are directly linked to the radiated noise are very low on the whole frequency band. Tuned absorbers which consist in adding a mass spring system to the rail offers the possibility to enhance the decay rates [4].

In this case, the objective is to maintain on the whole frequency band a decay rates around 3 dB/m, mainly around 1KHz to reduce the SPL in dB(A).
Examples of tuned absorbers for ballasted track are presented figure 7. Figure 8 shows how the decay rates are modified.

Figure 7: CORUS (left) and SOCITEC (right) tuned absorbers

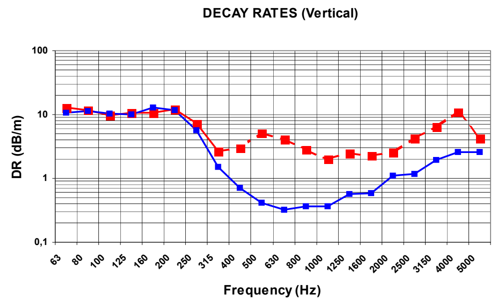

Figure 8: decay rates measured on a ballasted track without (blue)/with(red) tuned absorbers.

Using the Track Wheel Interaction Noise Software (TWINS), the impact of the decay rates modification on the noise radiated by the system is estimated. Due to the poor decay rates on the steel bridge, the expected efficiency of tuned absorbers is around 6 dB(A), that is to say, 1 or 2 dB(A) much more than on a ballasted track.

CONCLUSION

To confirm simulation results, tuned absorbers will be added to the rail of the Gavignot bridge in april 2004. SPL reduction and decay rates will be measured.
If its efficiency is validated, this solution may offer a good alternative to the noise barrier solution wich is around 2,5 times much more expensive.
In the same time, the SNCF homologates two tuned absorbers for ballasted track to complete its noise reduction solutions panel.

REFERENCES

[1] P. DINGS, “Measures for noise reduction on steel railway bridges”, Inter-Noise Budapest, 1997.
[2] J. G. WALKER, N. S. FERGUSON, M. G. SMITH, “An investigation of noise from trains on bridges”, JSV, 193(1), 1996.
[3] F. POISSON, L. DIELEMAN, “Noise of railway steel bridges: a complete study”, WCRR, 2003.
[4] L. GIRARDI, F. FOY, M. FUMEY, “Mise en voie d’absorbeurs dynamiques sur le rail pour la réduction du bruit de roulement”, Revue Générale des Chemins de Fer, octobre 2003.