Road Traffic Noise of Expansion Joints – Get a Grip on it

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Introduction

Expansion joints used in road traffic bridges can be a serious source of noise nuisance. This is caused by the impulsiveness of the sound of vehicles passing over the joints and sometimes the presence of low frequencies in the sound.

In the Netherlands large-scale application of low noise road surfaces creates a need for low noise expansion joints. Therefore Rijkswaterstaat has created a guideline to deal with noise of expansion joints. The goal is to avoid excessive noise problems by setting noise limits in contracts.

The approach in the guideline is based on existing calculation and measurement methods with which there is already considerable experience in the field of low-noise road surfaces. The application of these methods to the noise caused by expansion joints is new.

Traffic Noise Abatement

Since1988 traffic noise abatement around the highway road network in the Netherlands has led to large scale application of porous asphalt (PA 0/16 ~75% in 2008) and placement of noise barriers on locations with severe noise problems.

Porous asphalt results in around 3 dB lower noise levels. Since 2005 two-layer porous asphalt with a noise reduction of 6 dB is used on hot spots.

Figure 1: noise abatement measures.

To avoid noise complaints flexible plug expansion joints have been used in combination with the low noise road surface.

Expansion Joints

Expansion joints span the open space between the decking and the abutments on viaducts and bridges. They absorb movement caused by contraction and expansion from temperature variations.

Noise events due to vehicles passing over expansion joints can result in serious complaints from people living nearby the road. The noise is induced by the unevenness of the surface of the expansion joint itself and of the road surface before and after the joint.

Unevenness like step functions will result in impulsive noises of the tyres. Large unevenness can also lead to noises from the moving payload of freight trucks.

When the noise emission occurs from beneath the construction the noise is usually dominated in the lower frequency range.

The average lifetime expectancy of a flexible plug expansion joint is around 3,6 years which is much less than around 11 years for the porous asphalt road surface. The low durability leads to increased maintenance costs (20 M€ in 2001), traffic safety issues and traffic hindrance during repair works. This unwanted situation on the heavy trafficked network system created the demand for “durable” and “low noise” expansion joints.

Measurement method

The aspect of noise emission from expansion joints has not been issued on national level in the Netherlands or in Europe by EOTA WG 01.07/02 “Expansion Joints for Road Bridges”.

First problem thus was the lack of a harmonized measurement method for the evaluation of the noise emission of expansion joints. A literature study [1] showed that several methods for determination of the noise emission of expansion joints are used in EU member states.

In general the methods used resemble the Statistical Pass-By method for road surfaces (ISO 11819-1:1996) [2]. Deviations are the use of different measurement distance or microphone height. In the Netherlands a height of 5 meter is used for determination of the noise reduction of road surfaces [3].

Decision was to use the existing measurement method for road surfaces in the Netherlands, and add a measurement position beneath the bridge for evaluation of the noise emission there. Measurements were done on several bridges

to gather data and evaluate the method. Figure 1 shows a picture of the measurement setup.

Figure 2: Measurement setup with microphones above and below the bridge.

Results

The measurement result in figure 3 show increasing SPB noise levels for passenger cars at 100 km/h for a flexible plug joint, a nosing joint and a modular joint. The noise level ranges from 78 dB(A) to 89 dB(A).

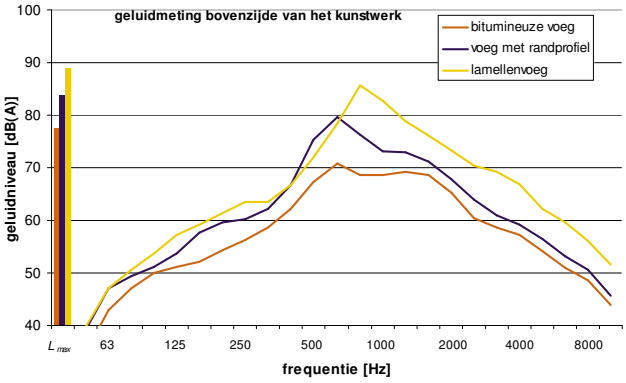

Figure 3**: SPB cars 100 km/h at 5 meters height above the bridge.**

Figure 4 shows the results of below the bridge, maximum noise levels for heavy trucks. Here the noise level is 65 for the flexible plug joint, and increases with more than 10 dB for the other joints. The increase in noise level is dominated by low frequency noise at 500 Hz and 125 Hz.

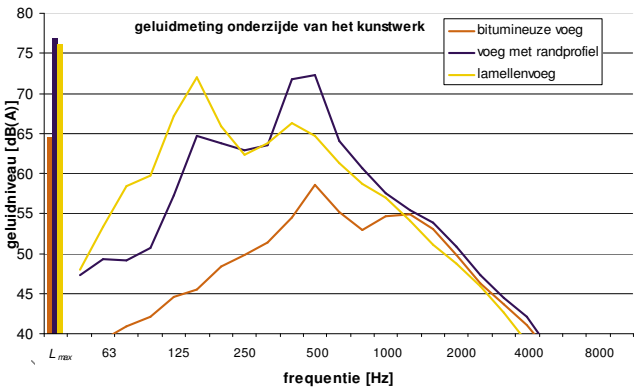

Figure 4**: LA_max for heavy trucks below the bridge**

Guideline NBD 00401

Based on the preliminary measurements in 2006 a Rijkswaterstaat Guideline [4] was written that consists of a description of the measurement method and the calculation method for requirement values for "low noise" expansion joints. The guideline is used in contracts to prevent the risk of "noisy" expansion joints.

The definition of "low noise" is based on the general approach for maximum noise levels in the assessment of environmental noise [5]. It is to be expected that maximum noise levels exceeding the average equivalent noise level more than 10 dB(A) will cause increased noise complaints. Also a penalty of 5 dB has to be applied to the noise level when impulse noise is detected in the assessment of environmental noise. Secondly maximum noise levels over 65 dB(A) at night time are only acceptable when technical measures have been applied according to the ALARA principle "As Low As Reasonable Achievable".

The noise of a expansion joint will depend on the position of the receiver. This is shown in figure 5. Close tot the joint (3) the absolute noise level will be the highest. At larger distance along the road (1,2) the joint can be heard well.

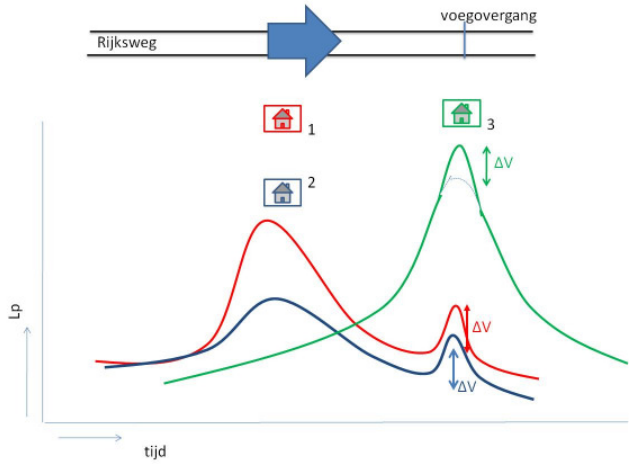

Figure 5**: Noise profiles for dwellings at different locations.**

For the noise of expansion joints this has been interpreted in a way that the normal soundscape caused by road traffic passing by should not be negatively affected by the expansion joint. The definition "silent" is therefore based on the noise emission of vehicles on the "low noise" road surface. On top of that the 5 dB penalty for impulsive noise is used as a limit value for the increase of the maximum noise levels.

The limit values above and below the bridge deck are defined as;

- Passenger cars (above)

SPB (joint) < SPB (surface) + 5 dB (1)

- Heavy trucks (below):

LA_max (joint) < LA_max (surface) - 10 dB (2)

For porous asphalt 0/16 in the Netherlands system for road surfaces this results in values like:

- Passenger cars (above) :

SPB (joint) < 78 + 1 - 3 + 5 dB = 81 dB at 100 km/h

- Heavy trucks (below):

LA_max (joint) < 85 + 1 - 3 - 10 dB = 73 dB at 80 km/h

Classification

Since the NBD 00401 Guideline was published measurements have been done on several types of expansion joints [6]. In figure 6 the results show a range of about 15 dB between the lowest and the highest sound levels. For separate classes the range is about 5 dB. This showes that classification of the noise of expansion joints is possible. Within the open European market this also creates the possibility of product labeling.

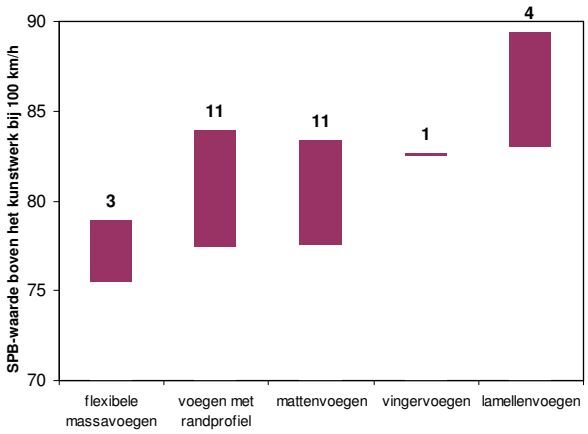

Figure 6**: SPB values for passenger cars at 100 km/h on flexible plug joints, nosing joints, mat joints finger joints and modular joints.**

For large bridges with large dilatation capacity application of modular joints is inevitable. Figure 6 shows that the limit value of 81 dB in the NBD guideline cannot be met, not even with a low noise cantilever joint. Therefore is the case of modular joints the ALARA principle has to be applied.

Innovation

In the end of 2007 Rijkswaterstaat started a contest for "silent & durable expansion joints" with the goal to support product innovation. The contest started with 16 competitors who did send in a proposal that was evaluated by a jury of experts. The result was that 10 products were selected for further evaluation on durability of the construction with a FEM study. Based on the evaluation a final selection was done on 4 products, all reinforced flexible plug joints.

In 2009 the finally selected products will be tested further and evaluated on durability and noise emission.

The joints will be tested in a laboratory stand called LINTRACK at the Technical University in Delft.

Secondly the joints will be build in a small concrete bridge in the A50 near Nistelrode. Construction is planned at the end of april 2009. The joints will be monitored for a period of at least 2 years.

Figure 7: the A50 test site at Nistelrode

Conclusions

The Rijkswaterstaat Guideline on noise of expansion joints NBD 00401 provides a system to prevent unacceptable noise annoyance situations.

The system in the guideline consists of

- a measurement method that is adopted from the already standardized SPB-method for road surfaces (ISO 11819-1)
- proposes a way of setting limits to the noise emission levels of expansion joints to be used in contracts

Innovations on flexible plug joints are generated in the contest "silent & durable expansion joints". Final results of a testing program on 4 products are expected in 2011.

As result of the Guideline a future European approach is possible with:

- measurement method to be accepted in EOTA
- product labeling

References

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