Measurements of the Effectiveness of Measures for Reducing Low Frequency Noise of Railway Bridges

Manfred Liepert, Alexander Martens

Möhler + Partner Ingenieure AG, 80336 Munich, Germany, Email: info@mopa.de

Introduction

In the context of the "Konjunkturprogramm II" different types of innovative technologies for noise abatement against railway noise were tested under on-site conditions. Amongst these technologies were:

- rail dampers
- rail lubrication
- foaming of ballast
- reduction of bridge noise
- lubrication for retarders
- low noise barriers
- high speed grinding
- sub ballast mats
- padded sleepers
- coated rails etc.

The noise reduction of these technologies was determined by measurements before and after the installation of the measures.

In the following measurements of three different types of bridges using different technologies are presented. In case of bridges both, the raised noise emission of the bridge and the effect of the noise abatement measures are evaluated.

According to the draft of new Schall 03 [5] following correction factors for bridge noise (in comparison to ballasted track) are of interest:

Type of bridge	Correction factor for bridge noise: K_{Br}	Correction factor for noise reducing measures: K_{LM}

Table 1: Correction factors according to the draft of the new Schall 03 [5]

Scope of the measurements

A general measurement method was developed by DB Systemtechnik [4] in order to quantify effectiveness of innovative noise abatement technologies. These measurement methods are based on a comparison of measurements before and after installation of the technologies accompanied by reference measurements in nearby sections without change.

The slight different measurement method for measures against bridge noise is described in detail in the presentation by Dorothee Stiebel of DB Systemtechnik at DAGA 2012 [2]. An overview of the measurement positions and the date of the measurements is given in the following figure:

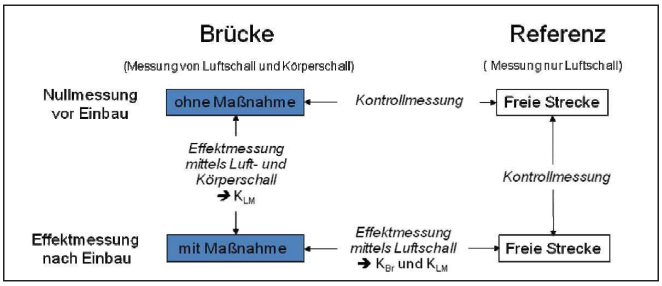

Figure 1: Measurement procedure for bridge noise (by DB Systemtechnik [4])

The measurement method for airborne noise was conducted according the ISO 3095 [2] method with microphone positions at a distance of 7.5 m to the middle of the track. As acoustical value the transit exposure level (TEL) is determined in third-octave bands. For the evaluation of noise reduction of bridge noise additional measurements of vibration on different parts of the bridge construction are conducted.

As a result of the measurement procedures the correction factors K_{Br} and K_{LM} as shown in table 1 can be retrieved. Because of the annoying effect of low frequnency bridge noise all these values are given as non-weighted noise levels.

Types of Bridges and tested Noise abatement measures

In the draft of the new german calculation method Schall 03 2006 [5] four different types of bridge constructions can be distinguished:

- Steel bridges
- Steel bridges with ballasted track
- Concrete bridges
- Bridges with slab track

In the presentation the measurements and the results of the following three types of bridges will be shown and discussed:

Passau Innbrücke	steel bridge (track directly on the steel-construction)
Winterhausen	replacement of a steel bridge by a concrete bridge
Leipzig: Linkelstraße, Pittler Straße, Dortmunder Straße	steel bridges with ballasted track

Table 2: Bridges and noise abatement measures

Results

Dampening of a steel bridge

In 2010 the steel bridge over the river Inn in Passau was dampened. The rail on the bridge has been fastened on wooden sleepers that were directly placed on the steel construction of the bridge.

Figure 2: Passau Inn bridge

As noise reduction measures the following technologies were installed in three steps:

1st measure	Highly elastic rail fastening, renewal of grids
2nd measure	Noise barriers as railings
3rd measure	Rail damper

Table 3: Noise reduction measures on the Inn bridge

The installation of these measures was done at three different times of the year so that there was enough time to do measurements between each installation. The effect of each measure could be determined separately.

Figure 3: Highly elastic rail fastening (left), noise barrier (middle) and rail damper (right)

The result for the noise reduction of freight trains is shown in figure 4. The figure illustrates the transit exposure level as an average over at least 15 pass-byes of freight trains in speed range of 40 km/h ± 5 %. The values are given as differences between the measurement point of airborne noise on the bridge and the measurement besides the bridge. All values are discriminated in third-octave bands.

The red line represents the bridge noise without any measure, the green line represents bridge noise after installation of the highly elastic rail fastening (effective at low frequencies), the blue one after construction of the noise barrier as railing (effective at high frequencies) and at last the yellow line after installation of the real dampers (effective in the mid-frequency range).

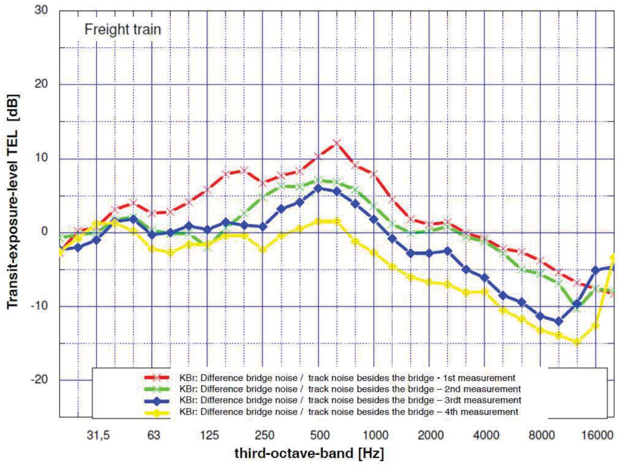

Figure 4: Noise reduction after installation of each measure

Assuming that A-weighted levels are not adequate for predicting annoyance of bridge noise the correction factors for bridge noise are given as non-weighted levels.

The resulting correction factors for pass-byes of freight trains (averaged over both tracks) are given in the following table:

	Correction factor for bridge noise	Correction factor for noise reducing measures
	K_{Br}	K_{LM}
Without measures	7,8	-
Highly elastic rail fastening		-3,8
Noise barriers		-1,0
Rail damper		-2,1

Table 4: Correction factors for *freight trains*, averaged over both tracks of the bridge

The correction factors given in table 4 slightly differ from those given in the final report of the "Konjunkturprogramm II" [3], because in this presentation the corrections factors are determined only based on freight trains, whereas other trains are disregarded.

Replacement of a steel bridge

In Winterhausen a two track steel bridge was completely replaced by a concrete bridge with embedded rail on both sides:

Figure 5: Winterhausen steel bridge

In one side of the bridge an additional noise barrier as railing was installed.

Figure 6: Concrete bridge with embedded rail

The resulting correction factors for pass-byes of freight trains (separated for both tracks) are given in the following table:

	Correction factor for bridge noise
	KBr
Steel bridge (track 1)	9,7
Concrete bridge	4,3
Steel bridge (track 2)	8,0
Concrete bridge with noise barrier	0,2

Table 5: Correction factors for *freight trains*,

Dampening of steel bridges with ballasted track

In the city Leipzig three steel bridges with ballasted track were dampened by installing under-sleeper pads in the first step and bridge dampers in the second step.

Due to adverse circumstances at these bridges (e.g. curve squeal) the results for one of the three bridges is given as an example for possible noise reduction in case of steel bridges with ballasted track in the following table:

	Correction factor for bridge noise	Correction factor for noise reducing measures
	K_{Br}	K_{LM}
Without measures	7,8	
Under-sleeper pads + Bridge Dampers	3,4	-4,3

Table 6: Correction factors for *freight trains* for one of the tested bridges

Figure 7: Steel bridge with ballasted track in Leipzig, Pittlerstraße

Conclusions

Summarizing the results of the measurements an overview of measured bridge noise and possible noise reduction is given in the following table:

	Correction factor for bridge noise	Correction factor for noise reducing measures	Measures
	K_{Br}	K_{LM}	
Steel bridge (Passau, Winterhausen)	8-10	-6	Highly elastic rail fastening, noise barriers, rail dampers
Steel bridge with ballasted track (Leipzig)	8	-4	Under-sleeper pads, bridge dampers
Concrete bridge (Winterhausen)	4	-4	additional noise barriers

References

[1] Innovative Maßnahmen zum Lärm- und Erschütterungsschutz am Fahrweg; Schlussbericht DB Netze; 15.06.2012

[2] Dr. Stiebel, D.: Lärmminderung an Eisenbahnbrücken – Messkonzept zur Ermittlung von Einfügedämmungen und Korrekturfaktoren. DAGA 2012 Darmstadt

[3] DIN EN ISO 3095, Bahnanwendungen – Akustik – Messung der Geräuschemissionen von spurgebundenen Fahrzeugen, November 2005

[4] 08-P-6835-TTZ112, Mindestanforderungen an Nachweismessungen zur quantitativen Bewertung von infrastrukturbasierten Innovationen zur Minderung des Schienenlärms, DB Systemtechnik 15.07.2010

[5] SCHALL 03 2006, Richtlinie zur Berechnung der Schallimmissionen von Eisenbahnen und Straßenbahnen; Entwurf, Stand: 21.12.2006