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NOISE EMISSION OF CONSTRUCTIONS FOR BRIDGE-TO-ROAD CROSSINGS

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1. INTRODUCTION

Bridges for road traffic are coupled to the road by bridge-to-road constructions (BTRC). This is done to cope with the thermal expansion of the bridge. Cars and lorries crossing the expansion gaps cause an excitation of the construction itself and of the vehicle tyres. At positions above the road surface the impulse noise of fast driving cars sounds like the slash of a whip. Neighbours living under a bridge often complain about the hollow beat caused by heavy lorries crossing the construction.
Numerous measurements have been carried out for a German manufacturer of BTRC, especially to investigate
- the noise emission from different construction types,
- the most important prameters for the sound emission, and
- means of noise control for reducing the impulse noise emission.

2. MEASUREMENTS

For describing the noise emission in the near field of a BTRC above the road, measurements of the sound pressure level (SPL) were carried out directly at and 25 m away from the BTRC. The microphones were placed always 1.5 m above the road surface and about 1 m from the border of the road. The maximum A-weighted SPL L_{AFmax} with the time constant „FAST" (125 ms) was evaluated for each passing vehicle.
Earlier measurements at different bridges using the general traffic [2] showed a standard deviation of the results between 3 dB and 6 dB. Differences between the sound emission of various BTRC lie within the corresponding error margin. Therefore, the measurements reported here have been carried out with test vehicles, i.e., always the same car and the

same lorry repeatedly passed the BTRC. In this case the standard deviation was less than 1 dB.
The increase in level L_{AFmax} at a BTRC - as compared to the normal road - was evaluated for various vehicle velocities. For the Test car with 80 km/h passing over mat-costructions, level differences between 3 dB and 5 dB were observed, at constructions with transverse steel beams between 6 dB and 9 dB. The level differences for the test lorry assumed values beween 2 dB and 6 dB in most cases.
Fig. 1 shows one-third-octave band spectra of the level L_{AFmax} measured at a BTRC with transverse steel beams and 25 m away for the test car at 80 km/h. In the frequency band centered at 800 Hz, the sound emission at the gap is much higher than that at the normal road.
Measurements under the gap close to the BTRC (0.1 m distance) and at some distance (more than 5 m) showed that the sound emission of the bridge construction itself is neglegtible in most cases.
From the measured levels L_{AFmax} the partial sound power levels L_{WAmax} have been calculated by adding the level of the measurement surface. These values describe the noise emitted in the upper and lower hemisphere when a vehicle passes the BTRC. Tab. 1 contains selected results for different types of BTRC.

Tabel 1: Maximum sound power levels L_{WAFmax} in dB re 1 pW of the sound emission of bridge-to-road crossings in the upper und lower hemisphere for test car and test lorry at 80 km/h.

bridge at river/location	type	vehicle	L_{WAFmax}, dB, upper hemisphere	L_{WAFmax}, dB, lower hemisphere
Inn/	Maurer D 400	car	109	85
Kraiburg		lorry	109	95
Donau/	Maurer DS	car	104	88
Donaustauf	400	lorry	112	98
Pilsach/	Maurer	car	106	93
BAB A3	Rollverschluß	lorry	-	103
Traun/	Maurer D 80	car	99	75
St. Georgen	B-Ü	lorry	108	81
Murr/	SHW-	car	107	83
Backnang	Transflex	lorry	107	92
	T 100/5			
Obere Argen/	Maurer DS	car	112	101
BAB A 96	1200	lorry	112	109

Measurements of structure-borne sound at the transverse steel beams showed the excitation of eigenfrequencies of the elements in the frequency range of 125 Hz and 180 Hz. The A-weighted velocity level measured directly under the BTRC showed a high correlation with the SPL below 125 Hz. However this frequency range is not relevant for the A-weighted SPL.
The major contributions to the overall SPL directly under the BTRC result from the frequency range above 315 Hz. This can be traced back to the dominant influence of the neoprene profiles between the transverse steel beams. Observations at a BTRC with transverse steel beams showed a 15 dB increase of the SPL under the BTRC in the frequency band from 400 Hz to 800 Hz after removing the dirt from the neoprene profiles.

3. NOISE CONTROL

The emission in the upper hemisphere can be attributed to the sound emission of the tyres. It can be supposed that the tyre is excited to vibrations by the discontinuities at the crossing from the road to the BTRC and emits the sound out of the wedge shaped air volume between tyre and road. Constructions have been investigated, which provide for a more continous rolling of the tyre.
After welding triangular or diamond shaped steel elements on the BTRC with several cross beams the noise emission could be reduced for the test car by 5 dB to 6 dB. The highest reduction was found by closing the extension gaps by elastic material. In this case, there was no significant difference between the measurement directly at the BTRC and 25 m away.
For reducing the sound emission underneath the BTRC, a simple enclosure was applied to the area near under the BTRC consisting of 200 mm mineral wool on 2 mm sheet metal. The reduction in sound power emitted in the lower hemisphere reached values up to 23 dB(A) for the test lorry.

4. SUMMARY

The results of the measurements at the BTRC quantify a theoretical model, describing the excitation of the tyres by the extension joints between the road and the following BTRC which results in sound emission with a maximum in the octave-band centered at 1 kHz. In the hemisphere under the bridge, the transverse steel beams in combination with the neoprene profiles between them radiate low frequency sound. To reduce the sound emitted in the upper hemisphere measures providing for a continous rolling of the tyre should be used. The hollow beat in the downward direction can be reduced by closing the area direct under the

BTRC with a common acoustic enclosure. At some distance of a BTRC the equivalent SPL of the continous traffic is just marginally higher than at locations without BTRC. The level L_{eq} isnot correlated with the reaction of people living close to a BTRC. To avoid additional annoyance, the level L_{AFmax} caused by the BTRC should be 10 dB below the level L_{eq}.

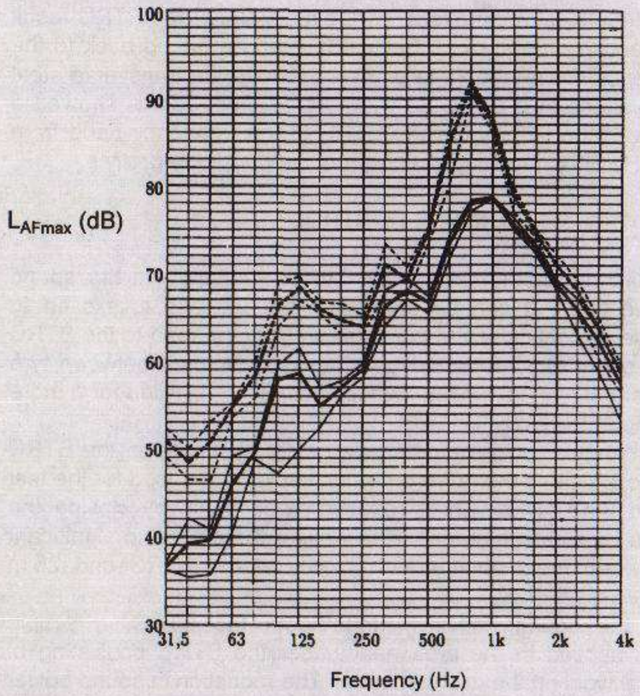

Fig. 1: One-third-octave band spectra of the maximum A-weighted SPL L_{AFmax} next to a BTRC with transverse steel profiles (------) and at a distance of 25 m (——), mean values and max-min values for the test-car, passing with 80 km/h.

References

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[2] G. Mosdzianowski, „Entstehung, Ausbreitung und Abschirmung von Straßenverkehrsgeräuschen durch Fahrbahnübergänge an Brücken (Untersuchungsabschnitt I)", Forschungsgesellschaft für Straßenwesen, Verkehrsführung und Verkehrssicherheit 3-26, 1992.