Phonobloc® rail track – in-situ tested low noise barriers in platform-design made of concrete

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Summary
The idea of a completely new and innovative product called Phonobloc® rail track was raised in 2012. The product uses the patented Phonobloc technology, which was developed by the Kirchdorfer Group within a FFG- and NÖ-funded research project. The main scope of the product concept was to develop low noise barrier elements, which on the one-hand should be placed as close as possible to the source of noise (wheel-on-rail contact), directly installed on the planum, and on the other hand should not complicate the maintenance process. From the very beginning the acoustic planning process was accompanied by psiacoustic. In a first step the acoustic effect of different types was investigated computationally within a feasibility study using simulations according to ISO 9613. To validate the results of the simulations, in-situ measurements were carried into execution at the Slovenian Railways near the village Njiverce by psiacoustic. The noise emission of the trains was measured by an acoustic railway monitoring system, so called acramos®. Additional to the pass-by levels, the third octave spectra of each train category were described and evaluated. However, the noise reduction of the A-weighted pass-by level, in dependence on the different train categories, distances and heights, could verified up to 6dB.

1. Introduction

Today noise barriers are the common method to reduce the impact of railway noise for the local population. However, the passengers as well as the residents near the railway tracks do not appreciate the in some cases severely limited sight that comes with the use of these barriers.
The idea of a completely new and innovative product called Phonobloc® rail track was raised in 2012. The product uses the patented Phonobloc technology, which was developed by the Kirchdorfer Group within a FFG- and NÖ-funded research project.
The main scope of the product concept was to develop low noise barrier elements, which on the one-hand should be placed as close as possible to the source of noise (wheel-on-rail contact), directly installed on the planum, and on the other hand should not complicate the maintenance process. From the very beginning the acoustic planning process was accompanied by psiacoustic. In a first step the acoustic effect of different types was investigated computationally within a feasibility study using simulations according to ISO 9613. To validate the results of the simulations, in-situ measurements were carried into execution at the Slovenian Railways near the village Njiverce. For these measurements, 80 Phonobloc rail track elements were placed for a length of 160m along the track.
This paper is focusing on the development of the product concept and on the comparison between the feasibility study using simulations according to ISO 9613 and the in-situ measurements.

2. Design concept

2.1. Material development

Currently used noise reducing devices made of precast concrete elements in the area of roads and railways consist of a structurally necessary load-bearing layer made of reinforced concrete, and a second layer on one or both sides for absorption. The innovation is that the developed lightweight aggregate concrete has sufficient load-bearing capacity to replace the conventional load-bearing layer. The entire layer at the same time meets the requirements of load-bearing capacity and acts collectively as a sound absorber, see Figure 1. In addition, the sealing-layer – mainly required for airborne sound insulation – may be used to design the backside-surface.

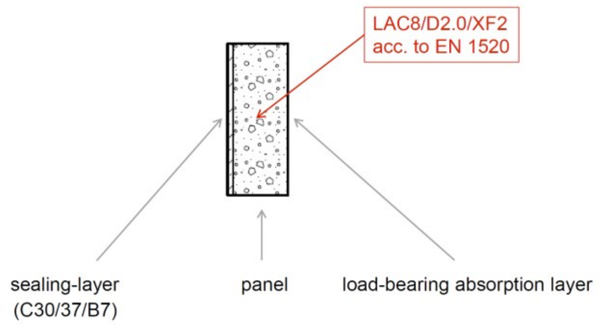

Figure 1. Innovative idea: merging of load-bearing and absorption layer.

2.2. Product development

Due to the specific characteristics of the Phonobloc-material it is possible to use it for a variety of products. An overview is shown in Figure 2.

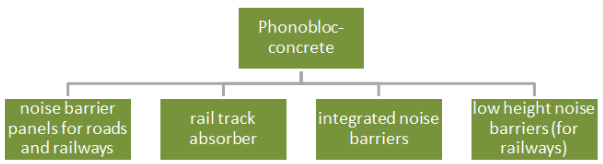

Figure 2. Phonobloc – product range.

The design concept of Phonobloc® rail track is based on the idea that the low noise barrier should be placed as close as possible to the source of noise (wheel-on-rail contact) – directly installed on the planum – without complicating the maintenance process. By this means several significant advantages can be achieved:

- No deep foundation required (removable in case of maintenance)
- Low height: the landscape and the view of the rail passengers are not affected negatively
- Emissions in the area of the wheel-on-rail contact are shielded directly
- Cost reduction in comparison to conventional noise barrier systems
- Simple installation process

As shown in Figure 3 the Phonobloc rail track element is placed in a distance of 2,10m from the railway axis. The distance between the horizontal platform and the rail top edge is 0,53m.

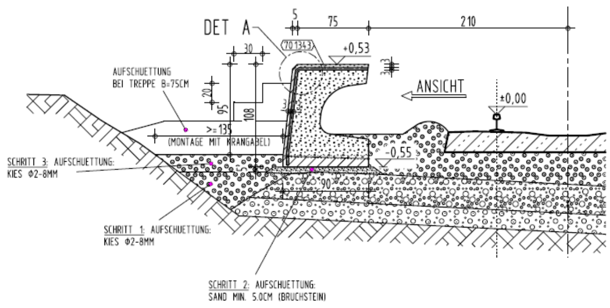

Figure 3. Phonobloc® rail track.

3. Acoustic Simulations

In a first step the acoustic effect of the Phonobloc 530 barrier was calculated according to ISO 9613 by using noise calculation software (IMMI, Wölfel-Messsysteme-Software).

The calculation was done for a single track and for different heights and distances from the rail. According to MA39, the material of the barrier was rated “high absorbing” [2]. The soil damping was assumed to be G=0 and the reflections up to 2nd order were considered in all calculations. As noise source, two line sources where simulated at the top of each rail.

To show the effects of the noise barrier, six immission points where chosen: Three IPs at a distance of 7,5m from the centre line of the track and at a height of 1,5m and 3,5m above the rail surface. At the same height but at a distance of 25m from the centre line of the track, three additional IPs were chosen.

3.1. Results

Figure 4 shows the shielding effect of the Phonobloc 530 noise barrier. To show the acoustic effects of the Phonobloc barrier compared to the situation with free sound propagation, the figure as well shows the difference profile (= acoustic effect).

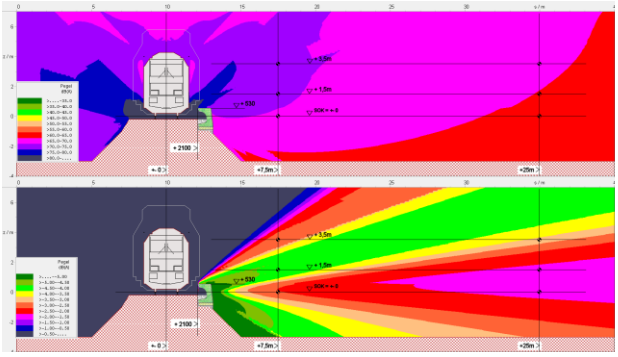

Figure 4. Shielding effect (overall sound pressure level) for the Phonobloc 530 noise barrier (top) and acoustic effect (differences in noise levels) compared to free sound propagation (buttom).

The results show that the Phonobloc 530 noise barrier (d=2100mm) for a single track can achieve a reduction in the A-weighted noise level ranging from 1,9dB up to 4,4dB with the maximum reduction at a distance of 7,5m from the centre of the track and 1,5m above rail surface.

measure	Height of noise impact [m]	noise reduction to propagation without measures [dB(A)] in 7,5m	in 25m
Phonobloc 530 (d=2100mm)	3,5	2,8	3,4
	1,5	4,4	1,9
	SOK	2,4	1,9

Figure 5. Acoustic effect by the Phonobloc 530 elements in different distances and heights.

4. In-situ measurements

4.1. Measuring concept

For these measurements, 80 Phonobloc noise barrier elements were placed for a length of 160m along the track. The noise emission of the trains was measured by an acoustic railway monitoring system, so called acramos® in four different microphon positions (two distances and two heights), according to EN ISO 3095. The acramos® system permits the automatic and vehicle selective acquisition of noise emission data from trains in daily operation and includes an automatic data processing and automatic train categorisation, based on the axle pattern.
In a first step, the noise emission was measured without the Phonobloc elements for a time period of two weeks. After mounting the elements (within 3 days), the measurements took place for a second time (with the same measurement setup).

Figure 6. Tested Phonobloc® 530.

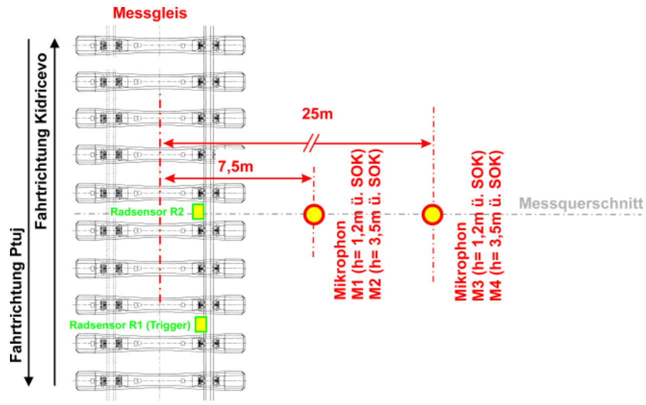

Figure 7. Schematic view of the measurement site.

Figure 8. Overview of the measurement site.

4.2. acramos®

acramos (acoustic railway monitoring system) is a new dimension for monitoring of noise and vibration emissions from trains and rolling stock in daily operational.

Axle patterns are recorded in parallel with pass-by noise and vibrations. The parallel recording allows matching noise and vibration data with the position of the train. With an air-conditioned, weatherproofed case, acramos can be used temporarily and is remote controlled by mobile internet.

Output from acramos

- Direction of the train and speed of each axle
- Axle pattern of the train (= distance between the single axles)
- Automatic categorisation of trains based on the axle pattern
- A-weighted pass-by level $L_{p,A,eq,T}$ of a train
- A-weighted level statistic of a train
- A-weighted pass-by level $L_{p,A,eq,AX}$ of each single axle in a train
- A-weighted pass-by level $L_{p,A,eq,WG}$ of single vehicles in the train
- 3rd octave spectra of a train or vehicle
- Results are stored in a database: statistic analyses of speed dependency of A-weighted pass-by level per train category
- Recording of time signals during train pass-by

4.3. Results

The overall noise reduction (average of all train categories) at a distance of 7,5m from the centre of the track is 3,6dB at a height of 1,2m above the rail surface and 1,6dB at a height of 3,5m. For the measurement positions at a distance of 25m the reductions are slightly lower. At the measurement point MP3 (25m/1,2m) the average noise reduction was 2,4dB and at MP4 (25m/3,5m) a reduction of 1,4dB could be measured.

The highest reduction can be observed at the position MP1 (7,5m/1,2m) which is due to the highest detour for the sound propagation. If the different train categories are inspected further, the highest reduction can be found for passenger coaches of the type ŽS 813 (5,4dB at MP1), which describes the category with the highest amount of measured pass-bys. The category of the freight trains was the one with the lowest measured noise reductions.

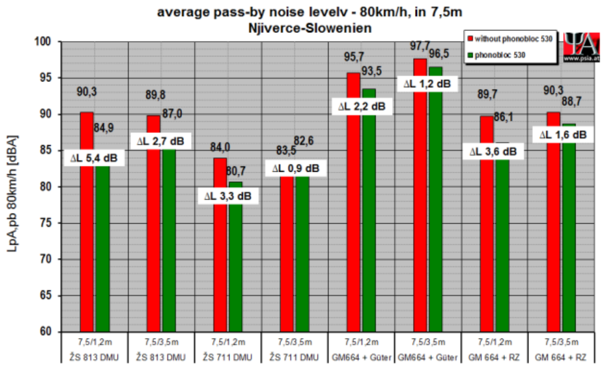

Figure 9. Average pass-by noise level in 7,5m distance related to 80km/h; measurement without elements vs. measurement with Phonobloc 530 elements.

Category of rolling stock	Number of measured trains		average noise reduction (80km/h) in dB(A) by Phonobloc 530 elements			
	Without Phonobloc 530	Phonobloc 530	MP1 (7,5m/1,2m above rail surface)	MP2 (7,5m/3,5m above rail surface)	MP3 (25m/1,2m above rail surface)	MP4 (25m/3,5m above rail surface)
ŽS 813	104	106	5,4	2,8	3,7	2,9
ŽS 711	35	75	3,3	0,9	2,7	0,7
GM 664 + Coaches	5	14	3,6	1,6	2,6	2,0
GM 664 + Freights	58	62	2,2	1,2	0,6	0,2
Total	202	257	3,6	1,6	2,4	1,4

Figure 10. Acoustic effect in 7,5m an 25m distance to the centre of the track.

5. Conclusions

After the installation of the Phonobloc® elements a reduction in the pass-by noise level for all train categories in relation to the reference measurement could be observed. The average noise reduction for all measured categories of rolling stock could be verified up to 3,6dB(A). The highest noise reduction could be reached at the microphone position M1 in 7,5m distance and 1,2m height above rail surface (up to 5,4dB(A) for the ŽS 813 category).

In the frequency range of 500Hz up to 2kHz, the highest noise reductions can be observed. For the low frequency range (<250Hz) only slight reductions were measureable.

In general it should be considered that traction noise, which is typically located at a height above the top of the barrier, cannot be affected by such a low height noise barrier. In addition to this fact, the acoustic effect for vehicles with a pass-by speed of <50km/h (higher influence of the traction noise on the overall noise level of the train) is at a lower level.

Compared with the calculations (acoustic simulation), the results match the measured values quite well. For the category ŽS 813 the measured reductions were partly higher than the results of the calculations.

Due to the fact that the measurements were conducted on a single track section, the effect of the noise barrier for neighbouring tracks could not be evaluated.

Additional measurements should be planned on a electrified two track line, allowing the testing of middle elements as well.

Finally, it should be noted that the monitoring of the Phonobloc rail track system is needed over an extended period of time (maintenance process, use of snow plough).

Acknowledgement

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