Auxiliary steel railway bridge with dynamically soft rail fastenings

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Reduction of the noise emission of a steel railway bridge by means of resilient rail fastenings with dynamically soft baseplate pads

By

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INTRODUCTION (1)

- Steel bridges with direct rail fastenings but without ballast are the loudest railway bridges.
- Nowadays they are rarely used, in the case of new tracks of German Railways (DB AG) they are generally not built any more.
- Nevertheless, bridges of this type are finding increasingly frequent used as auxiliary bridges within a limited period of time in situations when tracks must be reconstructed.

INTRODUCTION (2)

- In the course of the restoration of the light rail viaducts in a track near the Humboldt harbour in Berlin, an auxiliary steel bridge with direct rail fastenings has been built over nine viaduct bows.
- For operational reasons, this solution has to remain in use for several years.
- In the immediate vicinity there were complaints because of the noise radiation of the bridge structure.
- Therefore, measures to reduce the noise emission of the steel bridge were necessary.
Essentially, the following measures are possible to reduce the noise from steel bridges without a bed of ballast:

- Emplacement of ballast along the entire bridge span
- Laying of ballast between the sleepers only
- Sandwich coating of the bridge structure
- Installation of vibration absorbers
- Installation of resilient rail fastenings

Since the bridge structure in question is an open bottom construction, meaning there is no closed bridge floor between the rails, only the last three measures listed above are applicable.

Therefore, the department of acoustics of the Centre for Research and Technology of German Railways in Munich proposed:

- to replace the stiff rail fastenings by resilient fastenings with the softest possible baseplate pads as the most effective noise reduction measure possible in technical and economical respect.
NOISE MEASUREMENTS

- Before and after installation of the resilient rail fastenings noise measurements were carried out by the acoustical consulting company Müller-BBM.
- In this lecture the situation at the starting point and then the most important acoustic characteristics of the resilient rail fastenings, especially of the elastic Sylodyn® baseplate pads, will be described first.
- After that, the essential results of the airborne noise measurements, taken at locations near to the bridge are presented.
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Fig. 1: Stiff rail fastening before modification of the steel railway bridge:
RP: Rail pad with very high stiffness,
Static spring rate: \( c_{\text{stat}} \approx 500 \text{ MN/m} \)

Foto: W. Weißenberger, Müller-BBM GmbH
Fig. 2: Resilient rail fastening, type Ioarg 314 after modification of the steel railway bridge:

RP: rail pad with very high stiffness,
    static spring rate: $c_{\text{stat}} \approx 500 \text{ MN/m}$
BP: dynamically soft Sylodyn® base plate pad,
    static spring rate: $c_{\text{stat}} = 18 \text{ MN/m}$
**Fig. 3:** Load deflection curve of the Sylodyn® baseplate pad, type Zwp 110, for rail fastenings, type Ioarg 314. Secant stiffness between loads 18 kN and 68 kN, i.e. static spring rate: $c_{\text{stat}} = 18 \text{ MN/m}$

**Fig. 4:** Static and dynamic stiffness of the Sylodyn baseplate pad, type Zwp 110 as a function of load:
- static stiffness
- dynamic stiffness at 40 Hz
Before and after the installation of the resilient rail fastenings, measurements were taken at identical locations while various types of Berlin light rail trains (Stadtbahn) crossed over tracks 3 and 4 of the 4-track municipal railway line.

The structure-borne noise of the bridge structure as well as the airborne noise in the vicinity of the bridge and in the surrounding area were measured.

The complete measurements and the results are given in the report prepared by W. Weißenberger of Müller-BBM.

Here the results of the airborne noise measurements taken at the following locations near the track (near viaduct bow No. 323) are presented to describe the effectiveness of the changes:

<table>
<thead>
<tr>
<th>Location of measuring points</th>
<th>Distance from track center, Track 4</th>
<th>Height above rail(^1)</th>
<th>Height above ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mp 1: Below the bridge</td>
<td>0 m</td>
<td>-1 m</td>
<td>7.7 m</td>
</tr>
<tr>
<td>Mp 2(^2): In front of the house of the complainant</td>
<td>27 m</td>
<td>-3 m</td>
<td>6 m</td>
</tr>
</tbody>
</table>

\(^1\) above top of rail
\(^2\) 0.5 m in front of an open window in the first floor
NOISE MEASUREMENTS
Remarks

- The rails were not replaced in the course of the reconstruction. From this one can conclude that the condition of the rail surface after the reconstruction did not differ significantly from their previous condition.
- Therefore, one of the boundary condition, which is amongst others most important with regard to the creation of rolling noise and structure-borne noise at the wheel/rail contact point, remained as similar before and after the reconstruction as technically possible.

Fig. 5: 1/3-Octave-band spectra of the noise measured below the bridge during the passage of light rail trains, type ET 477:
Fig. 6: 1/3-Octave-band spectra of the noise measured near the house of the complainant during the passage of light rail trains, type ET 477:

1/3-Octave-band-level difference measured during train passages below the auxiliary steel bridge before/after installation of the resilient rail fastenings:

- Upper limit of scattering
- Average of all train types, track 3
- Lower limit of scattering
Figure 7: 1/3-Octave-band-level difference measured during train passages below the auxiliary steel bridge before/after installation of the resilient rail fastenings:

- Upper limit of scattering
- Average of all train types, track 4
- Lower limit of scattering
In the course of the restoration of the light rail viaducts in a track near the Humboldt harbour in Berlin, an auxiliary steel bridge with direct rail fastenings has been built over nine viaduct bows.

In the immediate vicinity there were complaints because of the noise radiation of the bridge structure.

Nevertheless, for operational reasons, this solution has to remain in use for several years.
Therefore, the Centre for Research and Technology of German Railways in Munich proposed to replace the stiff rail fastenings by elastic fastenings type Ioarg 314 with the softest possible baseplate pads;

This construction was considered to be the most effective noise reduction measure possible in technical and economical respect;

In this case baseplate pads with the dynamically high effective material Sylodyn®, with a static stiffness of 18 MN/m and a thickness of 15 mm have been used.

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Before and after installation of the resilient rail fastenings noise measurements have been carried out by the acoustical consulting company Müller-BBM;

The measurement results show that the radiation of the bridge noise has been reduced by approximately 8 - 10 dB in the frequency range above 125 Hz;

After the installation of the resilient rail fastenings no further complaints were made.
Thank you very much for your attention!