RTR
RAIL TECHNOLOGY REVIEW

1|2013
March 2013 | Volume 53
Euro 25,– | 13914
www.eurailpress.de/rtr
ISSN 1869-7801

RAILWAY DEVELOPMENT
System developments in rail-guided passenger transport
Infrastructure modernisation in Slovakia

INFRASTRUCTURE
Semi-integral viaducts
Repairing concrete bridges
Concrete slabs, rail pads and ballast mats

ROLLING STOCK
Knorr-Bremse: a system supplier
Condition monitoring for running gear

Long-term behaviour of Sylomer® ballast mats

Inspection and stiffness tests of a 21-year old Sylomer® D 220 ballast mat lying on a DB railway bridge within the Hanover-Würzburg high-speed line showed no relevant change in its properties.

Fig. 1: Bartelsgraben Bridge *(source: Wikipedia, photograph: Störfix, 01.07.2006)*

The bridge where the ballast mats were installed long ago is the Bartelsgraben bridge (Fig. 1). It is located near Würzburg in the southern section of the Hanover–Würzburg high-speed line which was put into service in June 1988, three years before the rest of the line went into service. The bridge is 1160 metres long and carries two tracks. Construction of the pre-stressed concrete box-girder bridge began in 1984 and was completed in 1986. Its longest supported span between pillars measures 58 metres. The line initially describes a 10,000 m radius curve before straightening out. The gradient falls steadily by 12.5%.

1 Installation of the mats

The ballast mats were installed in 1987. They were delivered in rolls and laid out on the cleaned subsurface. After laying out, the mats were folded back halfway on one side. Using a two-component PU adhesive, the mats were spot-bonded on the bridge according to the DB AG installation instructions for ballast mats. The other half was bonded during a second work step. Bonding in this way ensured that the mats did not move during the later ballasting process. In terms of noise requirements, bonding to the subsurface is generally not necessary to guarantee effectiveness (Fig. 2).

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During the installation of the Sylomer® D 220 ballast mats from Getzner, an examination and research assignment was carried out for the Bundesbahn Central Office (BZA) in Minden. The focus of the project was to investigate the deflection of the rails in subsurfaces of different elasticities when a train passed overhead. Data was obtained for deflections in the:

- Ballasted track directly on the bridge
- Ballasted track on the bridge with ballast mats
- Ballasted track on a subgrade

Trackside tests and measurements were taken by TU Munich, the testing institute for the construction of land traffic routes.

2 Application areas of ballast mats

Ballast mats are used to provide structure-borne sound insulation in dense urban areas where railway lines pass close to buildings. Other uses include the protection of structures and buildings sensitive to vibrations, such as concert halls, museums,

Fig. 2: Installation of the D 220 ballast mat on the Bartelsgraben Bridge in 1987

Fig. 3: Removed ballast mat showing indentations from ballast stones

hospitals, historic buildings or vibration-sensitive laboratory, testing or measuring equipment. Ballast mats also reduce the secondary airborne noise radiation from bridges.

They are an economical and proven method of increasing the elasticity of the ballasted track and bring about a long-term improvement in track bed quality and ride comfort. Extended tamping intervals and higher track availability has a positive impact on life cycle costs.

Ballast mats generally have a two-layered structure. The load distribution layer is on the side exposed to the ballast and protects the layer below from the sharp-edged ballast stones. It also ensures an even load distribution. Embedded ballast stones increase the load transfer area, prevent the premature destruction of the ballast and also protect the track bed. The spring layer is made of microcellular polyurethane materials. This structure makes the ballast mats volume compressible, negating the need for any profiling or cavities to achieve the desired elasticity. The thickness of the microcellular materials is selected to achieve the desired static and dynamic stiffness.

3 Two decades later

While renewing the ballast on the Bartelsgraben Bridge between Würzburg and Hanover, DB AG removed a test sample of the Getzner D 220 ballast mat. The extract in question was taken from a mat installed in 1987. For 21 years it had suffered an operational load of approx. 384 million tonnes. This tonnage is far in excess of the load stipulated under fatigue strength testing as per DB TL 918071 [1]. At the time the mats were supplied a load cycle of 2.5 million was required as the prerequisite for installation on railway lines operated by Deutsche Bahn. Based on an axle load of 22 tonnes, we can calculate a fatigue stress of 17.5 million load cycles, which corresponds to a figure seven times higher than that defined in DB TL 918071. The static and dynamic stiffness of the removed sample were measured and compared against the values when the mat was new. These variables can be used to show the creep behaviour and the performance of the ballast mat.

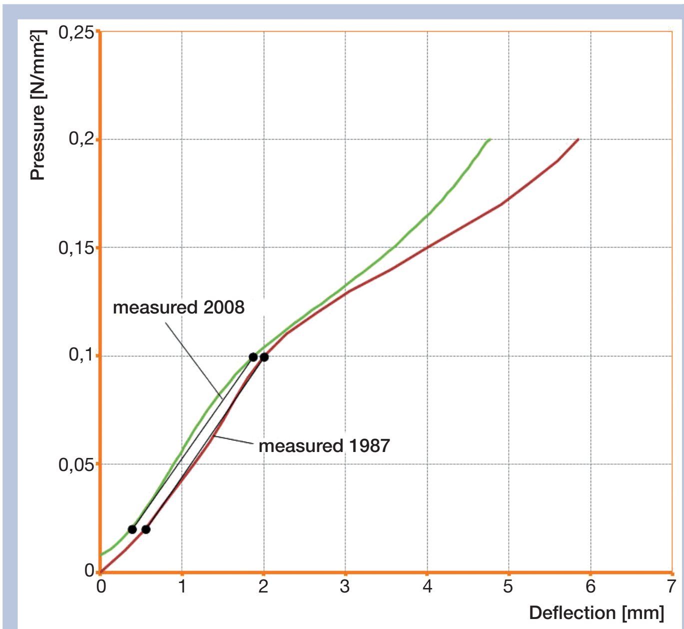

Fig. 4: Measuring static stiffness on the D 220 ballast mat sample (before installation and after removal)

4 Visual inspection

The visual inspection of the ballast mast reveals some plastic indentations from individual ballast stones in the load distribution layer of the D 220 ballast mat. Due to the load distribution through the ballast, these indentations typically occur directly in the loading area of the sleeper and thus meet with expectations. This effect was also observed following the creep behaviour testing undertaken at the time. The indentations indicate that the ballast stones were properly embedded in the load distribution layer and load peaks on the ballast/concrete contact areas had been permanently avoided. As a result the loading on the superstructure was lower, which ultimately led to lower maintenance costs due to the stable track bed and longer tamping intervals. No signs of damage to or perforations in the load distribution layer could be established (Fig. 3). We can therefore conclude that the ballast mat withstood the high mechanical loads and will continue to satisfy all its functional requirements for decades to come.

5 Testing and results

5.1 Static stiffness

The static stiffness of the removed ballast mat was determined according to DB TL 918071. The test was conducted on samples measuring 500 x 500 mm. Secant stiffness was evaluated between the load points 0.02 and 0.1 N/mm². A static bedding modulus of 0.0529 N/mm³ was calculated, which met the specification at the time of 0.06 (+/– 0.01) N/mm³. Compared with the value measured on a new ballast mat by TU Munich [2] (0.0571 N/mm³), this represents a change of 7.9 % after 21 years in-situ (Fig. 4).

5.2 Dynamic stiffness

The dynamic stiffness was measured on 200 x 200 mm samples according to the dynamic properties measurement specified by the Müller BBM 12506/1 report [3] of January 1986, in which preloads of 0.03 N/mm² and 0.1 N/mm² were applied at a test frequency of 40 Hz. The removed ballast mat returned values of 0.092 N/mm³ (0.03 N/mm² preload) and 0.090 N/mm³ (0.1 N/mm² preload). Compared with 1986, this corresponds to a deviation of 11.2 % and 9.6 % (Table 1).

	Preload 0.03 N/mm³ dyn. bedding modulus C_{dyn} at room temperature [N/mm³]	Change [%]	**Preload 0.1 N/mm³** dyn. bedding modulus C_{dyn} at room temperature [N/mm³]	Change [%]	Result
Mat D 220 before installation	0.083	**11.2**	0.082	**9.6**	**OK**
Mat D 220 21 years after installation and 384 million tonnes	0.092		0.090		

Table 1: Comparison of ballast mat dynamic data at the time of installation and after removal

6 Summary

The sample tested showed no relevant change in its properties (less than 15 %) after 21 years under the track and having withstood 384 million tonnes. During these 21 years, the ballast mat was installed on a bridge and exposed to all the associated weathering effects, together with thousands of frost-thaw transitions. Water has had no negative impact on the properties of the ballast mat. The testing, which is in a way equivalent to a real-life long-term test, has shown that ballast mats made from Sylomer® provide sustained effectiveness and do not exhibit any noteworthy signs of ageing or degradation.

The values measured are still within the tolerances (+/– 15 %) which were valid at the time of installation and which remain so to this day. No cracks or perforations in the mat can be found even when subjected to the closest scrutiny. This result shows that ballast mats made from Sylomer® are largely unaffected by weathering effects. It is expected that the ballast mats will continue to remain completely effective for another 30 years at least.

References

[1] DB TL 918071 – 1978 edition
[2] Müller BBM Report 12506/ 1
[3] TU Munich Report GÜ 49/ 89

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