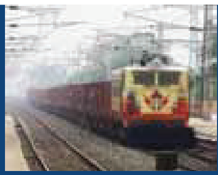

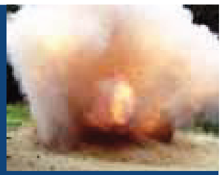

Railway Gazette

INTERNATIONAL

Understanding the life of ballast mats

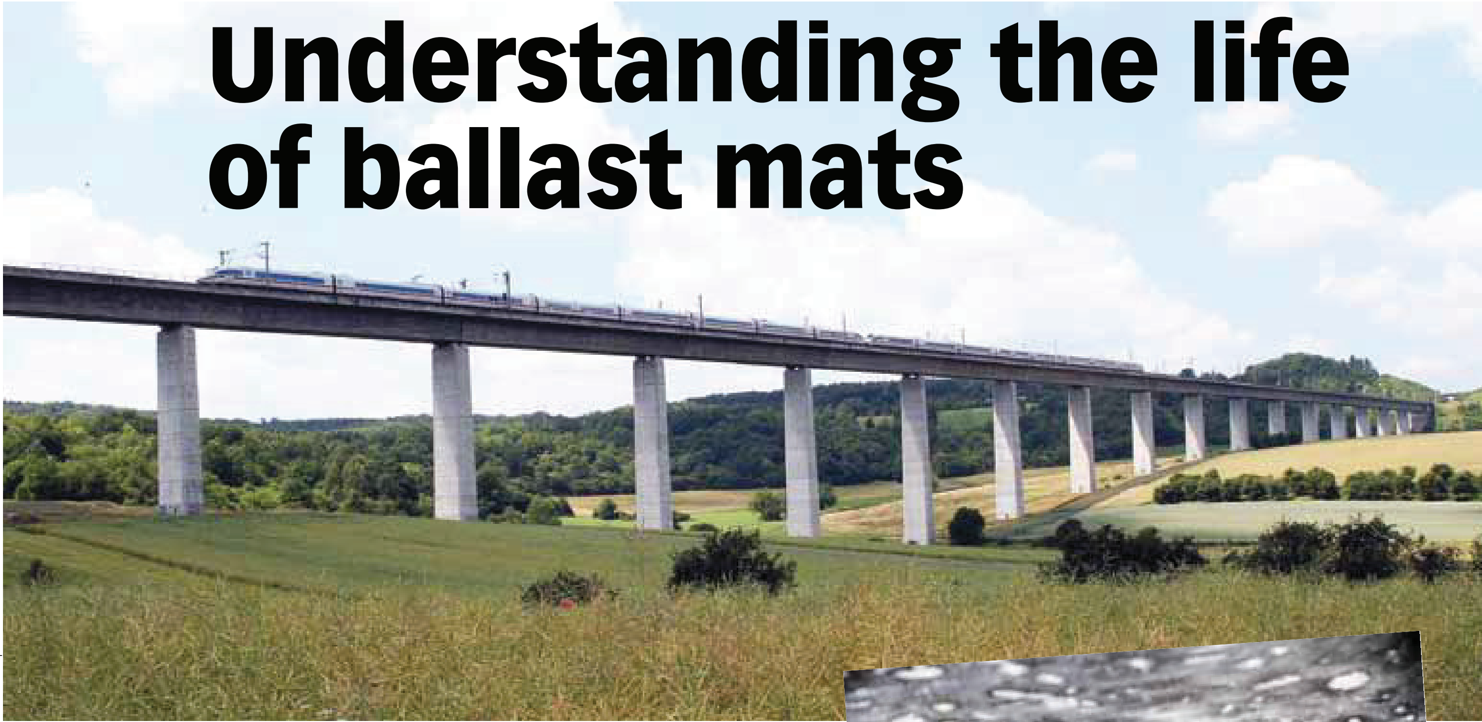

Photo: Wikipedia/Störfix

RESILIENCE A ballast renewal programme on the Hannover – Würzburg high speed line provided a valuable opportunity to examine the condition and performance of a resilient under-ballast mat installed 21 years earlier.

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Above: **The Bartelsgraben bridge carries the Hannover – Würzburg line over a valley between Zellingen and Leinach.**

Right: **The indentations from ballast stones can be clearly seen on the removed sections of mat.**

Although railways have been installing resilient under-ballast mats for many years, there have been few opportunities to assess how well they are performing after decades of service. However, when renewing the ballast on the Bartelsgraben bridge on its Hannover – Würzburg high speed line a few years ago, DB Netz removed a test sample of the Sylomer D 220 ballast mat that had been installed in 1987. This provided the opportunity for a detailed examination of the performance of the mat, which had carried an estimated 384 million gross tonnes over a 21-year period.

Installation history

Located at Km 312 between Zellingen and Leinach northwest of Würzburg, the 1 160 m long Bartelsgraben bridge carries a double-track section of the high speed line 55 m above the valley floor. Completed in 1986, it is a prestressed concrete box-girder bridge with a longest span of 58 m. Located on a 1·25% gradient falling towards the south, the line initially describes a 10 000 m radius curve before straightening out. South of the bridge, the track passes over a short section of embankment before continuing onto the adjoining Leinachtal bridge.

The ballast mat was installed in 1987. The material was delivered to site in rolls and laid out on the cleaned subsurface. They were then folded in half lengthways (p46), and each half in turn was spot-bonded to the bridge with a two-part adhesive in line with DB's installation standards. This bonding ensured that the mats did not move during the subsequent ballast laying process, but bonding is generally not essential to guarantee effective noise mitigation.

During installation, TU München undertook an initial study of the mat on behalf of DB's central research institute (BZA) in Minden. This was commissioned to investigate the deflection of the rails on sections of ballasted track with different sub-surface elasticities during the passage of a train. Data was obtained for deflections in:

- track laid directly on the bridge
- track laid on the bridge with a resilient under-ballast mat
- track on a subgrade.

TU München was also involved in testing the recovered sample, to assess the performance of the mat following a lengthy period of service

The benefits of ballast mats

ELASTICITY: Resilient under-ballast mats can provide an economical method to increase the elasticity of ballasted track, offering a long-term improvement in trackbed quality and ride comfort, together with extended tamping intervals and higher availability of the track which have a positive impact on life-cycle costs. They can also be used to reduce the secondary airborne noise radiation from bridges, and are often deployed to provide structure-borne sound insulation in dense urban areas, or to protect particularly sensitive structures and buildings.

Ballast mats typically have a two-layered structure. A load distribution layer on the side exposed to the ballast helps to protect the spring layer below from the sharp-edged ballast stones. It also ensures an even load distribution, as stones become embedded in the mat, increasing the load transfer area, preventing the premature deterioration of the ballast and protecting the trackbed. The actual spring layer is made of microcellular polyurethane materials, giving the mat a compressible volume and, negating the need for any profiling or cavities to achieve the desired elasticity. The thickness of the microcellular material is selected to deliver the desired static and dynamic stiffness.

and exposure to different weather conditions.

Inspecting the sample

Over the 21-year period, the mat on the Bartelsgraben bridge had withstood an operational loading of approximately 384 million gross tonnes. This is far in excess of the load stipulated for the fatigue strength testing. At the time of installation the mats were only required to support 2·5 million load cycles. But based on a 22 tonne axleload, the fatigue stress was calculated at 17·5 million cycles, which is seven times the figure defined in DB's 1978 standard TL 918071.

Visual inspection of the mat sample revealed some plastic indentations in the load distribution layer from individual ballast stones. These typically occur in the loading area directly below the sleepers, which was in line with expectations. The same effect was observed during the fatigue behaviour testing undertaken at the time of installation.

The indentations indicate that the ballast stones had been properly embedded into the load distribution layer, helping to avoid any load peaks in the contact area between the ballast and the concrete bridge structure. As a result, ballast degradation was reduced, leading to lower maintenance costs and longer tamping intervals.

No signs of damage or perforation of the load distribution layer could be established. It was therefore concluded that the ballast mat had successfully withstood the high mechanical loads and prevailing weather conditions, and would continue to do so.

Stiffness testing

The static and dynamic stiffness of the sample were also measured, in order to compare them against the values recorded when the mat was new. These variables can be used to show the ageing behaviour and the performance of the ballast mat.

Static stiffness was determined according to the procedure set out in the DB specifications from 1987, using 500 mm square samples of the mat. Secant stiffness was evaluated between the load points 0·02 and 0·1 N/mm^2. The static bedding modulus was calculated at 0·0529 N/mm^3, which still met the original specification of 0·06 ± 0·01 N/mm^3. Compared with the value of 0·0571 N/mm^3 for the new mat as measured by TU München, this represents a change of 7·9% after 21 years (Fig 1).

Dynamic stiffness was measured using smaller 200 mm square samples, according to the dynamic properties measurement process described by the Müller BBM 12506/1 report of January 1986. In this method, preloads of 0·03 N/mm^2 and 0·10 N/mm^2 were applied at a test frequency of 40 Hz. The mat sample returned values of 0·092 N/mm^3 and 0·090 N/mm^3 for the two cases respectively, which corresponds to deviations of 11·2% and 9·6% since 1986 (Table I).

Good to continue

The sample tested showed no relevant changes greater than 15% to any of its properties after 21 years of use and 384 million tonnes of traffic. Having been installed on a bridge, the ballast mat had been exposed to all the associated weathering effects, together with thousands of frost-thaw transitions. But the water has had no negative impact on the properties of the ballast mat. The testing confirmed that the Sylomer mat was still proving effective and did not exhibit any noteworthy signs of ageing or degradation.

The measured values were still within the tolerances specified at the time of installation and which remain valid to this day. No cracks or perforations in the mat were found, even when it was subjected to the closest scrutiny. As a result, the expectation is that these ballast mats will continue to remain completely effective for at least another 30 years.

Installation of the Sylomer D 220 ballast mat on the Bartelsgraben bridge in 1987.

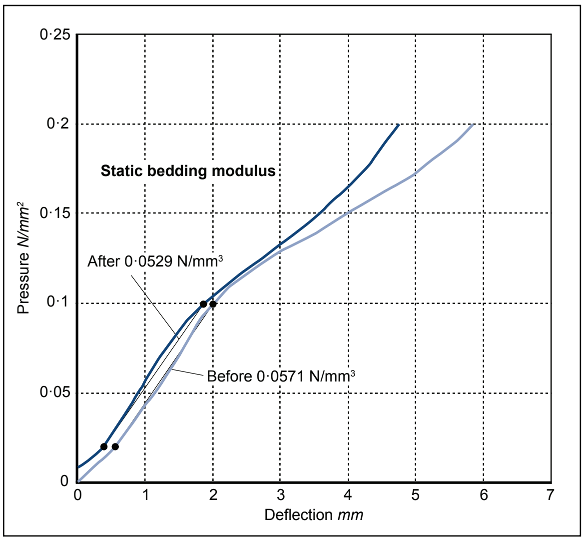

Fig 1. Comparison of the static stiffness of the mat sample, before installation and after removal.

Table I. Dynamic performance of the D 220 ballast mat

Dynamic bedding modulus c_{dyn} at room temperature	Before installation	After 21 years and 384 MGT	Change
Preload 0·03 N/mm^3	0·083	0·092	11·2
Preload 0·10 N/mm^3	0·082	0·090	9·6