

Keeping it QUIET below Berlin

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THE FOUR-track railway being built in the heart of Berlin is intended to create a 9 km link between the northern and southern sides of the city's inner rail ring (RG 6.97 p379).

About 3.5 km of the route runs underground, from the Landwehrkanal, beneath the commercial centre of Potsdamer Platz, and under the government district to Lehrter station, where the line intersects with the existing east-west elevated Stadtbahn. When completed, the new Berlin Hauptbahnhof at this point will become a major interchange for Germany's east-west and north-south inter-city routes.

Vibration and secondary airborne noise emissions from the railway must not impair the use and environment of these important buildings along the route, and so the inclusion of preventative measures was a high priority when designing the infrastructure.

DB ProjektBau GmbH is building the line on behalf of Deutsche Bahn AG, and commissioned engineering consultants Dr Heiland to model the transmission of vibrations from the tunnel floor into adjacent buildings. This model formed the basis for the design of mass-spring measures to reduce vibration and noise.

Instead of being fixed to the tunnel floor, the track sits in a massive, rigid concrete trough which is supported above the floor by individual and full-surface resilient polymer bearings designed and supplied by Getzner. The inertia of this slab interacts with the resilient springs to damp the vibrations caused by trains. A total of six different mass-spring arrangements were chosen for use in the tunnel, with the heavy mass-spring systems having calculated frequencies of 7 to 12 Hz, and light examples natural frequencies of 15 to 23 Hz.

The diverse requirements for specific bearings were met using bearings with a range of geometries, from the smallest at 380 x 310 mm to a maximum of 500 x 460 mm, with thicknesses ranging from 60 to 95 mm. Each of the mass-spring systems has been individually approved by the Federal Railway Authority (EBA).

Installation

Assembly of the heavy mass-spring systems involves installing a lining on the tunnel floor, then pouring the



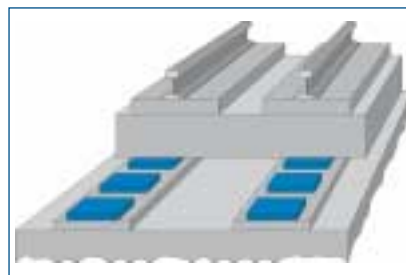
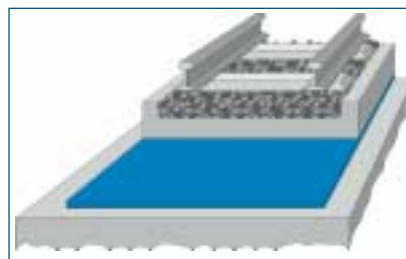
Building a main line railway under the heart of Berlin demands the highest standards of vibration and noise prevention. The answer is to use concrete slabs supported on polymer bearings

concrete slab in situ, up to 700 mm thick. This ensures that the slab will replicate the shape of the tunnel with great precision.

The use of a lining ensures that once hardened the entire slab can be lifted by up to 110 mm without damage, using synchronously-controlled hydraulic jacks which are placed in openings left in the slab during casting. The slab is lifted in 200 m sections, weighing in excess of 1 500 tonnes, and a template is used to position the bearings precisely using a sliding gauge, before the trough is lowered onto the bearings with millimetre-accuracy.

Up to eight individual bearings can be installed at each opening. Each bearing is numbered, and written and photographic records are made of its installation site.

In the light mass-spring systems the



As part of the process to install the track slabs through the low-level platforms at Berlin's new Hauptbahnhof, Sylomer mats and reinforcement bars were laid (top) before the concrete slabs were cast (right). On the north-south link, both full-surface and discrete supports were used (Fig 1, inset right)



concrete trough is poured directly onto a double layer of pre-installed, full-surface elastic 50 mm thick mats, which act as sacrificial formwork. Some 35 000 m² of slab in the Berlin tunnel is being fitted with full-surface resilient mountings.

The two layers are installed with the joints offset by half the width of the mat, and the upper layer joints are sealed with an adhesive band to prevent concrete slurry penetrating between the mats. Any such seepage could lead to the creation of 'sound bridges', which would reduce the effectiveness of the anti-vibration measures.

The thickness of the resilient mats is reduced from 50 to 25 and 12 mm across the transitions between sections with and without the mats, and by adjusting the effective stiffness of the mountings this will prevent excessive bending stresses on the rail and slab at the transitions. Once the mats are in place the steel reinforcing bars are installed, and concrete is pumped in.

The restricted space available in the tunnels requires close co-ordination

between Getzner and the site supervisors to ensure continuous and just-in-time deliveries of the 1.5 m wide and 4.2 m elastic mats as construction progresses.

Full-surface elastic mounting of the concrete track slabs on the mats has gone smoothly, with a low additional cost above that of the sections without vibration protection.

Quality assurance

Heavy mass-springs are a technically high-quality way of meeting extremely stringent requirements, and using Sylodyn polyurethane bearing elements it is possible to achieve this at an acceptable price. Similar noise and vibration protection measures were installed on the Köln – Frankfurt high speed line.

The quality of the bearings installed is checked using comprehensive quality assurance methods developed for the project by ARGE FF/MFS (Heitkamp/Porr), Dr Heiland and the Technical University of München's Institute for Road, Railway & Airfield Construction. Measurements of the

ABOVE LEFT: Sylomer mats were installed in the transition areas to adjust the track stiffness between the rigid and resiliently-mounted track slabs

ABOVE: Casting of track slabs in the main cross-city tunnel

natural frequencies of track sections which have been completed provide further data, ensuring that the installation work was being performed properly.

Constant measurements of ground and structure-borne noise are being made during the work in Berlin, and up to now the results obtained confirm that the forecast levels of vibration and noise in surrounding buildings have been achieved.

Construction of the line is well advanced, and almost all of the slabs have now been laid. The final section, totalling around 4 000 m² of slab, is due to be completed by March, completing the link between the low-level section of the Lehrter Bahnhof and the entrance to the north-south tunnel. ■

BELOW: Installation openings are left during the casting of the track slab, so that it can be jacked up for the bearings to be installed

BELOW RIGHT: Up to eight individual bearings can be positioned using each hole to an accuracy of a few millimetres

RIGHT After the bearings are installed, the slab is lowered into position so that the resilient elements can take the full load

