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Switches & crossings: defined elasticity for new turnout designs

The requirements placed on modern railway track are increasing: heavier axle loads, longer trains and higher train frequencies result in an ever-increasing loading of tracks. At the same time, a fail-safe performance and a constant availability of the track are right at the top of the list of priorities for every railway operating company. A "maintenance-free track" would be ideal, but surely cannot be easily realised. However, over recent decades, one thing has become evident: defined elasticity seems to be a tried and tested way of bringing this ideal scenario within touching distance. This article looks at how this is coming true for turnouts, and it also presents the new Getzner Sensor Sleeper.





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Background and objectives

Due to their complex geometries, the workload and maintenance costs for switches and crossings are significantly higher than for plain track. In particular, construction-related differences in bedding stiffness within the turnout itself lead to an uneven load transmission in the track. This results in additional track loading when a train passes (Fig. 1).

Fig. 1: Turnout bedding stiffness can be improved by implementing defined elasticity

The use of elastic elements provides significant improvements in terms of load distribution across the track and vibration mitigation [1], [2], [3], [4], [5] – Fig. 2. Considerably less stress is placed on the ballast, and tamping intervals are extended. Sleeper damage, overloaded tension clamps, rail corrugation and worn rail pads can be avoided, resulting in a considerable reduction in the life-cycle cost (LCC) of a turnout.

In order to take elastically-mounted turnout systems to the next level, the elasticity requirements and overall track behaviour must be taken into consideration. To meet these demands, a non-linear calculation model based on the finite element method (FEM) has been further refined. The FEM model from Getzner Werkstoffe has the ability to place elastic polyurethane (PUR) elements in various parts of a turnout to optimise the bedding stiffness within the system (Fig. 3).

The enhanced FEM model, which has also been adopted in an ongoing Shift2Rail project, has already achieved very positive results, as alluded to in the following.

Fig. 2: Tailored PUR elements made from Sylomer® and Sylodyn® for track optimisation

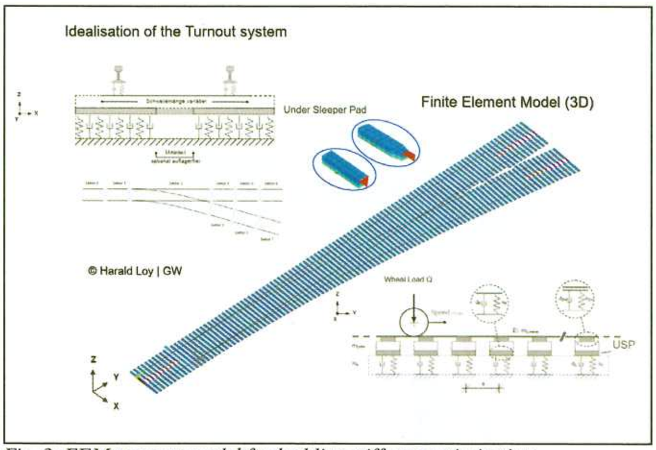

Fig. 3: FEM turnout model for bedding stiffness optimisation

Overall approach

To reduce maintenance efforts, the standard turnouts of Austrian Federal Railways (ÖBB) have been fitted with the first generation of tailor-made Sylomer® under-sleeper pads (USPs) in recent years. By selecting the appropriate parameters in the enhanced FEM model used in the Shift2Rail project [6], the geometric constraints, ground stiffness, and axle loads can be taken into account. This means that the optimum solution can be calculated for practically every requirement.

Computer simulations and validating in-situ measurements have shown that elastically-mounted turnouts have very remarkable advantages as compared to turnouts without elastic mountings: rail seat forces are reduced and ballast pressure can be lowered significantly.

Within the framework of the project, in order to reduce ballast pressure in critical zones that are subjected to high loads, the width of the sleeper ends in these zones was increased. The outer sleeper ends had been widened to 350 mm (the width of the inner sleeper ends remained at 300 mm) – Fig. 4. The same widening was applied to the short sleepers that follow the last continuous long sleeper, but in this case only the inner sleeper ends were widened. The under-sleeper pads were modified accordingly. In addition, specially developed rail fastening systems were used for the frog area of the turnout that feature highly elastic Sylodyn® baseplate pads [7], which is expected to bring further improvements in terms of load distribution.

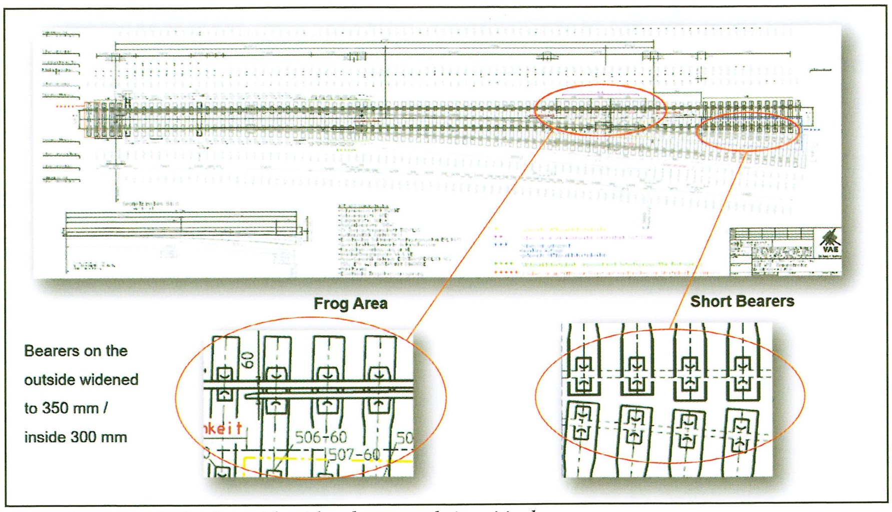

Fig. 4: Design optimisation with wider sleeper ends in critical zones

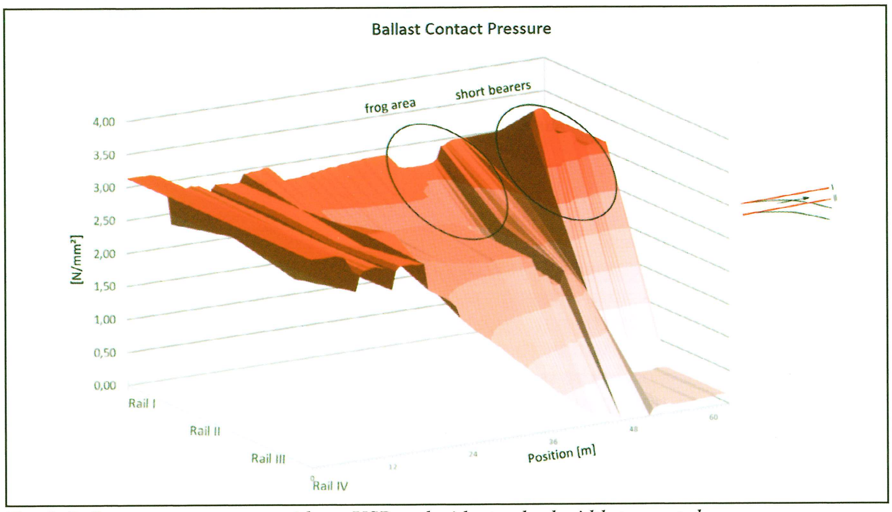

Fig. 5: Ballast contact pressure without USP and with standard-width turnout sleepers

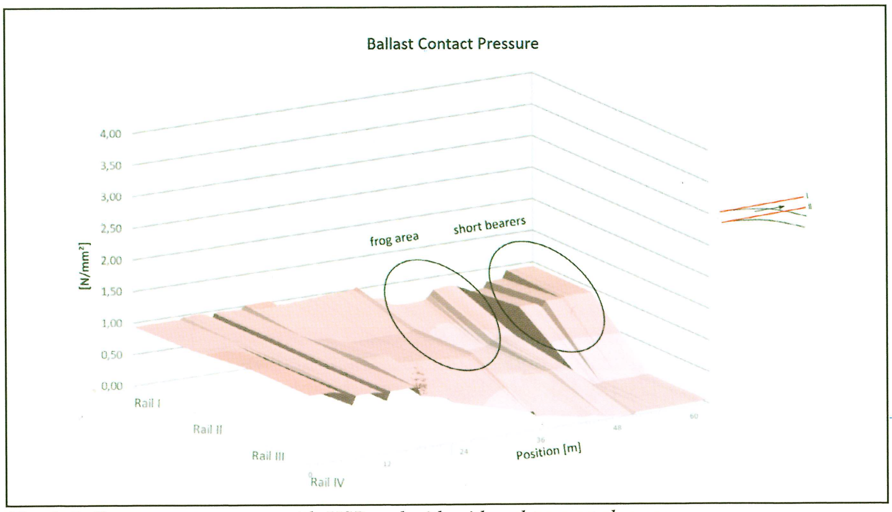

Fig. 6: Ballast contact pressure with USP and with widened turnout sleepers

Calculation results and developments

Comparative simulations can clearly demonstrate the average ballast contact pressure across the entire turnout, for both the non-elastically and the elastically mounted ones. In Fig. 5, the ballast contact pressure for a turnout with no elastic mountings (without USP) is shown and, in Fig. 6, that for a turnout with implemented elastic improvements (with USP).

To optimise load transmission within the rail fastening systems, the new ERL NG fastening system was developed in a collaboration between voestalpine Railway Systems and Getzner Werkstoffe [7].

The ERL NG rail fastening system features a ribbed baseplate and a highly elastic Sylodyn® baseplate pad. It consists of an internal movable system and two rigidly mounted guide pieces (Fig. 7).

The two guide pieces secure the ribbed baseplate and the highly elastic Sylodyn® baseplate pad, both longitudinally and laterally. They are attached to the concrete sleeper using spring washers that are preloaded by a sleeper bolt. Each bolt is anchored to a peg that is cast into the concrete sleeper.

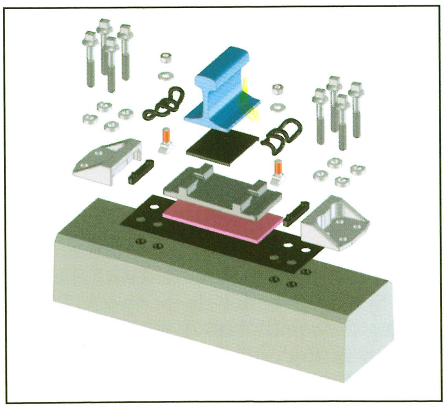

Fig. 7: ERL NG rail fastening system [7] with highly elastic Sylodyn® baseplate pads

Elastomer springs placed in the guide pieces ensure a secure clamping to the sleeper across the entire stiffness range of the baseplate pad.

The elastic Sylodyn® baseplate pad from Getzner Werkstoffe has a nominal static stiffness of 25 kN/mm under the frog fastenings, and 60 kN/mm under the check-rail fastenings (Fig. 8). The ribbed baseplate, which has a load bearing and distribution function, sits on top of the elastic baseplate pad.

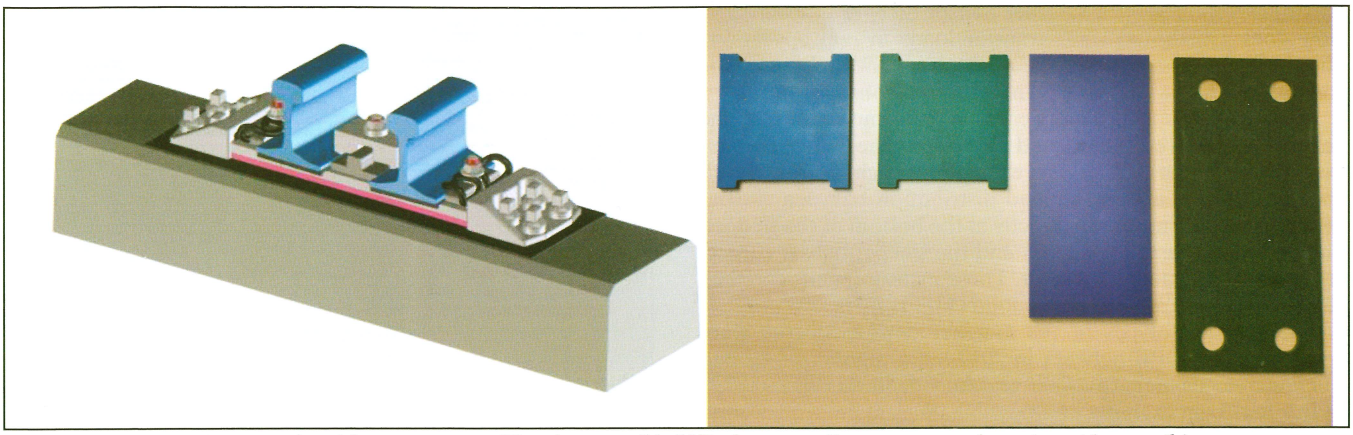

Fig. 8: ERL NG rail fastening system [7] with compatible PUR elastomers (frog area – sample version with two rails)

The rails are fastened to the baseplate using either bolted spring elements (e.g. a clamp, clip bolt, nut and washer) or an inserted clamping element, such as an E-Clip, a FastClip or a SKL.

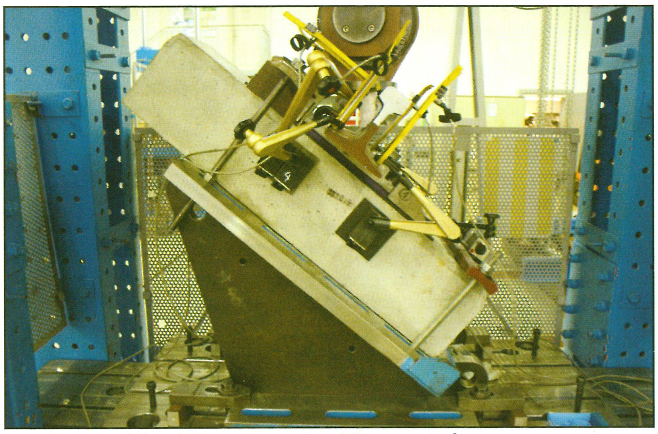

Fig. 9: ERL NG rail fastening system [7] – test rig for dynamic testing according to EN 13146-4 [8]

The relative movement between the ribbed baseplate and the guide pieces (or the sleeper) in the vertical direction of between 1 mm and 4 mm is defined by the spring stiffness of the elastic Sylodyn® baseplate pad. An additional thin baseplate is used to smooth out any unevenness of the sleeper; it also acts as an electric isolator between the electrically conductive components and the concrete base.

The official approval tests of the ERL NG rail fastening system were conducted at the Technical University of Munich (Chair and Institute of Road, Railway and Airfield Construction).

All tests, like restraint testing, fatigue testing, electrical resistance, and the effect of environmental conditions, were conducted in accordance with the European Standard EN 13146:4 [8], and passed successfully (Fig. 9).

Implementation of bedding optimisation in the Shift2Rail demonstrator turnout

The newly implemented developments are expected to significantly improve the long-term behaviour of the turnout, as compared to the present state-of-the-art solutions. In Figs. 10 and 11, the varying elasticity zones for the demonstrator turnout of the Shift2Rail project are shown.

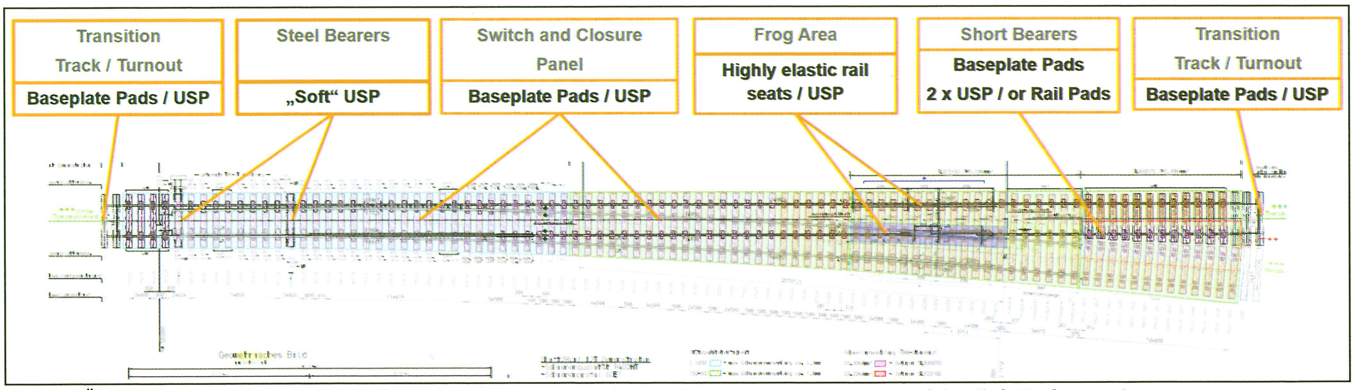

Fig. 10: ÖBB turnout showing bedding stiffness optimisation potentials (installed demonstrator turnout of the Shift2Rail project)

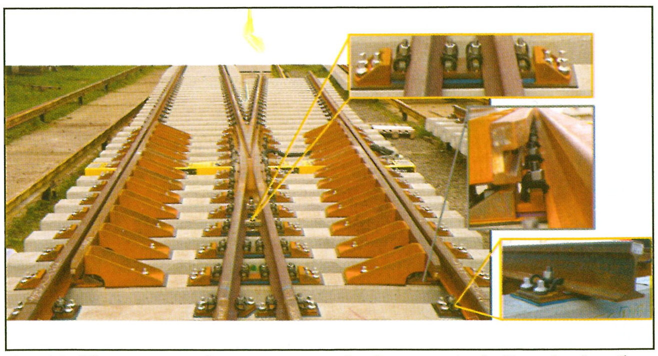

Fig. 11: Elastomer implementation in the frog area including check rails

The implemented elastic elements are intended to achieve the following results:
- increase the bending line (load distribution across several turnout sleepers);
- increase the ballast contact area (reduction of ballast contact pressure);
- stabilise the uppermost layer of ballast (interlocking effect in the elastomer).

This will provide the following benefits:
- a homogenous loading of the turnout components;
- a reduced ballast deterioration;
- a reduced settlement of the ballasted track;
- a higher lateral stability of the turnout sleepers.

A new development – the Getzner Sensor Sleeper

How does a ballasted track transfer loads in real operation? This is a tricky question that might be answered using the possibilities that are offered by new technical innovations.

Fitting sensors to products enables real-time data from the field to be measured, stored, and processed. The Sensor Sleeper from Getzner Werkstoffe is an example of such a newly developed product. It allows the load distribution between sleeper and ballast to be measured directly at the bottom of the sleeper. Thin sensors measure the loads and the sleeper/ballast contact pressure as the train passes over. These measurements can then be processed and stored in the cloud (Fig. 12).

The first prototypes of the Getzner Sensor Sleeper were installed in the ÖBB network in 2017, on a number of L2 and L17 concrete sleepers (partially and fully padded) [9].

In Fig. 13, an example of a possible illustration of measured sleeper/ballast contact area and mean sleeper/ballast contact pressure is shown.

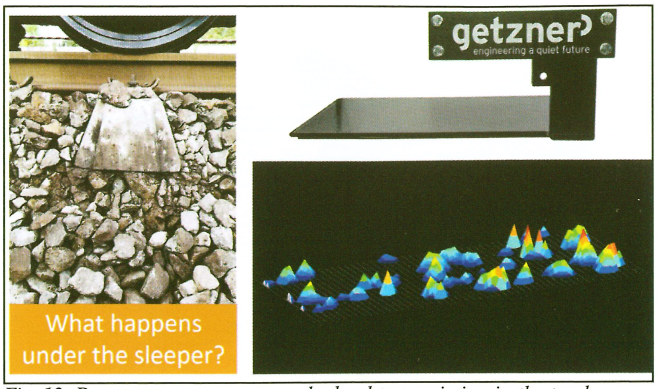

Fig. 12: Pressure sensors measure the load transmission in the track

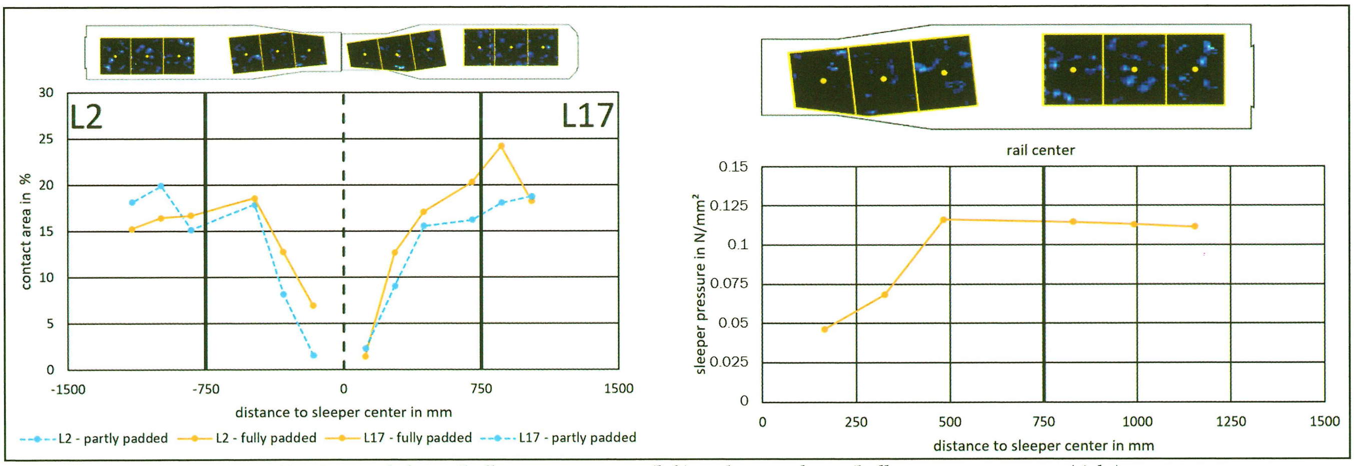

Fig. 13: Measured sleeper/ballast contact areas (left) and mean sleeper/ballast contact pressure (right)

As the initial measurements were promising, this new technology is now being actively pursued. During the Shift2Rail project, the opportunity arose to create an innovative development and to use it for the first time in reference and demonstrator turnouts. Initially, a total of four turnouts were fitted with the second generation of the "Getzner Sensor Sleeper" (Fig. 14). The measurements will continue, so that long-term experience data can be gathered and provided.

The potential application of the Getzner Sensor Sleeper can generally be described as follows:

— proof of concept (evaluation of track measures; sensors will be supplied with the product);
— new research results (to improve the track components rail pad, baseplate pad, rail fastening, sleeper, under-sleeper pad, etc.);
— predictive maintenance (fixing problems before they occur);
— monitoring of load spectrum (how trains are loaded);
— safety monitoring (monitoring of sleeper behaviour in the ballast bed; voids, lateral track displacement at hotspots (e.g. crossings, pronounced settlement, etc.).

Fig. 14: Equipped demonstrator sleeper of the Shift2Rail project

Data can be accessed remotely via the cloud from any location. In Fig. 15, the measurement chain is shown.

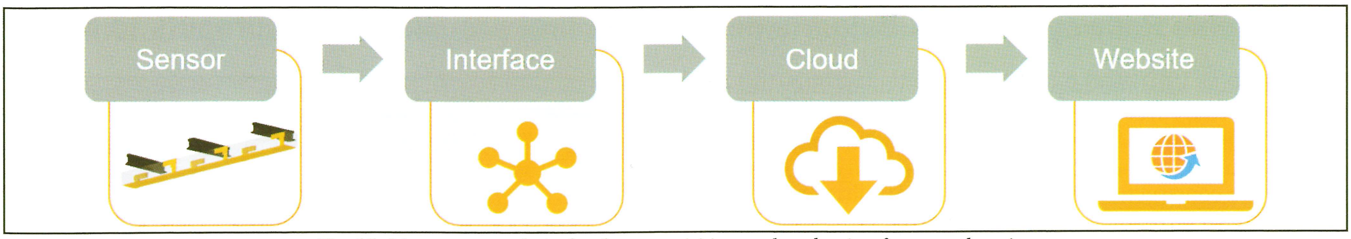

Fig. 15: Measurement chain for data acquisition and evaluation from any location

Outlook – Smart PSS

A Product Service System (PSS) is a marketable set of products and services that is offered to customers as a bundled solution [10]. Getzner Werkstoffe GmbH has set itself the task of adding the emerging technical developments in the field of sensors to its capabilities [11]. This is done with the aim of maximising the benefits to rail infrastructure managers and railway operating companies by offering tried and tested elastomer solutions for both plain track and turnouts.

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