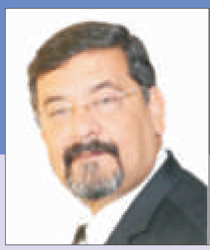
The DFCCIL JOURNAL

ISSUE VI, MARCH 2020

डेडीकेटेड फ्रेट कोरीडोर

Heavy Haul Superstructure Improvements at Hot Spots with Under Sleeper Pads



Sanjay Risbood
Getzner India Pvt. Ltd., 24 Tejas Society.
Kothrud, PUNE 411038. INDIA

Stefan Vonbun
Getzner Werkstoffe, Herrenau 5,
Bürs 6706, Austria

Dr. Ferdinand Pospischil
University of Innsbruck,
Unit of Intelligent Transport Systems,
Technikerstraße 13, Innsbruck 6020, Austria

Dr.Harald Loy
University of Innsbruck,
Unit of Intelligent Transport Systems,
Technikerstraße 13, Innsbruck 6020, Austria

The following contribution presents information regarding Under Sleeper Pad(USP) technology in ballasted track and its benefits with regards to maintenance reduction in heavy haul lines. It refers to the latest findings of a coordinated system of elastic elements in railway superstructure and especially at so-called 'hot spots' like turnouts and transition zones. The state of the art finite element modelling is compared with in situ measurements and feedback from track operators.

1. Introduction

In the railway superstructure USP are primarily used for ballast protection and to improve track quality. They increase the contact area between concrete sleepers and the top ballast layer, reduce the formation of hollowness beneath sleepers and lower superstructure settlements. Next to the standard track Under Sleeper Pads can also be used to smoothen the deflections of transition zones and increase the life cycle value of all track components.

Figure 1: Padded concrete sleepers with polyurethane USP installed in track.

1. Methods

High quality superstructure systems are based on evenness and resilience and therefore a lower force excitation due to passing trains. These forces alter the track bed quality. Hollow areas below the sleepers and signs of wear on the wheel and rail surface, both of which arise over time, increase these processes as well as being the result of them. The track vibrates more and more, thereby also increasing the emissions. By tamping and adjusting, the superstructure has to be returned to its original position. The period of time this deterioration takes is largely dependent on the initial quality of the track superstructure. The creation of the conditions necessary for a good, durable line that is as inherently stable as possible should therefore be the primary goal when installing new track. In this context, evenness and resilience are important starting points for a high-quality superstructure system. Especially at higher velocities, axle loads and train frequencies, problems in the quality of the track superstructure have a great impact on the degradation, the maintenance and comfort of the passengers. Through the defined arrangement of elastic elements, such as Under Sleeper Pads, the railway track edges nearer to achieving this goal.

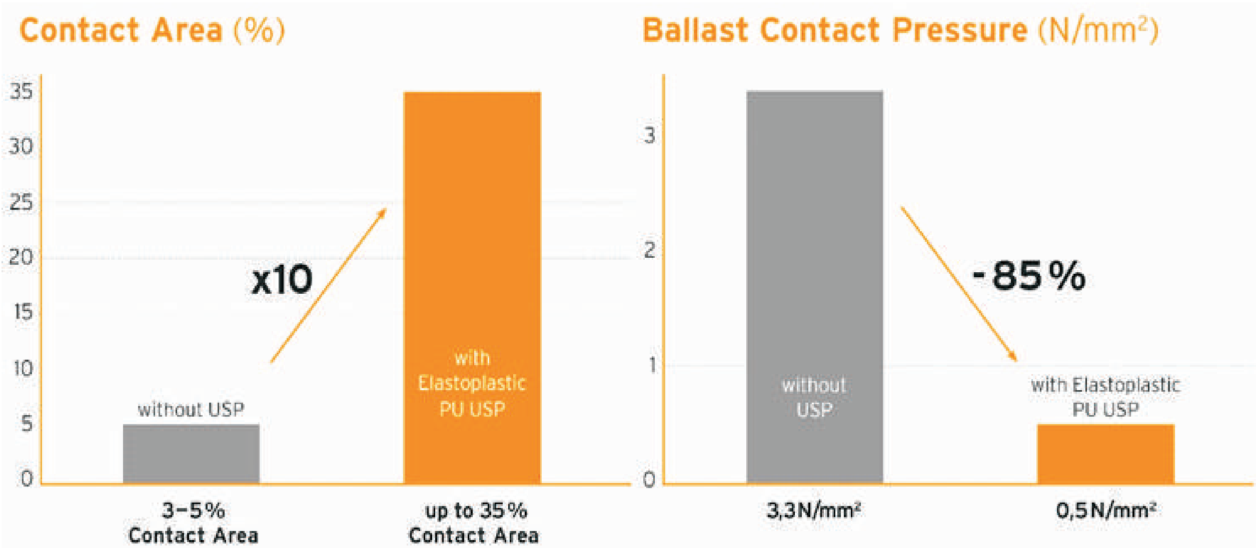
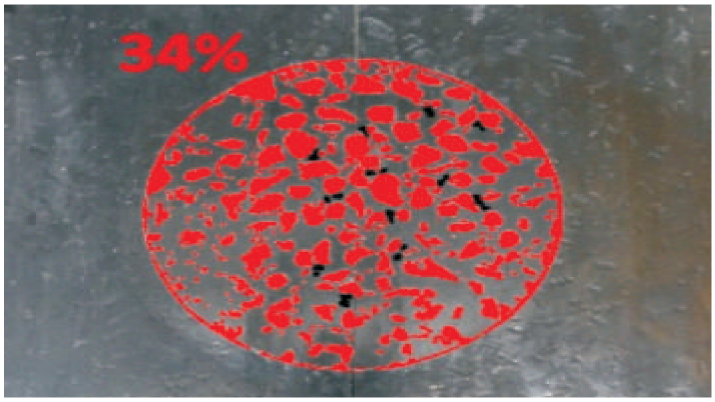


Figure 2: High contact area of elastoplastic polyurethane USP drastically reduces ballast contact pressure.

Arranging polyurethane (PU) Under Sleeper Pads beneath concrete sleepers prevents a hard impression directly on the ballast. The upper-most layer of ballast can bed into the padding material, increasing the contact area (from 2-8% without padding or EVA padding, to 30-35% with PU padding, refer to Figure 2) and thereby also avoiding excessive contact pressures. The larger ballast contact area and more even bedding lead to increased stability of the ballast bed, less track settlement and reduced wear to significant track components. Laboratory and field testing are presented showing the positive impact of the under sleeper pad on lateral resistance and settlement of the track.

Figure 3: Deflection measurements at the transition zone (top). Determining the contact area in the lab (bottom).



3. Results

With the results from open track data the next step is to have a closer look upon hot spots like transition zones between different superstructure types or turnouts. These abrupt changeovers along different superstructure constructions manifest themselves as a discontinuity in track parameters, such as deflection and bedding and result in accelerated wear of the superstructure.

The defined introduction of elastic elements into the track can drastically reduce rates of wear. Polyurethane products have been proven in the laboratory, but even more importantly: in the field. Modern simulation methods help engineers to develop an all-embracing design that takes into account the different elastic layers. A hot spot that has been optimized in terms of stiffness and settlement helps sustain track quality for longer and increases the availability of the rail network.

To extend the longevity of a hot spot the approach of optimization is as follows: dividing the hot spot into a number of sections, with the stiffness gradient minimised over a longer length. Various elastomers can be used depending on the specific function in question. Laboratory experiments and in-situ measurements round off these theoretical studies. As the aforementioned sample projects illustrate, this facilitates the targeted use of Under Sleeper Pads. Existing conflict points can even be neutralised retrospectively without having to rebuild the entire superstructure, because retrofitting of these products is also possible.

3.1 Transition zones

Transition zones can be found anywhere in a railway network where a change in superstructure build-up occurs (refer to figure 4). Very common transitions zones are:

(1) Transition from ballasted track to slab track

(2) Bridge approaches

(3) Tunnel to open track (very high difference in the stiffness of the track sections)

(4) Transition from open track to turnout and other special track work

A change in superstructure results in a sudden change in bedding modulus (stiffness), USP technology is used to smoothen this stiffness change. The length of transition zones is determined by the speed of the trains running on the line, often the "one second rule" applies: every stiffness step of the improved transition zone should have a length consistent with the distance the train travels in one second.

For a train travelling at e.g. 100kph this distance would be 28m. If the stiffness is adjusted in two steps with two different USP types, the total length of the transition zone would be 56m. The absolute minimum for reasonable transition zone length is the bogie to bogie centre distance.

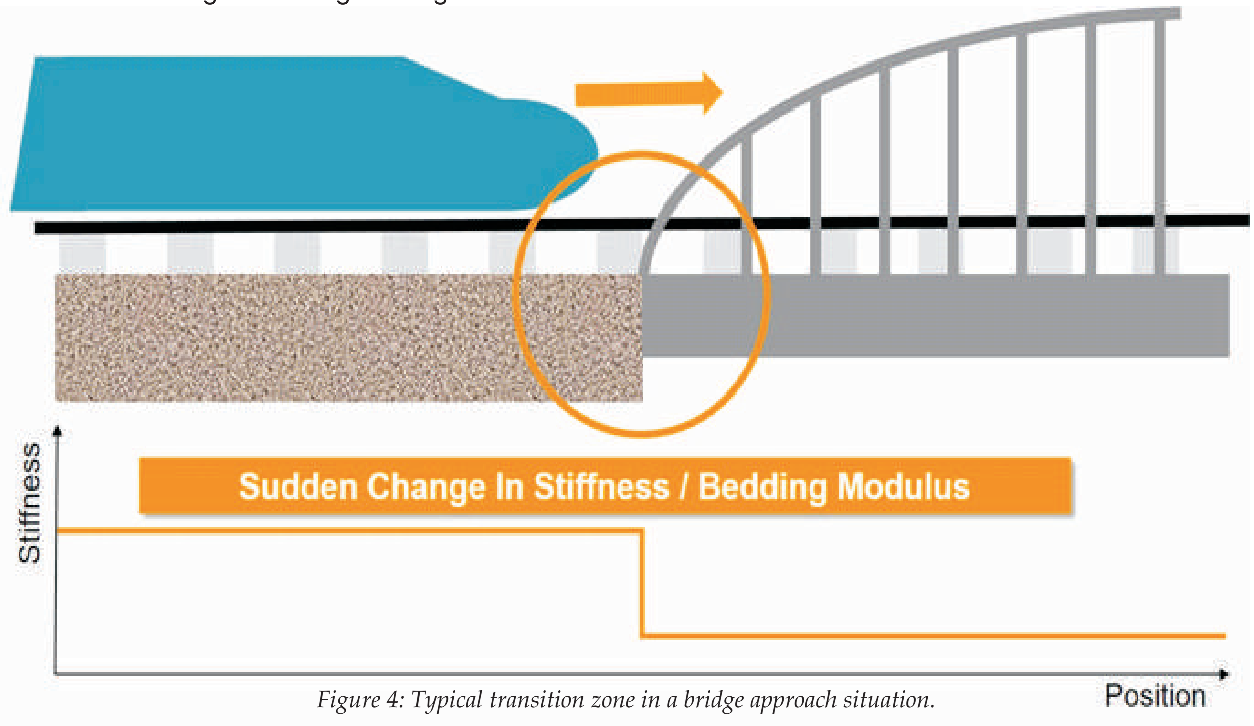


Figure 4: Typical transition zone in a bridge approach situation.

3.2 Turnouts

Compared to straight track, for which calculations are easy to conduct due to the relatively homogenous geometry with constant rail profiles and sleeper mounting surfaces, calculating elastic elements in turnouts is far more complex. The main reasons for higher effort include the varying profiles of the rails, the additional construction elements and the generally strong variations in the sleeper conditions. These parameters result in varying degrees of vertical load deflection. High-quality elastic elements, perfectly tailored to one another using modern computational methods, guarantee improved track bed quality and ensure enhanced availability of the rail network.

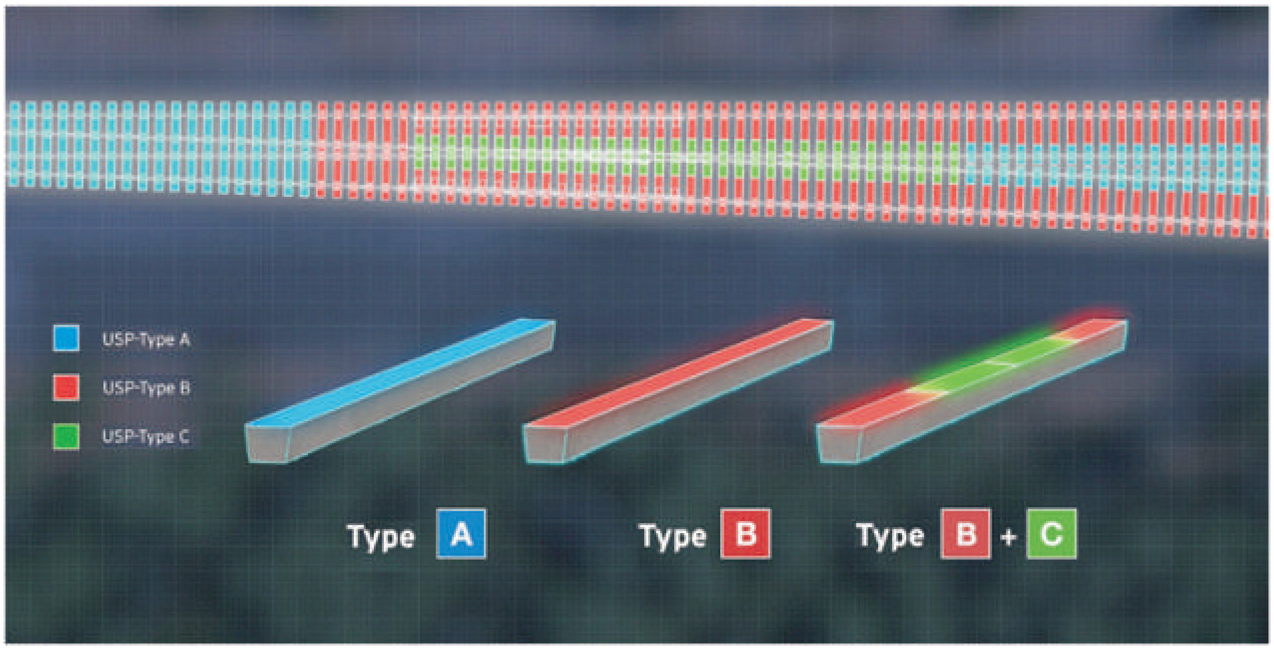


Figure 5: Using different PU USP types to optimize a turnout.

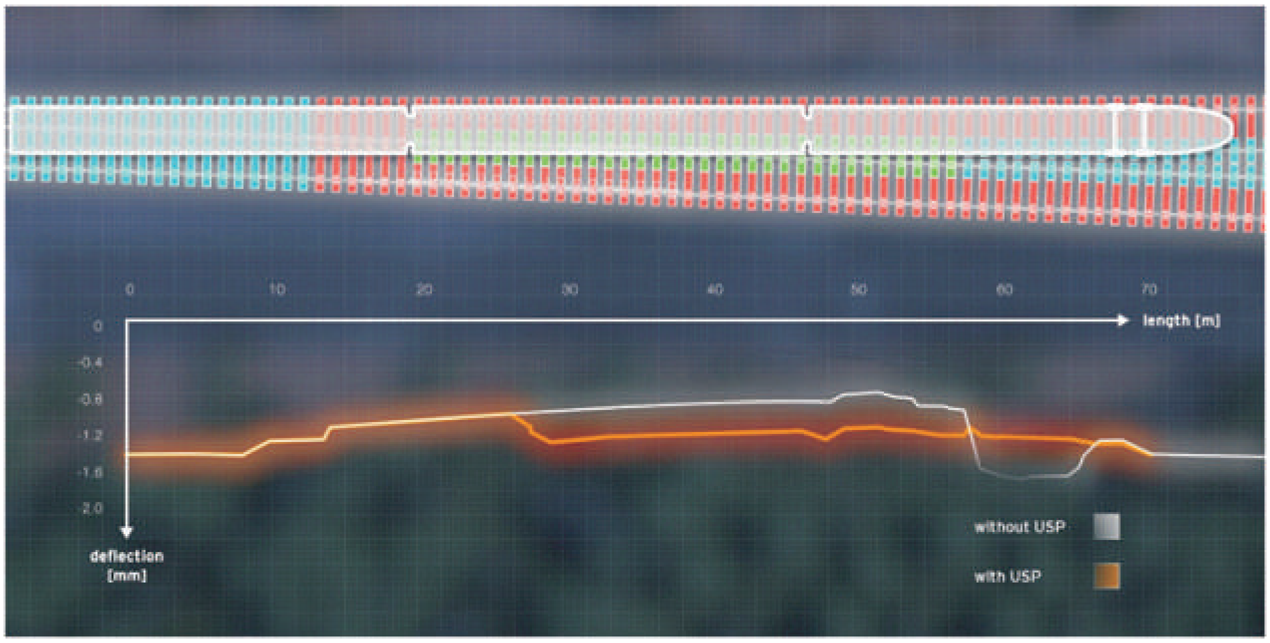


Figure 6: Smoother rail deflection due to defined elasticity introduced by PU USP.

Reference at EDFC:

One turnout in the Eastern DFC at Daud Khan is equipped with PU Under Sleeper Pads since 2019.The performance monitoring of this padded turnout is currently in progress to confirm the advantages of using PUR USP for reduced turnout maintenance. For demonstrating the benefits, the padded turnout is compared with a non-padded turnout on the same line.

The positive effects of Under Sleeper Pads have long been proven in railway tracks across the globe and PU USP are now standard components in the track superstructures of Deutsche Bahn (Germany), ÖBB (Austria), RFI (Italy), Network Rail (UK) and SNCF (France) amongst other.

Excerpt of global references in Heavy Haul:

Heavy haul operators have already successfully adopted PU USPs in their networks, significantly decreasing their track maintenance efforts.

- FMG (Australia)
- VALE, MRS (Brazil)
- DaQin Coal Line (China)
- Malmbanan (Sweden/Norway)

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Conclusion

With the introduction of PU based Under Sleeper Pads (USP),several railway operatorshave alreadytaken a huge step towards maintenance reductions in the superstructure and therefore an efficient and sustainable railway track. With the help of laboratory and in-situ track measurements the finite element model was calibrated and is ready to improve superstructure hot spots such as transition zones, bridge approaches and turnouts. Positive feedback from railway operators around the globe proves the link between theory and reality. Long-time measurements show the importance of a good track quality and emphasize the positive effects of Under Sleeper Pads and their improved contact area.

Benefits of USP:

- Under Sleeper Pads increase tamping intervals by at least a factor of two. (60.000 cross-sections examined in the network of ÖBB, Austrian Federal Railway)
- Maintenance costs and operational hindrances are greatly reduced.
- Service life of track assets are increased by 20-30%
- Economic benefits are proven by Technical University of Graz (Austria), the world's leading experts in lifecycle management and LCC analyses.

Truncated Sections of Dedicated Freight Corridors (East-West and East-Coast)

Truncated Sections of East-West & East-Coast DFCs

Name of Corridor	Route Length (km)	Symbol
Truncated Section of East-West (Hijli to Sindi)	1,152	
Truncated Section of East-Coast (Hijli to Kottavalasa)	751	
Total	1,903*	

*Route length including connections with IR network=2090 km (i.e. Equated Length)

Dedicated Frieght Corridors

Name of Corridor	Route Length(km)	Symbol
Under Construction		
Eastern (Ludhiana to Dankuni)	1,760	
Western (Dadri to JNPT)	1,468	
Under Planning		
North-South (Delhi to Chennai)	2,328	
East-West (Kolkata to Mumbai)	2,328	
East-Coast (Kharagpur to Vijayawada)	1,115	
Southern (Goa to Chennai)	893	
Total	9,892	

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Dedicated Freight Corridor Corporation of India Limited

(भारत सरकार का उपक्रम)

(A Govt. of India Enterprises)

5th Floor, Pragati Maidan Metro Station Building Complex,
New Delhi -110001 Ph-011-23454700, Fax-23454701

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