# Field tests confirm the effectiveness of the Dynamic Track Stabiliser

Lateral track resistance is a decisive factor for a stable track geometry, which is a crucial element in rail traffic safety. Field tests have been conducted to determine the effect of dynamic track stabilisation on lateral track resistance for different types of track structure, which have yielded a good insight, as alluded to in this article. Furthermore, it is expected that lateral track resistance could be further increased by adjusting machine parameters – laboratory tests to investigate this are in progress.

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## TRACK GEOMETRY STABILITY: LTR AND DYNAMIC TRACK STABILISATION

A ballast bed must be homogeneous and stable so that it can fulfil its functions, i.e.:

— allow a uniform distribution of the dynamic forces generated by rail traffic onto the track substructure;
— provide a high resistance to sleeper displacement (both longitudinal and lateral);
— ensure that a durable track geometry is maintained as long as possible.

Track geometry stability is a crucial element of safety in rail traffic. Lateral track resistance (LTR) is a suitable parameter for a quantifiable description of track geometry stability.

### Dynamic track stabilisation

By deploying the Dynamic Track Stabiliser (DTS) following tamping a high LTR and, thus, track geometry stability can be achieved.

While tamping only compacts the ballast underneath the sleepers, the DTS produces a homogenous compaction of the entire ballast bed and ensures that any cavities underneath the sleepers are reduced. To achieve this, following tamping, the DTS travels over the track at a continuous speed and puts the track panel and ballast into a targeted horizontal vibration, whilst at the same time applying a static vertical load. In this manner, a friction-free and homogeneous re-arrangement of the ballast stones and an even consolidation of the entire ballast bed is effected. As a result, the track panel is firmly established in the ballast bed and a high resistance to lateral displacement is achieved, obviating the need for speed restrictions.

As a rule, track stabilisation using the DTS is carried out immediately following tamping. For over 40 years now, the DTS has been successfully adopted in a large number of countries, where it has become a part of the standard maintenance procedures for ballasted track, as by its use speed restrictions following track work can be avoided. However, restrictions for DTS use still exist in Germany where, since 1995, it is governed by German Rail (DB AG) Regulation DS 820 03 15 [1], which defines that, on German high-speed and upgraded railway lines, the DTS is to be deployed following the first tamping pass and that it could also be deployed following the second tamping pass. In other words, using the DTS following the second tamping pass is not an obligation, but an option. Additional restrictions exist for its deployment on track sections with nearby buildings (distance to the track axis <10 m), on steel bridges and arched bridges, as well as in tunnels with walls made of bricks, dimension stone or non-reinforced concrete [1].

Field tests, conducted within the framework of a research project to quantify the increase in LTR that is achieved by DTS use following tamping, have confirmed that a reduction in speed restrictions can be achieved by DTS use, as also alluded to in the following.

### DynlaTrack research project – impact of DTS use on LTR for different types of track structure

Based on the ongoing further development of the DTS and the introduction of new track components with varying degrees of stiffness, an extensive research project is being conducted by the Institute of Road, Railway and Airfield Construction of the Technical University of Munich (TUM), in cooperation with Plasser & Theurer, to investigate the impact of DTS use on LTR for different types of track structure featuring components with varying degrees of stiffness.

Known as DynlaTrack, this research project embraces the conducting of:

— *field tests:* these are aimed at determining the maximum LTR quality that can be achieved for different types of track structure featuring sleepers with and without sleeper pads, using current standard DTS machine parameters;
— *laboratory tests:* these are aimed at investigating the potential for further increases in LTR by adjusting DTS machine parameters, based on the experience gained during the field tests. A large-scale test bed has been set up especially for these laboratory tests

### Aim of the two-part test series – impact of DTS use on lateral track resistance (LTR)

The aim of the two-part test series is to determine how changes to the DTS machine parameters lead to an optimal increase in LTR for different types of track structure. LTR is the most important safety factor for lateral track geometry stability. If there is insufficient resistance, track buckling or track deformation can occur. LTR describes the force needed to displace a sleeper laterally, measured in kN. When it refers to track length, it is measured in N/mm. As LTR is a decisive measurement parameter when evaluating track geometry stability, it has been selected as an indicator of the quality of track stabilisation achieved during both the field and laboratory tests.

## FIELD TESTS – TEST SET-UP AND MEASUREMENT PROCESS

Two field tests were conducted, i.e.:

— *Field Test 1,* which was conducted near Wiesloch, southwest Germany, by DB Systemtechnik GmbH;
— *Field Test 2,* which was conducted near Hildesheim, northwest Germany, by the Institute of Road, Railway and Airfield Construction of TUM.

In terms of the test set-up adopted for the LTR field measurements, the difference between the measurement method adopted by DB Netz AG and that by TUM to determine LTR is minimal. The comparability of the results obtained by both measurement methods is also confirmed on the basis of several comparable measurement procedures that are described in the UIC publication "Lateral Track Resistance" [2].

In the following, the steps comprising LTR measurement at a single sleeper are described using the measurement process developed by TUM. In Fig. 1, the respective test set-up is shown.

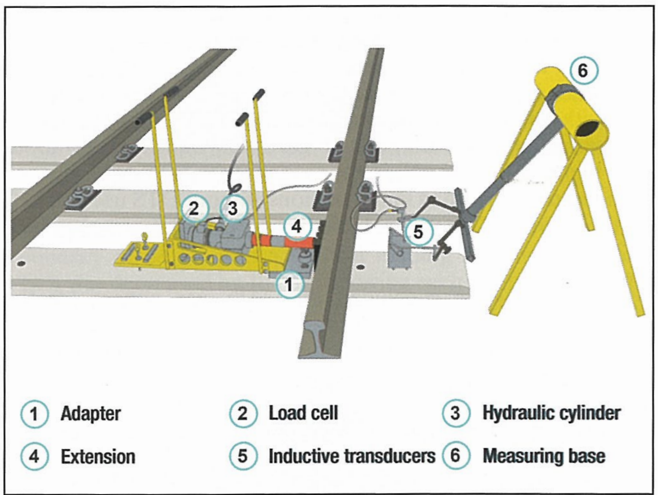

*Fig. 1: Test set-up for LTR field measurement as adopted by the Institute of Road, Railway and Airfield Construction of TUM*

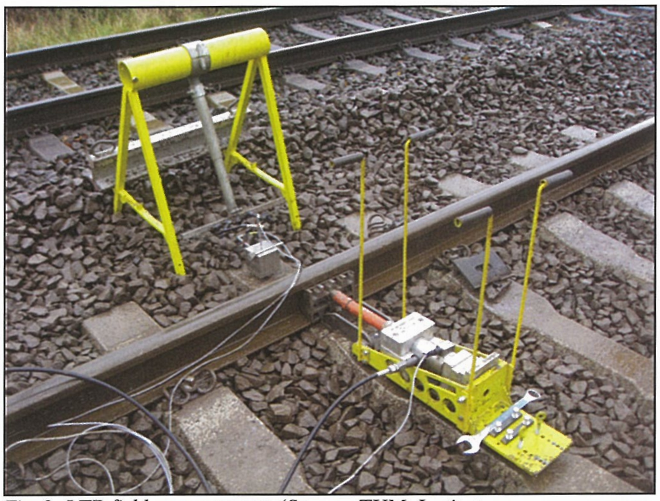
*Fig. 2: LTR field measurement (Source: TUM, Institute of Road, Railway and Airfield Construction)*

**Preparation of the test sleeper**

Before a LTR measurement can take place, the sleeper to be measured must be prepared accordingly. First, the rail fastenings along the relevant section of track are loosened. Then, the rail pads and rail fastenings or, if applicable, the angle guide plate are removed from the sleeper that is to be measured. Following this, the other sleepers are fastened to the rail again. This force-fit connection of the neighbouring sleepers creates the abutment needed for the displacement process. Further, by removing the rail pads from the sleeper to be measured, it is ensured that this sleeper does not come into contact with the bottom of the rail base during the lateral displacement process. For this displacement process, a loading unit is positioned and secured into place between the rails (see also Fig. 1). The loading unit consists of a hydraulic cylinder, a load cell, and an extension that connects it to an adapter located in the rail web. The loading unit presses itself via the extension against the adapter in the rail web, where the centre of gravity of the rail is located, in parallel to the underside of the sleeper. An adjustable electric pump pressurises the hydraulic cylinder.

**The LTR measurement process**

During the LTR measurement, the sleeper is continuously displaced laterally by approx. 6-10 mm by means of the hydraulic cylinder. The calibrated load cell records the force required for displacement. Calibrated inductive transducers located at the end of the sleeper measure the lateral displacement, as well as the concurrent vertical lifting of the sleeper.

A separate measuring base is positioned in the ballast at the sleeper end, away from the path of sleeper displacement (see Fig. 1). It is stabilised with a piece of rail and held in place in the ballast in such a manner that a flawless measurement result is guaranteed. Measuring arms and hydraulically adjustable tripods are attached to the measuring base, which are used to position the inductive transducers horizontally and vertically over a measuring block (a flat block of solid steel) located on the end of the sleeper. In Fig. 2, the set-up of the field test is shown. The power supply, measuring amplifier and data collection equipment can be carried on an on-track platform.

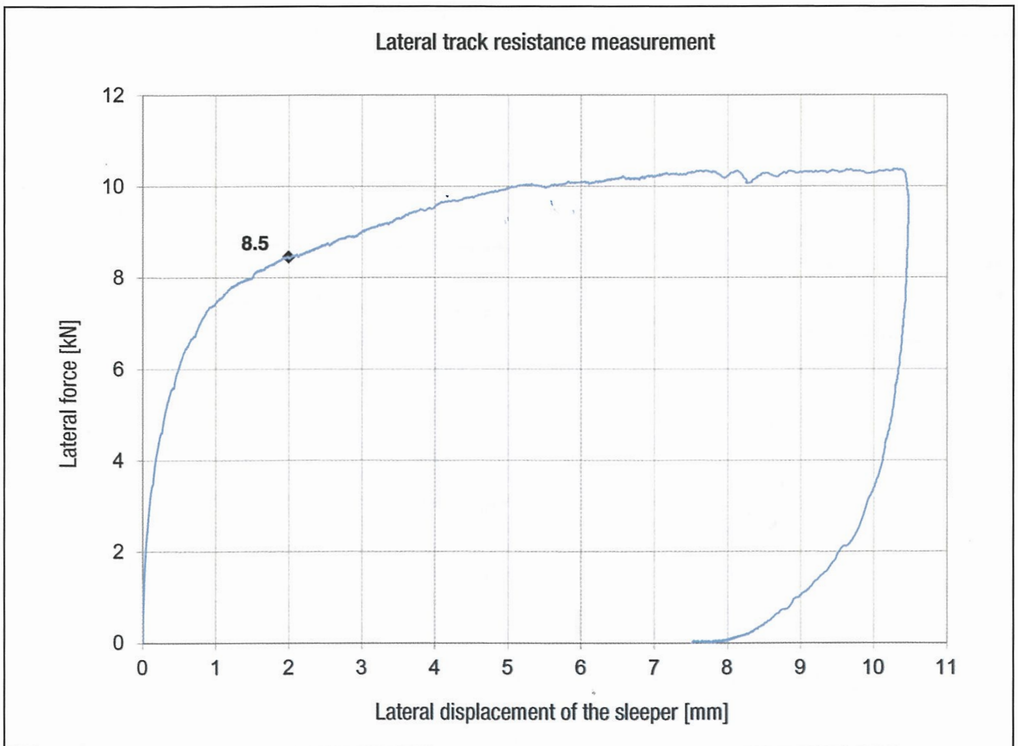

*Fig. 3: Example of a LTR measurement result (Source: TUM, Institute of Road, Railway and Airfield Construction)*

In Fig. 3, an example of force displacement behaviour of a LTR measurement is shown. The result comprises a continuous-action recording of the lateral displacement path of the sleeper and the horizontal force required for this displacement.

Usually, LTR measurements show a quasi-bilinear force-displacement behaviour. The decisive value for LTR analysis is the force that is activated for a displacement of 2 mm. In relation to a single sleeper, this value can be expressed as LTR (2 mm) in kN; it can also be used to refer to track length in which case, based on the actual sleeper spacing, the resulting value is then w (2 mm) in N/mm. Ideally, the sleepers are not displaced by more than 10 mm.

**Field tests conducted at two locations**

As noted earlier, field tests were conducted at two different locations in Germany, i.e. one in the vicinity of Wiesloch by DB Systemtechnik GmbH, and the other in the vicinity of Hildesheim by the Institute of Road, Railway and Airfield Construction of TUM, the results of which are alluded to in the following.

## FIELD TEST 1 – CONDUCTED NEAR WIESLOCH, SOUTHWEST GERMANY

The field test conducted near Wiesloch focused on how the formation protective layer (FPL) and layer-by-layer consolidation of the ballast bed influence LTR. The track sections selected for the field test were particularly suitable, as the subsoil conditions in this area vary greatly.

Two test track sections were selected: one with FPL and one without. Both sections were divided into three subsections each, i.e.:

— *Subsection 1:* in this section, no dynamic track stabilisation was adopted at all – this subsection served as a control section;

— *Subsection 2:* in this section, dynamic track stabilisation was adopted only following the first tamping pass;

— *Subsection 3:* in this section, dynamic track stabilisation was adopted following each tamping pass.

In order to prevent any mutual interference between the subsections, appropriate transition zones were defined between them. Dynamic track stabilisation was conducted with a vibration frequency of 32 Hz and a vertical loading of 80 bar.

Each test track section featured B70 sleepers, type W rail fastenings, type Zw900 rail pads and type 60 E2 rail throughout the duration of the test. DB Systemtechnik GmbH measured the LTR at 25 sleepers per subsection. In each of the six subsections, three LTR measurements were conducted (and ballast specimens collected), i.e.:

— one directly following tamping with/without DTS use;

— one following a traffic loading of 100,000 load tonnes;

— one following a traffic loading of 1.5 million load tonnes.

**Conclusion Field Test 1 – DTS use only makes sense when it is done following each tamping pass**

The field test conducted near Wiesloch yielded no significant difference in results in terms of LTR for the track sections with and without FPL. The measurements conducted immediately following tamping with/without DTS use indicated an about 30% higher LTR (7.3 kN) in the sections with DTS use following each tamping pass than in the sections without DTS use (5.6 kN) or those with DTS use only following the first tamping pass (5.3 kN).

Thus, it can be concluded that DTS use only yields the desired results when it is done following each tamping pass. Doing so is the only way in which a homogeneous consolidation of the ballast bed and a durable track geometry can be achieved. This conclusion is in line with the following passage from the latest version of Regulation 824.2200A01 of DB Netz AG: "[...] dynamic track stabilisation following each tamping pass delivers a better work result than a single DTS use (only following the first tamping pass)" [3].

In order to be able to draw conclusions about the effectiveness of DTS use as regards ballast bed consolidation, the LTR mean values obtained following a traffic loading of 100,000 load tonnes without DTS use were compared with those obtained immediately after DTS use following tamping. With regard to the B70 sleeper, the results confirm that DTS use results in a consolidation of the ballast bed that corresponds with that from a traffic loading of about 100,000 load tonnes. An analysis of changes in granulation size showed no increased wear of the ballast stones as a result of DTS use.

## FIELD TEST 2 – CONDUCTED NEAR HILDESHEIM, NORTHWEST GERMANY

The field test near Hildesheim was conducted by the Institute of Road, Railway and Airfield Construction of TUM during the course of track renewal work. In addition to the B70 sleeper, which was part of the field test conducted near Wiesloch, the B07 sleeper with sleeper pads (B07So) was included in the test. Thus, two test track sections were selected, one featuring B70 sleepers with type Zw687 rail pads and one with B07So sleepers with type Zw1000 rail pads, with both sections featuring 60 E2 rail and type W rail fastenings.

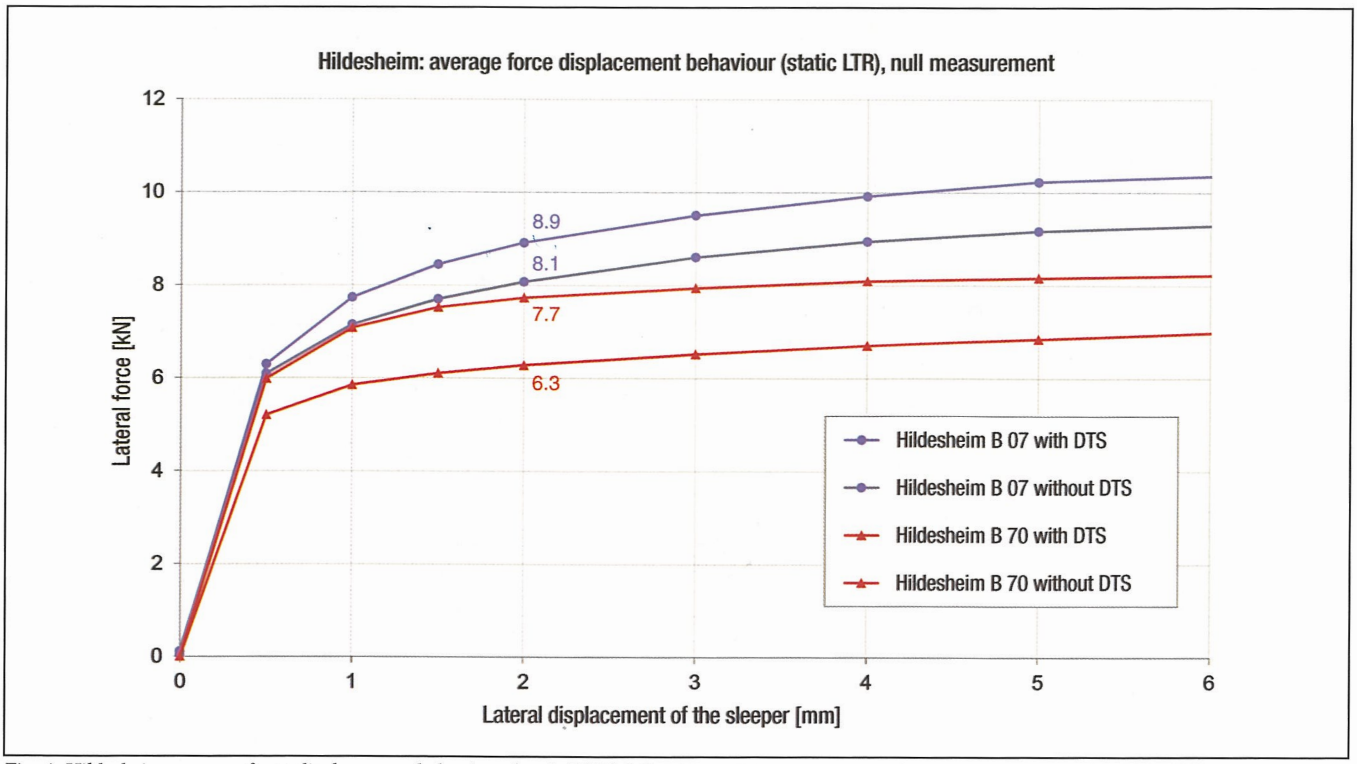


*Fig. 4: Hildesheim: average force displacement behaviour (static LTR) following each tamping pass [4] (Source: TUM, Institute of Road, Railway and Airfield Construction)*

Following the field test near Wiesloch, it was concluded that these two track sections would be divided into two subsections each instead of three, i.e.:

— *Subsection 1:* in this section, no dynamic track stabilisation was adopted at all – this section served as a control section;
— *Subsection 2:* in this section, dynamic track stabilisation was adopted following each tamping pass.

Dynamic track stabilisation was conducted with a vibration frequency of 31 Hz and a vertical loading starting at 70 bar, which was decreased by 10 bar following each tamping pass. The construction firm in charge of the track renewal had defined these settings.

The static LTR was measured at 15 sleepers per subsection, as well as the vertical and horizontal sleeper acceleration during DTS passage. The latter serve to verify laboratory experiments that are being conducted by the Institute of Road, Railway and Airfield Construction of TUM.

In each of the four subsections, three LTR measurements were conducted, i.e.:

— one directly following tamping with/without DTS use;
— one following a traffic loading of 100,000 load tonnes;
— one following a traffic loading of 1.5 million load tonnes.

In Fig. 4, the average force displacement behaviour following tamping is shown.

**Conclusion Field Test 2: increase in LTR is larger for sleepers without sleeper pads than for those with – increase potential can be expected**

The field test conducted near Hildesheim has shown that DTS use clearly increases LTR in the case of both sleepers with sleeper pads and those without. As in the case of the sleepers without sleeper pads (B70) the initial LTR value is lower, the relative increase in LTR for these sleepers is larger than for those with sleeper pads (B07So).

In the case of B70 sleepers without sleeper pads, DTS use increases LTR by approx. 30%. In the case of B07So sleepers with sleeper pads, the frictional connection between ballast and sleeper pad is higher from the start. Even so, in this case, DTS use leads to an increase in LTR of about 10%.

It is expected that by a targeted adjusting of the DTS machine parameters to the stiffness properties of the respective type of sleeper, there is potential for further increases in LTR. In this respect, laboratory experiments are being conducted at the Institute of Road, Railway and Airfield Construction of TUM that aim to determine the extent to which the machine parameters need to be adjusted, the results of which will expectedly be published in the form of a dissertation at the end of 2020.

## PROMISING RESULTS OFFER BRIGHT PROSPECTS

The results obtained from the two field tests have confirmed the positive effect of dynamic track stabilisation on LTR, which offers very good prospects for this technology, such as:

— *introduction of new regulations as to DTS use:* for instance, Regulation 824.2200A01 of DB Netz AG states that: "the next amendment of this Regulation will foresee in a compulsory DTS use for every tamping pass within the scope of track laying and renewal" [3]. The measurement results obtained from the field tests have shown that the increase in LTR through DTS use depends on the respective type of sleeper. The increase in LTR achieved in the case of B70 sleepers using standard DTS machine parameters is almost three times higher than that of B07So sleepers. In the case of B70 sleepers, DTS use following tamping results in an increase in LTR that is comparable to that of a traffic loading of 100,000 load tonnes;
— *optimisation of machine parameters investigated in laboratory experiments:* the data gained from the field tests has highlighted that there is still unlocked potential for further increases in LTR by DTS use. As noted earlier, laboratory tests are being conducted by the Institute of Road, Railway and Airfield Construction of TUM to examine this more closely and to prove this scientifically which, subsequently, will be succeeded by further field tests to verify the laboratory results.

## FINAL REMARKS

The field tests conducted in Germany have yielded a good insight into the effectiveness of dynamic track stabilisation as regards lateral track resistance (LTR), and that this may be further enhanced by adjusting machine parameters. The latter is the subject of laboratory experiments that are being conducted by the Institute of Road, Railway and Airfield Construction of the Technical University of Munich (TUM), as well as of subsequent further field tests.

DTS use immediately following tamping leads to a high initial LTR and track geometry stability, which in many cases obviates the need for temporary speed restrictions and reduces the risk of track buckling or track deformation, thus increasing both track availability and safety.

## REFERENCES


[1] German Rail (DB AG) Regulation DS 820 03 15: 'Dynamische Stabilisierung von Gleisen und Weichen (Dynamic stabilisation of tracks and turnouts)'.

[2] 'Lateral Track Resistance LTR', International Union of Railways (UIC), Edition No. 1, June 2019, ISBN 978-2-7461-2827-9.

[3] DB Netz AG Regulation 824.2200A01: 'Oberbauarbeiten durchführen (Carrying out track maintenance work)', June 2018.

[4] 'Bestimmung des statischen und dynamischen Querverschiebewiderstands (Determining static and dynamic lateral track resistance)', Institute of Road, Railway and Airfield Construction, Technical University of Munich (TUM), Report No. 3706, Munich, Germany, May 2018.