Tracking the Dynamic Track Stabiliser — results of large-scale investigations provide a better understanding of its effectiveness

Using the Dynamic Track Stabiliser for the final compaction and homogenisation of the ballast bed following tamping has a significant positive effect on the resistance to lateral displacement of the track. New large-scale investigations yield a better understanding of the system behaviour of ballast and the interactions between the rail and the permanent way, as well as the key interactions of the Dynamic Track Stabiliser in this respect.

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SAFETY FROM A STABLE TRACK GEOMETRY – THE ROLE OF THE DYNAMIC TRACK STABILISER

The development of the continuous welded rail (CWR) track – see box – has led to a significant increase in the quality and speed of rail traffic. However, this also did away with the benefit of the rail joint gap, since significantly higher forces arise from temperature changes in CWR track that have to be transferred safely into the track, whereby the resistance to lateral displacement of the track plays a significant role. The lateral track resistance is a decisive safety factor for a stable track geometry. If this resistance is too low, the track panel can buckle (lateral distortion) and, in the worst case, a train can derail. Particularly on high-speed lines and in sharp curves, lateral track resistance is a safety-relevant criterion.

Straight after track work, such as new construction, renewal or maintenance, the lateral track resistance is reduced to up to 50% of its original value. To avoid track buckling resulting from traffic loading, the track may only be travelled on at a reduced speed. This speed restriction has to remain in force until the track panel is again firmly established in the ballast bed, i.e. until the correct lateral track resistance value has been achieved again.

At the same time, rail infrastructure operators face huge challenges:
— ever shorter track possession times;
— an increasing pressure on line availability;
— a strict avoidance of delays or failures.

The Dynamic Track Stabiliser (DTS) is the optimum answer to these challenges, in that "A well-consolidated ballast bed can transfer impact momentum to the subsoil without any great deformations, while a badly consolidated track will suffer much greater deformations under the same loads", as noted by Karl Kienzer, who established this theoretical basis for the DTS and its functioning in his doctoral dissertation [1].

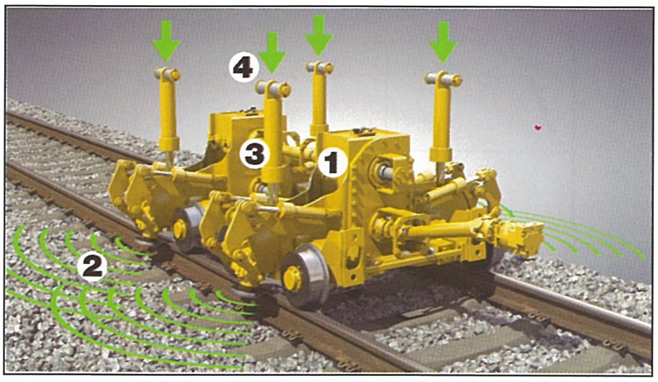

Fig. 1: Variable imbalance (1) generates horizontal vibration (2), hydraulic cylinders (3) effect the vertical load (4)

CWR track – the basis for high-speed rail traffic

The Stockton & Darlington Railway Line in England plays a crucial role in railway history. Its 1,435 mm wide gauge laid the foundation for the standard-gauge track. It was put into operation in 1825 as the first public railway line that was also approved for passenger transport. Just under 200 years and many technological innovations later, the railway has become an integral, indispensable part of our society and everyday lives.

Another system milestone in railway history was the introduction of the continuous welded rail (CWR) track in 1952, which marked the end of the rail joint gap – this made high-speed rail traffic, as we know it today, possible. The rail joint gaps represented an irregularity in the track, resulting in a more or less rapid deterioration in the quality of the track geometry and track components. The introduction of CWR track removed these irregularities, resulting in lower rail infrastructure maintenance costs and, at the same time, a higher track quality.

Working principle and effectiveness of the DTS

As a rule, the DTS is adopted immediately following machine tamping – it promotes the artificial "settling process" of the track panel in the ballast bed. During tamping, the track panel is lifted from the ballast bed and put into a new position. The ballast stones within reach of the tamping tines are rearranged and a uniform ballast compaction underneath the sleepers is created. The ideal working parameters for tamping are:
— a vibration frequency of 35 Hz; and
— a vibration amplitude of 4-5 mm.

While tamping only compacts the ballast underneath the sleepers, the DTS produces a homogeneous compaction of the entire ballast bed and ensures that any cavities underneath the sleepers are reduced. As a result, the track panel is firmly established in the ballast bed and a high resistance to lateral displacement is achieved, thus obviating the need for speed restrictions following tamping. 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 [2], whilst at the same time applying a static vertical load (Fig. 1). 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. This results in a controlled settling of the track – the consolidation effect can be influenced by the load cylinders of the stabilising unit, and the level of the track can be controlled.

The DTS increases the lateral track resistance, which following tamping is reduced by approx. 50% compared to a fully consolidated track, to up to at least 80%, thus obviating the need for speed restrictions [2]. The effect of the DTS, i.e. the increase in lateral track resistance achieved, corresponds to a traffic loading of 100,000 load tonnes [3].

More options due to variable imbalance

With the development of the adjustable imbalance, the DTS operation can be adapted even better to the respective areas of deployment, thus optimising the work result even further. The decisive parameters for the effectiveness of the DTS have been and still are:

— vibration frequency;
— amplitude;
— vertical load.

The frequency-dependent impact force of the vibration can be determined from the given eccentric mass. Up until now, it was only possible to control this indirectly via the vibration frequency.

With the use of the adjustable imbalance, the impact force can be adapted to the prevailing conditions without changing the vibration frequency. Also, the vibration can be reduced abruptly with this new technology. This is highly relevant in a scenario of frequent stop-and-go operation. Up until now, the DTS had to increase/decrease the vibration frequency gradually when starting working/stopping.

With the adjustable imbalance, it is now possible to stop and start working immediately. The eccentric shaft keeps moving at the pre-set frequency, only the imbalance and, thus, the impact force are reduced. Since the vibration can be reduced abruptly, the track geometry is not affected adversely if the machine has to stop. This function also offers great benefits when stabilising track on bridges, as excitation of the bridge in the resonance zone can be avoided.

This development offers significant benefits in turnouts and in the final tamping process of track construction and track renewal. The speed control adjusts the imbalance to the respective speed of progression, thus ensuring an even consolidation of the ballast bed.

FUNDAMENTAL BENEFITS OF DYNAMIC TRACK STABILISATION CONFIRMED BY NEW FIELD TESTS

Since the introduction of dynamic track stabilisation, the basic operating conditions have changed (e.g. new types of superstructure, the variable imbalance).

To take account of these changes, new large-scale investigations (field tests and laboratory research) have been conducted into the effectiveness and fundamental benefits of dynamic track stabilisation. For instance, extensive field tests conducted in recent years have yielded the benefits of dynamic track stabilisation alluded to in the following.

Benefit 1 – reduction of speed restrictions

In the course of the approval process for DTS use in Germany, extensive investigations were carried out into its effectiveness. Stabilised sections of track were compared with non-stabilised sections. Further, sections with and without sleeper pads were compared against each other. Both the lateral track resistance and the track geometry were taken into consideration in the assessment.

The first results confirmed the findings of measurements conducted in the past, in that it was again established that the increase in lateral track resistance due to DTS use corresponds to a traffic loading of approx. 100,000 load tonnes [4].

Thus, despite changed track configurations, this finding is still valid today and is of particular importance as regards the reduction of speed restrictions following track renewal or track construction. Only when the track panel is firmly settled in the ballast bed, buckling of the track panel due to temperature changes can be prevented.

Benefit 2 – consolidation in layers results in a higher resistance to lateral track displacement

In the course of the aforementioned field tests in Germany, the decision was made to also prove the effect of consolidating the ballast bed in layers (Fig. 2). For this purpose, three sections of track were selected, i.e.:

— *Section 1:* in this track section, dynamic track stabilisation was adopted following each tamping pass;
— *Section 2:* in this track section, dynamic track stabilisation was adopted only following the second tamping pass;
— *Section 3:* in this track section, no dynamic track stabilisation was adopted at all.

The lateral track resistance value was used to analyse the effectiveness of ballast compaction. The lateral track resistance values measured in Sections 2 and 3 were around 30% lower than that measured in Section 1, i.e. the stabilised section. Furthermore, the test showed that the development of the track geometry was more homogeneous in the stabilised section.

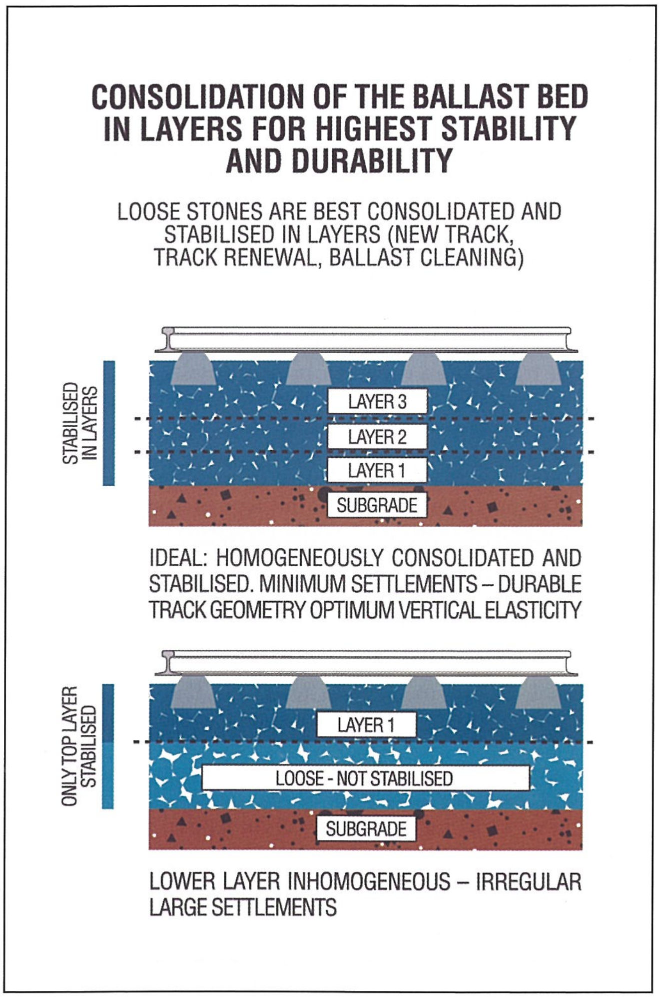

Fig. 2: Consolidation of the ballast bed in layers

Benefit 3 – stabilising track in turnouts

When stabilising track in turnouts, the consideration is not so much about the increase in lateral track resistance, but more about the vibrations caused by the DTS and their impact on the switching equipment. Both in France and the United Kingdom, investigations have been conducted in this respect.

France

At SNCF, thus far, the use of the DTS in turnouts or crossings has not been permitted. In order to improve line availability, however, SNCF would like to utilise the benefits of DTS use in turnouts to dispense with the required speed restrictions following new construction work.

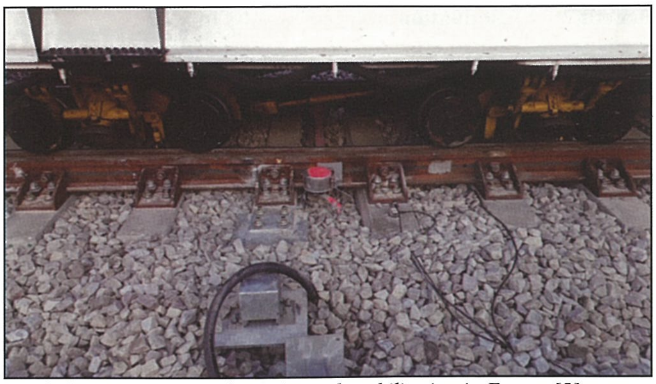

Fig. 3: Investigation into dynamic track stabilisation in France [5]

SNCF carried out a large-scale field test in Rambouillet (Fig. 3) to test the feasibility and effectiveness of the stabiliser and, if possible, approve its use in turnouts. Amongst others, the lateral and vertical accelerations onto the turnout and its components caused by the DTS were measured. No negative impact was established by the vibration measurements and the geometry measurements. The management at SNCF is confident that, based on these results, the DTS may soon be approved for use in turnouts and crossings. This would apply to both concrete and wooden sleeper turnouts [5].

United Kingdom

In 2015, Network Rail started a programme of investigations that, in the first instance, concentrated on the new construction and renewal of turnouts and crossings. The measurements established that the level of vibration on the track-side installations is largely within the range of vibrations that result from train traffic. Based on the project results, Network Rail decided to approve the use of the DTS on newly installed turnouts featuring concrete sleepers. As a next step, a similar investigation will be carried out into the stabilisation of track in turnouts and crossings in the course of maintenance work, so that the DTS may be approved for this type of work in the future [6].

LABORATORY RESEARCH PROJECT

Because of the changed operating conditions noted earlier (e.g. new types of superstructure, the variable imbalance), Plasser & Theurer has decided to start a large test series as regards the DTS, based on the many field tests and theoretical considerations made thus far. These are complemented, on the one hand, by additional field tests with new sleeper types (with and without sleeper pads) and machine technologies and, on the other hand, by laboratory tests at the Technical University of Munich (Fig. 4), as well as numerical simulation models.

The investigations aim to better describe the physical interactions and to optimise the work result of the DTS as regards its conditions of use.

Fig. 4: DTS experiment at the test laboratory of TU Munich, Germany

In the laboratory experiments, different machine settings are examined for their effectiveness under consistent conditions. The sleeper types B07So, B70 and B90, which are common in Germany, are examined to build an even better understanding of ballast and the system interactions between rail and permanent way. In the long term, this knowledge will result in more efficient machines.

CLOSING REMARKS

In recent years, a large number of investigations have been carried out into the effectiveness of dynamic track stabilisation, the results of which have confirmed the benefits of this technology: by adopting the Dynamic Track Stabiliser following tamping, a friction-free and homogeneous rearrangement of the ballast stones and an even and spatially consolidated ballast bed is effected, thereby achieving an accelerated "settling of the track" and, thus, a restoration of the lateral track resistance, which obviates the need for speed restrictions.

With the adjustable imbalance, the operation of the DTS can be adapted even better to the respective areas of deployment – for instance, this technology offers significant benefits for turnouts.

REFERENCES

[1] Kienzer K.: 'Das Scherverhalten von Oberbauschotter bei Stoßbelastung'; doctoral dissertation, 1983.

[2] Rießberger K., Wenty R.: '40 Jahre dynamische Gleisstabilisation'; Eisenbahningenieurkalender 2015.

[3] Janin G.: 'Der Querverschiebewiderstand der Eisenbahngleise', 1976.

[4] Freudenstein S., Feurig S.: 'Bestimmung des statischen und dynamischen Querverschiebewiderstands'; a research report, 2018.

[5] Laurens P.: 'Rapport de synthèse des résultats de l'essai de stabilisation dynamique d'un adv'; a SNCF research report, 2017.

[6] Jackson L.: 'Dynamic Track Stabiliser on S&C'; a Network Rail presentation, 2017.