

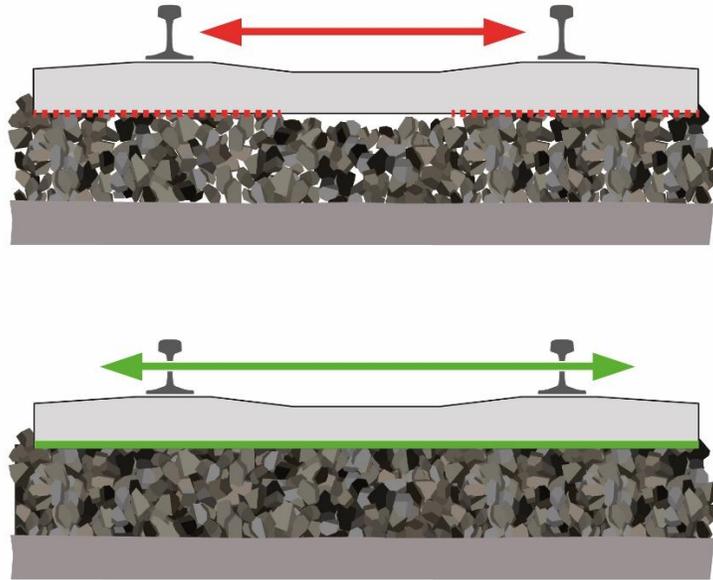
Dynamic track stabilisation

Principles, technology, benefits

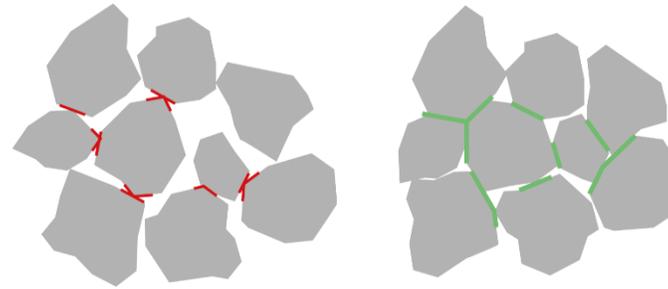


Esitys alle minuutissa

Stabilisointi



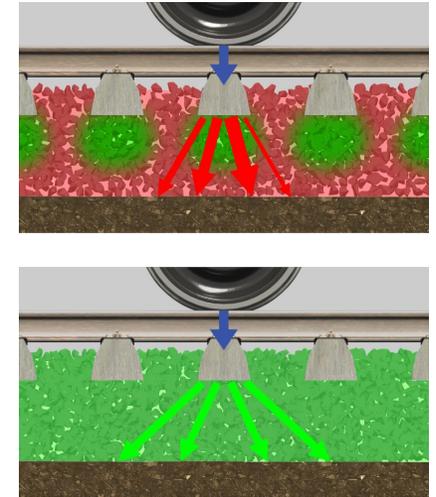
Lisätään kosketuspintaa
↓
Kitka kasvaa
↓
Poikittaisvastus kasvaa



Lisätään kosketuspintaa

Vähemmän epätasaista
asettumista

↓
**Radan geometria säilyy
pidempään**



Esitys alle minuutissa

Stabilisaattori



Stabilisaattori vaununa

- investointi < 1/2
- Yhteensopiva, 180 kW moottorilla



Taloudellisesti kannattava

01 Introduction/Summary

Proven technology for greater safety and lower costs

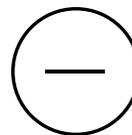
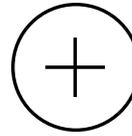


Introduction/Summary

Greater safety

Work on the superstructure reduces the track panel's lateral resistance against deformations. The Dynamic Track Stabiliser replicates operational loads in a controlled way, ensuring a controlled settlement

As a result, the track's resistance to lateral displacement and dangerous buckling increases considerably.



Lower costs

Thanks to the increased lateral track resistance, there is no need to impose speed restrictions after tamping. The homogenisation of the ballast bed ensures that the track geometry is significantly more durable. In addition, the intervention limit is reached much later and intervals between maintenance measures are extended. Maintenance costs are reduced.



What's the story of the “Dynamic Track Stabiliser”?



Starting in the 1950s, technological advances lead to ever-increasing requirements that were also placed on the superstructure. Engineers were particularly concerned about **lateral track geometry stability**. They were looking for practical solutions to increase lateral track resistance.

In the 1970s, the idea of developing a device that would be able to make the **track panel vibrate** in order to achieve **improved ballast compaction** and a more stable track geometry was born.

Within a few years, the “Dynamic Track Stabiliser” (DGS) had secured its place in track maintenance. It has become part of standard maintenance procedures on a global scale.

Introduction/Summary

Economic advantage—France: First reactions

In early 1981, a TGV set the new record on the Paris-Lyon line with a speed of 380 km/h, breaking the record set in 1955.

What was special about the preparation was that for the first time, a DGS had been regularly operated on a French line.

In a speech on the occasion of the world record, SNCF Deputy Director General Jean Dupuy commented on the economic benefit:

Image: World speed record of the TGV on February 26, 1981

Introduction/Summary

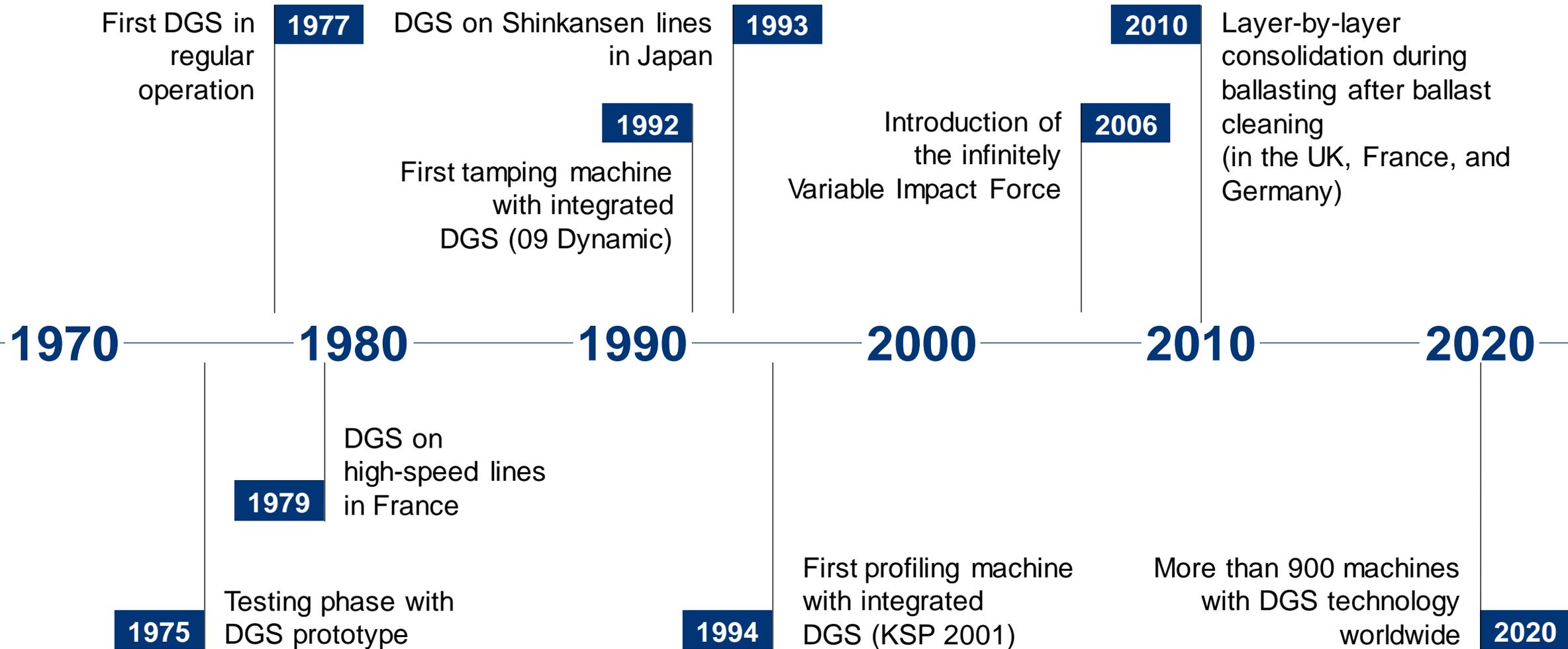
Economic advantage—France: First reactions

“The results achieved on February 25 and 26 were made possible by the fact that the track was virtually in top condition. The accuracy of the devices and the almost fully automatic methods that were applied for maintaining the track were proven in a spectacular manner.

Moreover, the high quality of wheel guidance and the low detectable forces suggest that the TGV trains will place even less stress on the track than we had anticipated.

These two observations have prompted us to **reduce the originally planned maintenance work for this new line in a way that also leads to a reduction in operational costs.**”

Milestones of dynamic track stabilisation



02 Principles

The track panel–ballast bed system,
terms and definitions,
effect of dynamic track stabilisation



Principles

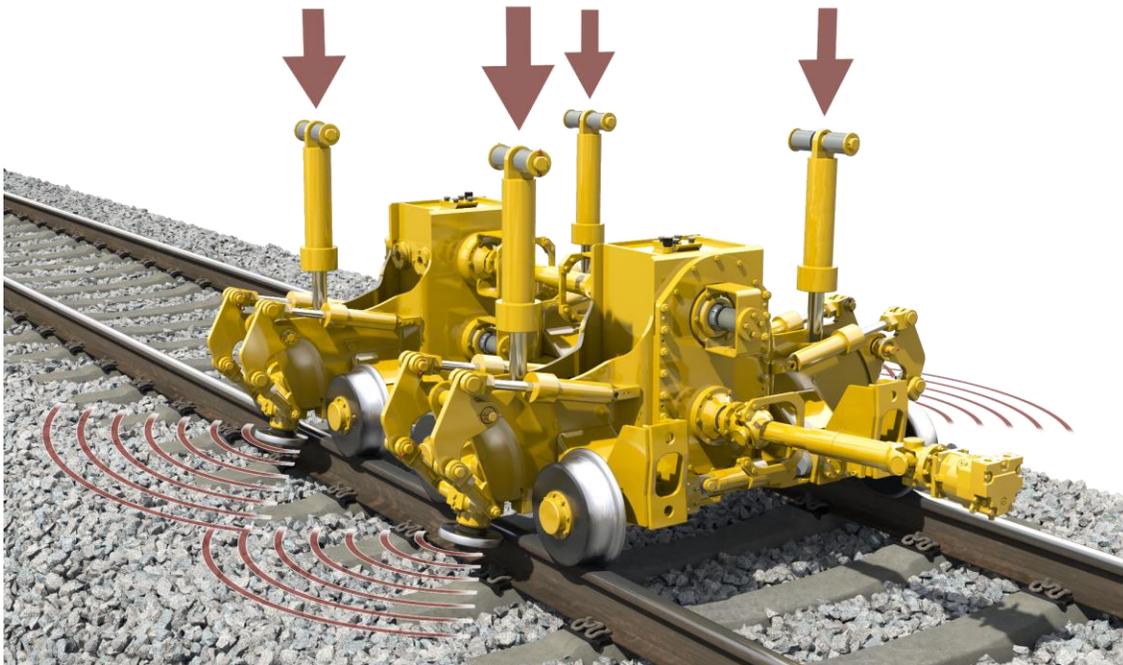
The track panel–ballast bed system

Key functions of the ballast bed

- Distributing the wheel loads uniformly to the subsoil
- Ensuring optimal elasticity of the track to reduce dynamic stresses
- Ensuring the optimal longitudinal and lateral track resistance
- Enabling easy restoration and conservation of the track geometry achieved during track maintenance

The ballast bed performs its tasks best if it is compacted continuously and optimally.

What is “dynamic track stabilisation”?

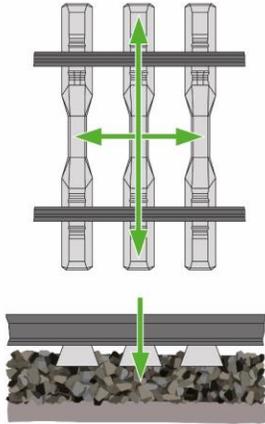


Dynamic track stabilisation is a **compaction method**, whereby dynamic excitation is introduced into the ballast **via the track panel**.

This excitation is realised as **horizontal vibrations**. At the same time, a **static vertical load** is applied.

The result is a spatially homogeneous compacted ballast bed and an increased track geometry stability.

Terms and definitions



Track geometry stability

Track resistance to lateral, longitudinal, and vertical displacement.



Track geometry durability

Describes how long the produced track geometry will last.

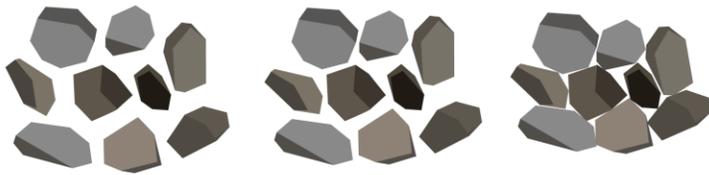


Track buckling

Unintended horizontal or vertical track deformation that poses a major safety risk.

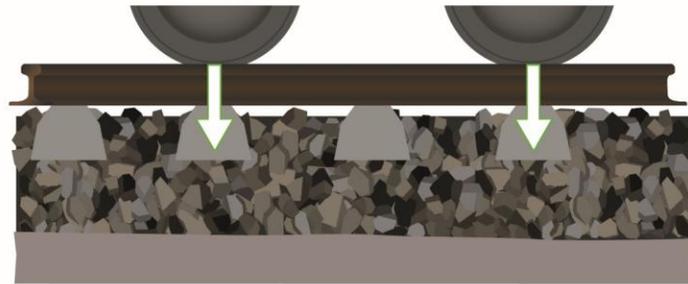
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"Gleisverwertung_ehem_Bf_Gütersloh_Ost_04_08_2013",
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Terms and definitions



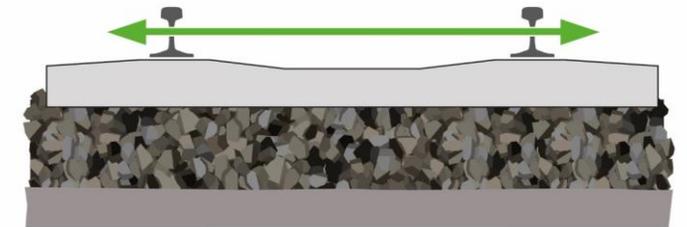
Ballast consolidation

Settlement process caused by railway operation, which causes the ballast stones to settle closer to one another.



Operational load

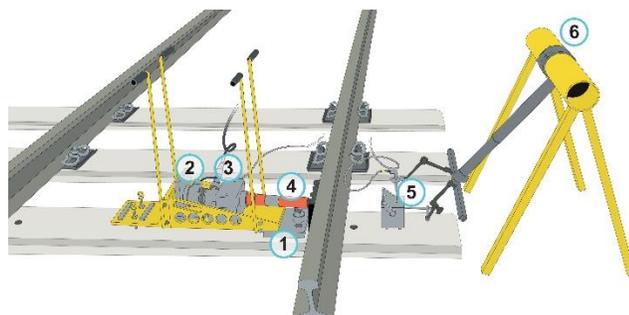
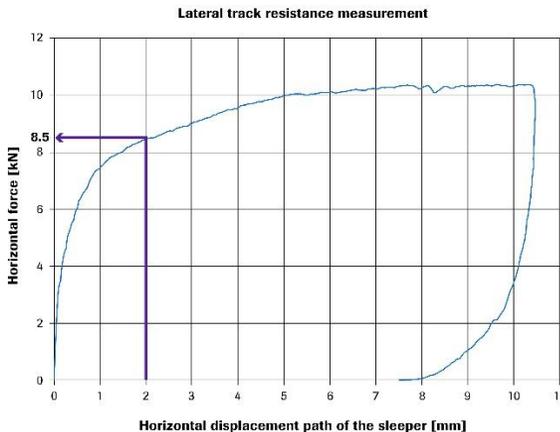
Sum of the axle loads of passing trains. The sum is indicated in load tonnes (Lt).



Lateral track resistance

The LTR counteracts the transverse forces and prevents the lateral displacement of the track panel.

How to calculate the lateral track resistance?



- ① Adapter
- ② Load cell
- ③ Hydraulic cylinder
- ④ Extension
- ⑤ Inductive transducers
- ⑥ Measuring base

The most common methods are:

Single-sleeper method

A hydraulic inspection device displaces the unloaded sleeper. Measuring instruments record the displacement path and the force required.

Panel displacement method

Instead of displacing a single sleeper, a track panel with several sleepers is displaced against firm abutment.

Mechanical methods

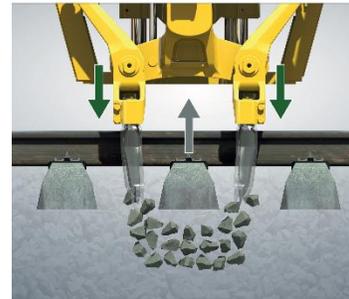
Track Loading Vehicles (TLV) apply a vertical load and simultaneously transfer a lateral force, determining the LTR under load conditions.

What is “tamping”?

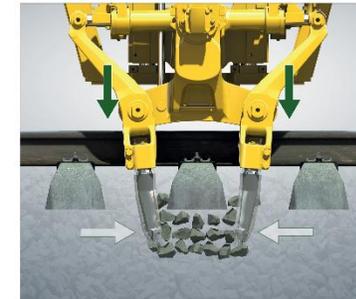
Tamping is a method that produces the correct track geometry.

Clamps place the track in the desired position by **lifting** (vertical) and **lining** (horizontal) it.

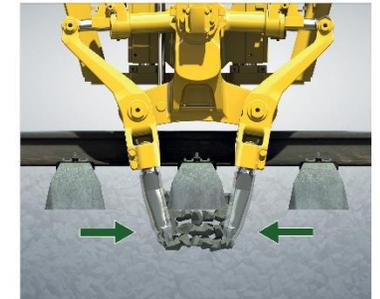
Then, vibrating tamping tines **push together** and **compact** the ballast below the sleepers to maintain the corrected track geometry.



LIFTING/LINING



FILLING

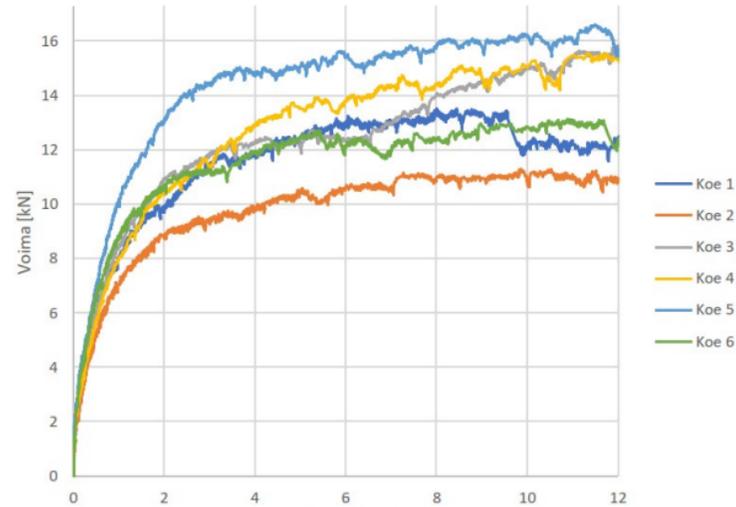


COMPACTING

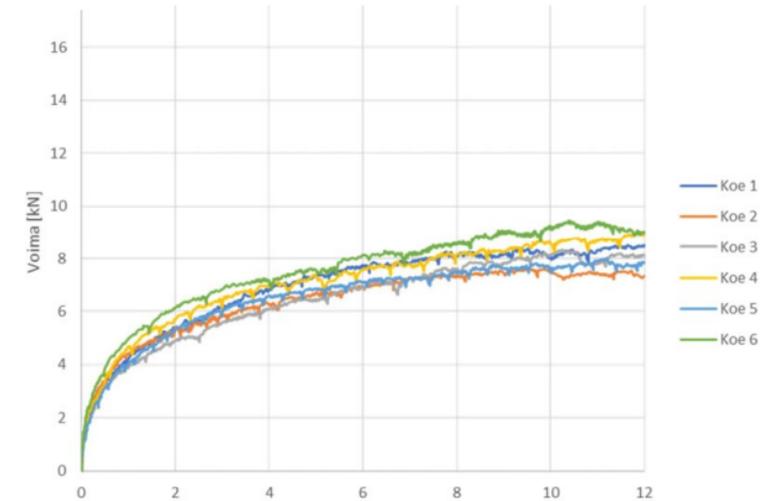
Yhden pölkyn työntökoe



Betonipölkky
pohjaimella



Siirtymä mm
Ennen
tuentaa



Siirtymä mm
Tuennan
jälkeen

What is the effect of dynamic track stabilisation?

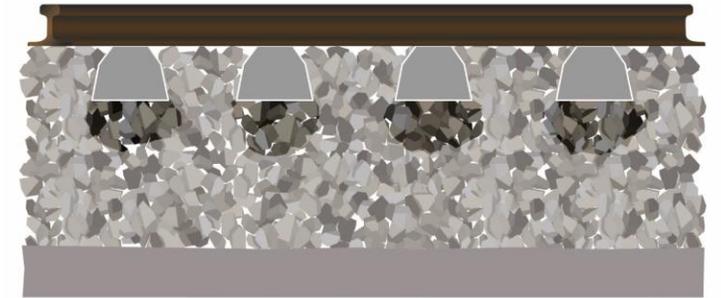
After tamping, the ballast bed shows **zones with various degrees of compaction**.

After ballast bed cleaning or renewal, the ballast structure is **not yet consolidated**, and the ballast stones are not in optimal position to one another.

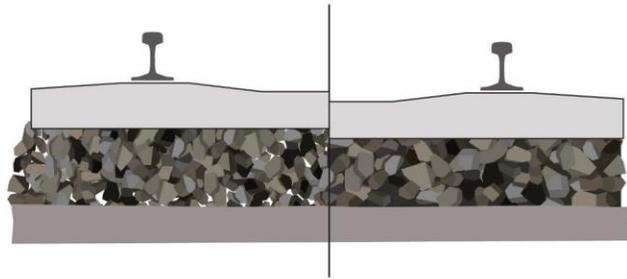
That is why the ballast bed lacks density and stability that are necessary for firmly anchoring the track into the ballast bed.

The **ballast stones rearrange themselves closer to one another** due to the **vibrations of the DGS**. This happens with virtually no force (ballast pressure of approx. 8 N/cm²).

This has the following effect:

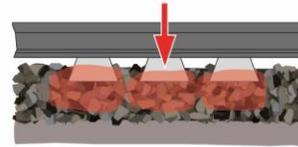


What is the effect of dynamic track stabilisation?

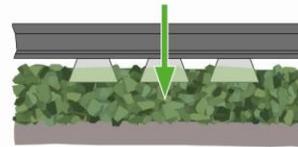


The ballast's **compactness** increases. This consolidation results in a settlement of the track.

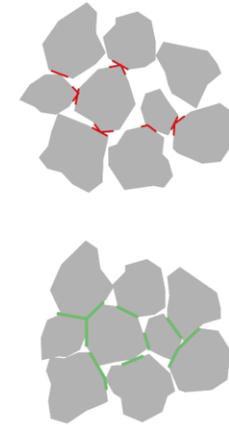
INHOMOGENEOUS COMPACTION



HOMOGENEOUS COMPACTION

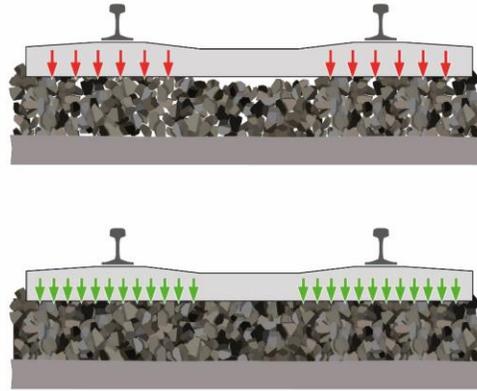
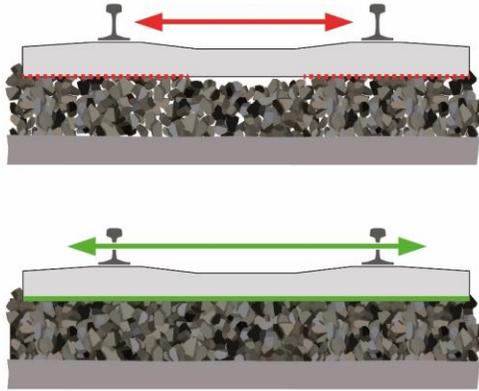


The ballast structure becomes more **homogeneous**: the degree of compaction is unified.



The ballast stones settle closer to one another and interlock. The **number of contact points and surfaces** between the ballast stones and the inner resistance of the ballast bed increase.

What is the effect of dynamic track stabilisation?



The **contact surface between sleeper and ballast** increases. As a result, friction and the LTR increase.

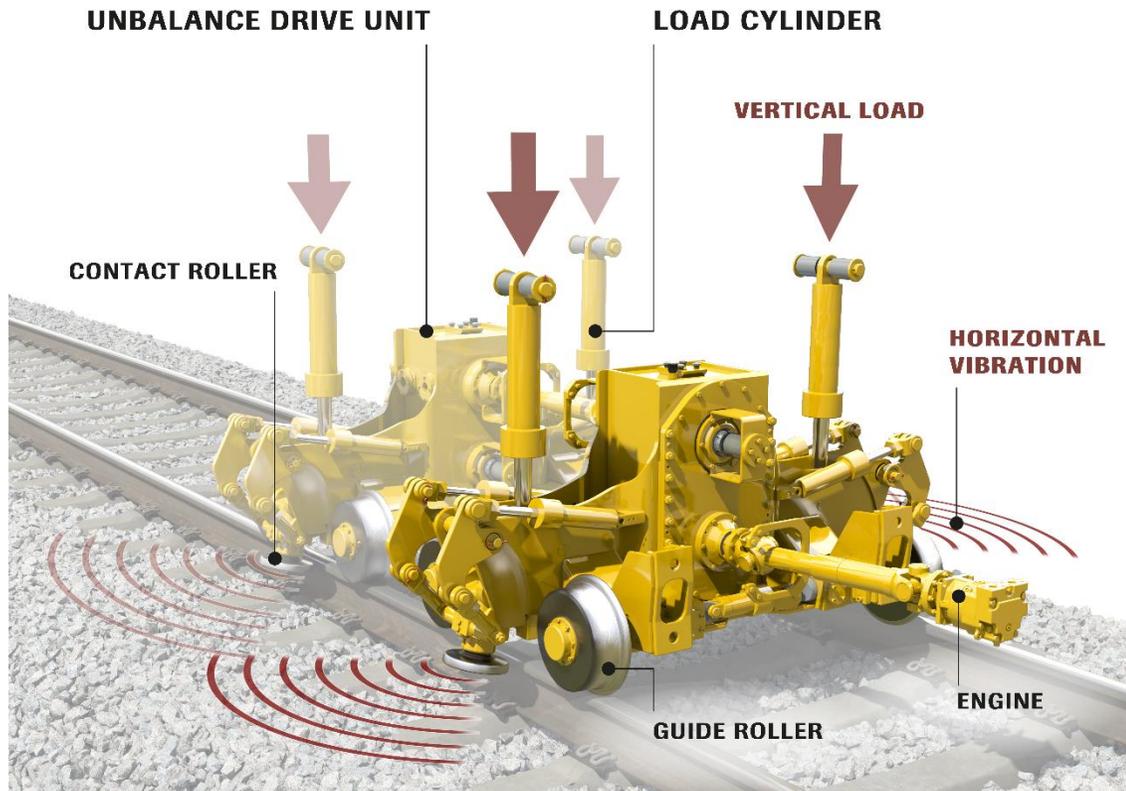
The **larger effective sleeper bed surface** reduces the ballast pressure under operational load.

03 Work technology

DGS mode of operation,
parameters



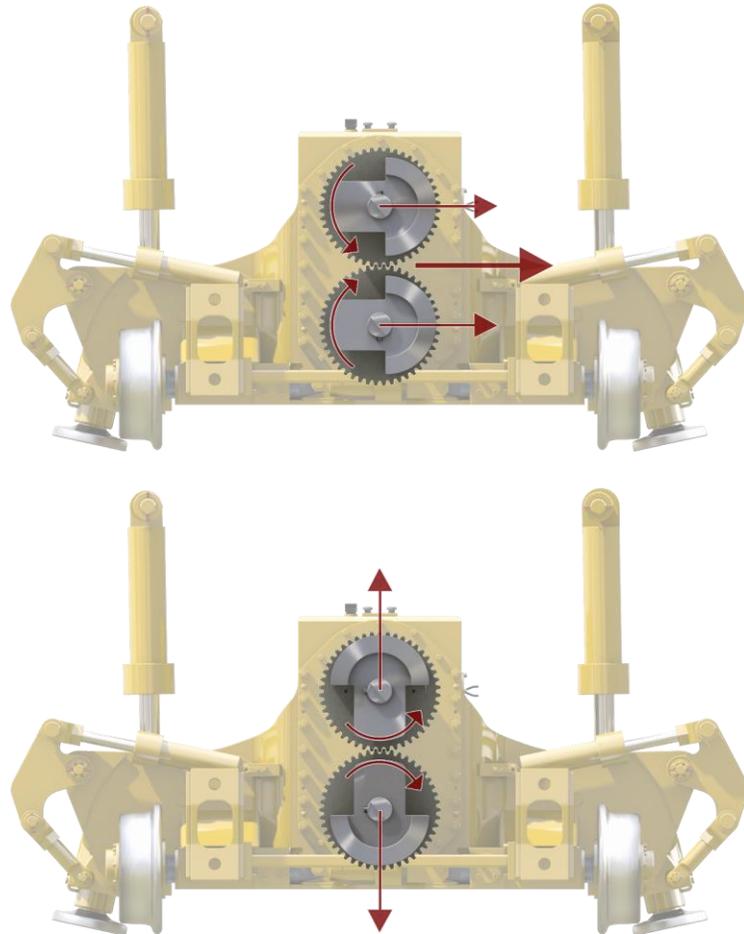
DGS mode of operation



A stabilising unit consists of two main components that work independently of one another: **unbalance exciters** and **vertical load cylinders**.

Depending on the machine, a single work unit or two work units coupled together are mounted.

DGS mode of operation



On every work unit, **unbalanced masses rotating in opposite direction** generate vibrations crosswise to the track. The unbalanced masses are synchronised via a gearbox. Their positioning makes it possible that the vertical force components cancel each other out and a purely horizontal vibration is produced.

In addition, every work unit is equipped with two **hydraulic load cylinders** that are supported on the machine frame and apply an infinitely variable load.

DGS mode of operation



Guide rollers and contact rollers transmit vibrations to the track panel and enable continuous working action.

In turnouts, the lateral contact rollers are temporarily lifted up on one side to avoid damage to turnout components. In the meantime, the guide and contact rollers transmit vibrations to the track panel on the side of the continuous rail.



Work technology

DGS mode of operation

Why is the vibration horizontal and not vertical?

In 1983, the Graz University of Technology did extensive research to determine the ideal parameters for dynamic track stabilisation.

The findings showed that ballast compaction is **up to seven times more efficient** if vibrations occur horizontally.

(J. Fischer: Einfluss von Frequenz und Amplitude auf die Stabilisierung von Oberbauschotter. Doctoral thesis, Graz University of Technology, June 1983)

Parameters

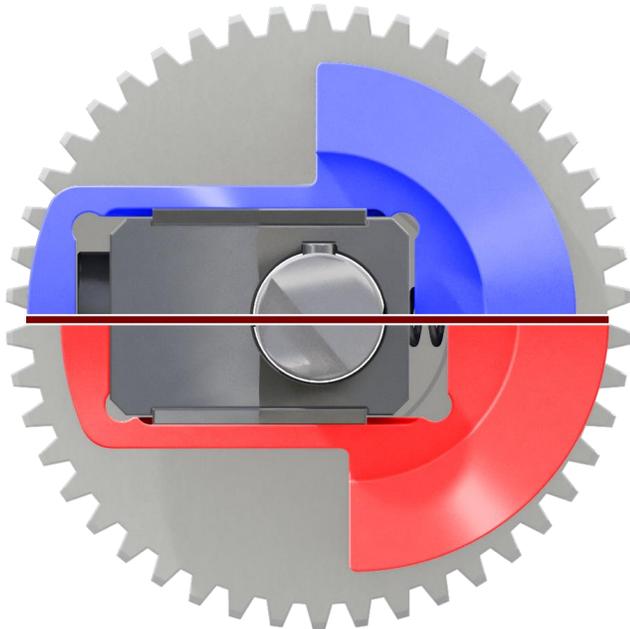
Vibration frequency

The vibration frequency greatly influences **ballast behaviour**. The DGS usually works at a frequency between 25 and 35 Hz, depending on the worksite and superstructure condition. This range enables optimal compaction while fully controlling settlement.

It is possible to infinitely control the frequency via the **speed of the unbalanced masses**.



No eccentricity
0 % impact force



Full eccentricity
100 % impact force

Impact force

In case of work units with constant unbalance, the impact force can only be controlled via the vibration frequency. That is why the variable unbalance (**Variable Impact Force**) has been developed.

It enables infinite control of the impact force between 0 % and 100 % regardless of the frequency. This is achieved via a hydraulically adjustable eccentricity of the unbalanced masses.

Parameters

Vibration frequency

In case of work units with **constant unbalance**, the rotational speed additionally affects the impact force thus influencing the vibration amplitude.

By contrast, work units with **variable unbalance** (Variable Impact Force) allow for impact force control regardless of the frequency.





Impact force

The dynamic impact force is the oscillating, horizontal force generated by the unbalanced masses. It affects the **compaction energy** introduced and is the one parameter that affects **track settlement** the most.

$$F_{dyn} = m \cdot r \cdot (2 \cdot \pi \cdot f)^2$$

m ... Unbalanced mass [kg]

r ... Eccentricity [m]

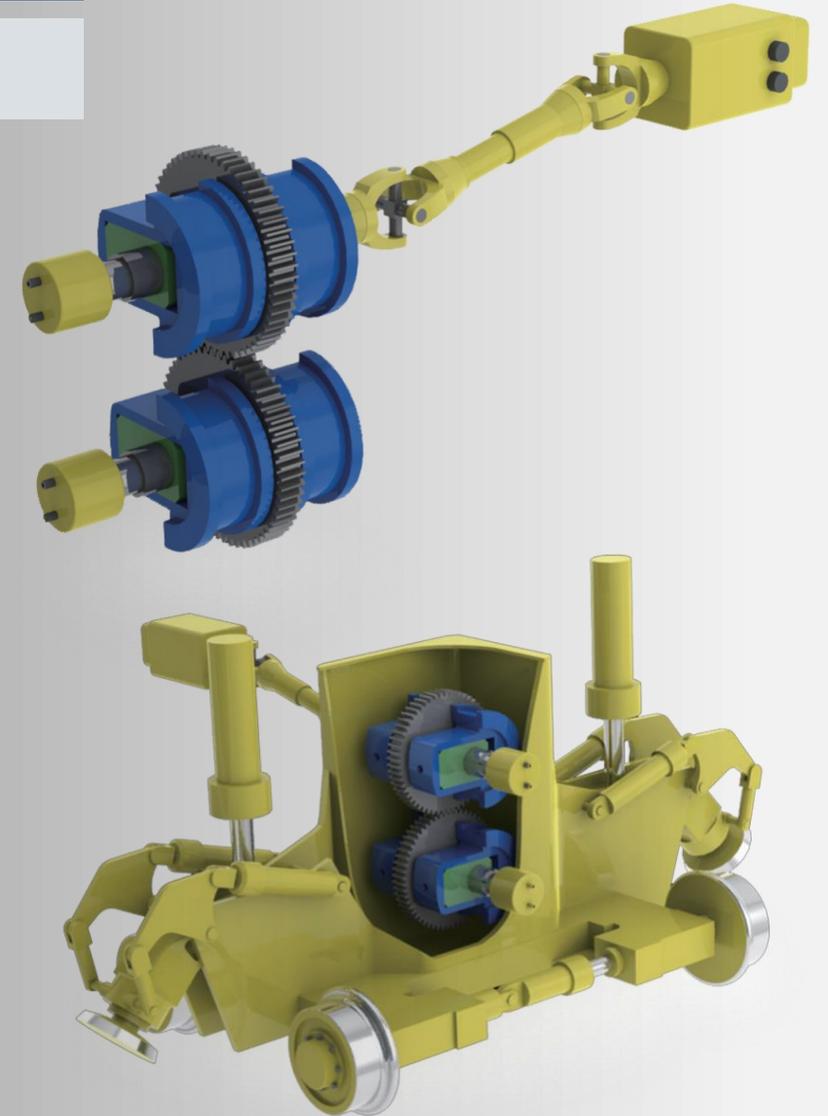
f ... Vibration frequency [Hz]

F_{dyn} ... Dynamic impact force [N]

Parameters

Advantages of the Variable Impact Force

- Full controllability of the impact force
- Ramping-up to the desired frequency with no vibrations
- Producing continuous transitions at bridges or ramps more easily
- Uniform results despite irregular working speed, e.g. in turnouts
- Reduced vibration propagation in track surroundings, specifically in urban areas and areas sensitive to vibrations



Parameters

Vertical load

The vertical load transmits vibrations to the ballast bed and is a vital precondition for **compaction effect** as well as **track settlement**.

In order to correct any existing super-elevation defects, it is possible to control the load cylinders in such a way that every rail is applied with the corresponding optimal load. The biggest machine type has a total load of up to 356 kN (36 t).





Working speed

The first vibrations introduced have a far higher compaction effect than the following ones. Therefore, working speeds of **up to 2,600 m/h** are possible without significantly impairing the compaction effect.

A **double DGS unit** is recommended for special conditions and for speed ranges from 1,000 m/h onwards, for example when using multi-sleeper tamping units.

04 Your benefit

What are the advantages
of dynamic track stabilisation?



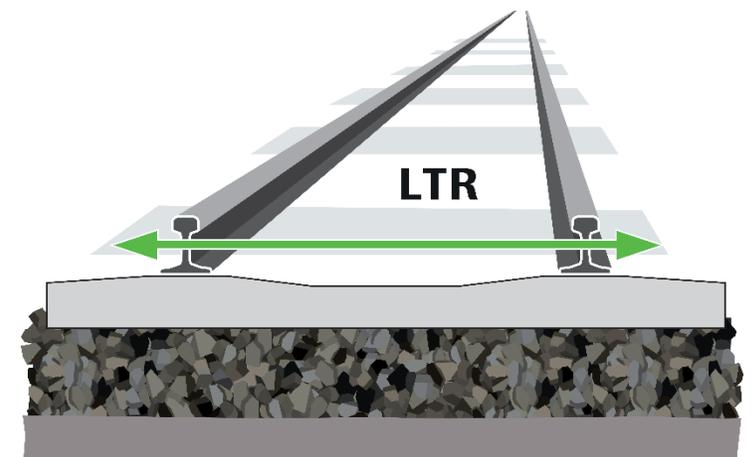
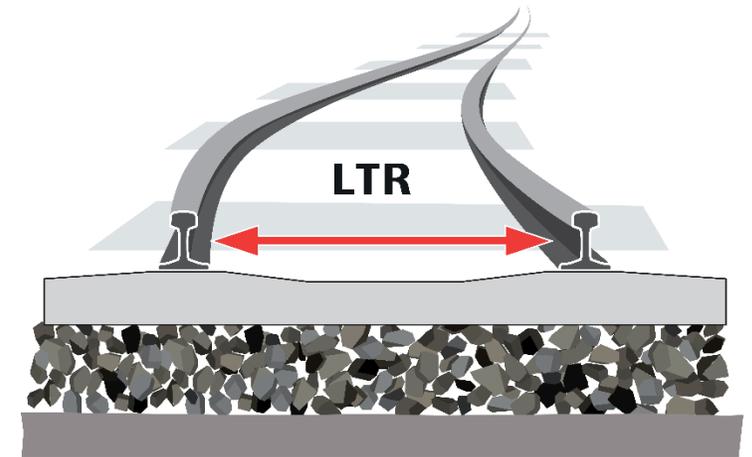
Your benefit

Increased resistance to track buckling

There is a **direct correlation** between **resistance to track buckling** and **lateral track resistance (LTR)**.

Due to thermal expansion, high temperatures lead to high longitudinal forces in the track. Train traffic causes additional horizontal forces, especially in curves and on high-speed lines or heavy-load lines.

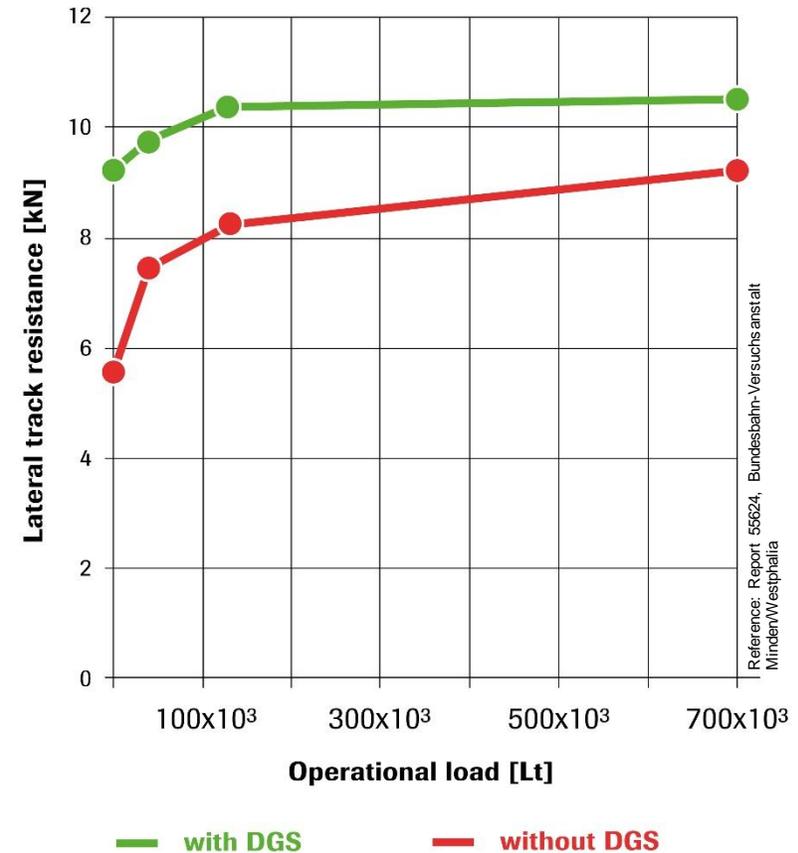
If the **LTR is too low**, the **track panel buckles laterally** as a result of these forces.



Increased resistance to track buckling

Manipulating the ballast bed during work on the superstructure naturally reduces the LTR. Without additional measures, the risk of track buckling increases significantly.

As the **LTR strongly depends on the degree of ballast compaction and the contact surfaces between sleeper and ballast**, dynamic track stabilisation is the measure of choice for quickly restoring resistance to track buckling.



LTR increase in line with the increasing operational load after track renewal.

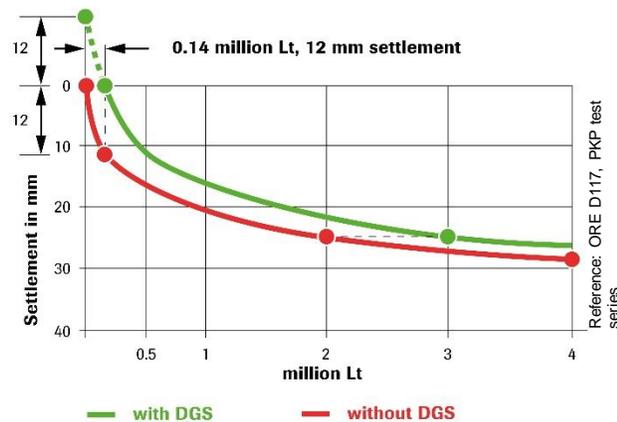


Less speed restrictions



After maintenance without subsequent track stabilisation, speed restrictions often are necessary until the operational load applied has caused the ballast to consolidate and the required LTR has been restored.

Dynamic track stabilisation **replicates the initial ballast consolidation** that would otherwise have to be achieved through operational load. Studies have shown that this results in an **immediate increase in LTR, equivalent to at least 100,000 Lt.**



◀ **Diagram:** Track settlement depending on the operational load

Your benefit

Increased resistance to track buckling

**Economic advantage—Japan:
No working restrictions during summers**

Until now, it was only possible to use tamping machines on tracks for eight months out of the year. During the four summer months, the risk for track buckling after tamping work was too high.

The DGS ensures the required LTR after a tamping machine has performed maintenance work.

This reduces or even completely eliminates operational restrictions during summers while **significantly increasing the machine's cost efficiency and productivity.**

Your benefit

Less speed restrictions

Initial settlements

Vibrations caused by train traffic cause the ballast stones to rearrange themselves with higher compactness and in an uncontrolled manner. This increases the stability, but also leads to uneven initial settlements.

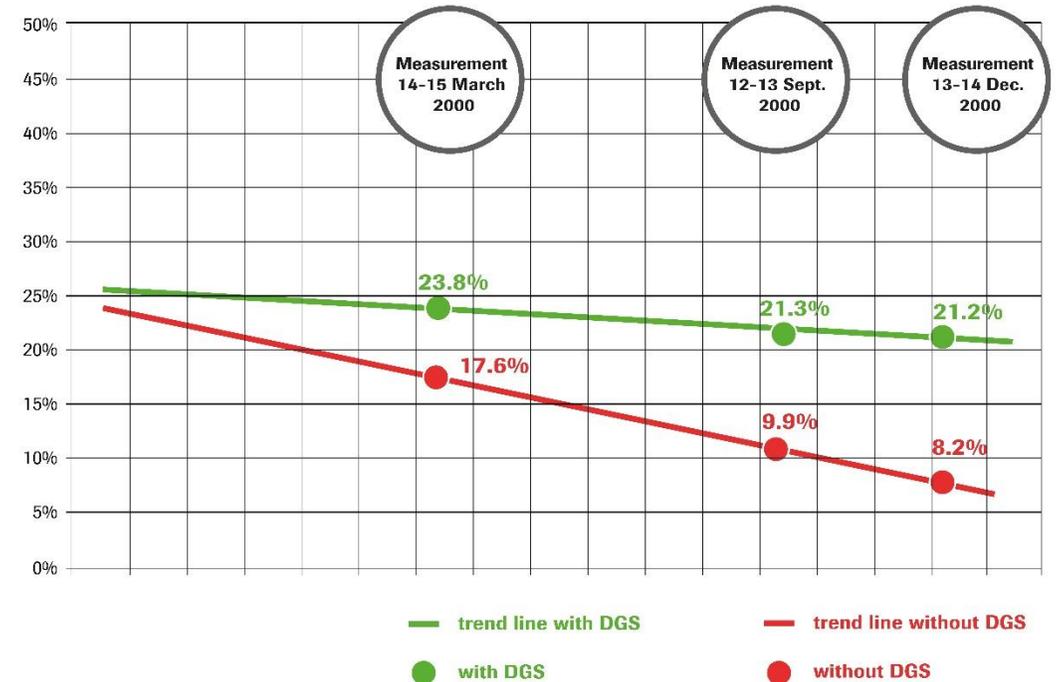
Dynamic track stabilisation replicates the initial settlements **in a targeted and controlled manner**. The **precisely controlled vibration** guarantees practically force-free and thus **gentle compaction** due to its frequency, amplitude, and direction (horizontal instead of vertical).

Your benefit

Longer maintenance cycles

Dynamic track stabilisation as a part of work on the superstructure replicates initial settlements in a uniform way.

Combined with the homogenisation of the ballast structure, this leads to a **reduction in uncontrolled, uneven settlements** during train operation. As a result, the **track geometry quality is maintained at a high level over a longer period of time.**



Example of a measurement series: average improvement of the track quality parameters measured with an OMWE track measuring trolley unit compared to the condition before tamping

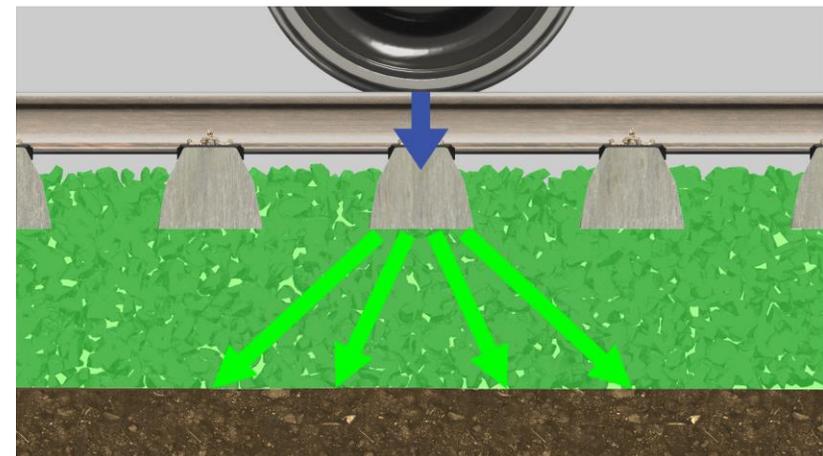
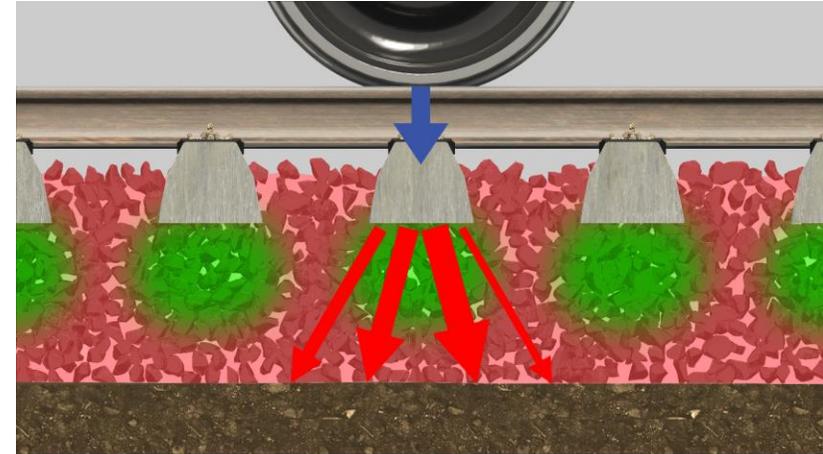
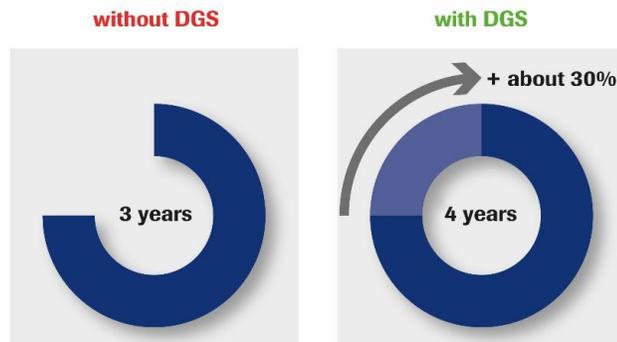


Your benefit

Longer maintenance cycles

In addition, a homogeneously compacted ballast bed transfers the **dynamic forces** of train traffic **more evenly to the formation**, which also positively affects the durability of the track geometry.

Experience has shown that dynamic track stabilisation results in **intervals between maintenance measures that are up to 30 % longer.**



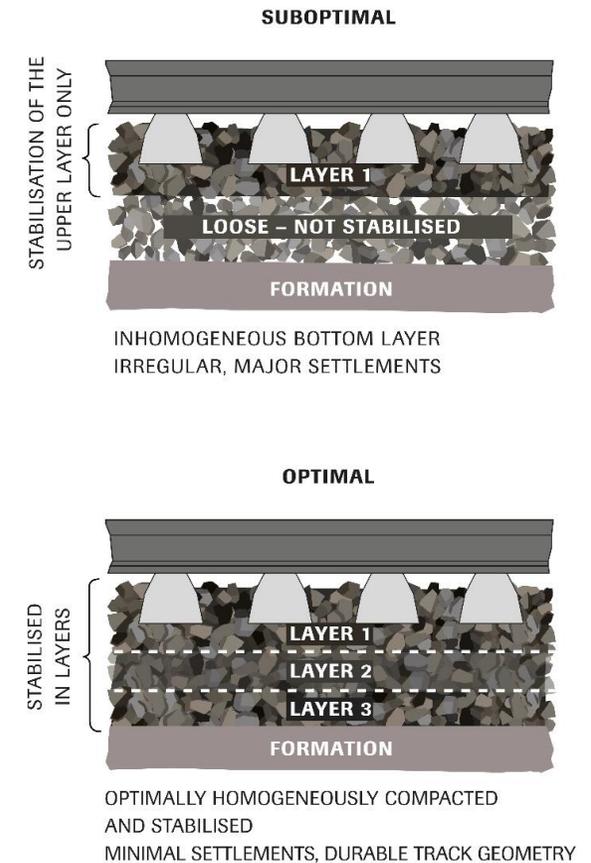
Your benefit

Expert tip:

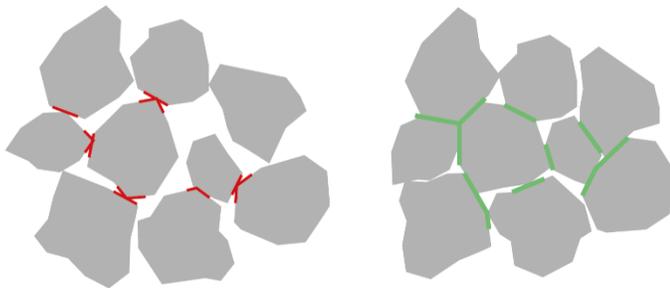
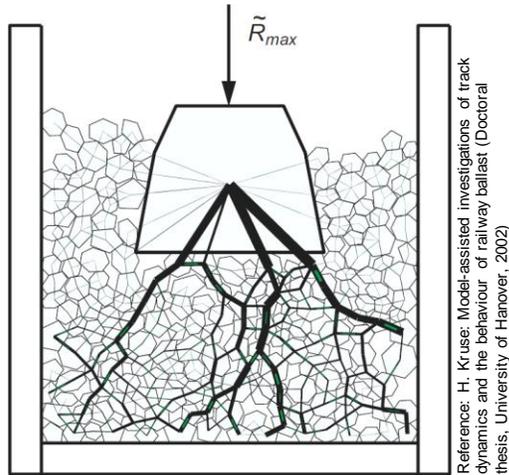
The initial quality greatly influences the service life. That's why homogenisation is a crucial step already during the construction of the ballast bed.

Homogeneity is best achieved through **layer-by-layer compaction**; immediately after placing the ballast, each individual ballast layer is compacted using dynamic track stabilisation.

Only in this way can the advantages in terms of extending the maintenance cycles and the track's service life take full effect.



Extended service life of the ballast bed



The operational loads introduced into the ballast by the sleeper are transferred into the subsoil via the contact surfaces of the ballast stones. However, this does not happen linearly, but via randomly formed force paths.

The more homogeneous the structure and the higher the compaction density, the greater the number of contact surfaces both between the stones and between the sleeper and the ballast.

The forces are thus dissipated more evenly, which **reduces the mechanical load on the ballast structure and increases its service life.**

Your benefit

Extended service life of the ballast bed

Economic advantage—Austria:

Westbahn line	R > 3 000 m	double track	with dynamic track stabilisation																																			
Total LT per day and track	rail	grade	substructure					sleeper																														
>70 000	60E1	R260	good					concrete with under sleeper pad																														
maintenance work	SL in years	36.0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
new track			1																																			
tamping			1							1							1							1														
grinding																	1																					1
elimination of defects			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Westbahn line	R > 3 000 m	double track	without dynamic track stabilisation																																			
Total LT per day and track	rail	grade	substructure					sleeper																														
>70 000	60E1	R260	good					concrete with under sleeper pad																														
maintenance work	SL in years	36.0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32			
new track			1																																			
tamping			1					1					1				1						1														1	
grinding																	1																				1	
elimination of defects			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	

Based on studies by Univ.-Prof. DI Dr. Peter Veit, Head of the Institute for Railway Engineering & Transport Economy at Graz University of Technology.



Yhteenveto

Stabilisaattorin hyödyt?

Tasainen radan
asettuminen lähellä
alkuperäistä tilaa

+

Homogeeninen
sepelirakenne

+

Lisääntynyt kontakti
kivien välillä, ja pölkyn ja
kivien välillä

Vähemmän epätasaista
radan asettumista

+

Poikittaisvastuksen
kasvaminen ja
geometrian kestävyys

+

Pienempiä ja
tasaisemmin jakutuvia
jännityskiä/voimia
sepelikerroksessa

Vältetään hellekäyrää

+

Vähemmän nopeusraj.

+

Pidemmät huoltovälit

+

Pidempi sepelikerroksen
elinikä

**Paranettu
turvallisuus**

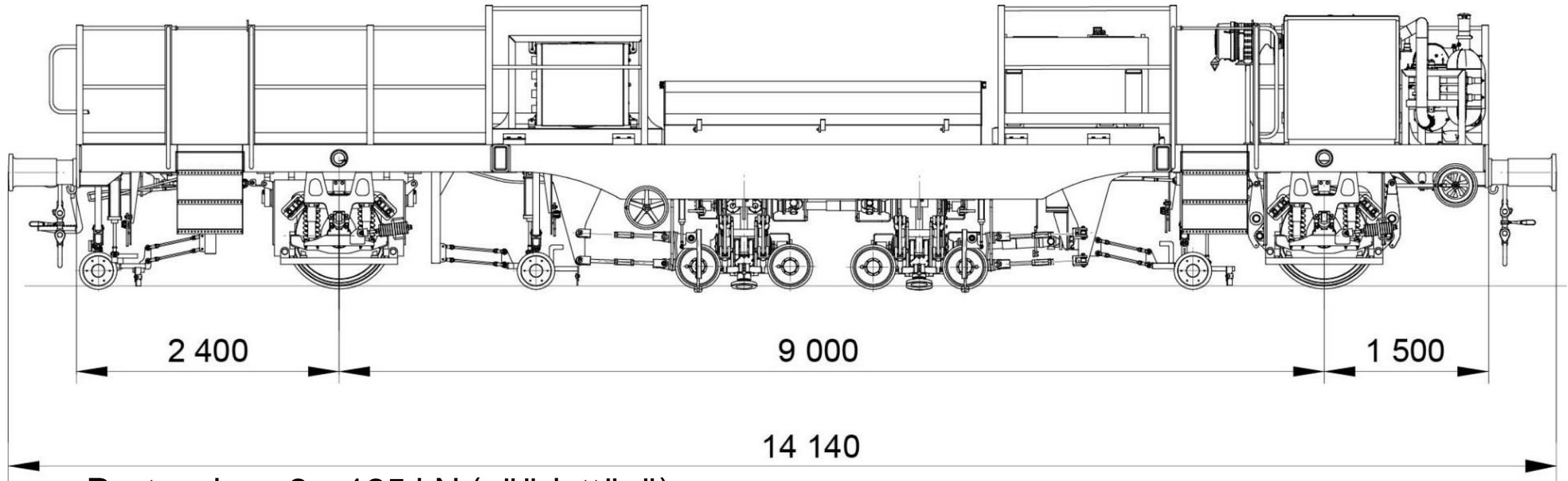
+

**Kustannus-
säästöjä**



Stabilisaattori vaununa

Italiaan tilattu jo 13 kpl.



Pystyvoima: 2 x 125 kN (säädettävä)

Paino: noin 40 t

Moottori: 180 kW

Diesel säiliö: 500 l

Track maintenance



High-capacity tamping machines are often equipped with an integrated double DGS.

In order to increase productivity and to reduce track closure times, staff and thus costs, it makes sense to integrate the DGS directly into the tamping machine.

Dynamic track stabilisation is used in particular on high-speed and heavy-load lines. This is why it is particularly useful to integrate the DGS into continuous-action high-capacity tamping machines (09 Dynamic series).

07 Annex

Sources and
further publications



These publications might interest you

G. Penfold: An introduction to intelligent DTS (Rail Infrastructure, Issue No. 148, January/February 2022, pp. 43-45, NPT Publishing, Newport, United Kingdom)

S. Feurig, W. Stahl, S. Freudenstein, B. Antony, F. Auer: Der dynamische Gleisstabilisator (DGS) auf dem Prüfstand (ETR – Eisenbahntechnische Rundschau, December 2020)

S. Feurig, W. Stahl, S. Freudenstein, B. Antony, F. Auer: Vom Feld ins Labor – der Dynamische Gleisstabilisator auf dem Prüfstand (Der Eisenbahningenieur, May 2020)

S. Gabl, B. Rüger, H. Loy, F. Pospischil: Einfluss der Kontaktfläche auf den Querverschiebewiderstand (ETR – Eisenbahntechnische Rundschau, March 2020)

S. Feurig: Experimental and theoretical investigations for the optimisation of the dynamic track stabiliser (DTS) with a view to improving track stability (Doctoral thesis, Technical University of Munich, 2020)

M. Dafert: Findings from measurements on the dynamic track stabilizer (Diploma Thesis, Vienna University of Technology, 2019)

F. Auer, B. Antony: Der Dynamische Gleisstabilisator auf Schiene (ETR – Eisenbahntechnische Rundschau, May 2019)

K. Rießberger, R. Wenty: 40 Jahre „dynamische Gleisstabilisation“ (EIK – Eisenbahn-Ingenieur-Kompodium 2015, pp. 55-76, DVV Media Group GmbH | Eurailpress, Hamburg)

E. Steiner, C. Kuttelwascher, G. Prager: Lastabtragung im Schotterbett – Änderungseffekte durch Konsolidierung und Bahnbetrieb (ETR – Eisenbahntechnische Rundschau, December 2014)

C. Kuttelwascher, M. Zuzic: Oberbauschotter – Kompodium für Österreich (EIK – Eisenbahn-Ingenieur-Kompodium 2013, pp.100-126, DVV Media Group GmbH | Eurailpress, Hamburg)

D. M. Read, R. Thompson, D. W. Clark, E. Gehringer: Results of Union Pacific Concrete Tie Track Panel Shift Tests (Technology Digest TD-11-004, February 2011, AAR/TTCI, Pueblo, Colorado)

K. Holtzendorff: Untersuchung des Setzungsverhaltens von Bahnschotter und der Hohllagenentwicklung von Schotterfahrbahnen, Doctoral thesis, University of Technology Berlin, 2003)

E. T. Selig, J. M. Waters: Track Geotechnology and Substructure Management (London: Telford, 1994)

J. Fischer: Einfluss von Frequenz und Amplitude auf die Stabilisierung von Oberbauschotter (Doctoral thesis, Graz University of Technology, June 1983)

