It's not magic, it's engineering.

GenieMat® RAIL

Vibration Mitigation and Track Stiffness Control

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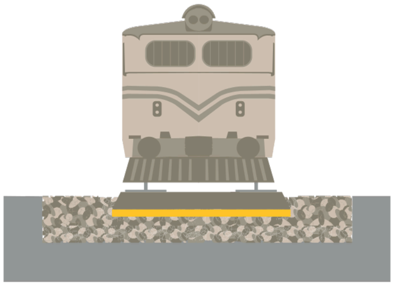
GENIEMAT® RAIL

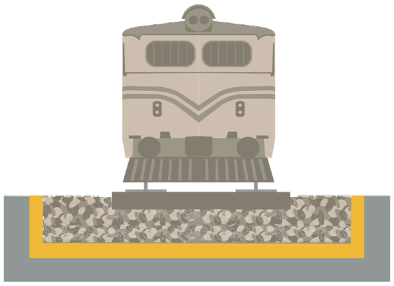
Vibration Mitigation and Track Stiffness Control

1. OVERVIEW

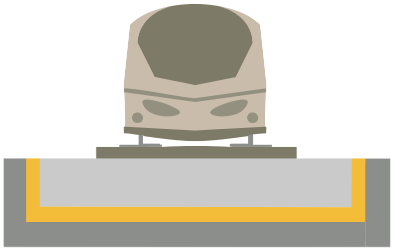
Pliteq's GenieMat RAIL products leverage the inherent advantages of rubber to provide engineered elastomer Systems for track applications improving ground-borne vibration mitigation, ballast preservation, and track stiffness control — including:



GENIEMAT® RAIL RTP
Under Tie Pads
(Under Sleeper Pads)



GENIEMAT® RAIL BST
Ballast Mat



GENIEMAT® RAIL FST
Floating Slab Track Isolation

Pliteq has a proven track record of over 20 years of successful track installations worldwide and holds multiple patents in acoustics. We demonstrate our commitment to engineering excellence by maintaining a rigorous monthly testing schedule, ensuring only the most recent data informs our designs.

We are continuing on a growth trajectory and are a leading innovator in acoustic vibration and sound control using rubber on a global scale.

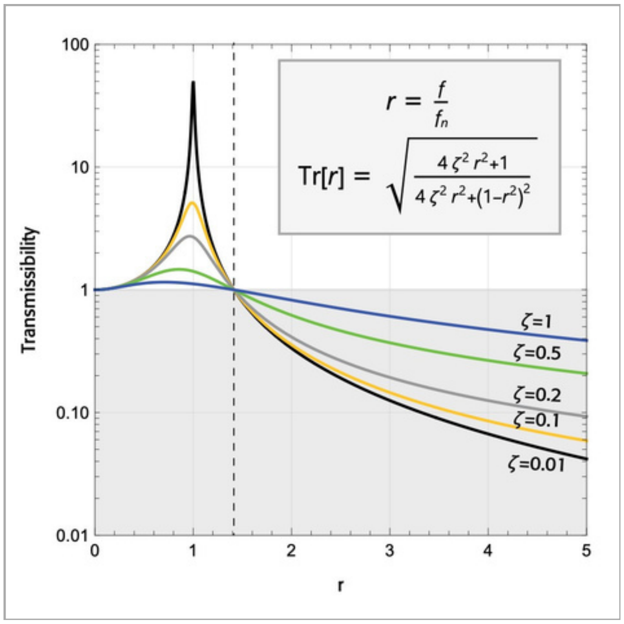
2. WHY RUBBER ?

Rubber’s unique material properties have established it as a critical component in numerous demanding industries, including aerospace, industrial machinery, and, crucially, railway infrastructure.

The molecular structure, characterized by long, flexible polymer chains linked by chemical bonds, is the foundation for effective vibration damping, precise stiffness control, and durability.

DAMPING AND STIFFNESS CONTROL

Rubber’s viscoelastic nature provides both significant energy dissipation (damping) and the ability to engineer specific stiffness characteristics. This dual capability is critical for reducing ground-borne vibrations and noise while precisely managing track deflection. The transmissibility curve shown on the right is one of the tools used to design and select systems for vibration mitigation.



PERMANENT ELASTICITY

Engineered rubber maintains its elastic modulus and structural integrity under repeated high-frequency loading, ensuring long-term performance and preventing fatigue-related degradation. This permanent elasticity is vital for the cyclical loading experienced in railway applications.

ENVIRONMENTAL RESISTANCE

Rubber’s durability and resistance to environmental degradation allow for its use in extreme conditions. This ensures extended service life and minimizes maintenance needs in harsh railway environments.

These properties make rubber the material of choice for demanding industries where resilience and reliability are critical.

3. DURABILITY AND LONGEVITY

Track elastomers are subject to millions of load cycles, and decades of exposure to various environmental factors.

FATIGUE TESTING

The **GenieMat RAIL** elastomers have been tested in accordance with the EN international standards for testing the durability of track elastomers, updated versions of previously used DIN standards.

The largest change in static and dynamic stiffness is less than 15%, which meets the rigorous EN recommendations for long term durability.

COMPRESSIVE AND TENSILE STRENGTH

Because the material is compressible and does not bulge under the compressive loads in its application, the compressive strength is a more important material property than the tensile strength.

In track under typical cyclical loading, an under tie pad (under sleeper pad) can experience up to 0.35 MPa (50.7 PSI), and an under ballast mat can experience up to 0.24 MPa (34.8 PSI). Maximum peak forces can exceed this by a factor of 2-4x. Pliteq GenieMat RAIL materials are designed to withstand up to 10 MPa (1450 PSI) instantaneous compressive forces, significantly higher than maximum forces in track.

CREEP

Pliteq has performed extensive creep testing on its **GenieMat** line of products. When tested in accordance with ISO 8013, the creep rate is 0.5 to 2.5% per logarithmic decade of time, which is well within the tolerance of 5% for elastomeric bearings in infrastructure.

4. RESISTANCE TO ENVIRONMENTAL FACTORS

AGING

GenieMat RAIL elastomers are resistant to freeze-thaw, heat, water, ozone, fire, and chemical agents / hydrocarbons. When tested in accordance with UIC/IRS guidelines and per EN standards, the elastomers are able to maintain their static and dynamic stiffness properties without any signs of cracking or other damage. This laboratory testing is backed by over 20 years of successful in-field installations.

TEMPERATURE

Temperature can have an influence over the viscoelastic behaviour of elastomers. Elastomers have very low heat transfer coefficients and thus take a very long time to attain a temperature that is in equilibrium with the external environment. The **GenieMat's** rubber composition has an operating range of -40 deg. F to 230 deg. F. (-40°C to +110°C).

5. ELASTOMER PROPERTIES FOR VIBRATION MITIGATION

Ground-borne vibration propagation is affected by numerous properties of the vehicle, rail, sleeper (tie), ballast or floating concrete slab, and subgrade. Determining the insertion loss performance of a specific track product requires an accurate understanding of the track's properties and the elastomer properties.

To accurately predict the performance of an elastomer in mitigating noise and vibration, it's essential to understand its key properties under dynamic loading. These properties can be determined by applying loads that simulate the conditions experienced in the track environment.

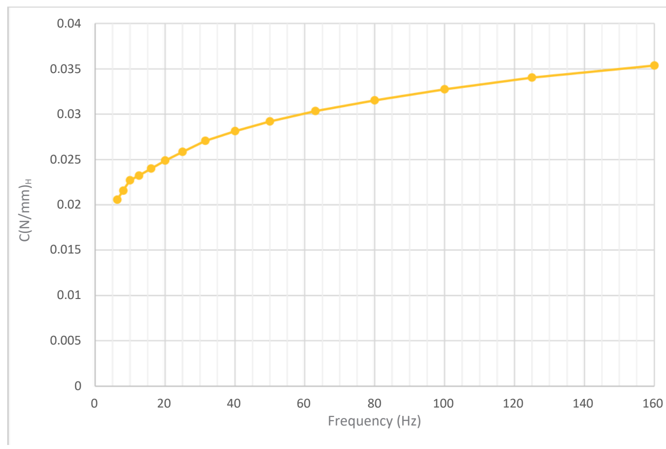
DYNAMIC STIFFNESS

A measure of how the **GenieMat RAIL** elastomer resists deformation under an oscillating load.

$$C_H = \frac{K^*}{A}$$

Where
- C_H is the dynamic stiffness ($N/mm^2/mm$ or N/mm^3)
- K^* is the complex stiffness (N/mm)
- A is the area of the material. (mm^2)

A lower value of the dynamic stiffness (C_H) indicates a more resilient elastomer capable of absorbing and dissipating greater levels of vibration.



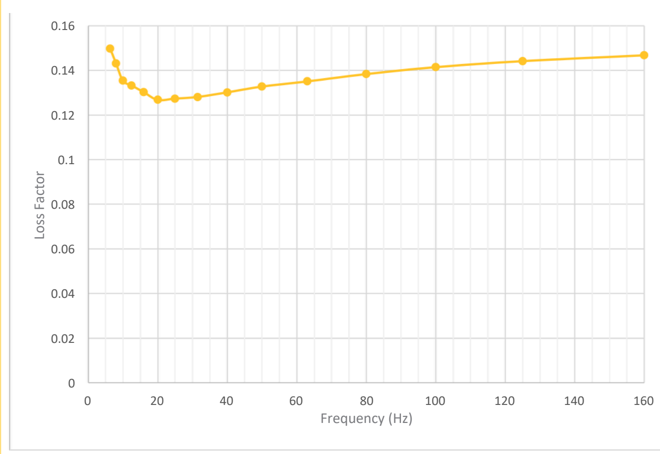
LOSS FACTOR

A measure of how well the **GenieMat RAIL** elastomer dissipates mechanical energy as heat when subjected to cyclic loading. This quantifies the damping efficiency of a viscoelastic material.

$$\eta = \tan\zeta \,;$$

Where
- η is the loss factor
- ζ is the loss angle, angular phase shift between the fundamental harmonic component of the applied force and the resulting deformation.

The magnitude of the loss factor η of an elastomer influences the dynamic magnification in the region of the natural frequency of the elastically supported track as an oscillatory system.



These properties are typically determined through standardized tests as outlined in DIN, EN, or other standards for track elastomers: a constant pre-load representative to that of in-field loads, is applied to the elastomer, followed by a constant amplitude cyclical force at the pre-load at the desired frequencies.

6. VIBRATION ISOLATION PERFORMANCE

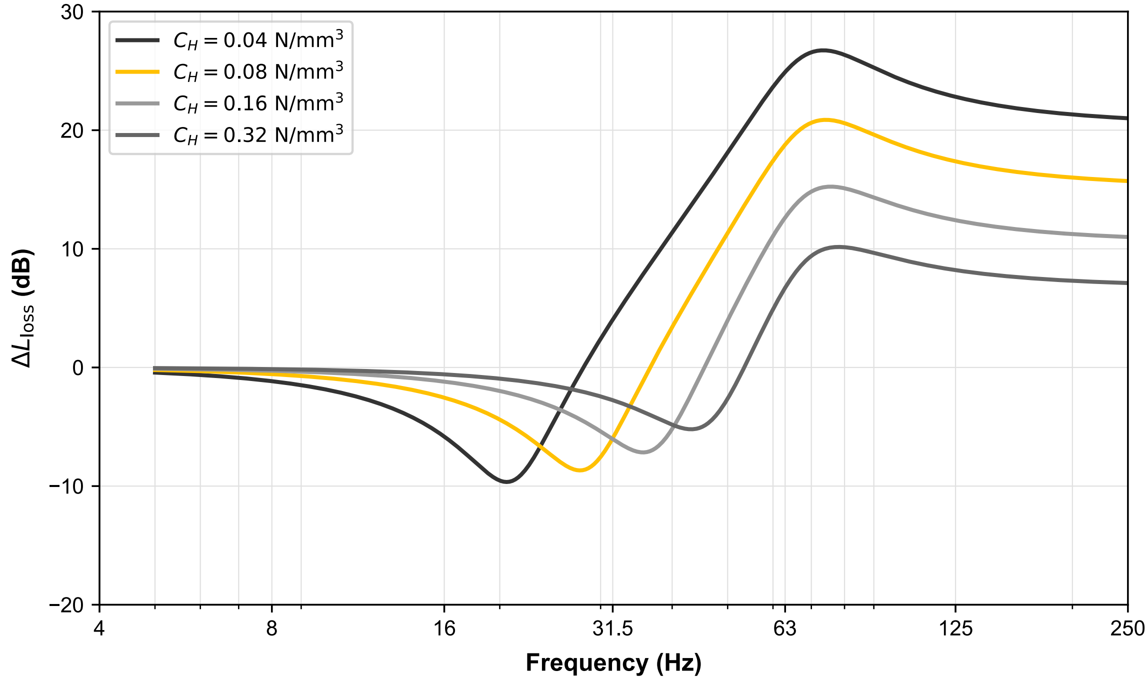
GenieMat RAIL products are engineered to be compressible, meaning that the material's volume decreases under compression.

This non-isovolumic behavior allows Pliteq's elastomers to achieve increased energy dissipation, lower natural frequencies, a lower modulus of elasticity, and maintain its properties under a wide range of loads and independent of shape factor.

Traditionally, elastomers are incompressible materials, that when compressed do not decrease in volume but rather bulge in other dimensions. These materials are referred to as isovolumic.

Varying the profile of the elastomer also allows for improving performance at specific load ranges. This allows for a broad offering with an acoustic stiffness range of as low as 0.006 N/mm^3 to help isolate highly sensitive receptors.

INSERTION LOSS



Insertion loss of varying ballast mat stiffnesses with an unsprung mass of 3000 kg and an infinitely stiff subgrade.

Adapted from: Measures to reduce structure-borne noise emissions induced by above-ground, open railway lines by Rüdiger G. Wettschureck.

Insertion loss (IL) quantifies the reduction in vibration achieved by introducing a new component into a system. The following graph illustrates the insertion loss for under ballast mat elastomers. It compares various stiffness options under identical track conditions, highlighting how mat selection directly impacts vibration damping.

Elastomers with a lower dynamic stiffness reduce the natural frequency the track, therefore mitigation vibration starting at lower frequencies. In addition, they provide a higher insertion loss, leading to more effective vibration isolation.

7. FACTORS AFFECTING TRACK BEHAVIOUR

Railway track systems contain multiple components which can all affect the vibration transmission and track deflection properties. Successful elastomer design requires an understanding of all the track components to properly take into account the loading and support conditions, which all affect the elastomer performance.

The axle loading will determine at what load range the elastomer material properties are determined at. The rail, tie (sleeper), ballast, and supporting foundation properties will all affect the insertion loss performance as well as the track deflection, regardless of the product used. As an example with under ballast mats, the subgrade condition (concrete vs soft soil) will significantly control the upper limit of performance for vibration mitigation.

Rail Pad

- Static Stiffness
- Dynamic Stiffness
  Loss Factor

Rail

- Rail Modulus
- Rail Moment Ixx
- Mass of Rail

Vehicle

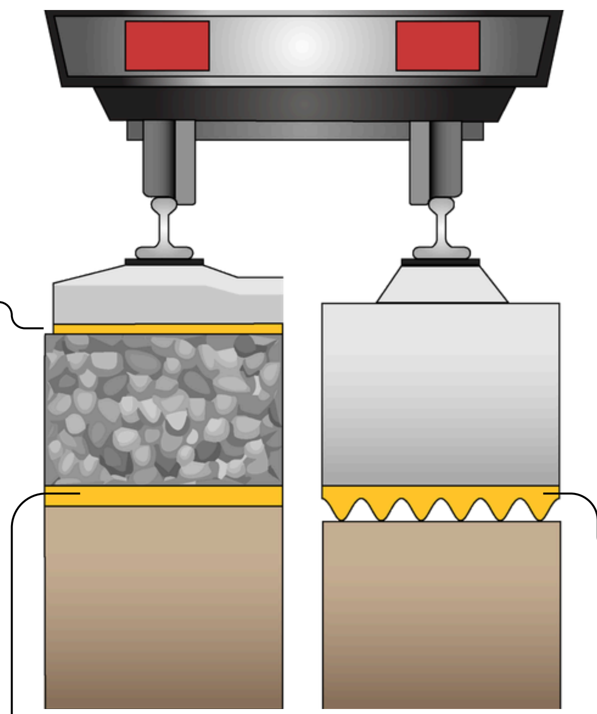
- Axle Load
- Unsprung Mass
- Vehicle Dimensions
- Maximum Vehicle Speed

Sleepers/Ties

- Tie Spacing
- Tie Width
- Tie Length
- Fraction Effective Tie
  Supporting Length
  Sleeper/Tie Mass

Fasteners / Rail Support

- Static Stiffness
- Dynamic Stiffness
- Loss Factor
- Fastener Mass



GenieMat RTP
Under Tie/Sleeper Pad

- Static Bedding Modulus
- Dynamic Bedding Modulus
- Higher Frequency Vertical Bedding Modulus
- Loss Factor

Concrete Slab

- Thickness
- Width
- Density
- Second Moment of Inertia, Ixx
- Young's Modulus
- Mass of Slab

Ballast

- Ballast Depth
- Ballast Stress Distribution Angle
- Complex Ballast Stiffness

GenieMat FST
Floating Slab Track Isolation

- Static Bedding Modulus
- Dynamic Bedding Modulus
- Higher Frequency Vertical Bedding Modulus
- Loss Factor

GenieMat BST
Under Ballast Mat

- Static Bedding Modulus
- Dynamic Bedding Modulus
- Higher Frequency Vertical Bedding Modulus
- Loss Factor

Subgrade

- Subgrade Stiffness
- Loss Factor

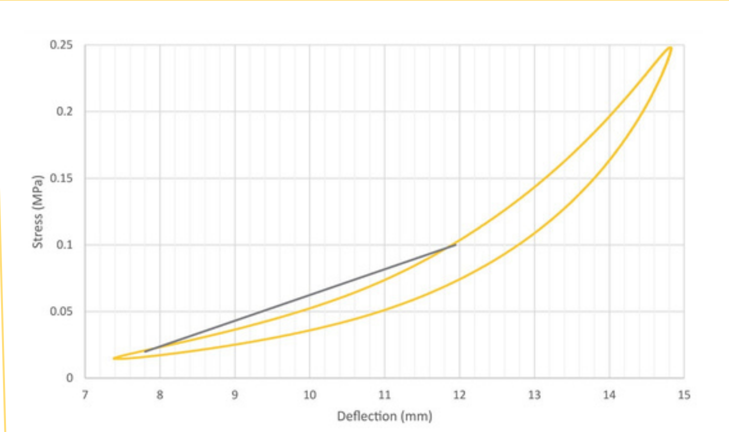
8. TRACK STIFFNESS CONTROL - ELASTOMER PROPERTIES

The deflection of the rail track can be determined by treating all the layers below the rail as springs in series. Combining their effects along a continuous beam, the rail deflection throughout the length of a car can be determined. Introduction of an elastomer into the track alters the rail deflection. The static and dynamic stiffness of the elastomer are two key material properties used in identifying the change in track stiffness.

STATIC STIFFNESS

The ability of the **GenieMat RAIL** elastomer to resist deformation under a static load.

$$C_{stat} = \frac{F_2 - F_1}{(d_2 - d_1) * A}$$

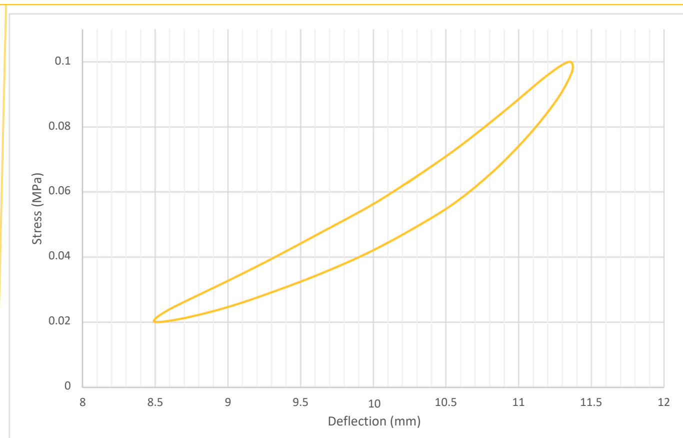


A higher Cstat value means less deflection of the elastomer under a static load (static train).

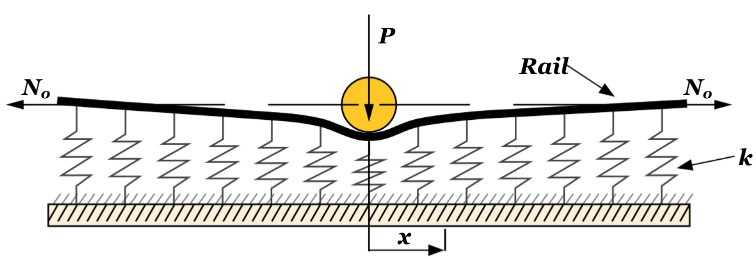
DYNAMIC STIFFNESS

The ability of the **GenieMat RAIL** elastomer to resist deformation under a cyclical dynamic load due to a train axle passing overtop a crosssection of track.

$$C_{dyn} = \frac{1}{10} \bullet \sum_{10} \frac{F_2 - F_1}{(d_{max} - d_{min}) \bullet A}$$



A higher Cdyn value means less deflection of the elastomer under a dynamic load (moving train).

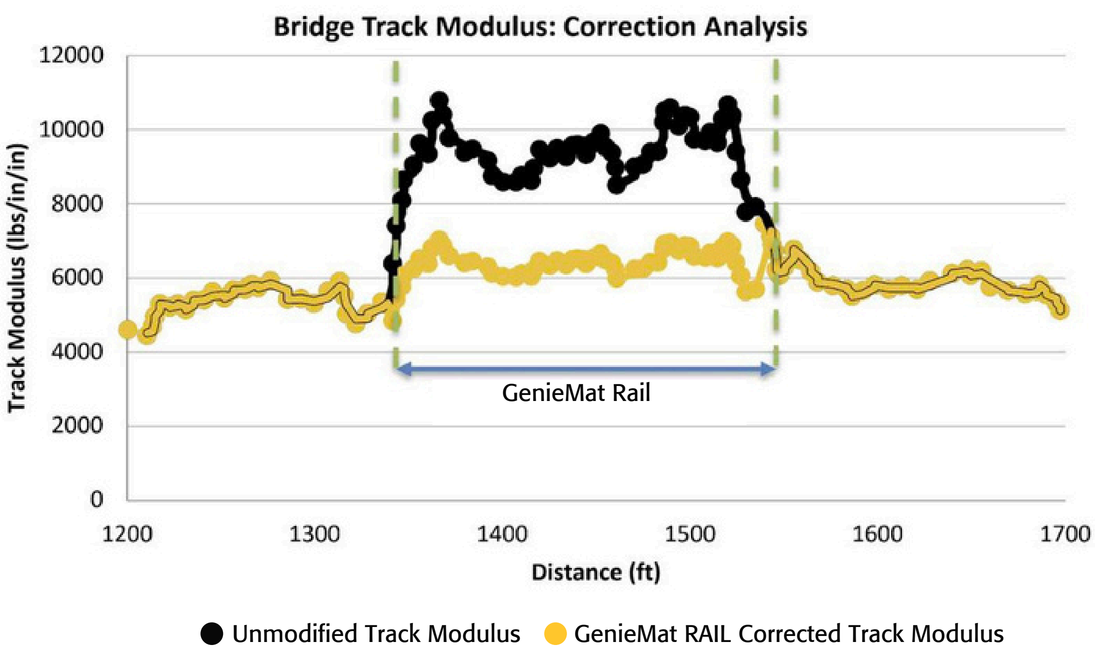


9. TRACK STIFFNESS CONTROL AT TRANSITION ZONES

WHY IS UNIFORM TRACK STIFFNESS IMPORTANT?

Variations in track stiffness, especially at bridge approaches, switches and crossings, and transitions between track types (ballasted to ballastless), cause:

• **Accelerated Component Degradation**: Ballast migration, tie damage, gauge widening, and ballast deterioration.
• **Track Geometry Deterioration:** Rapid degradation of track surface, alignment, and cross-level.
• **Increased Maintenance Costs:** Higher frequency and intensity of maintenance interventions.
• **Reduced Ride Quality:** Poor passenger comfort and potential for increased dynamic loading on rolling stock.



KEY USE CASES WHERE TRACK STIFFNESS MATTERS:			
USE CASE:	TUNNELS & HEIGHT RESTRICTIONS	TRACK TYPE TRANSITIONS (BALLASTED TO BALLASTLESS TRACK, SWITCHES AND CROSSINGS, DIAMONDS)	BRIDGES AND BRIDGE APPROACHES
PROBLEM	LIMITED CLEARANCE RESTRICTS BALLAST DEPTH	ABRUPT CHANGES BETWEEN BALLASTED AND SLAB TRACK CAUSE DIFFERENTIAL SETTLEMENT.	STIFFNESS DIFFERENCE BETWEEN EMBANKMENT AND BRIDGE DECK CAUSES HIGH DYNAMIC LOADS AND RAPID TRACK DETERIORATION.
SOLUTION	ENABLES TRACK CONSTRUCTION IN RESTRICTED SPACES	REDUCED DYNAMIC LOADS AT THE TRANSITION.	REDUCED MAINTENANCE, EXTENDED TRACK LIFE, AND IMPROVED RIDE.

GenieMat RAIL systems are essential for managing track stiffness, ensuring long-term performance, and reducing maintenance costs.

10. GENIEMAT BST - UNDER BALLAST MAT FOR VIBRATION ISOLATION

GenieMat BST under ballast mats are laid below the ballast and above the subgrade for the purposes of reducing ground-borne noise and vibration in sensitive urban environments.

Suitable for the full spectrum of rail transport, including Light Rail & Metro, Main Line, High- Speed Rail, and Heavy Haul operations. GenieMat BST is tested in accordance with EN 17282, experiencing less than 15% change in static and dynamic stiffness over 3 million loading cycles and designed for longevity.
Format: 4' (1.22m) wide rolls with varying lengths, or sheets.

	Axle Loads and Speeds According to EN 17282	Product Name	Cstat (N/mm3)	Cdyn 5Hz (N/mm3)	CH20Hz (N/mm3)
TC1	≤ 130 Kn axle load v ≤ 100 km/h	GenieMat BST25	0.014	0.02	0.025
TC2	≤ 160 Kn axle load v ≤ 140 km/h	GenieMat BST25	0.016	0.022	0.044
		GenieMat BST42NC	0.022	0.03	0.051
		GenieMat BST25NC	0.025	0.034	0.055
		GenieMat BST16	0.028	0.039	0.074
TC3	≤ 250 Kn axle load v ≤ 320 km/h	GenieMat BST42NC	0.022	0.031	0.067
		GenieMat BST25NC	0.026	0.035	0.077
		GenieMat BST25	0.019	0.026	0.075
		GenieMat BST16NC	0.038	0.052	0.114
		GenieMat BST16	0.033	0.044	0.12
		GenieMat BST12	0.041	0.054	0.149
TC4	≤ 300 Kn axle load v ≤ 120 km/h	GenieMat BST12	0.049	0.064	0.208
		GenieMat BST16NC	0.043	0.057	0.148

Contact Pliteq for information regarding higher axle loads.

11. GENIEMAT BST - TRACK MODULUS CONTROL & COMPONENT PROTECTION

Specific design challenges that can be mitigated with the use of GenieMat BST under ballast mats include:
- **Ballast and Structure Protection:** Extending the lifecycle of ballast and underlying structures (bridges, tunnels, and elevated stations).
- **Optimized Clearances:** Facilitating track stability in areas with reduced ballast thickness.
- **Transition Zones:** Managing stiffness at transition zones to prevent differential settlement.

	Axle Loads and Speeds According to EN 17282	Product Name	Cstat (N/mm3)	Cdyn 5Hz (N/mm3)
TC3	⩽ 250 Kn axle load v ⩽ 320 km/h	GenieMat BST12	0.041	0.054
		GenieMat BST16NC	0.038	0.052
TC4	⩽ 300 Kn axle load v ⩽ 120 km/h	GenieMat BST12	0.049	0.064
		GenieMat BST16NC	0.043	0.057
		GenieMat BST11F	0.09	0.12

Contact Pliteq for information regarding higher axle loads.

The ballast and waterproofing are two components that are susceptible to damage during the lifetime of the track. The use of **GenieMat BST** elastomers can provide protection for the ballast and waterproofing by reducing or distributing the dynamic forces from the train over a larger area, reducing the peak stress on the ballast or waterpoofing membrane.

BALLAST PROTECTION:

The ballast is subject to degradation over time due to
concentrated loads onto the rock, specifically in cases with concrete ties (sleepers) and/or a concrete subgrade.

Some examples include open track with concrete sleepers (ties), and areas with very stiff subgrade such as bridges and tunnels.

Using GenieMat BST elastomers can help reduce the peak stresses in the ballast, reducing the required ballast maintenance and increasing the longevity of the track.

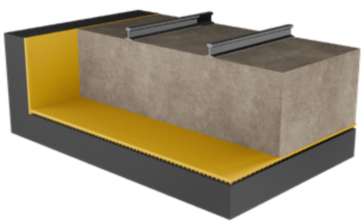
WATERPROOFING PROTECTION:

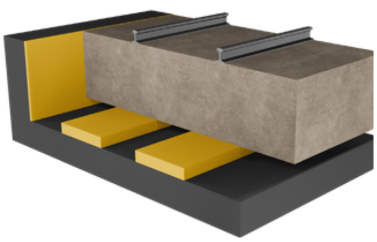
GenieMat BST provides a durable, resilient layer that is compatible with various waterproofing systems, including membrane, spray, and liquid-applied systems.

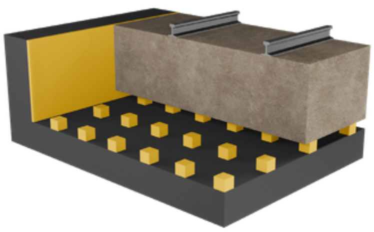
This high strength elastomer prevents punctures and tears, ensuring the longevity and effectiveness of the waterproofing system, and protecting the bridge structure from water damage.

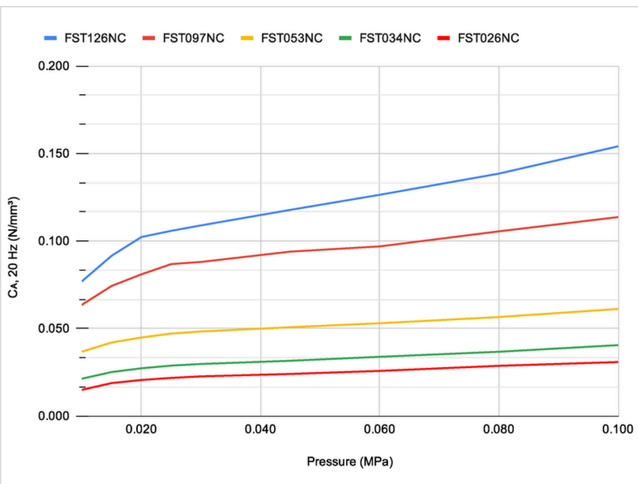
12. GENIEMAT FST - FLOATING SLAB TRACK VIBRATION ISOLATION

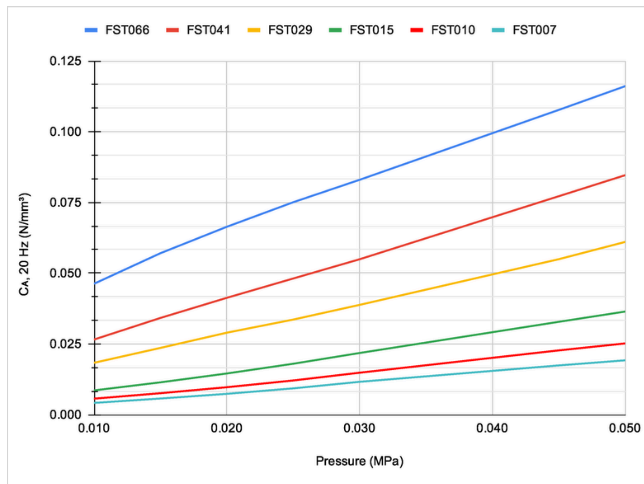
For substantial ground-borne vibration mitigation, a mass-spring system is considered the most effective vibration isolation design. The properties and configuration of the **GenieMat RAIL FST** isolators are dictated by the required insertion loss frequency range, vehicle axle-load, speed and surrounding soil properties among other parameters.



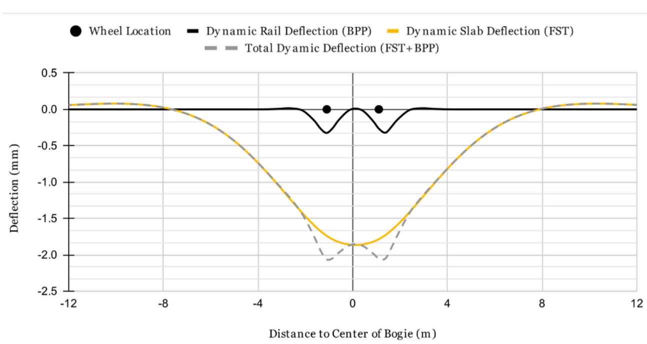


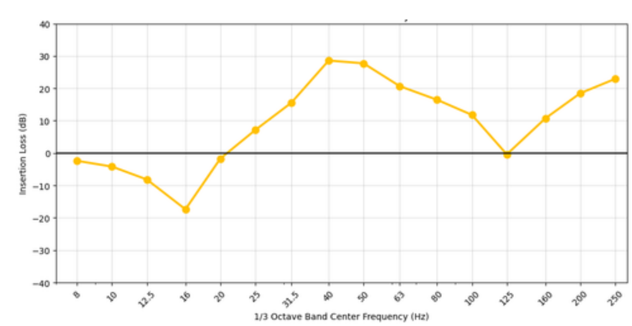






GenieMat FST CH data used to determine insertion loss (EN 17682, 20 Hz). Elastomer pressure is dependent on track loading conditions and isolator sizing.





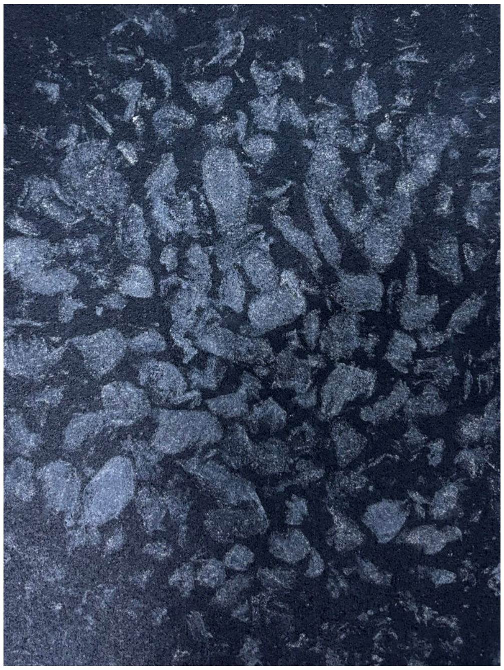
Insertion loss (2-DOF, 3-DOF) and static/dynamic rail deflection modelling available upon request.

13. GENIEMAT RTP - UNDER TIE PADS (UNDER SLEEPER PADS)

The interface between the ballast and the tie (sleeper) is susceptible to long-term degradation and increased maintenance compared to other track components. In particular, increased maintenance is noticed in areas with concrete ties (sleepers), turnouts, switches & crossing, and transition zones.

Installing the **GenieMat RTP** under the tie (sleeper) can help:

- **Load Distribution:** Distributes load evenly across the sleeper (tie) and increases the contact area with the ballast, reducing stress concentrations.
- **Ballast Protection:** Reduces pressure on the ballast, minimizing degradation and breakage.
- **Track Stability:** Improves lateral track stability, particularly in curves and turnouts.
- **Reduced Maintenance:** Significantly extends tamping cycles (field results show a 2-3x increase), reducing maintenance needs.
- **Vibration Attenuation:** Offers vibration mitigation (up to 8-10 dB reduction), contributing to quieter track.
- **Track Pumping Reduction:** Minimizes the effects of track pumping, maintaining track geometry.



GenieMat RTP contact area with ballast.

GENIEMAT RTP PERFORMANCE OVERVIEW:

- **Static stiffnesses:**
    - **GenieMat RTP120:** Light Rail: >0.12 N/mm^3
    - **GenieMat RTP150**: Commuter: > 0.15 N/mm^3
    - **GenieMat RTP180**: Heavy Freight: >0.18 N/mm^3

- **Fatigue testing:** after 3 million cycles (per EN 16730), <15% change in static and dynamic stiffness.
- **Pulloff strength*:** average of 3 pulls > 0.5 MPa, minimum of 3 pulls > 0.4 MPa.
- **Sizes:** Tailored to the sleeper. Available as a single full-length pad or a dual-pad set (two half-length segments) per sleeper.

Contact us

E. info@pliteqacoustics.com
W. pliteqacoustics.com
T. 1.416.449.0049

PLITEQ®

It's not magic, it's engineering.