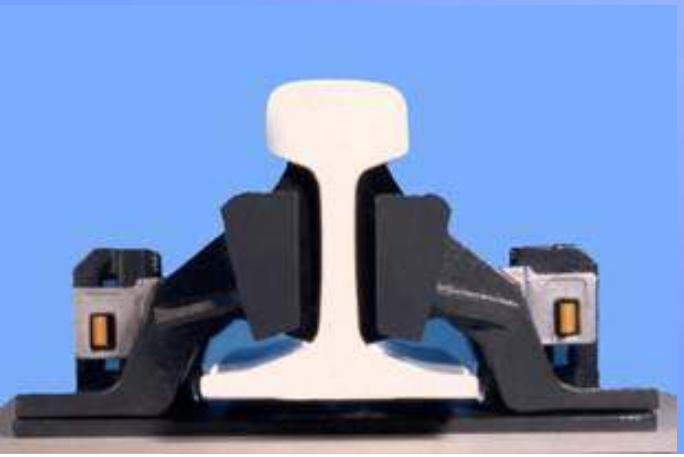
13ª SEMANA DE TECNOLOGIA METROFERROVIÁRIA 2007

O hotsite oficial está no ar!

28 a 31 de Agosto - Centro de Convenções Shopping Frei Caneca

Wheel/Rail Induced Noise & Vibration - and its Mitigation -



Keith Green
Pandrol Ltd

Noise & Vibration

Resilient baseplate

Vanguard

Construction

Conclusion

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Noise (or sound)

Sound energy is transmitted through the air, directly from the source to the receiver.

Frequency range for Humans is 20Hz – 20kHz.

Unit of Measure is the decibel (dB),

The decibel is a linear numbering scale used to define a logarithmic amplitude scale, thus compressing a wide range of amplitude value to a small set of numbers.

The human ear is not uniformly sensitive across the audible frequency range, it is less sensitive at high and low frequencies.

Weighting networks are used to modify a measured noise or vibration spectrum to approximate the response to that of the human ear.

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Sound Pressure Level	Environment
30 – 40 dB(A)	Quiet office
60 – 65 dB(A)	Conversation
85 – 95 dB(A)	Industrial workshop
130 dB(A)	Pain threshold

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The primary sources of directly transmitted noise, during the passage of a train are:

(a) Engine and motor noise.

(b) Aerodynamic noise.

(c) Squeal from wheels on curves.

(d) Rolling noise.

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Vibration

Steel wheels running on steel rails, generates high dynamic forces that can lead to elastic wave deformation of the support structure or ground, in other words - vibration.

Vibration is transmitted through a solid medium, from a source to a receiver.

Secondary Noise

Secondary noise is generated as a result of vibrations, stimulating the elements of a building or support structure to vibrate and transmit sound through the air.

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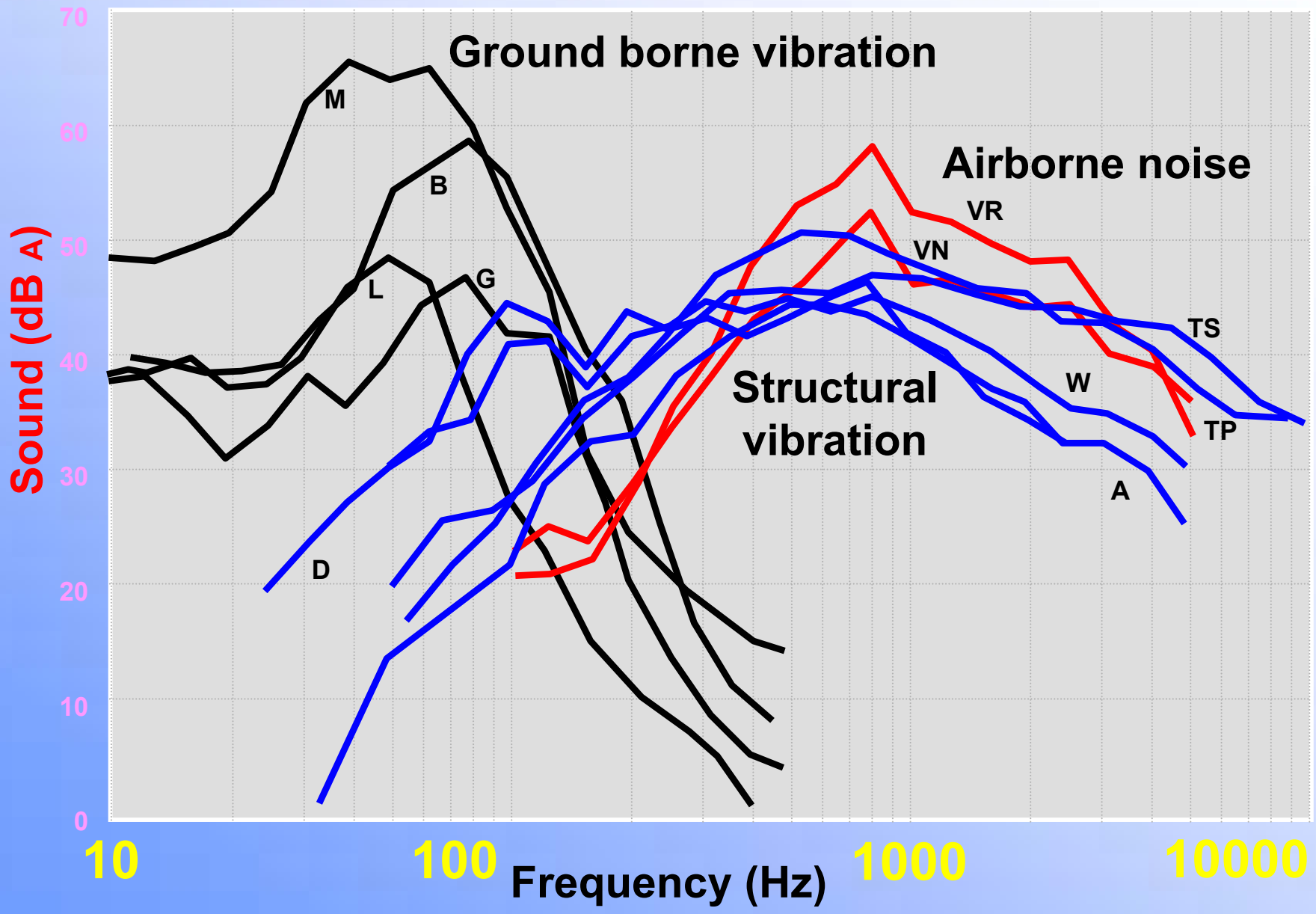

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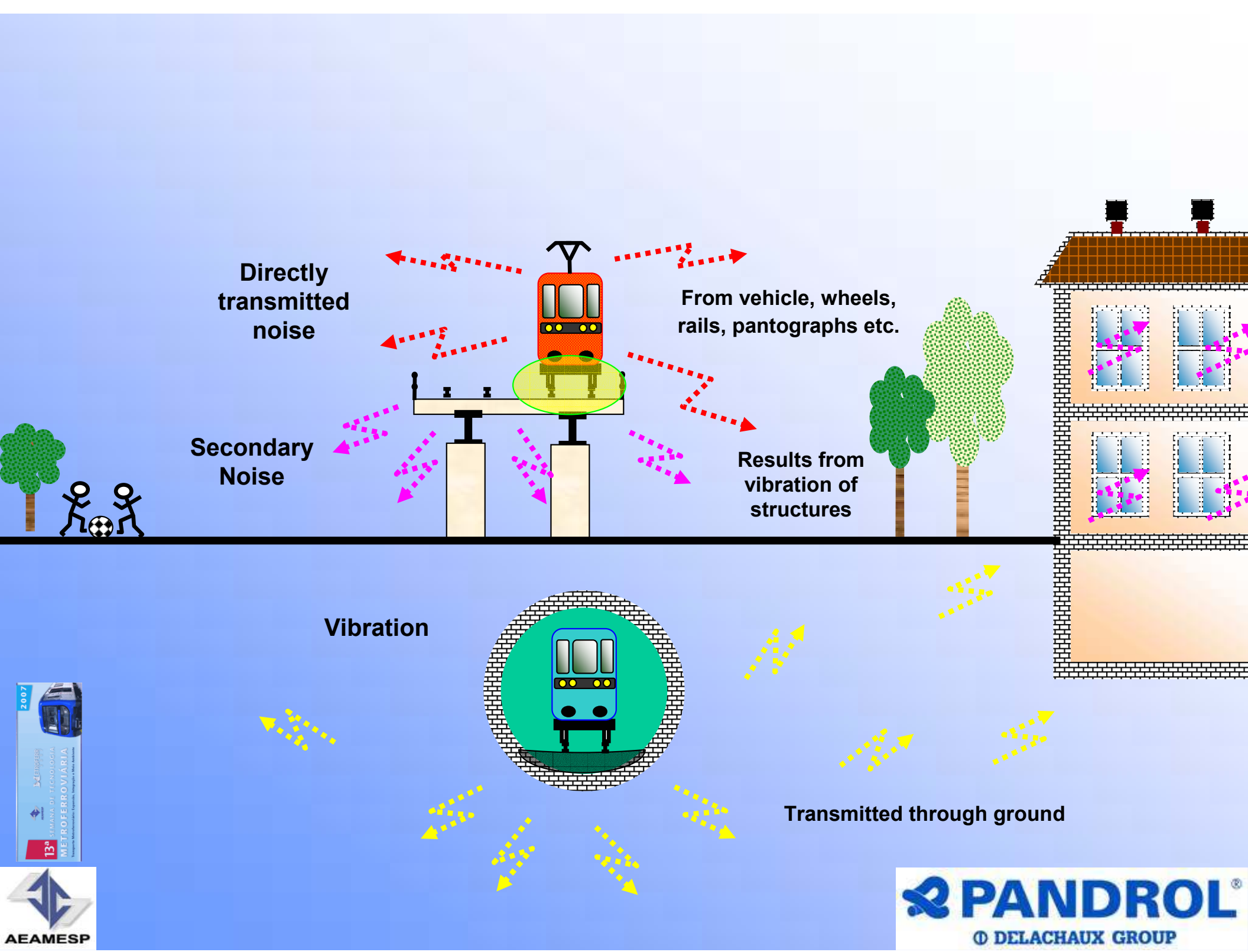
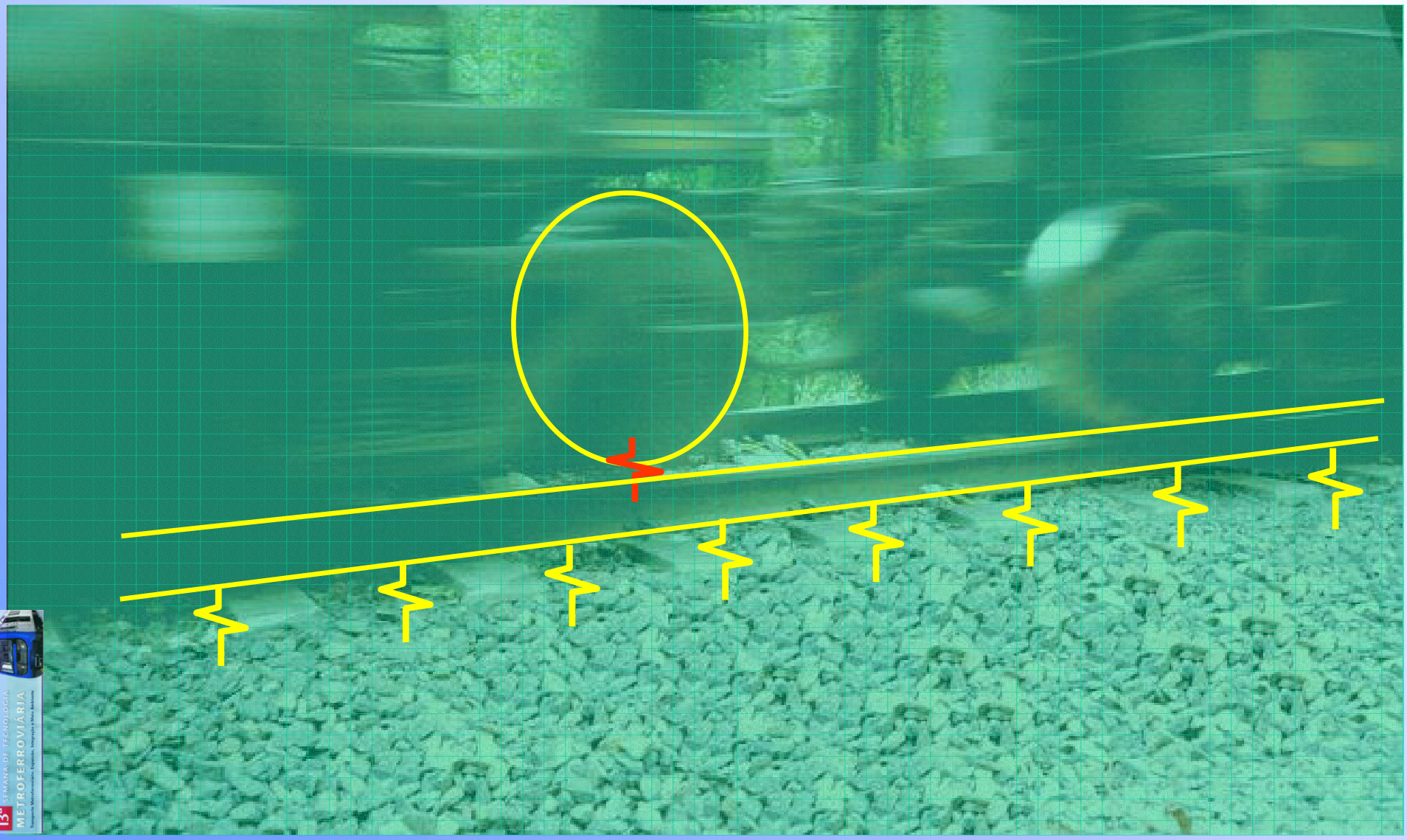
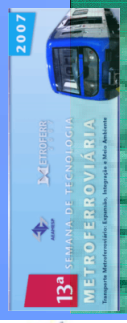


Modeling





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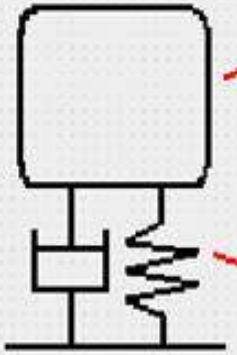
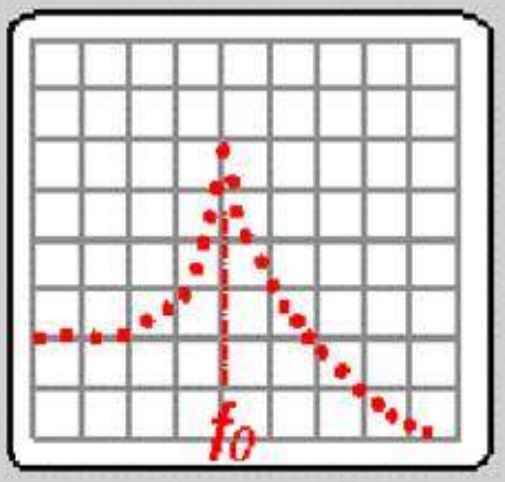
Modelling the Track Support System

Lumped unsprung mass of vehicle + resiliently supported track mass

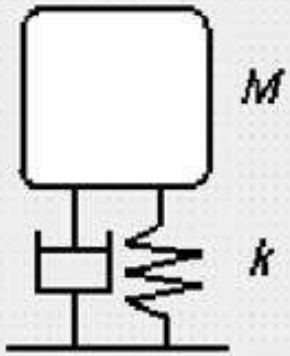
Simplified model – mass on spring system



Track support stiffness and damping



Loaded Track Resonance



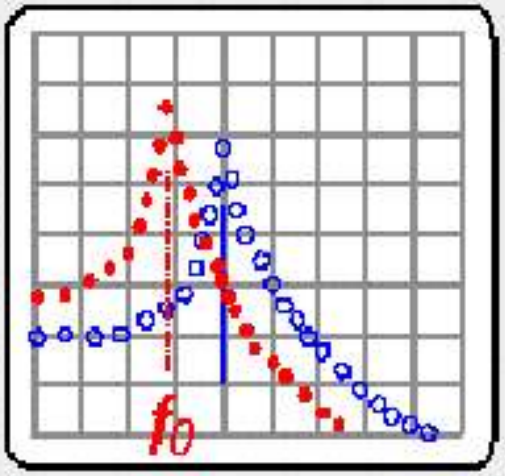
$$f_0 = {}^{1}/_{2\pi}\sqrt{{}^{k}/_{M}}$$

=> to reduce loaded track resonant frequency

– increase M

– decrease k

Strategies for Reducing Ground Vibration



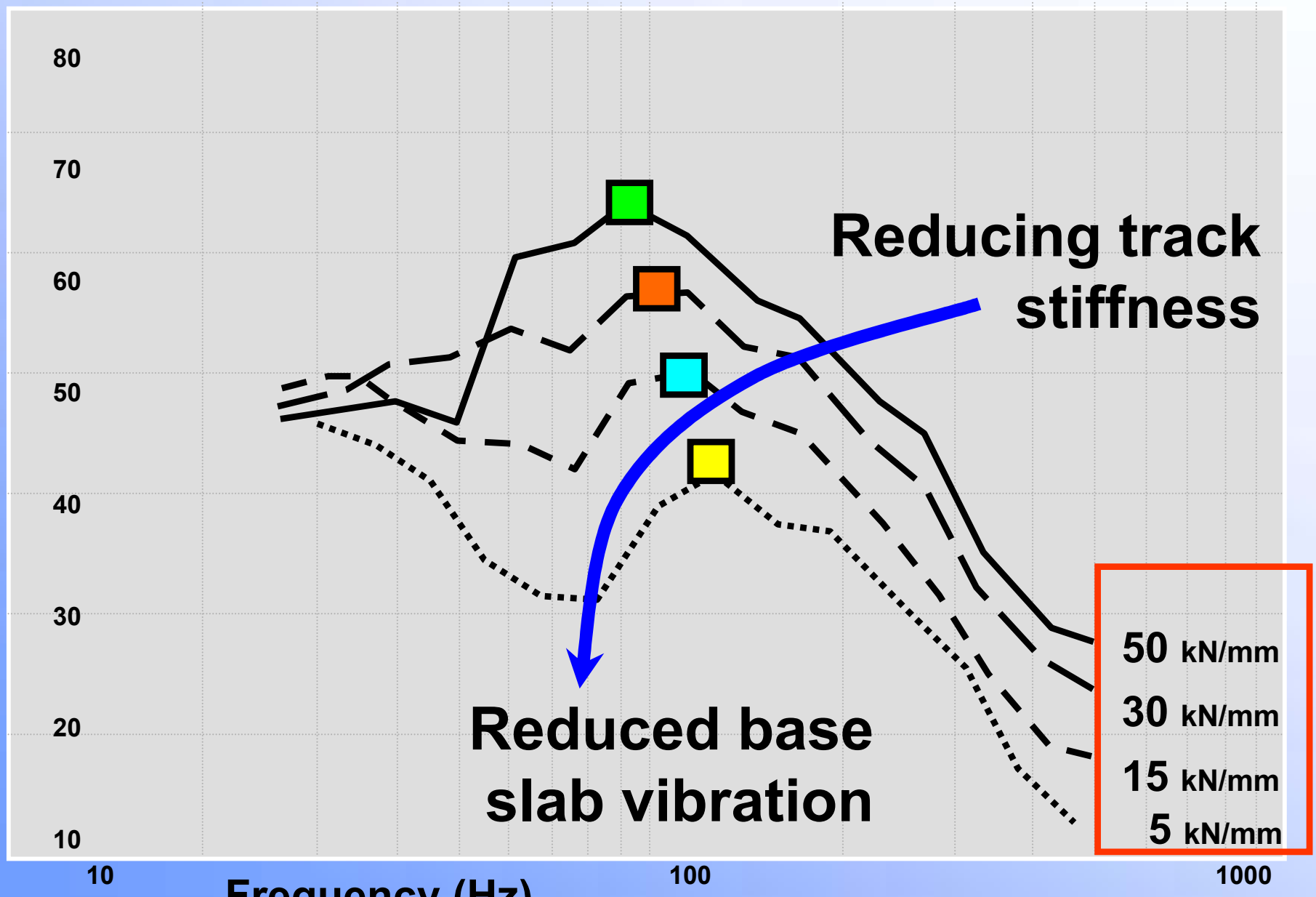
Loaded Track Resonance

Most commonly –

Reduce resonant frequency

– on the basis that vibrations are attenuated at frequencies above this resonance

Strategies for Reducing Ground Vibration



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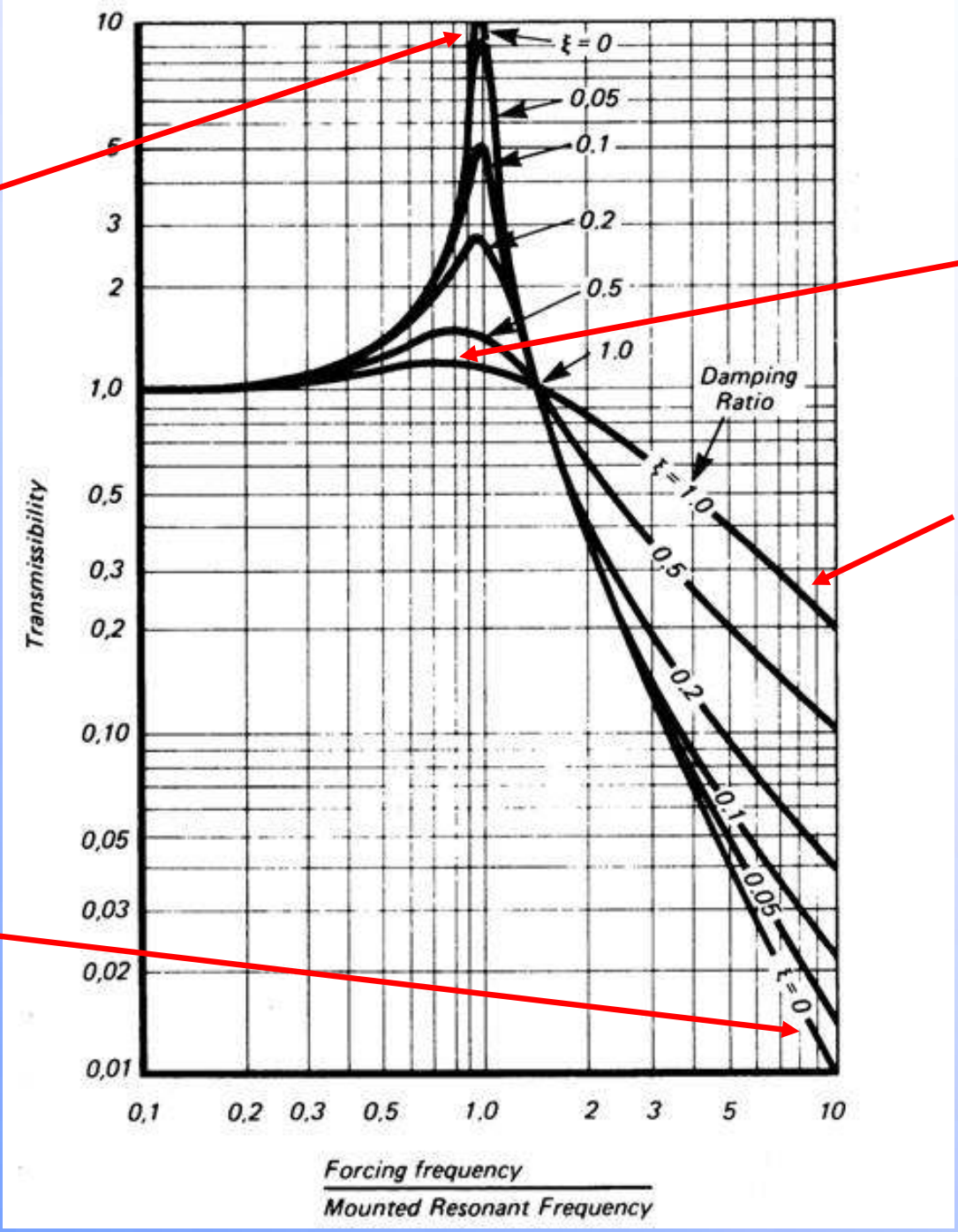
Low damping

High resonant peak



High damping

Low resonant peak

Less attenuation, poor isolation

Good attenuation and isolation

The effect of Damping

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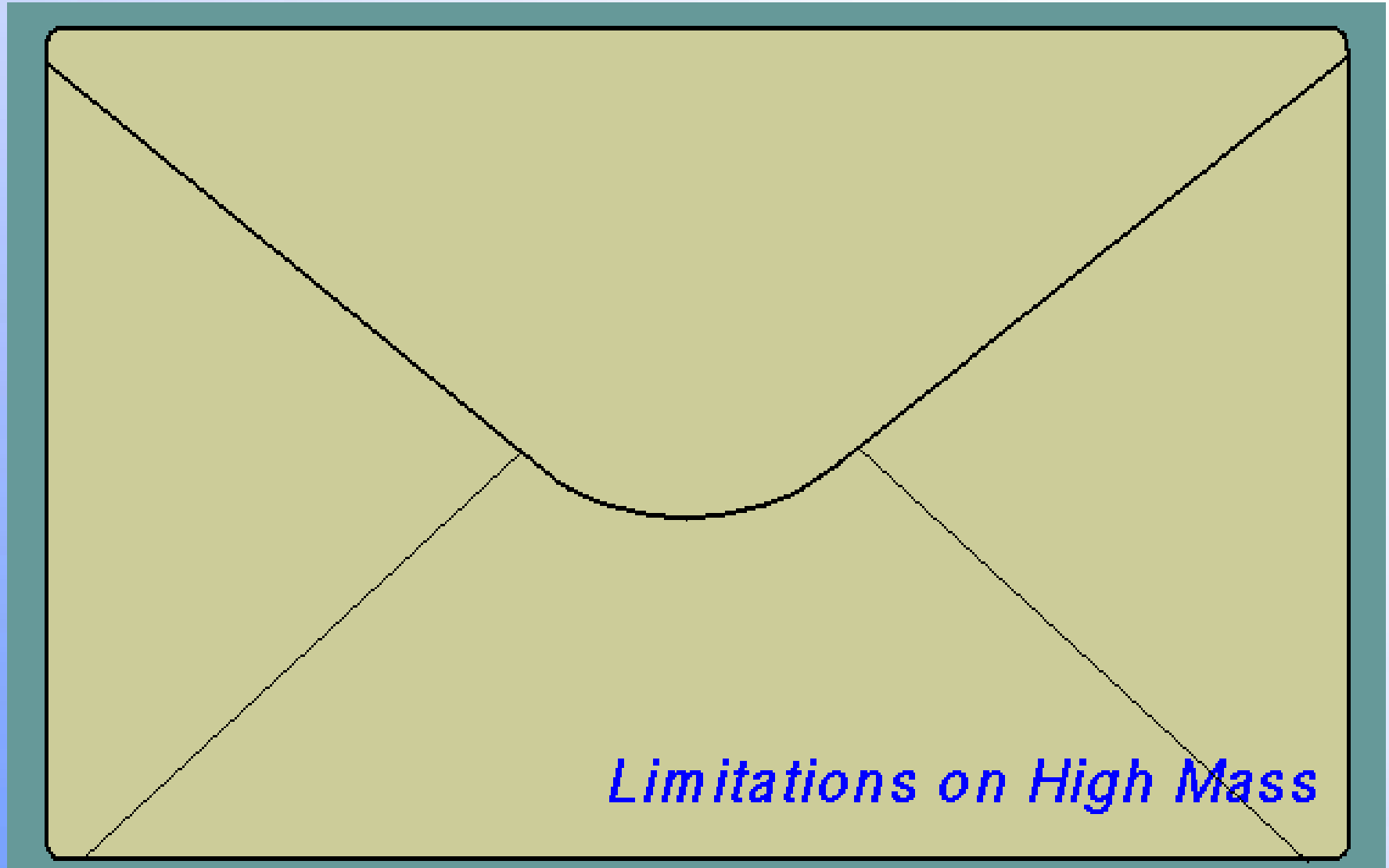

Pandrol Rail Fastenings

Current Concerns
Current Solutions

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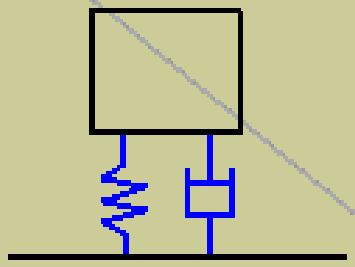
Typical parameters (one rail) :



say 750 kg (vehicle + rail)

say 100 kN/mm (track stiffness)

Limitations on High Mass

Pandrol Rail Fastenings *Current Concerns* *Current Solutions*

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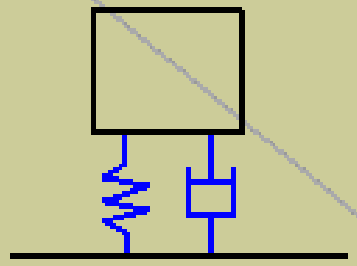
$f_o = 1/2\pi \sqrt{k/m}$



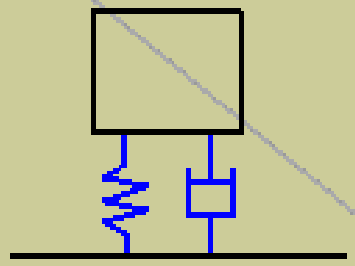
750 kg

100 kN/mm

$\Rightarrow f_o \approx 60$ Hz

Limitations on High Mass

Pandrol Rail Fastenings *Current Concerns* ***Current Solutions***



750 kg

100 kN/mm

$f_o \approx 60$ Hz

$f_o \approx 30$ Hz

Limitations on High Mass

Pandrol Rail Fastenings

Current Concerns
Current Solutions

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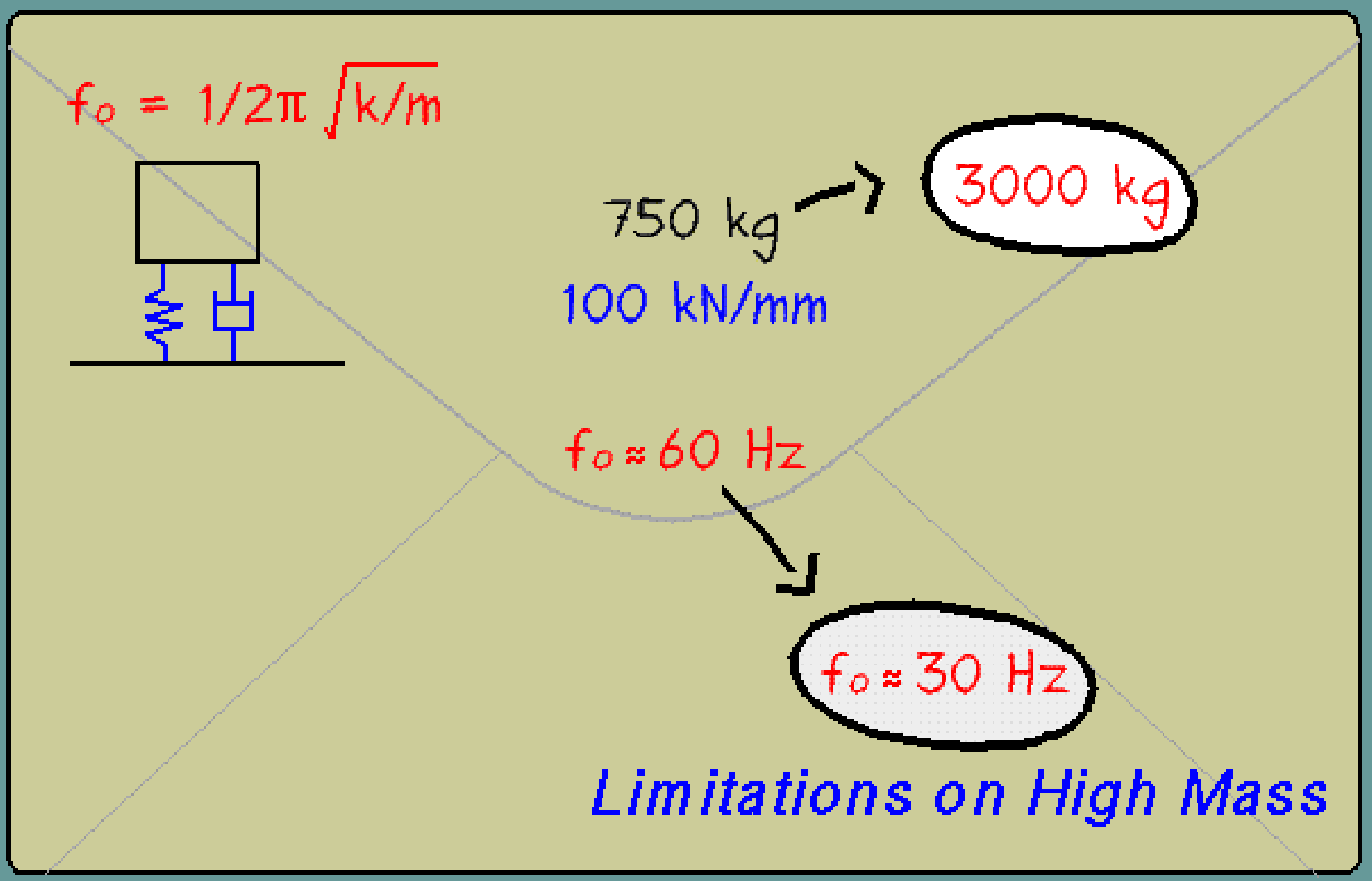
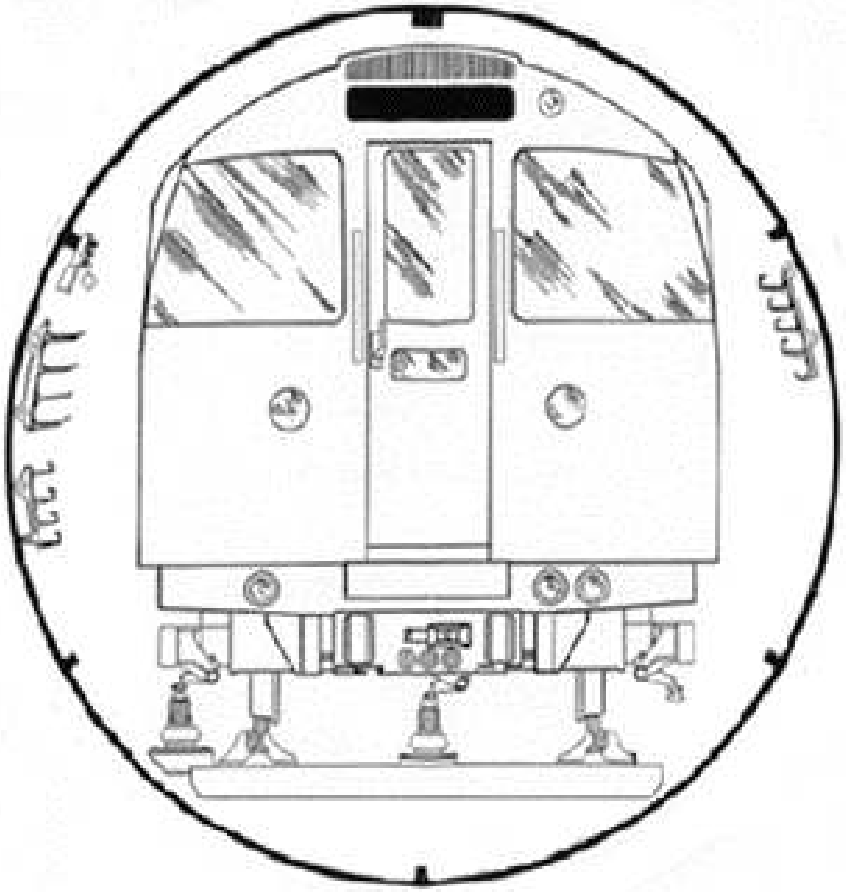


Pandrol Rail Fastenings

Current Concerns
Current Solutions



Pandrol Rail Fastenings

Current Concerns
Current Solutions

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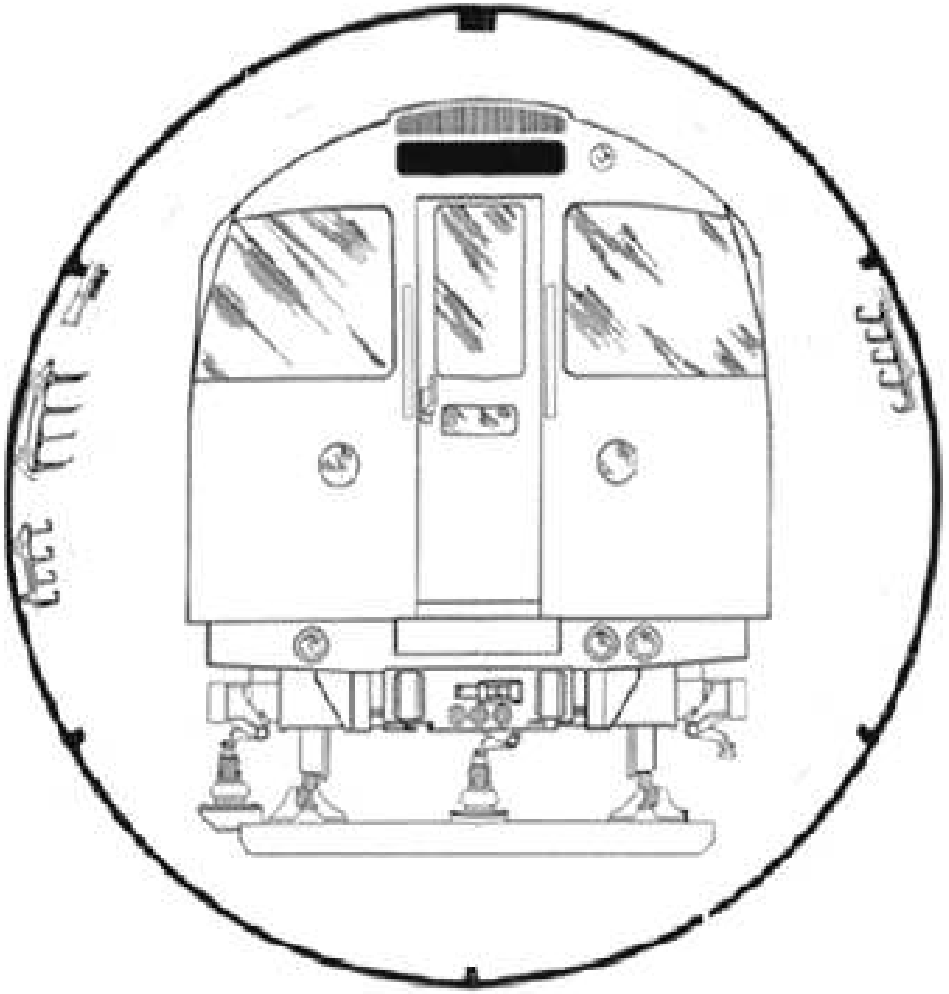

Pandrol Rail Fastenings

Current Concerns
Current Solutions

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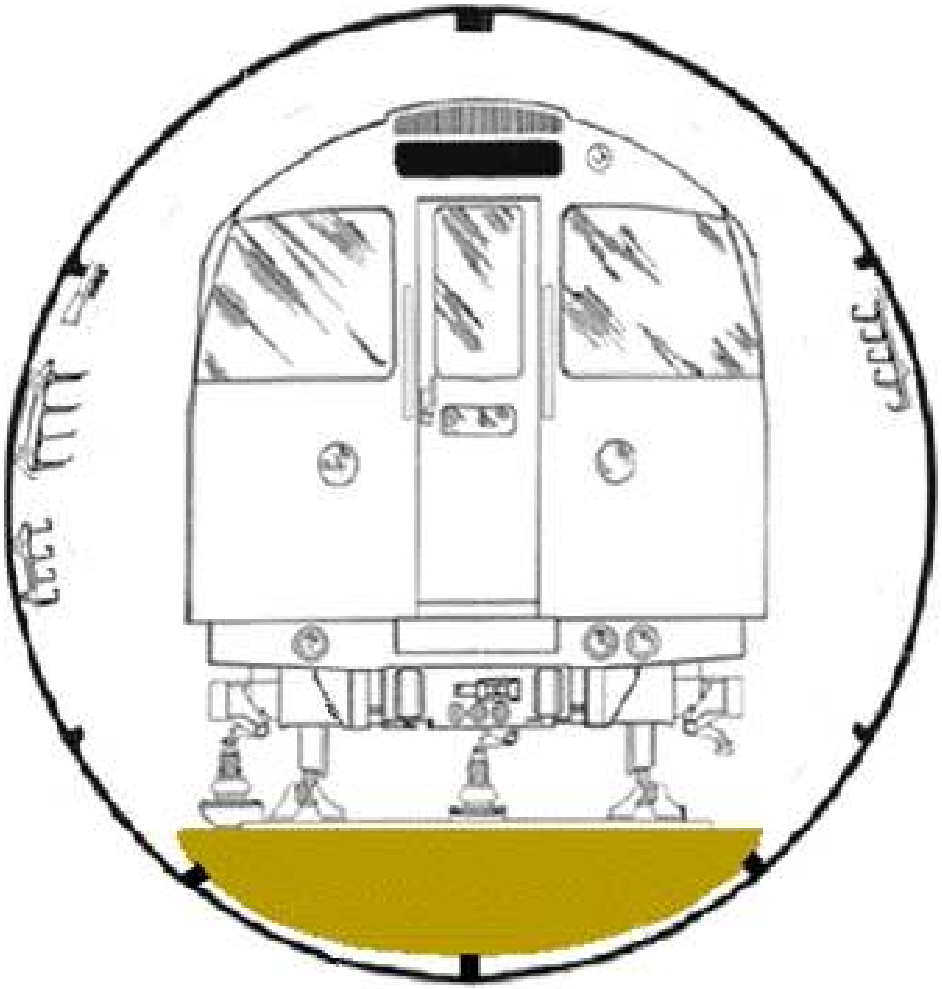

Pandrol Rail Fastenings

Current Concerns
Current Solutions

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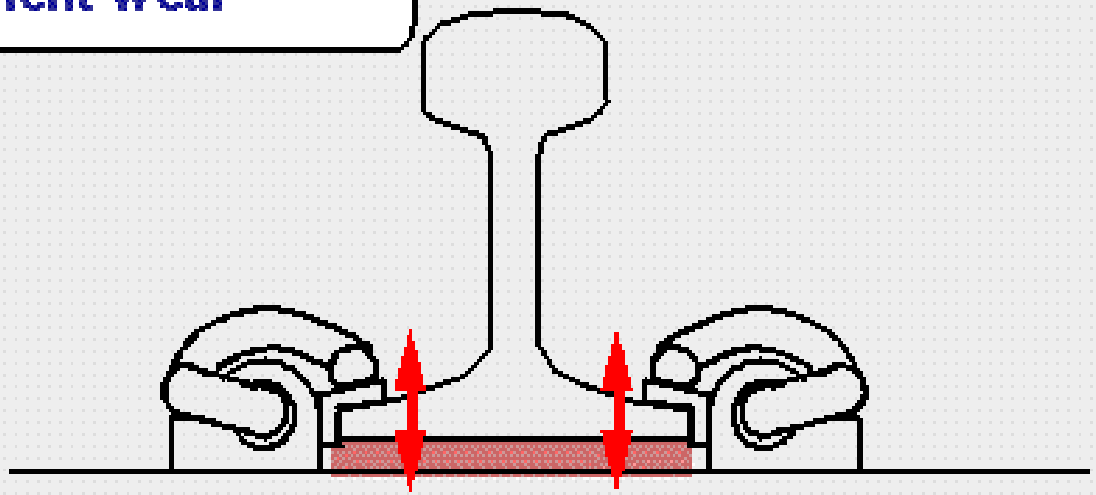
Fastening Fatigue Limit

Component Wear



Limitations on Low Stiffness

Pandrol Rail Fastenings

Current Concerns
Current Solutions

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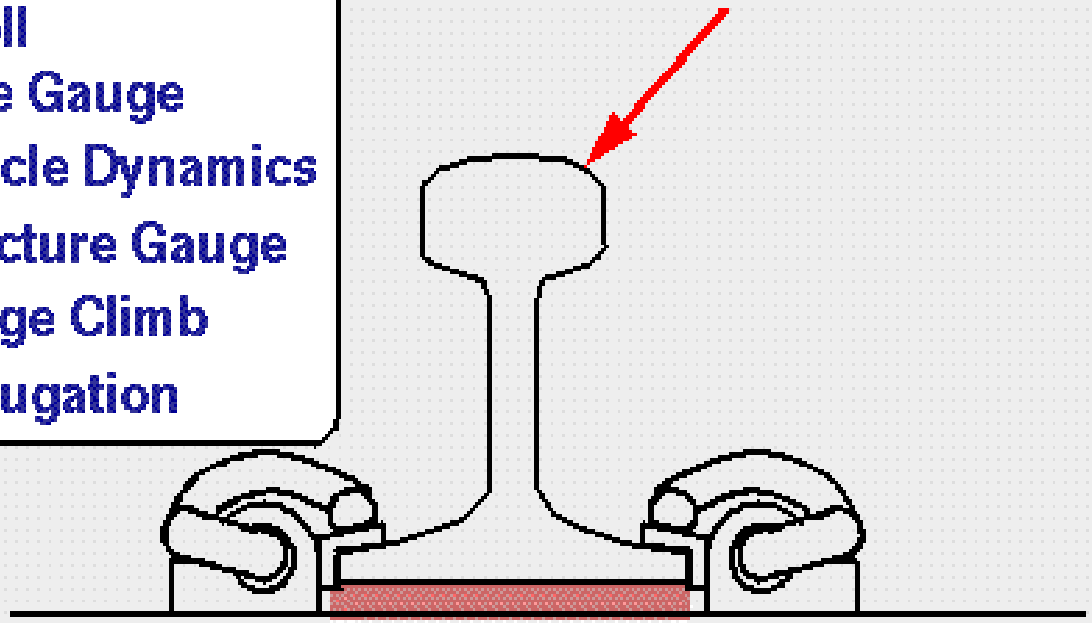
Rail Roll

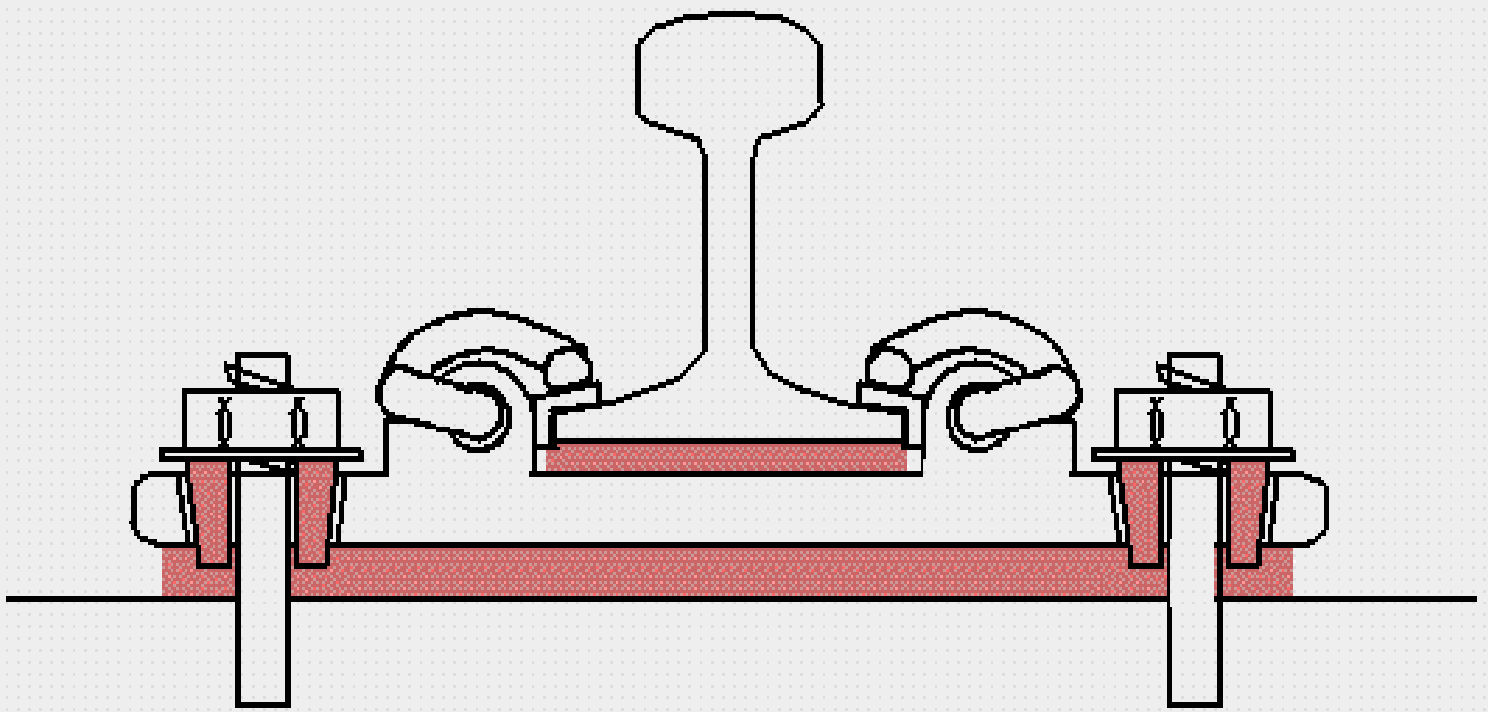
- Wide Gauge
- Vehicle Dynamics
- Structure Gauge
- Flange Climb
- Corrugation



Limitations on Low Stiffness

Pandrol Rail Fastenings

Current Concerns
Current Solutions



Limitations on Low Stiffness

Pandrol Rail Fastenings

Current Concerns
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Noise & Vibration

Resilient baseplate

Vanguard

Construction

Conclusion

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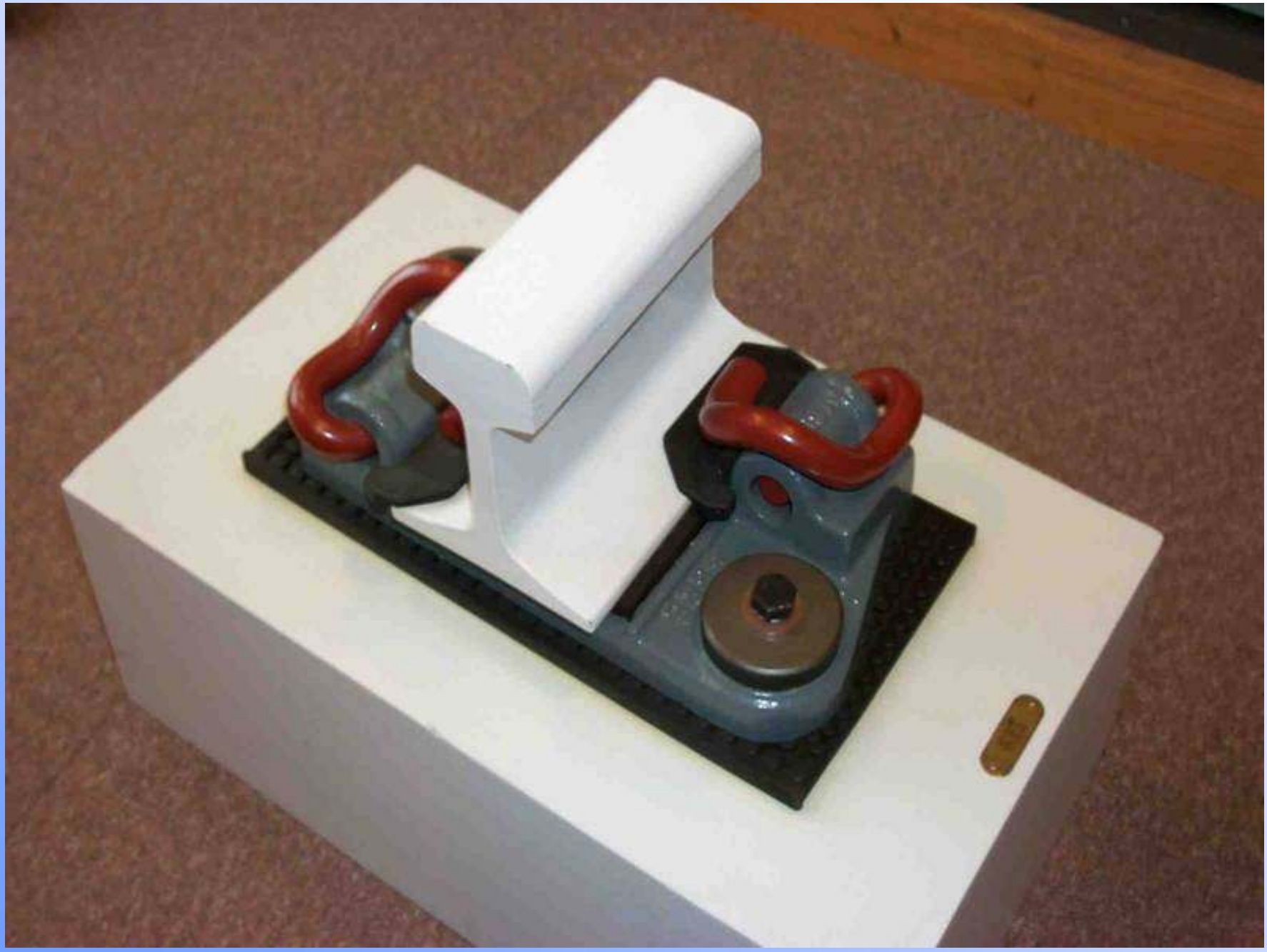
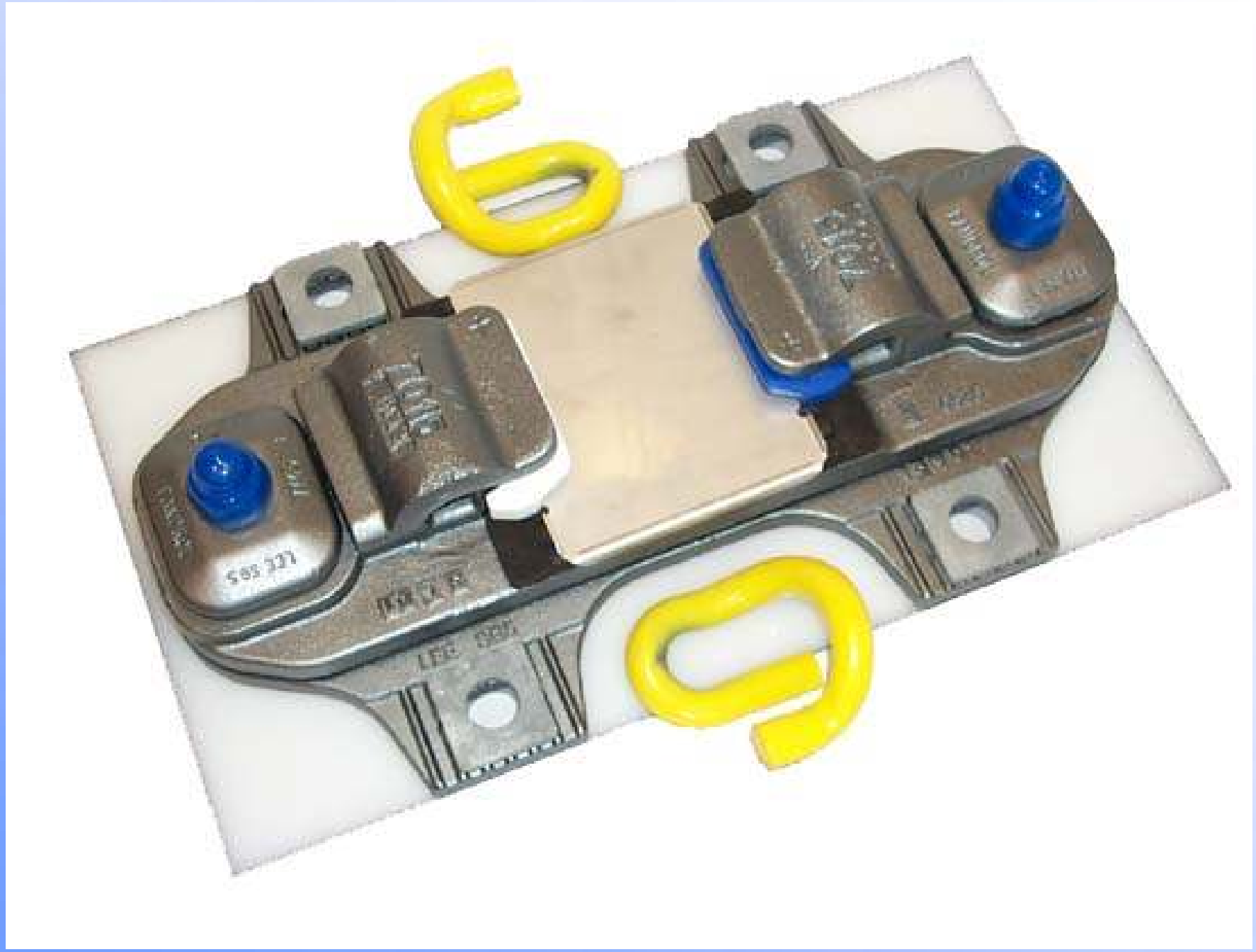
Docklands Light Railway, London: 1989.



Sao Paulo Metro

Klara Bridge – Sweden.

Normal, full toe load assembly



Rail free or ZLR assembly

Changi Airport Line, Singapore

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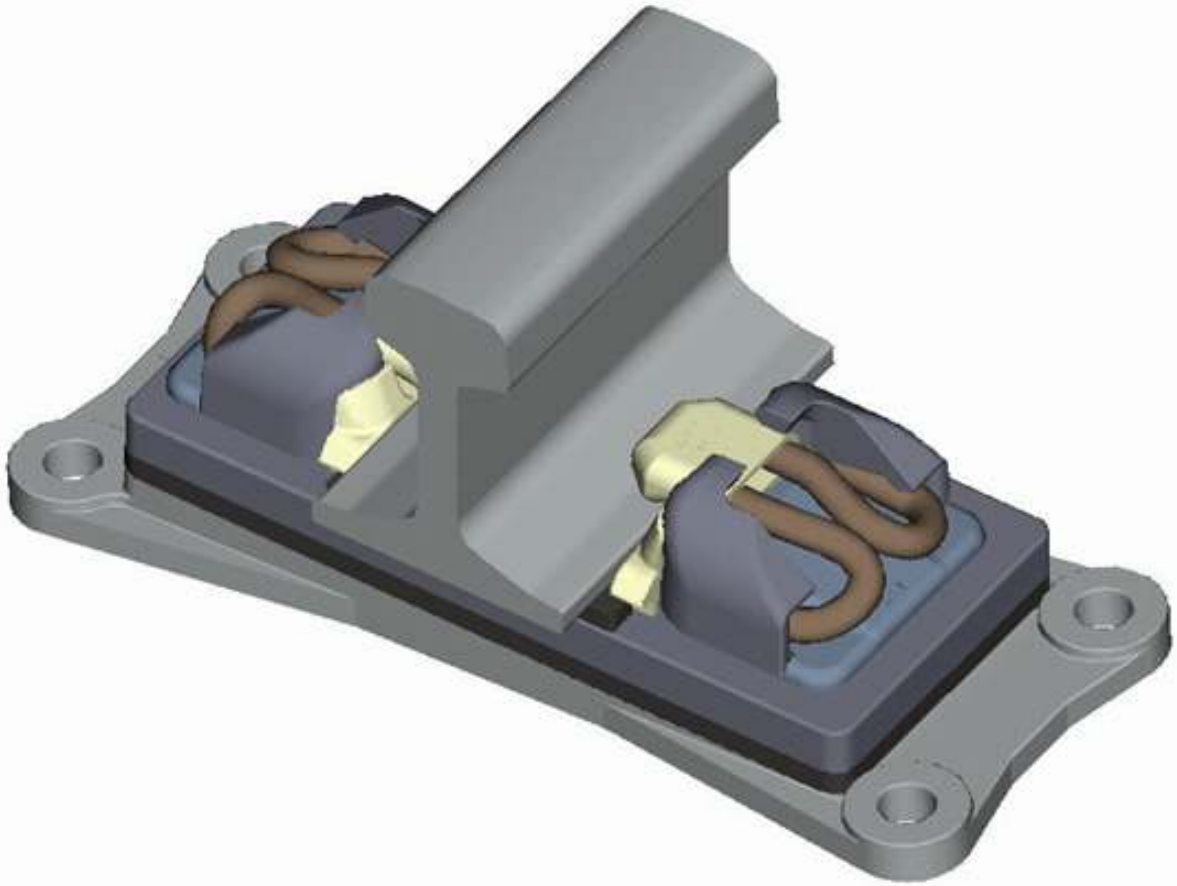

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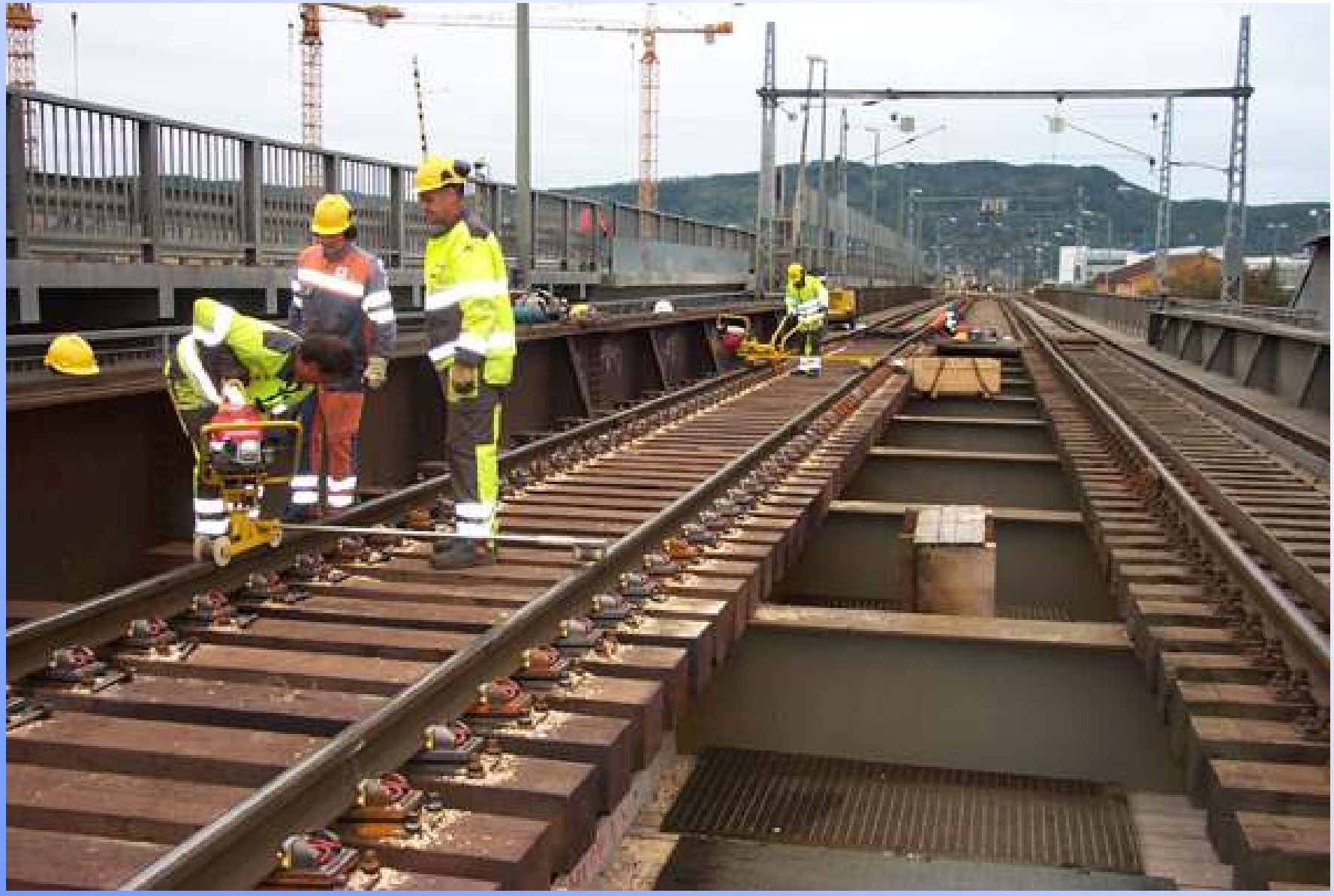
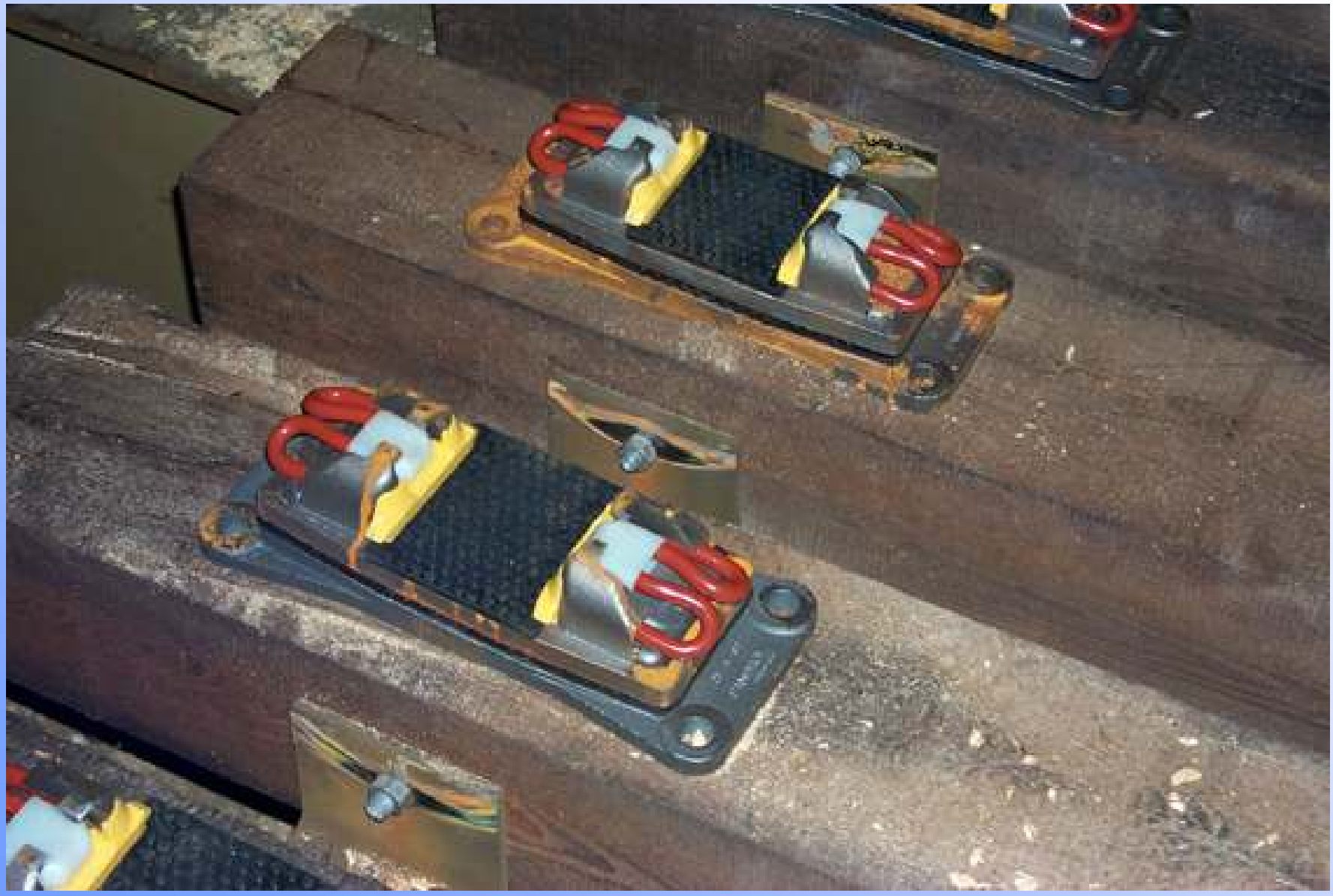
Nidelv - Norway





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Valhubert tunnel - Paris

Cosmesti Bridge - Romania

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Noise & Vibration

Resilient baseplate

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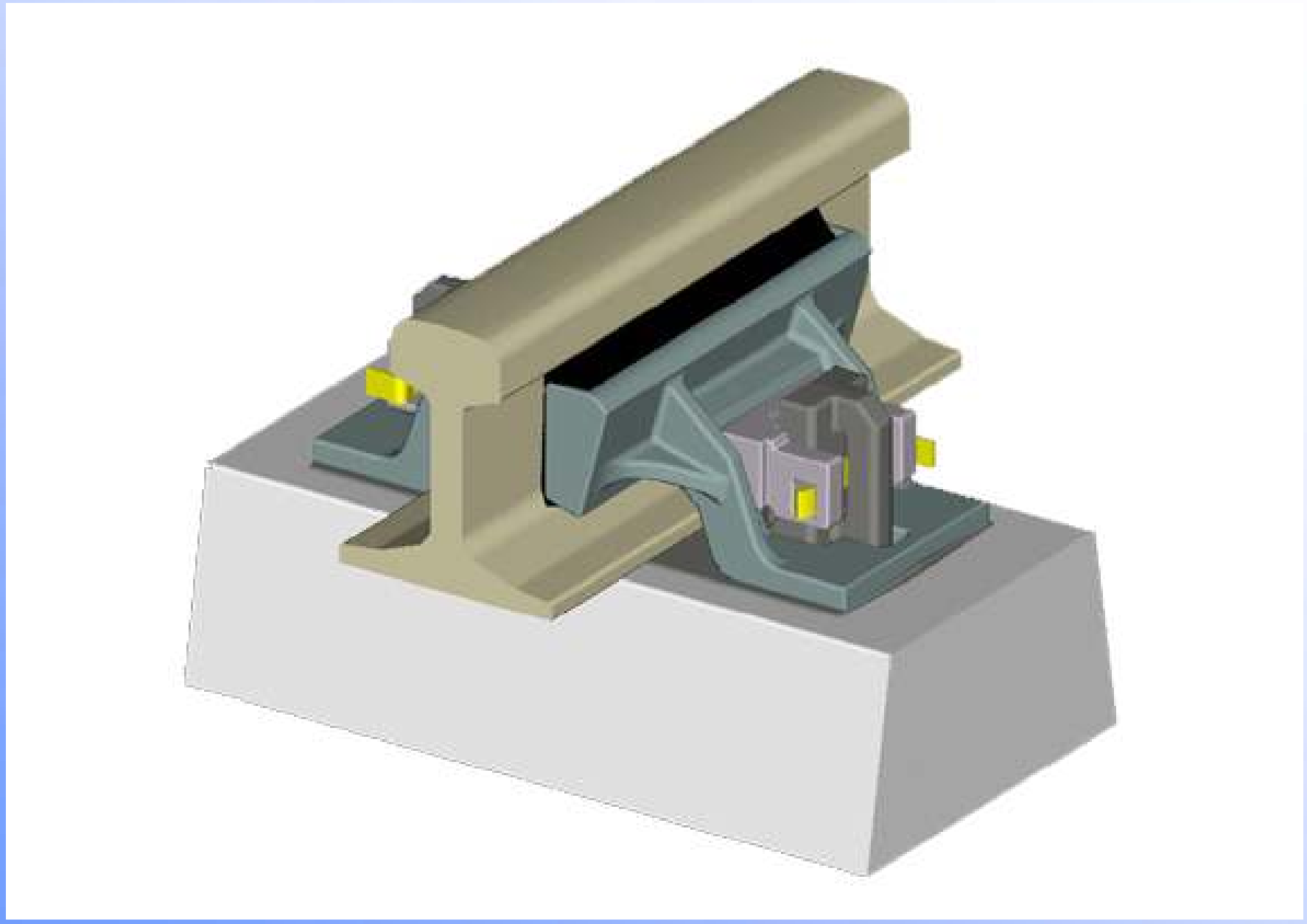

Pandrol Vanguard

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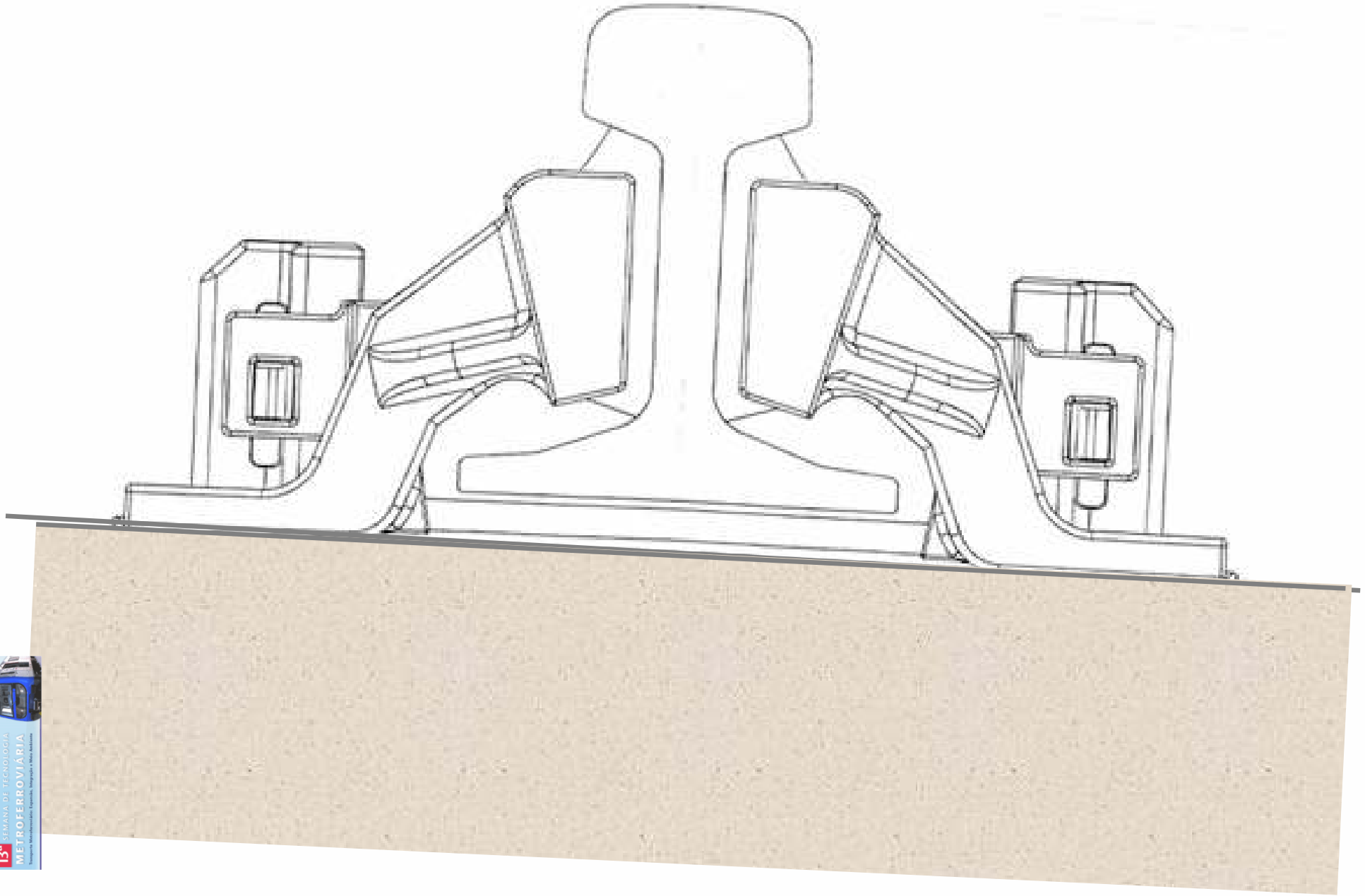
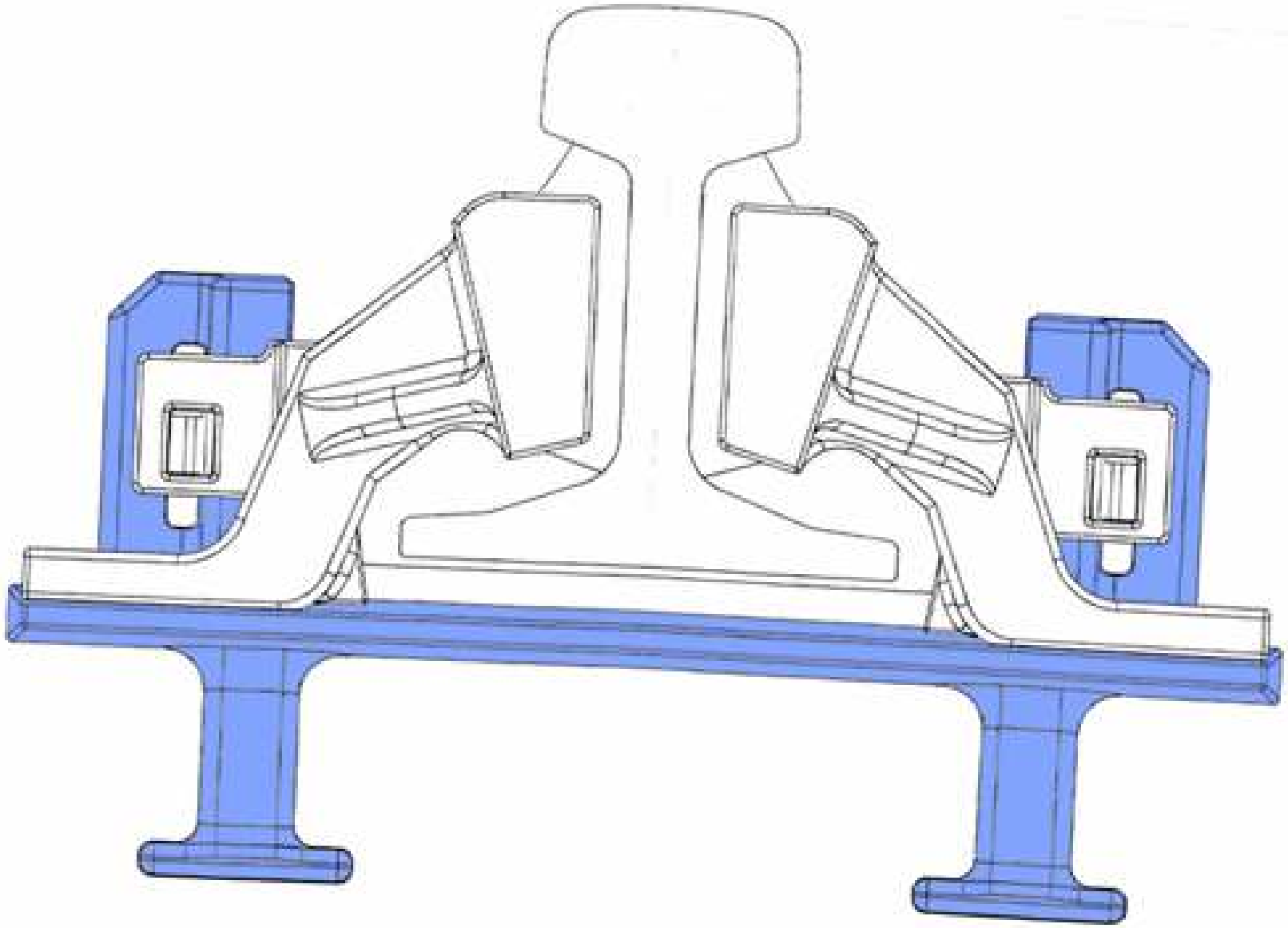
Pandrol Vanguard



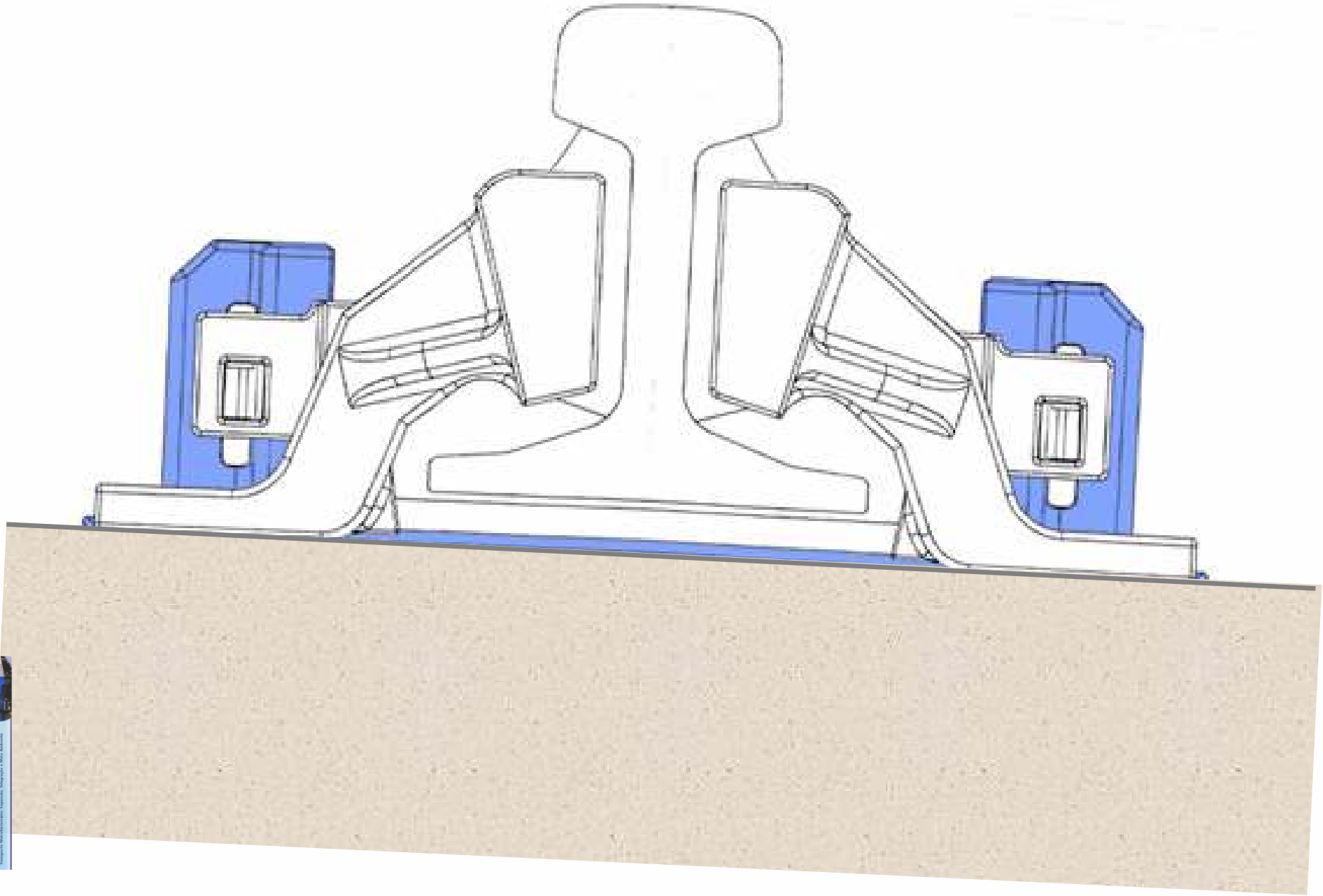
PANDROL VANGUARD ON LONDON UNDERGROUND

Cast SG iron plate with stems and shoulders …



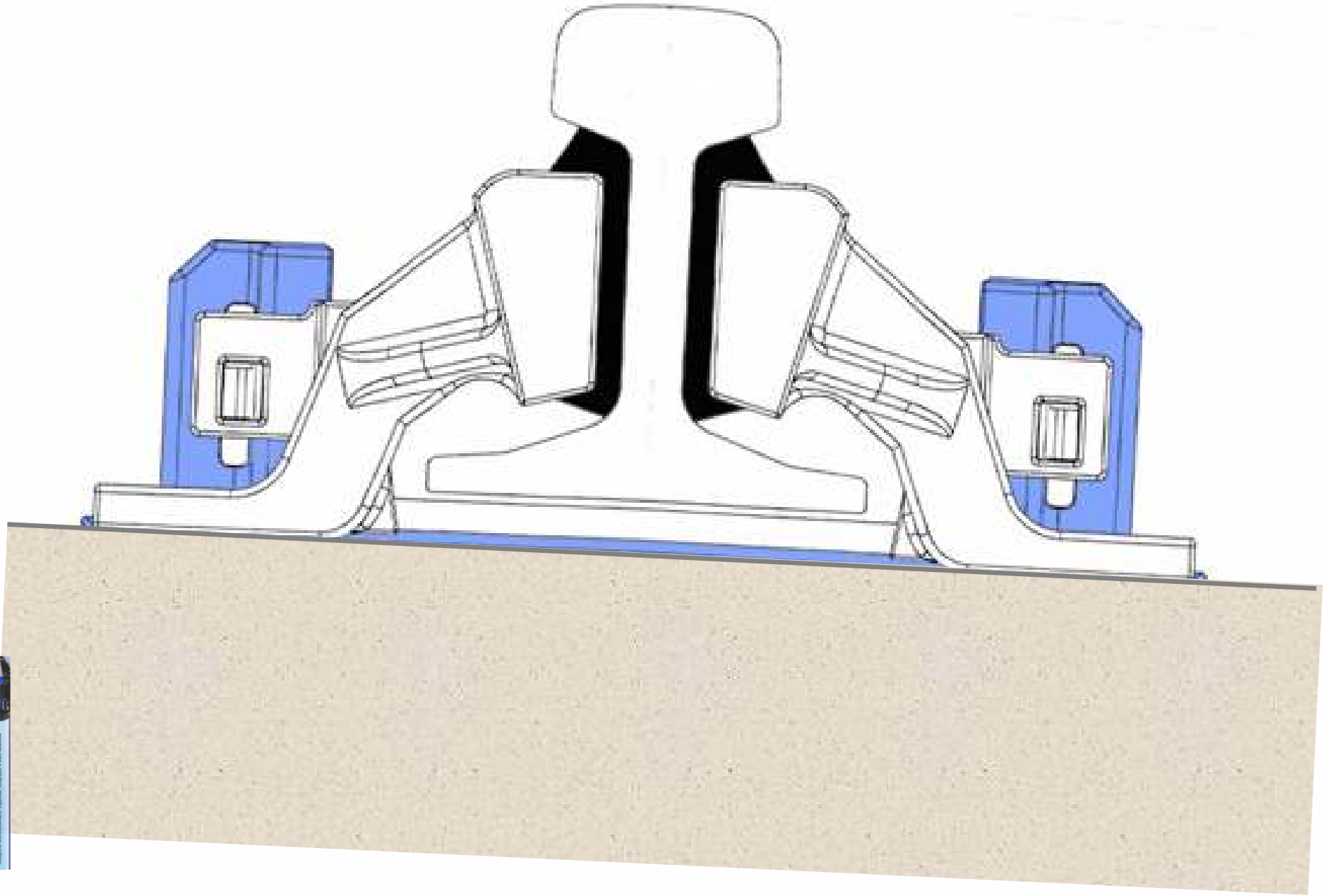
PANDROL VANGUARD ON LONDON UNDERGROUND

… cast into prestressed concrete sleeper



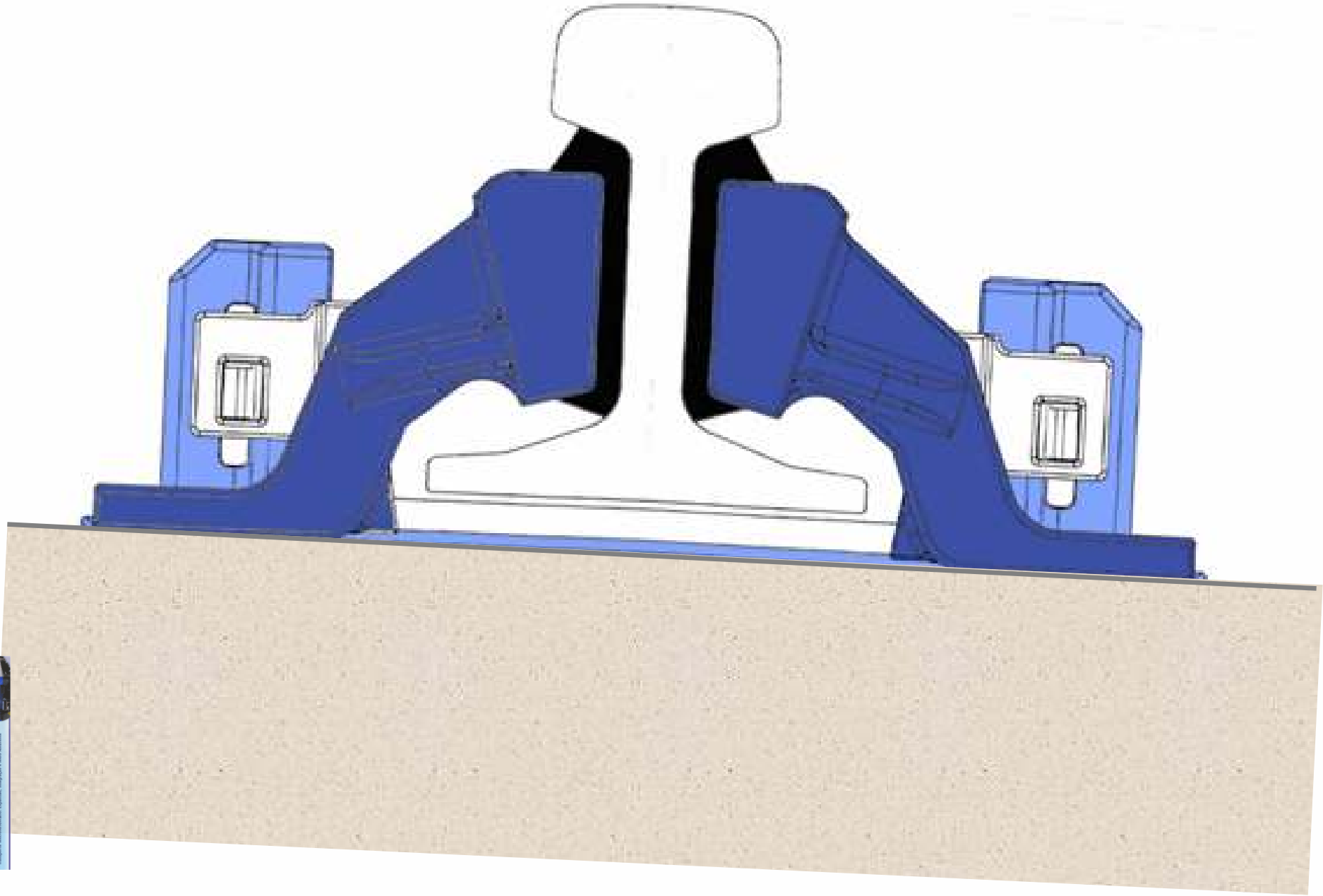
PANDROL VANGUARD ON LONDON UNDERGROUND

Natural rubber wedges support rail …



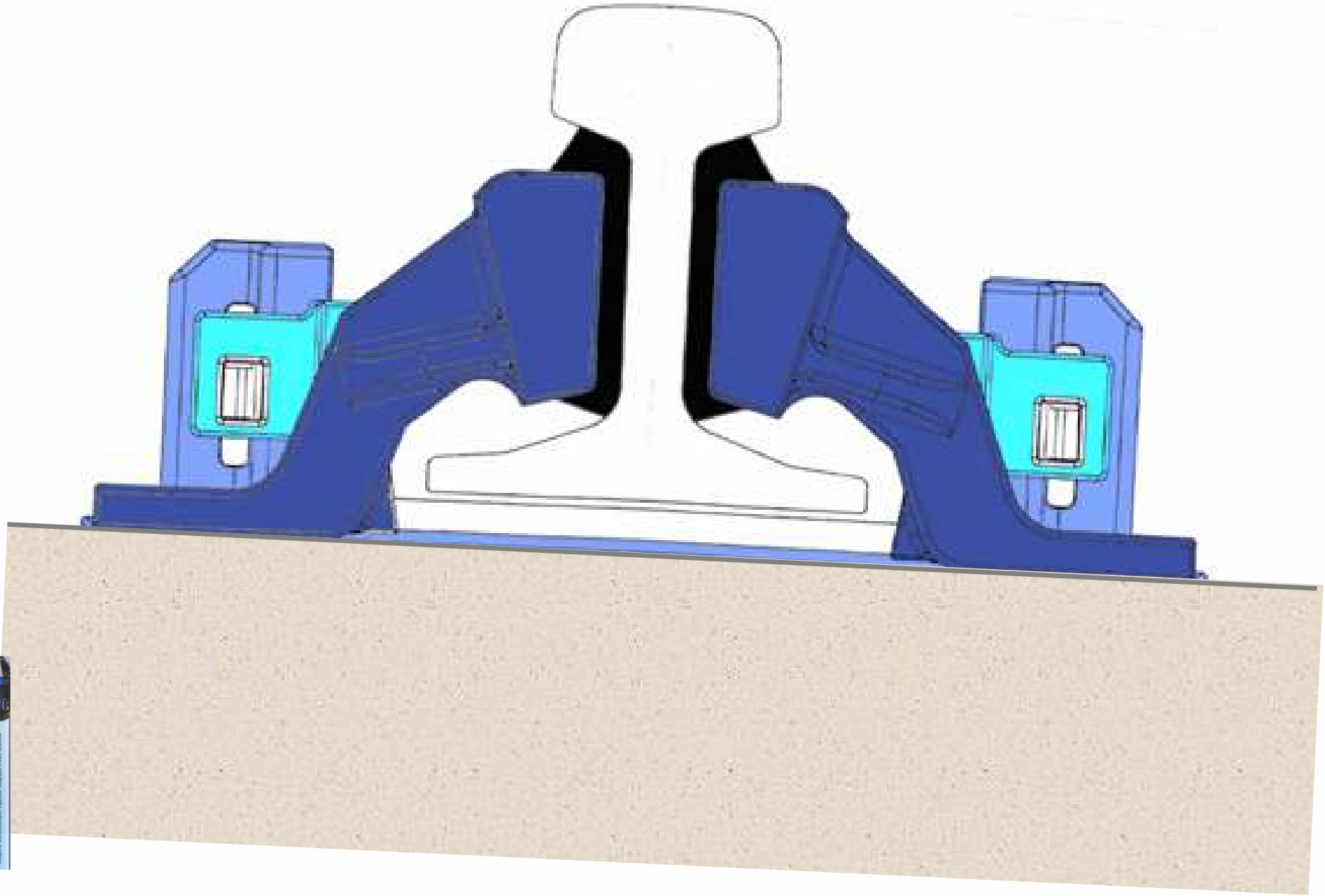
PANDROL VANGUARD ON LONDON UNDERGROUND

… and are in turn supported by cast SG iron side plates …



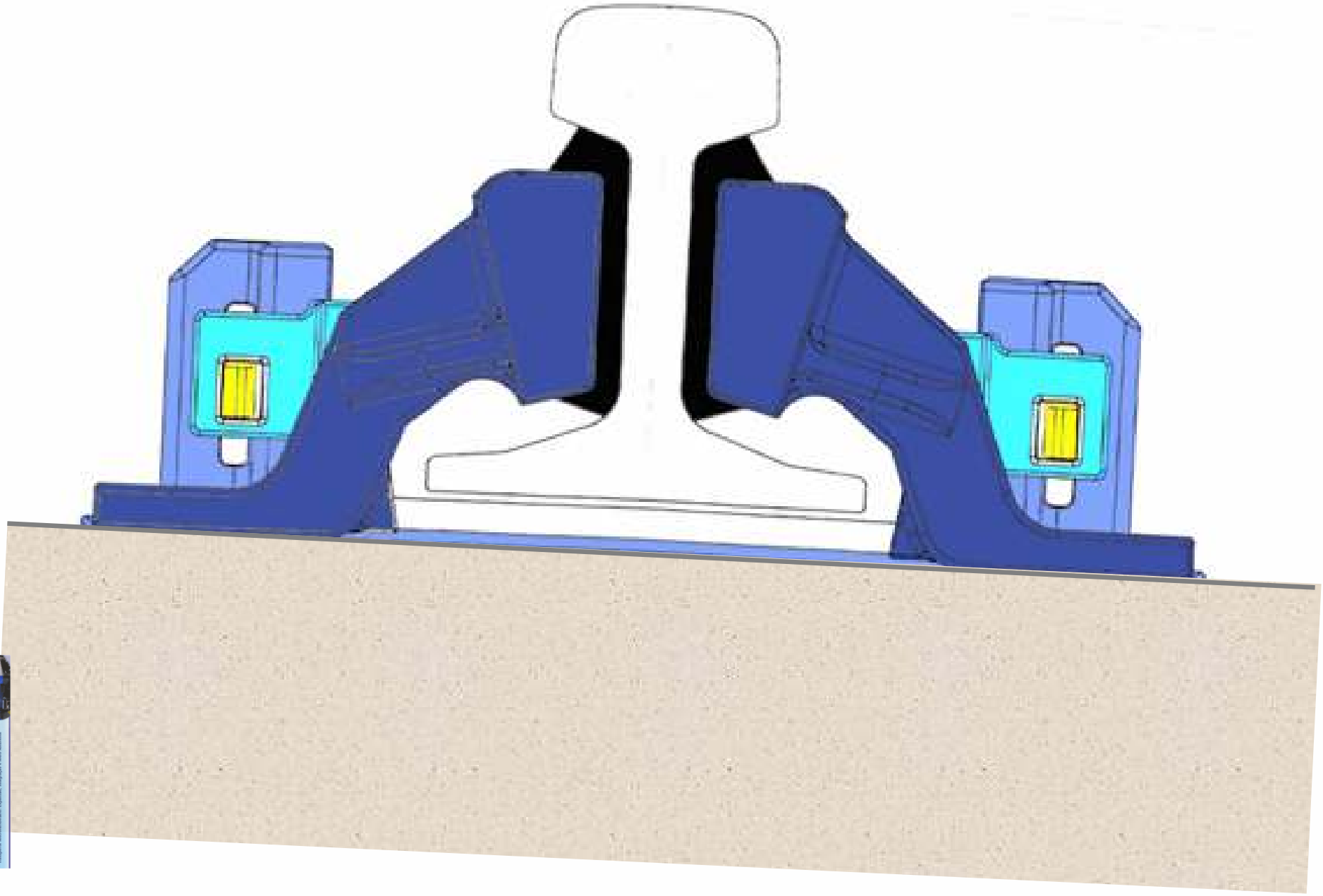
PANDROL VANGUARD ON LONDON UNDERGROUND

… which are locked in place with cast SG iron wedges …



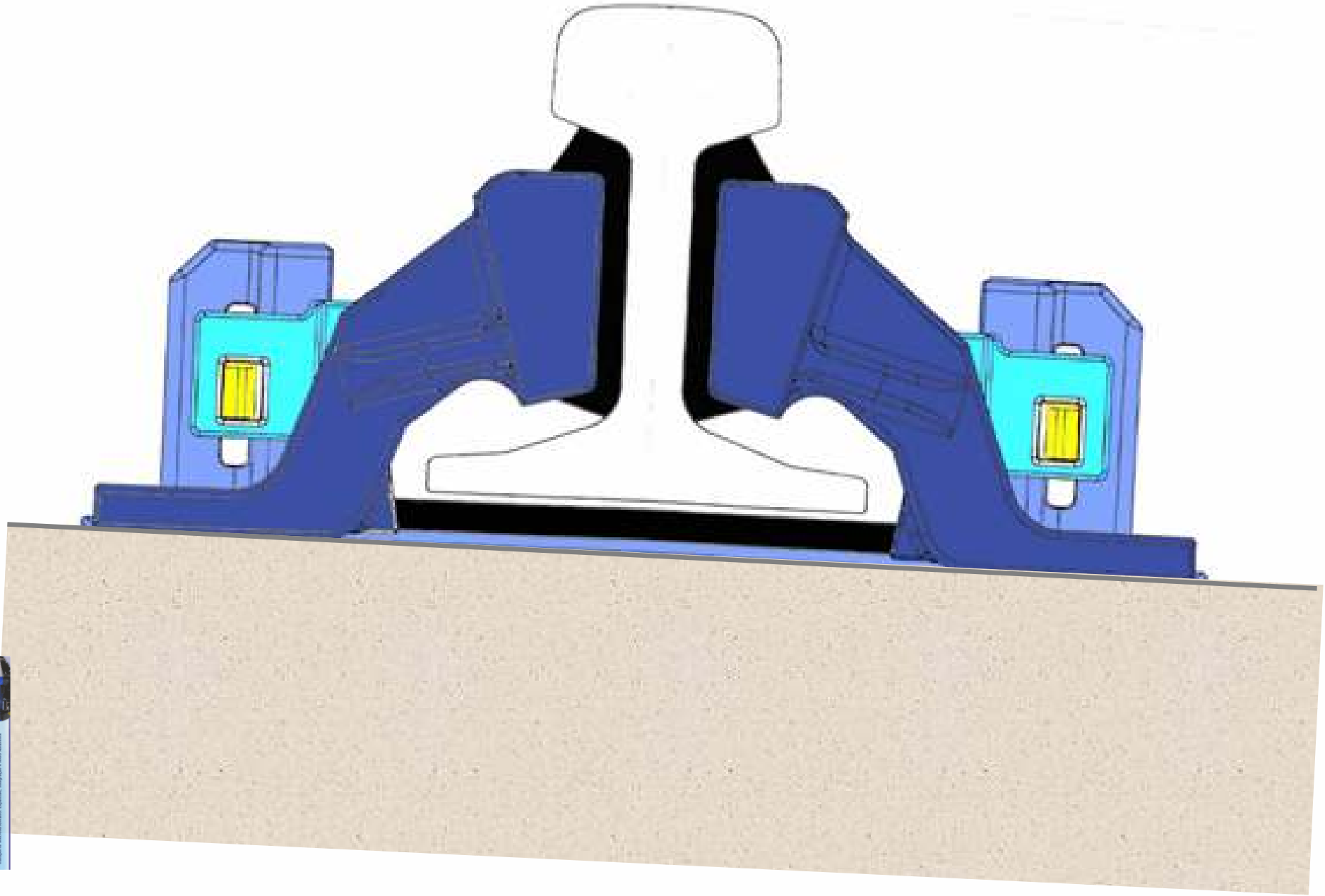
PANDROL VANGUARD ON LONDON UNDERGROUND

… spring steel clips locate these for added security …

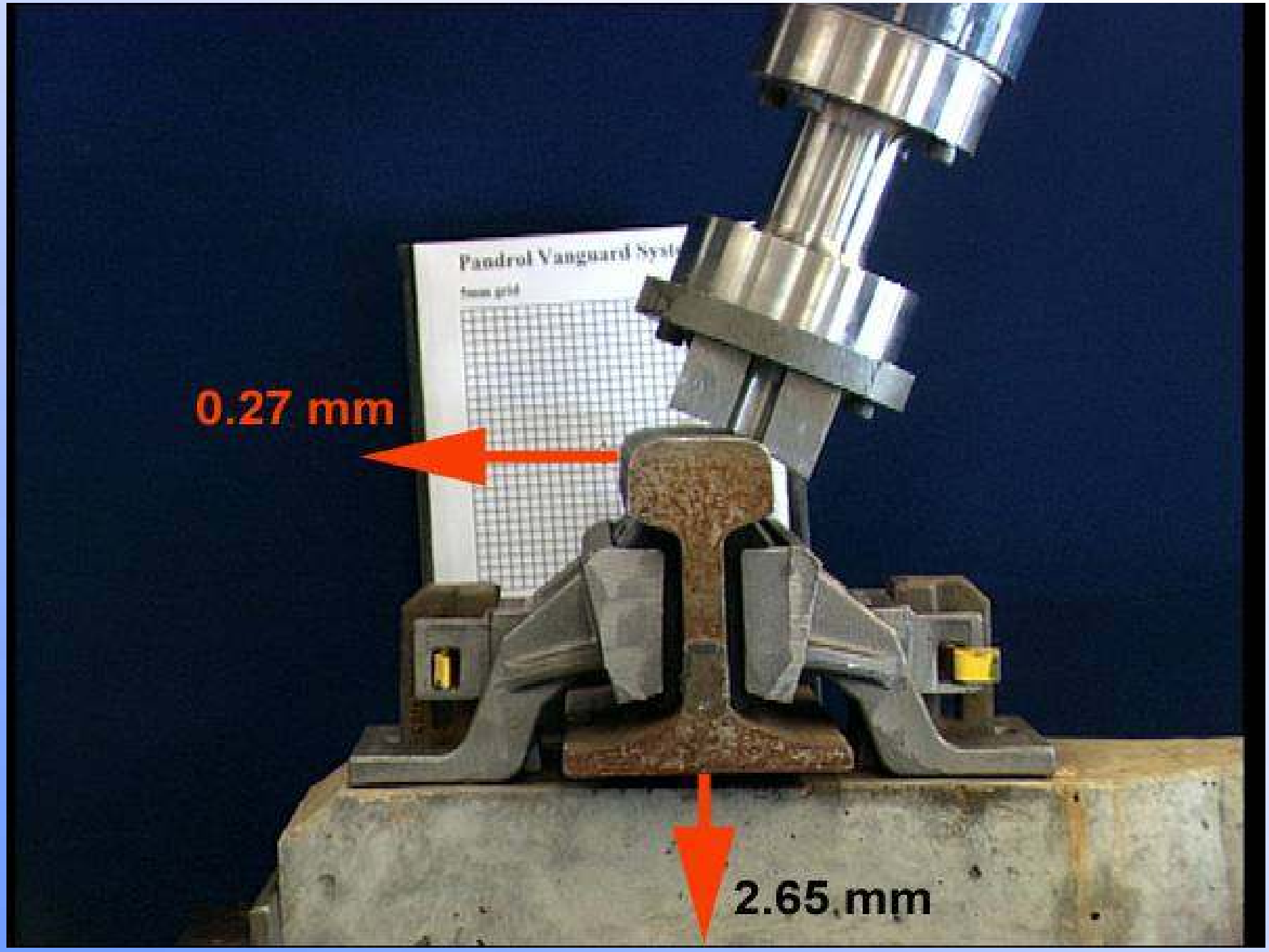


PANDROL VANGUARD ON LONDON UNDERGROUND

… and a natural rubber overload pad prevents excessive deflection



PANDROL VANGUARD ON LONDON UNDERGROUND



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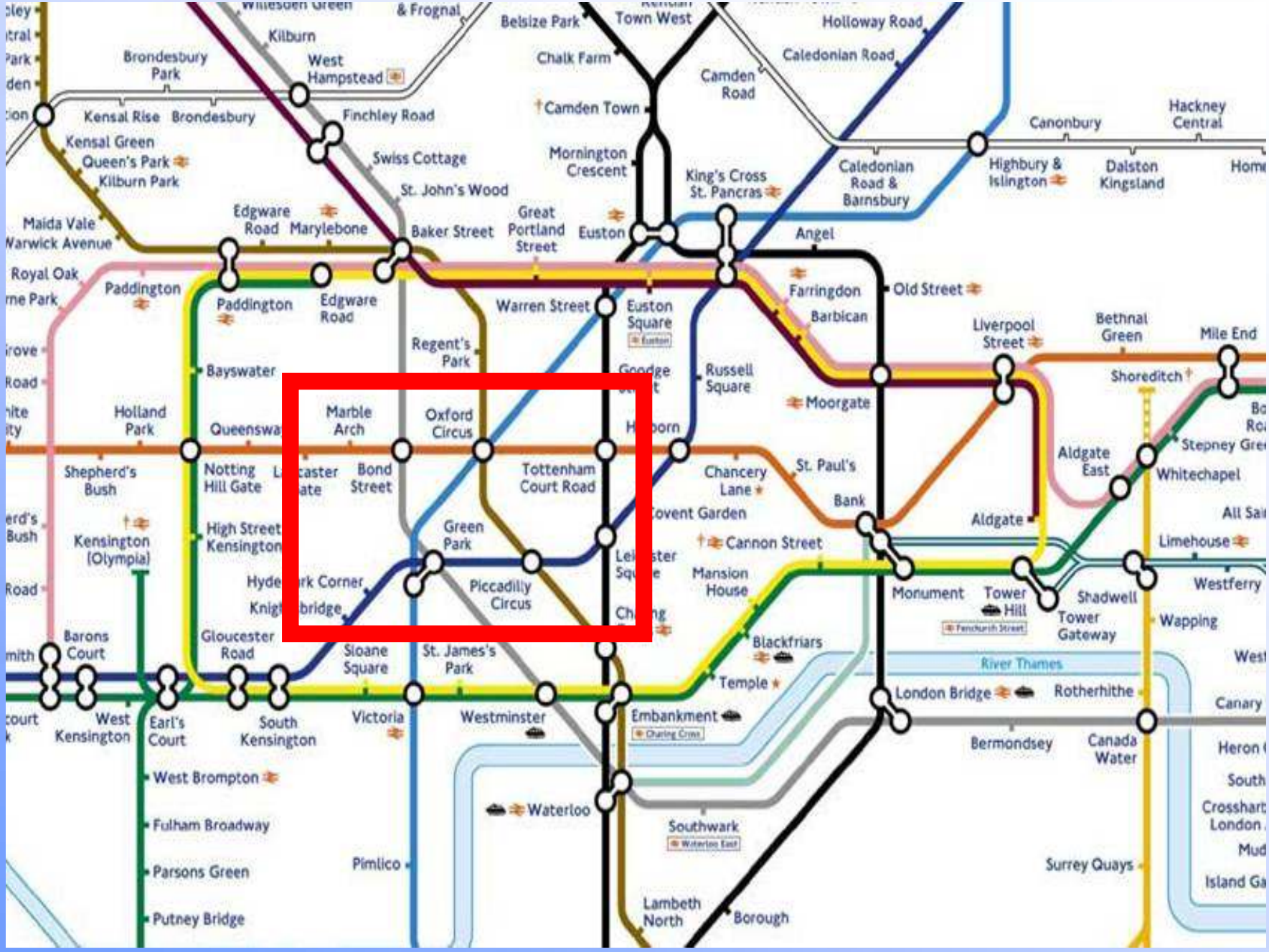

London Underground (The Tube)

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Existing Track: Ballast, wooden sleepers, cast baseplates, 8mm plastic railpads, PR401A clips, BS113A rail.

Mainline application (UK)

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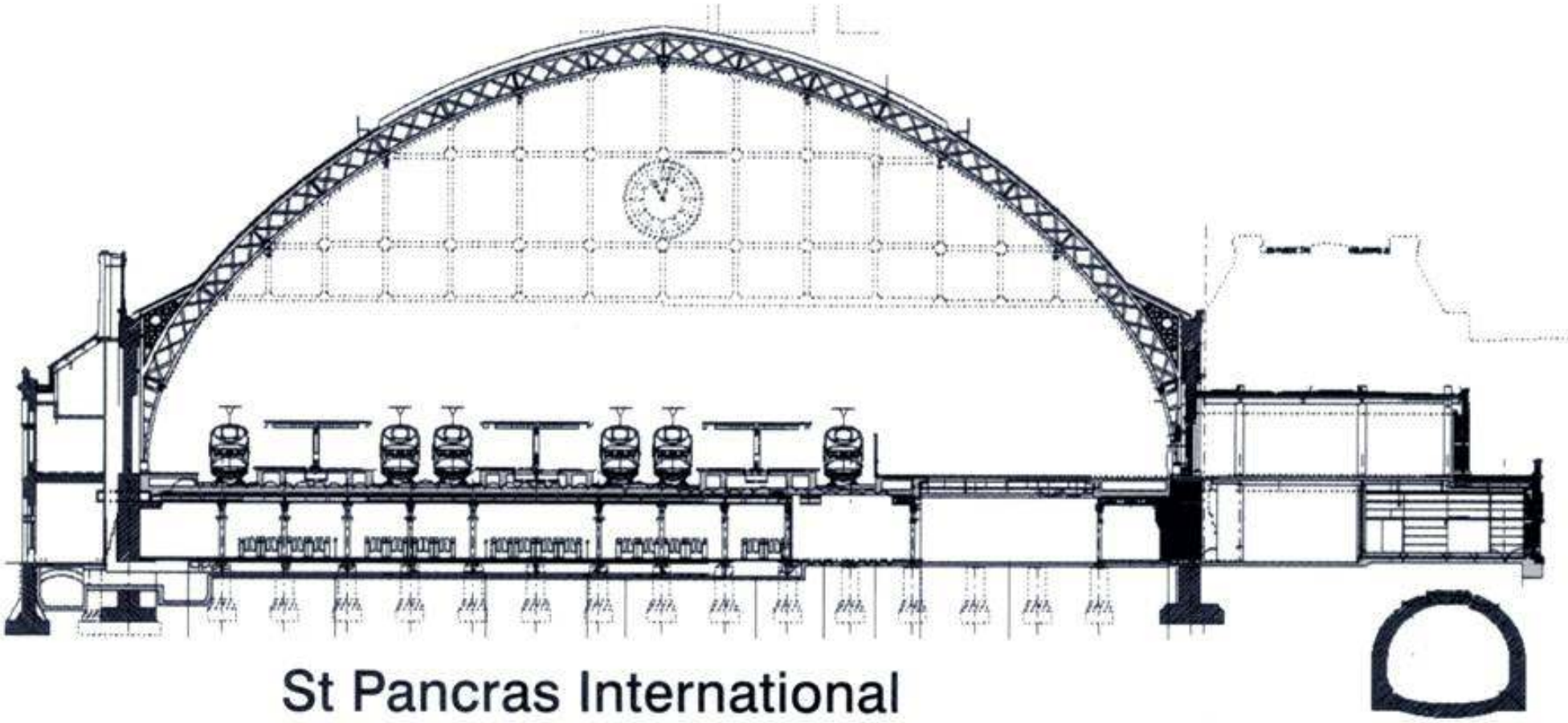
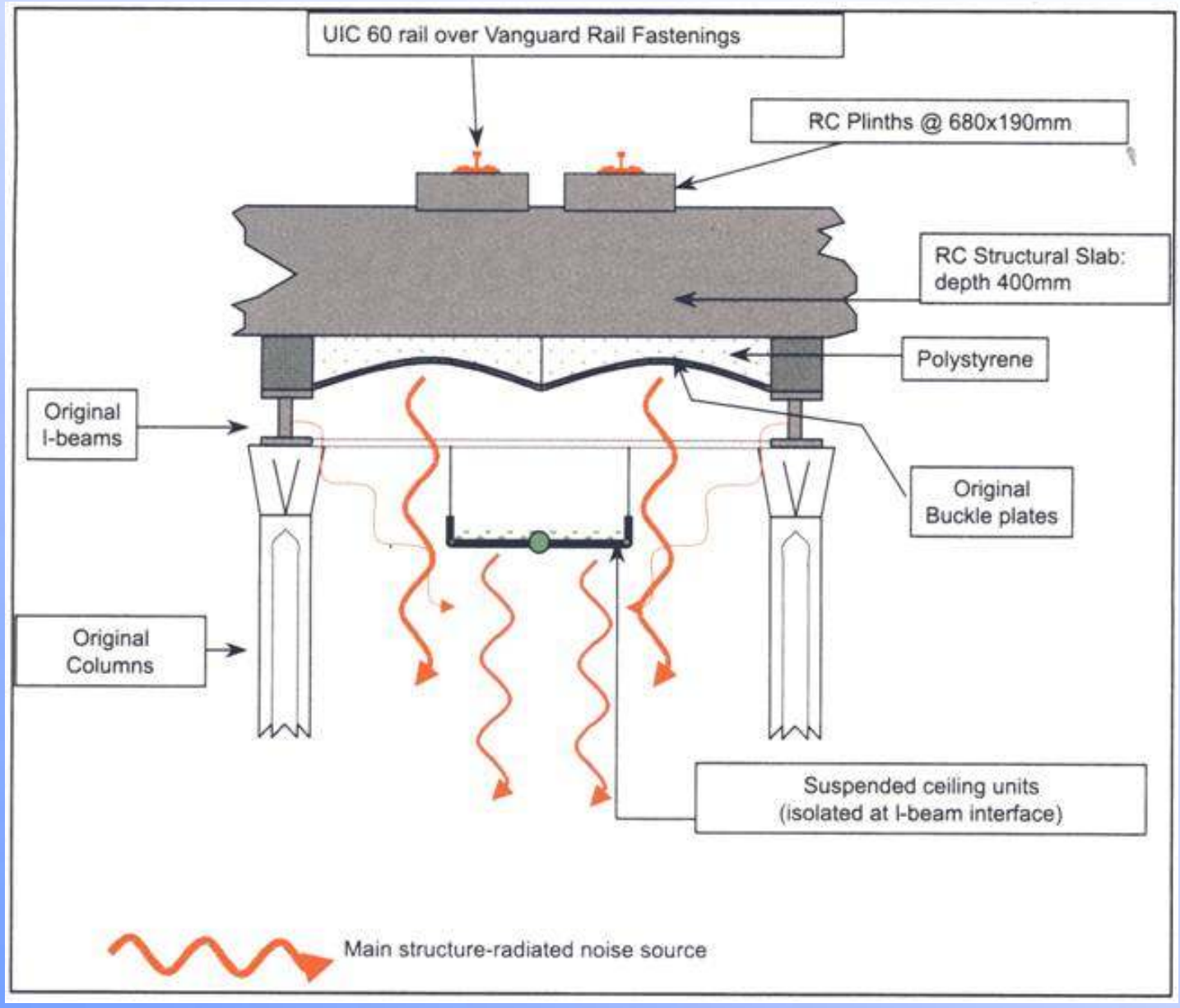
CTRL St Pancras – London



St Pancras International
(with concourses in undercroft beneath platforms)



St Pancras - London

Noise & Vibration

Resilient baseplate

Vanguard

Construction

Conclusion

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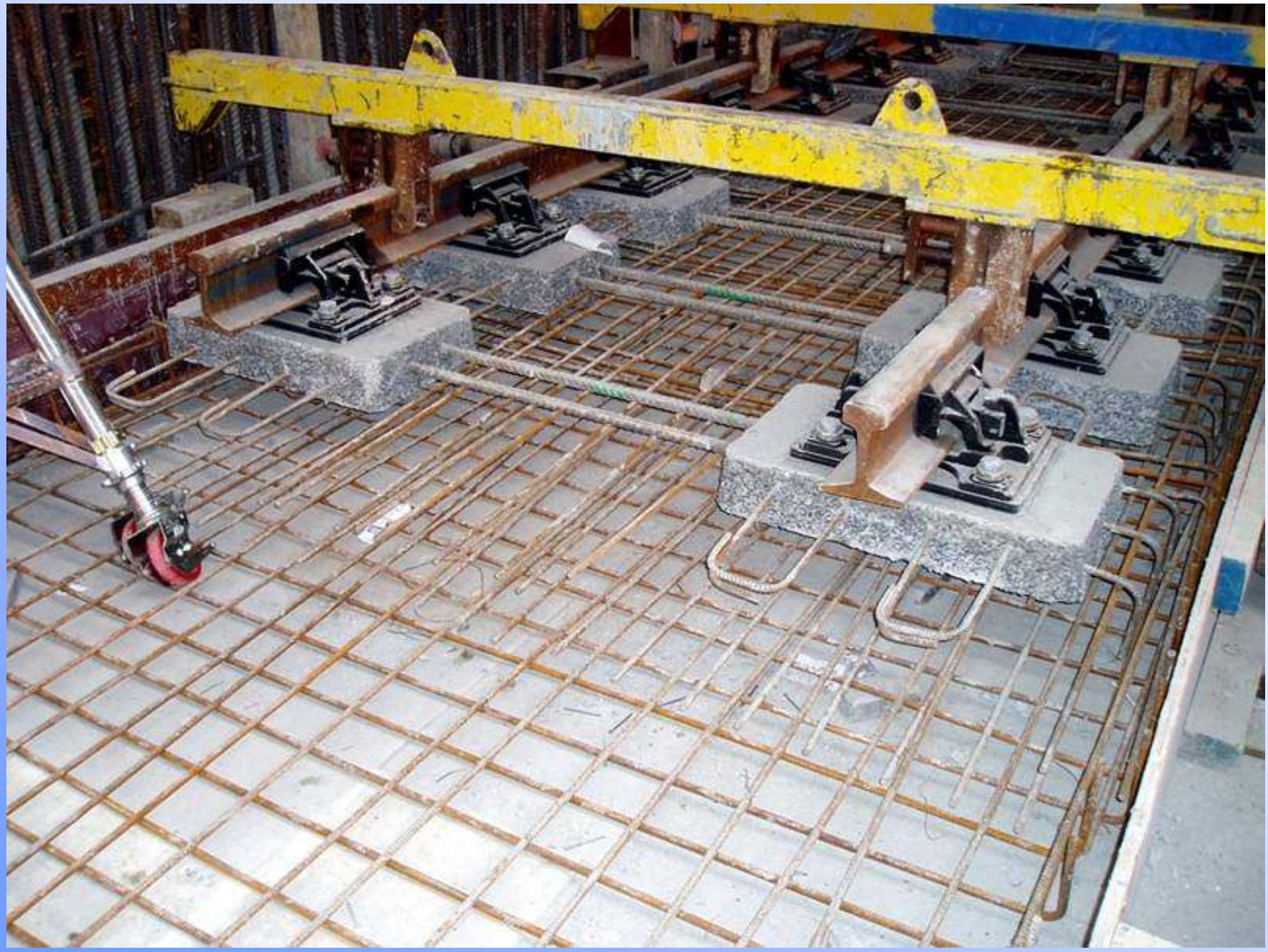
CTRL St. Pancras, London.

St Pancras - London

Thameslink Box Tunnel



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Methods of dealing with vibration

Vibration Isolation – the technique of reducing the transmission of vibration from a source to a receiver by interposing a resilient element between them.

Resilient railpad
Booted block
Resilient baseplate
Under sleeper pad
Ballast mat
Vanguard
Floating slab track
Base isolation of structures

Increasing performance --- >

Increasing cost ---------- >

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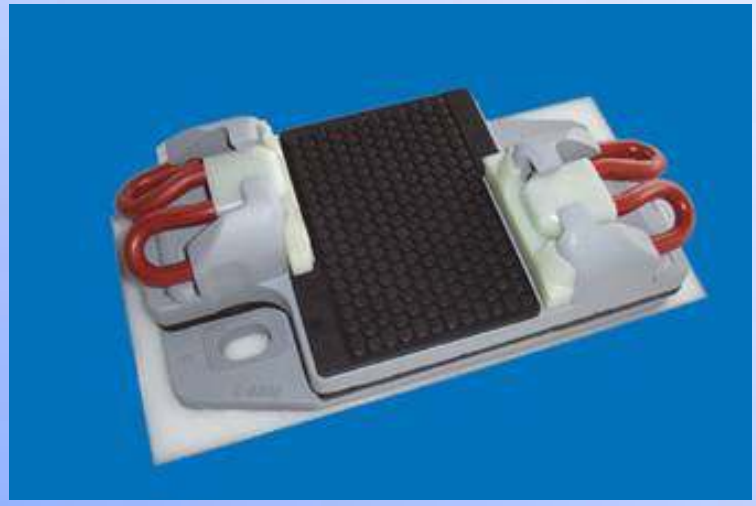
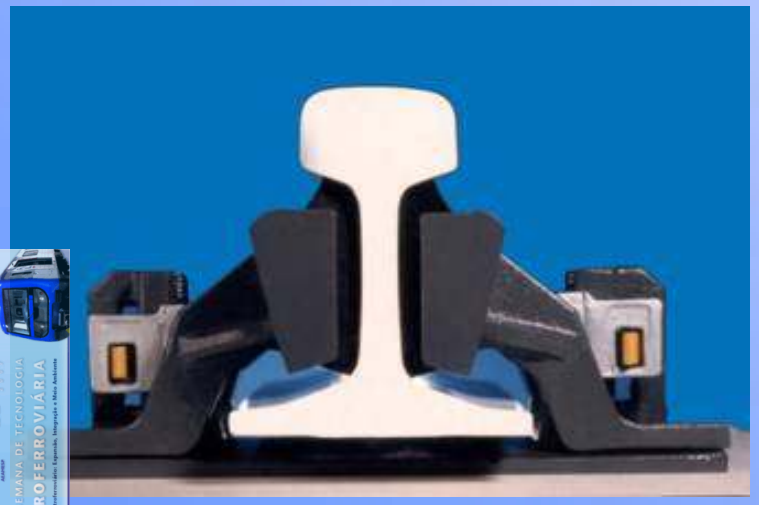


Pandrol Vipa resilient baseplate

Static stiffness 15-25 kN/mm

Dynamic stiffness 25-40 kN/mm

Damping loss factor 0.23 – 0.31



Pandrol Vanguard rail support

Static stiffness 5 kN/mm

Dynamic stiffness 7.5 kN/mm

Damping loss factor 0.22

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The End