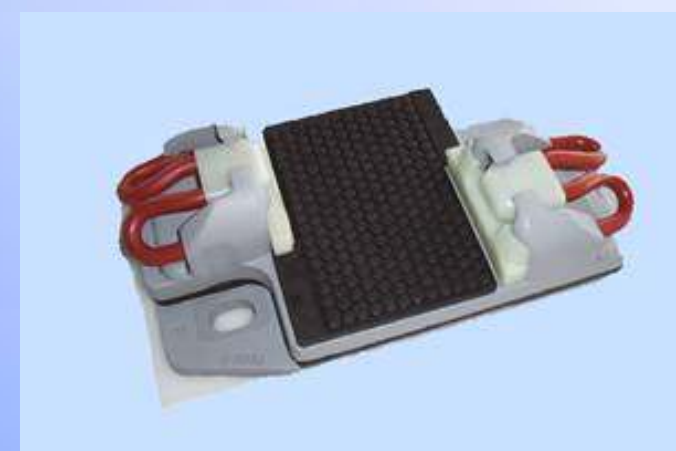




Wheel/Rail Induced Noise & Vibration - and its Mitigation -



Keith Green
Pandrol Ltd



Noise & Vibration

Resilient baseplate

Vanguard

Construction

Conclusion



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.



Sound Pressure Level

30 – 40 dB(A)

60 – 65 dB(A)

85 – 95 dB(A)

130 dB(A)

Environment

Quiet office

Conversation

Industrial workshop

Pain threshold



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.



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.

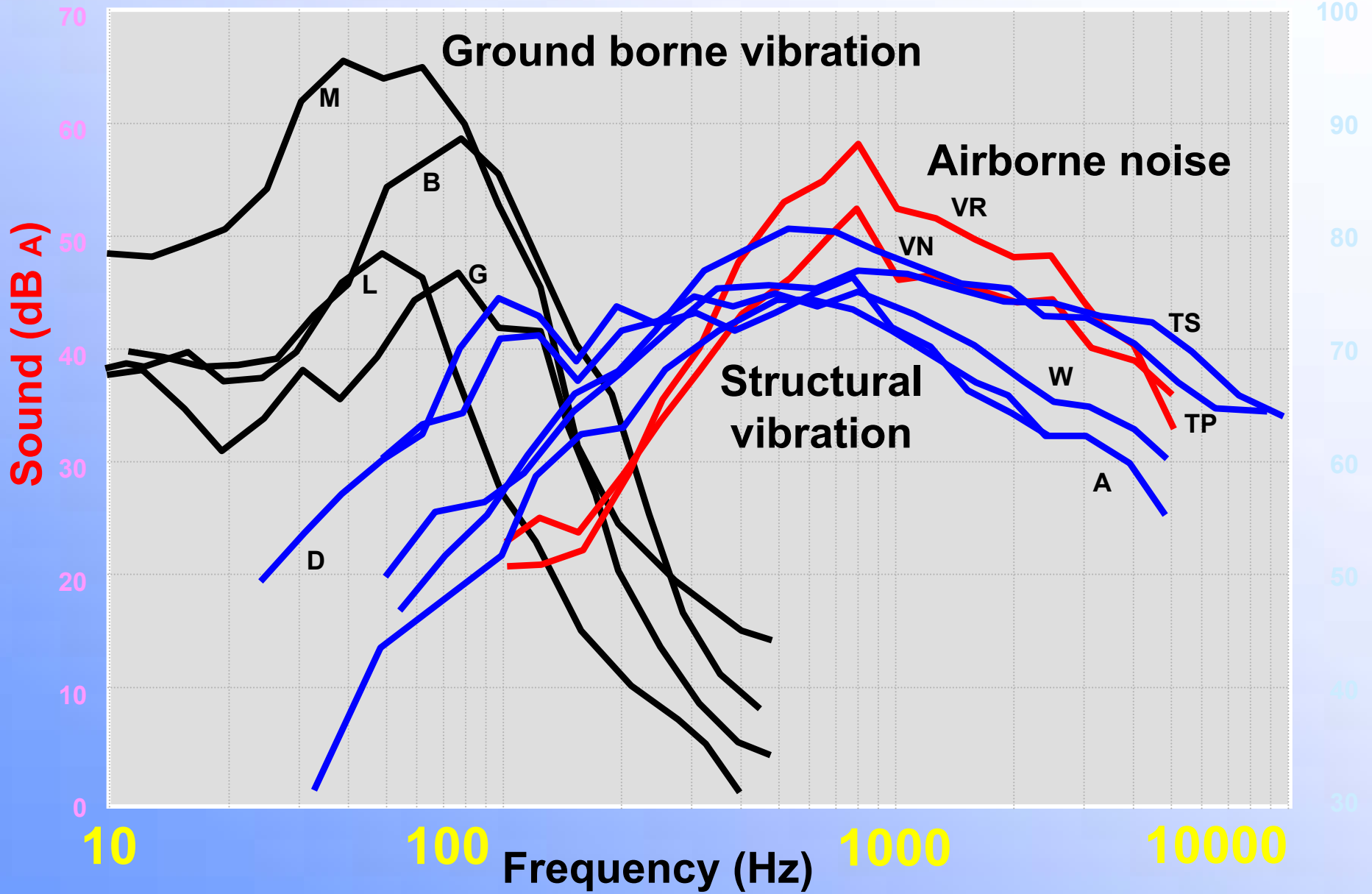
Vibration is transmitted through a solid medium, from a source to a receiver.

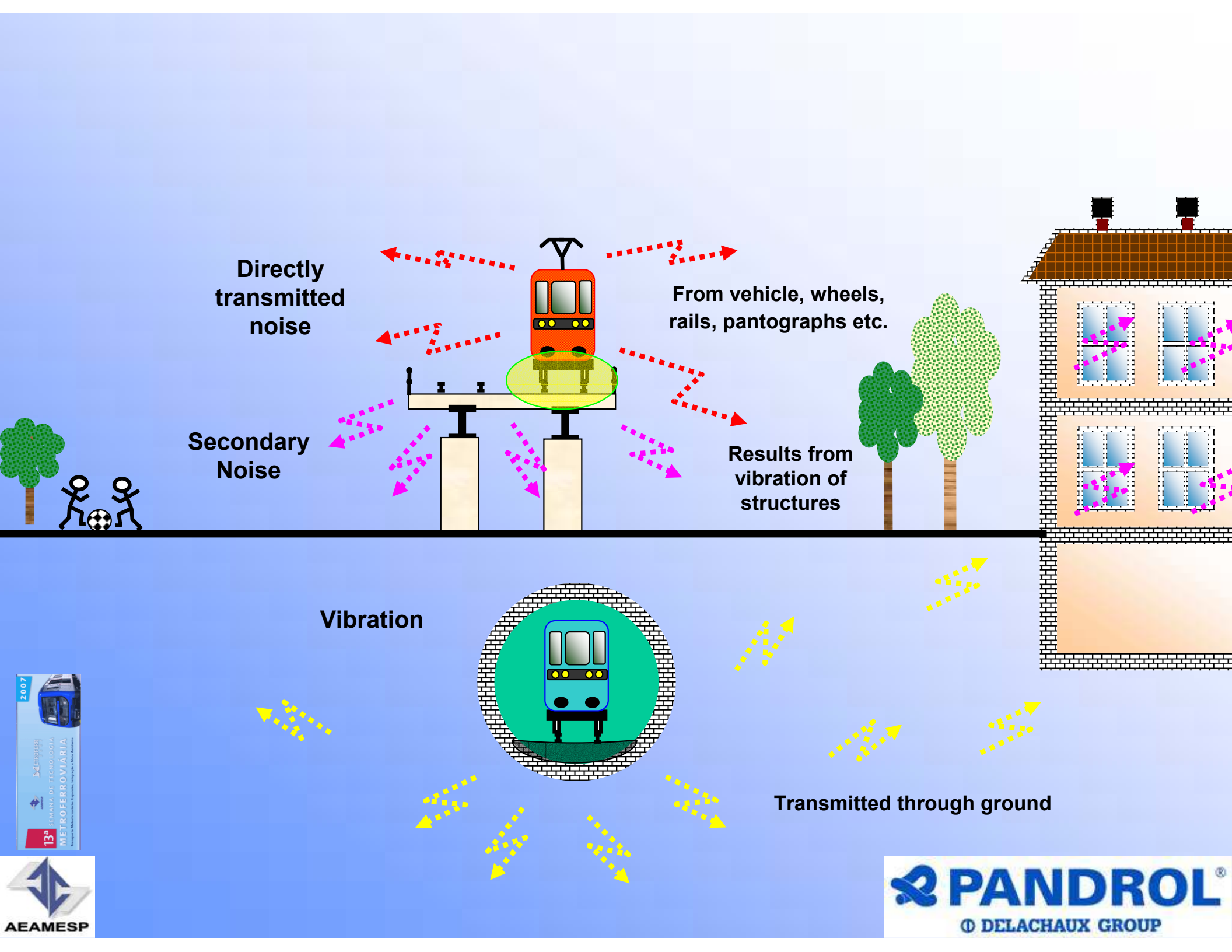
Secondary Noise

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.

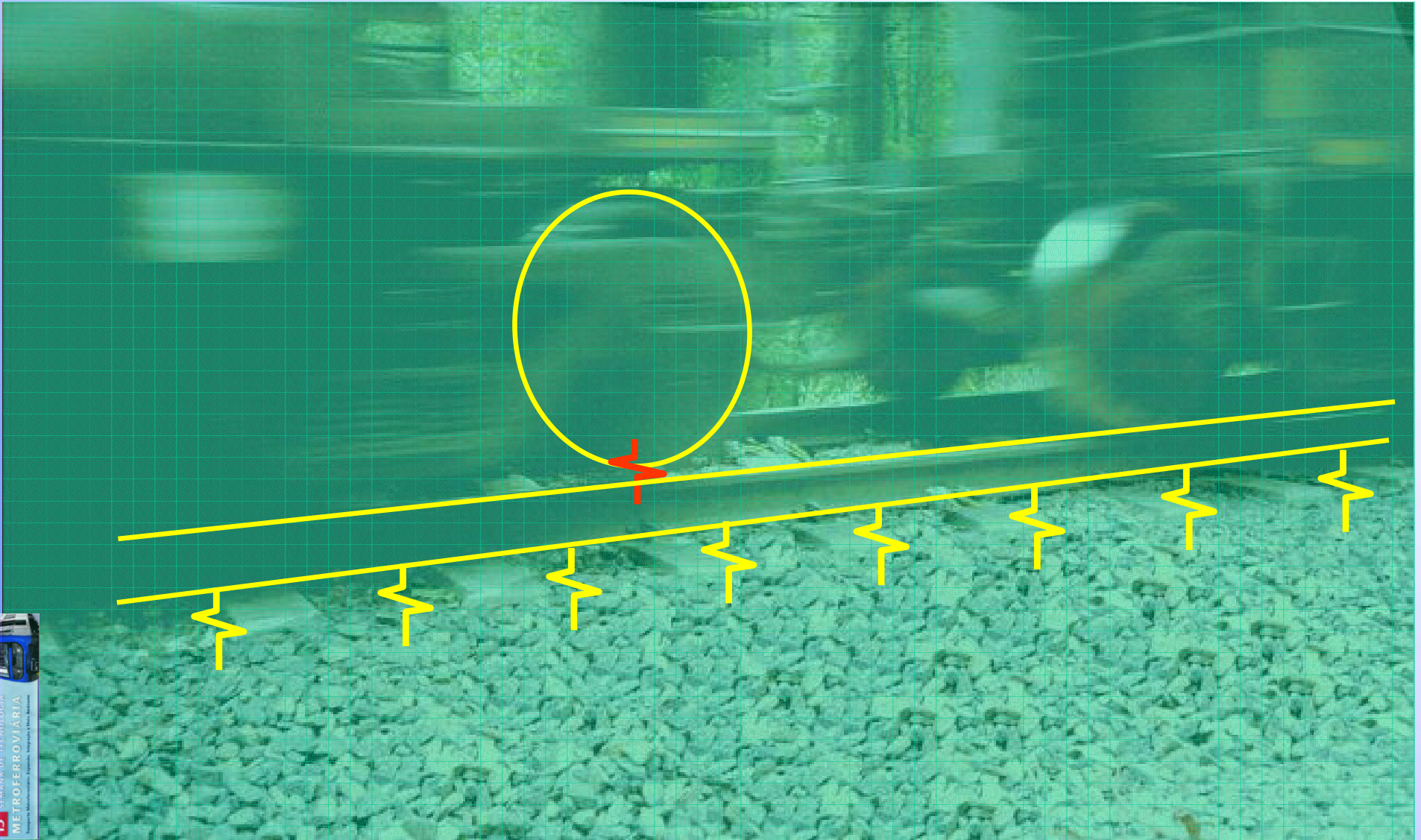


Vibration (dB ref 5e 8m/s)

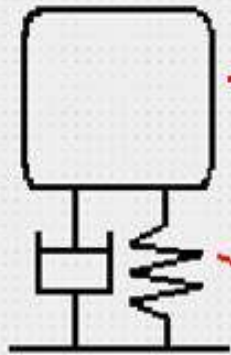




Modeling



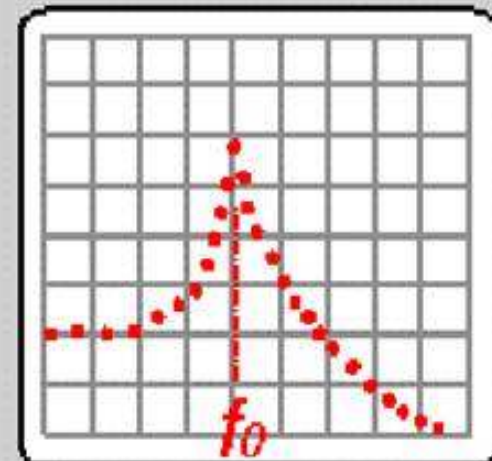
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Lumped unsprung mass of vehicle + resiliently supported track mass

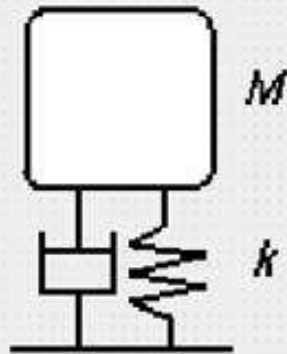
Track support stiffness and damping

Simplified model
– mass on spring system



Loaded Track Resonance

Modelling the Track Support System

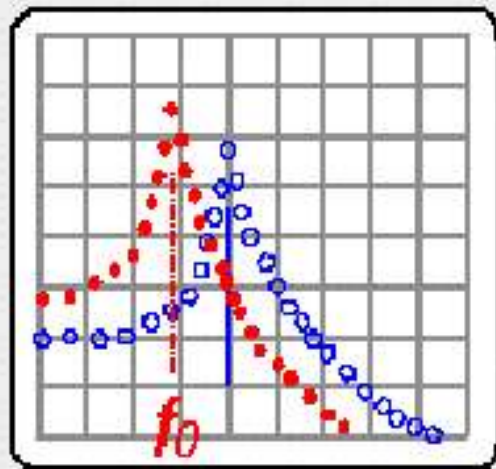


$$f_0 = \frac{1}{2\pi} \sqrt{\frac{k}{M}}$$

=> to reduce
loaded track
resonant frequency

- increase M
- decrease k

Strategies for Reducing Ground Vibration



Loaded Track Resonance

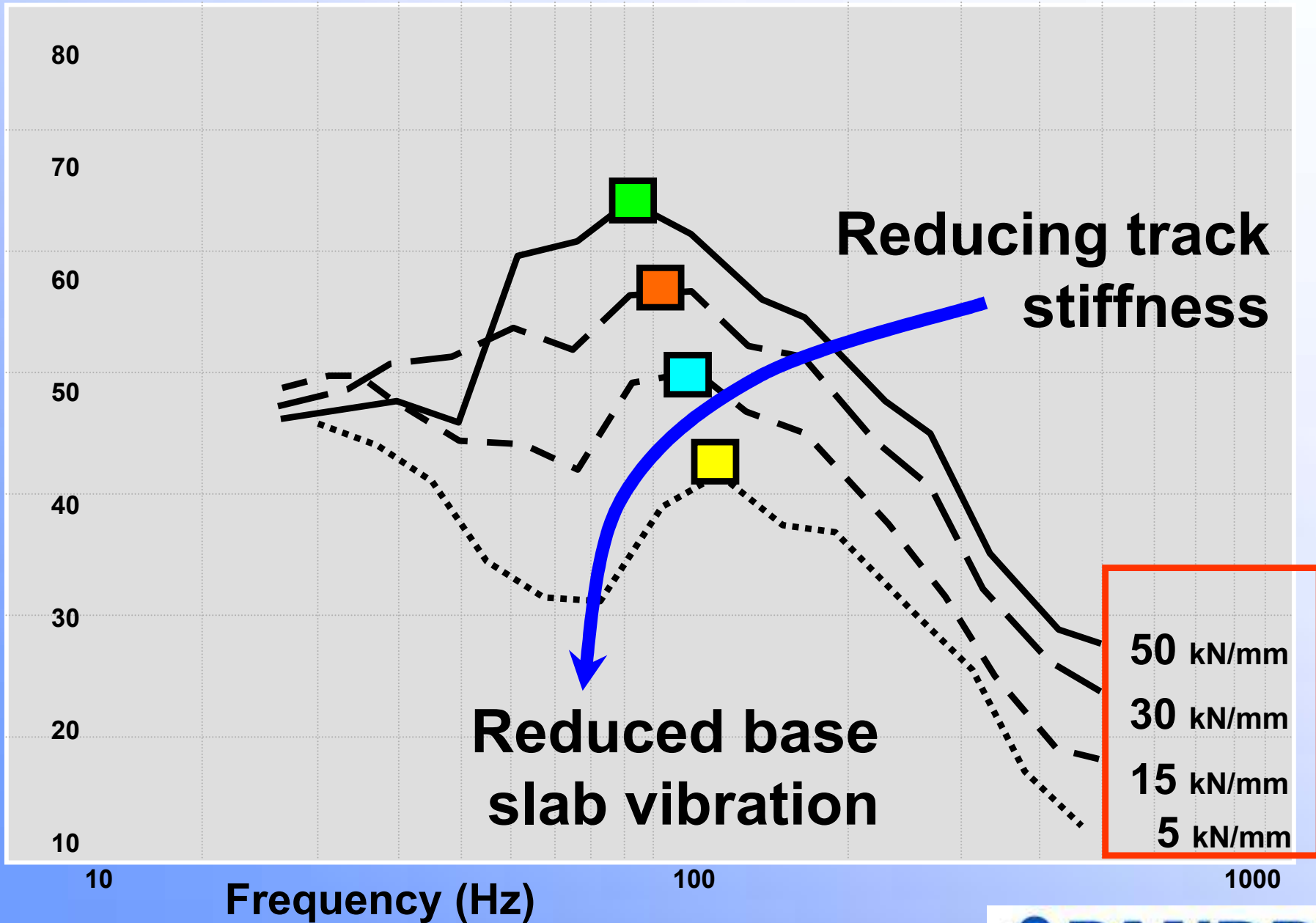
Most common only –

Reduce resonant frequency

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

Strategies for Reducing Ground Vibration

Vertical Vibration (dB ref 5e 8m/s)



Low damping

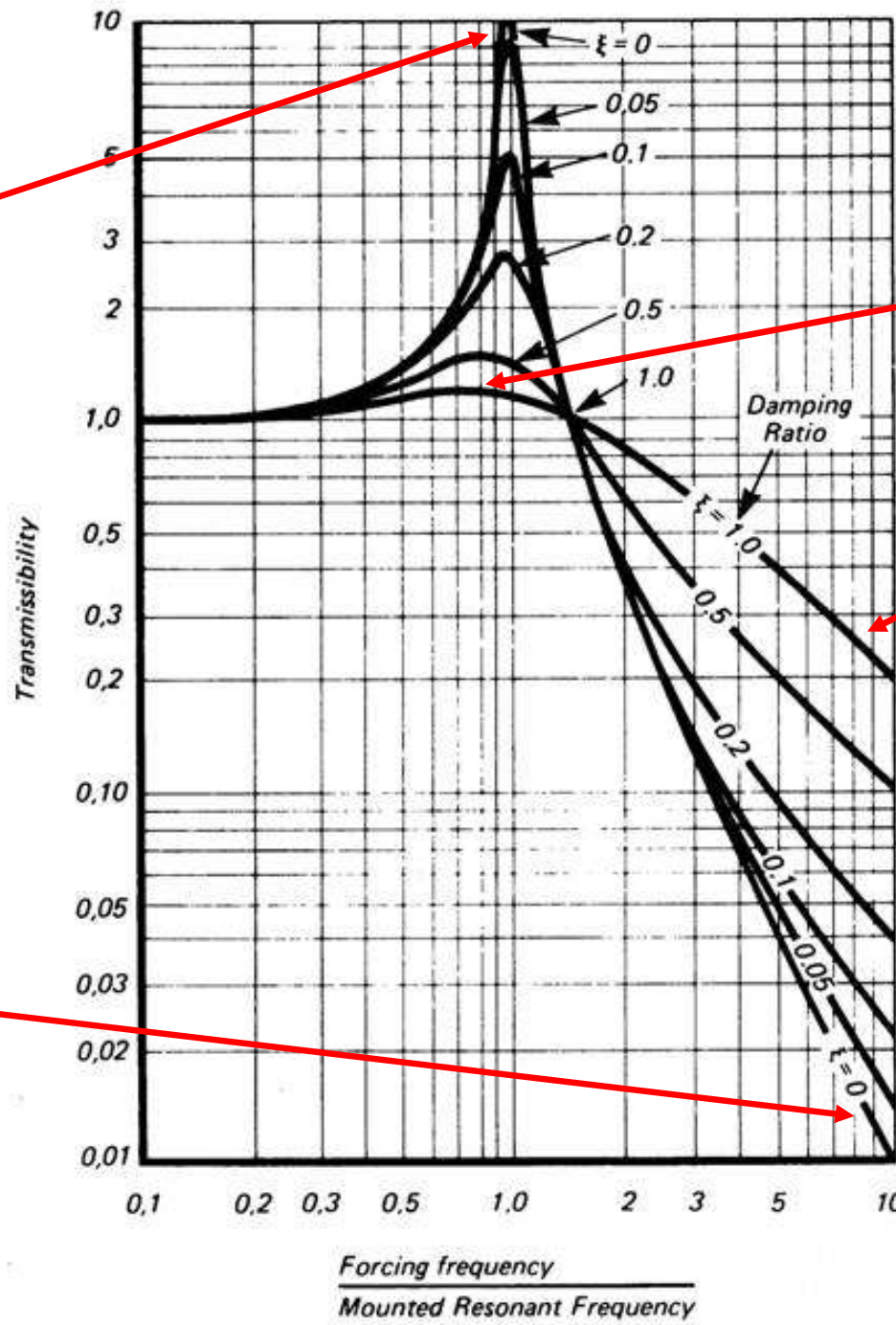
High damping

High resonant peak

Low resonant peak

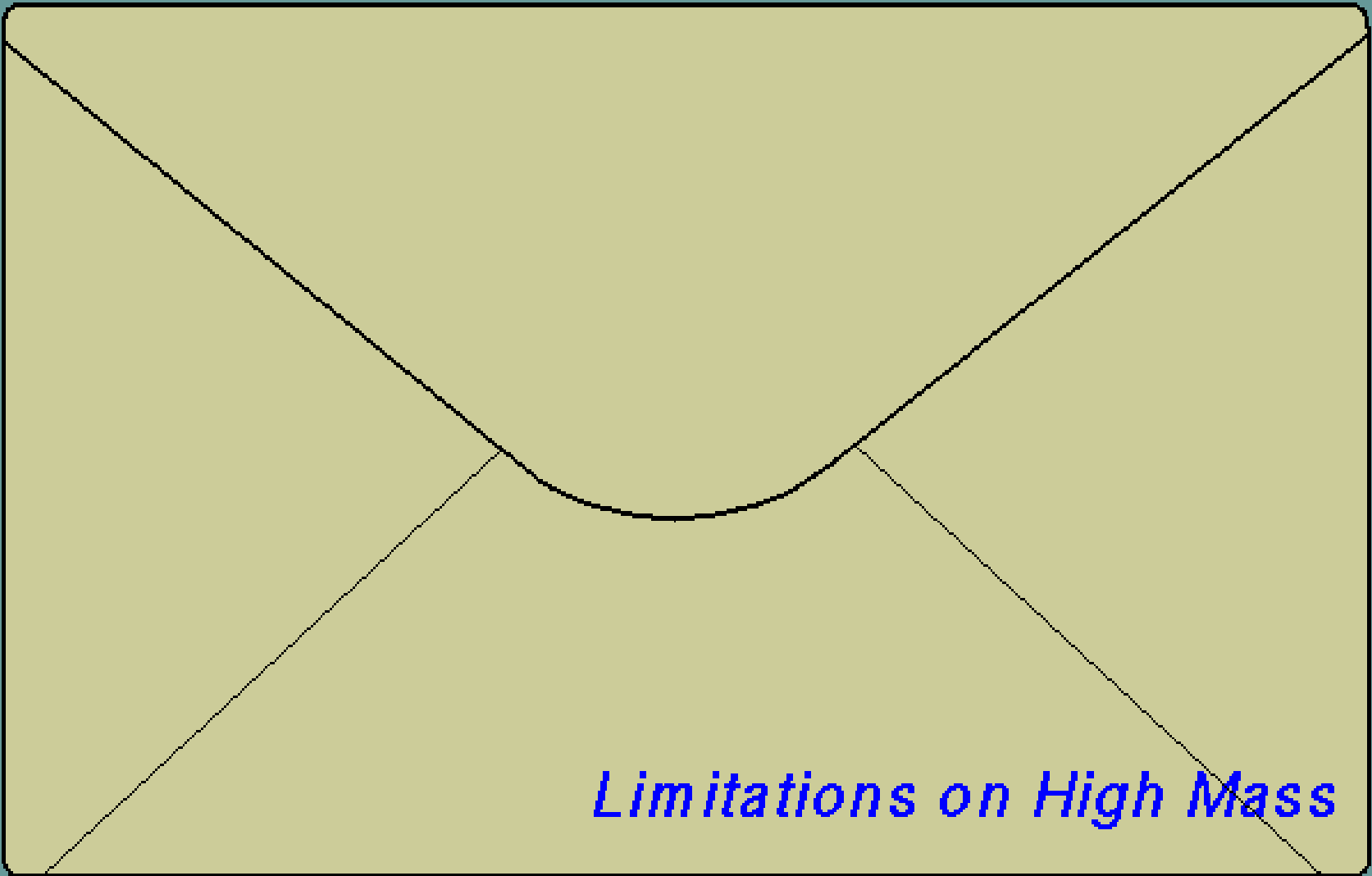
Less attenuation, poor isolation

Good attenuation and isolation



The effect of Damping





Limitations on High Mass

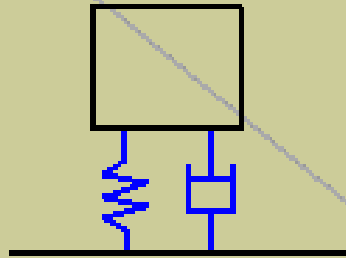


Pandrol Rail Fastenings

Current Concerns
Current Solutions



Typical parameters (one rail) :



say 750 kg (vehicle + rail)

say 100 kN/mm (track stiffness)

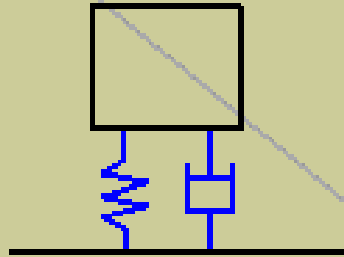
Limitations on High Mass



Pandrol Rail Fastenings

Current Concerns
Current Solutions

$$f_0 = 1/2\pi \sqrt{k/m}$$



750 kg
100 kN/mm

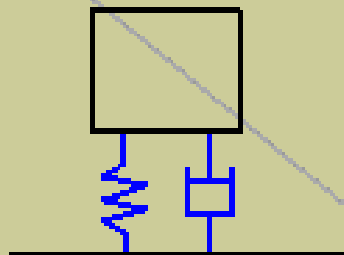
$$\Rightarrow f_0 \approx 60 \text{ Hz}$$

Limitations on High Mass



Pandrol Rail Fastenings

*Current Concerns
Current Solutions*



750 kg
100 kN/mm

$f_0 \approx 60$ Hz

$f_0 \approx 30$ Hz

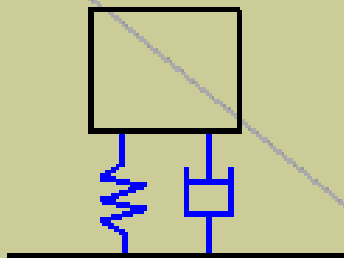
Limitations on High Mass



Pandrol Rail Fastenings

*Current Concerns
Current Solutions*

$$f_0 = 1/2\pi \sqrt{k/m}$$



750 kg →
100 kN/mm

3000 kg

$f_0 \approx 60$ Hz

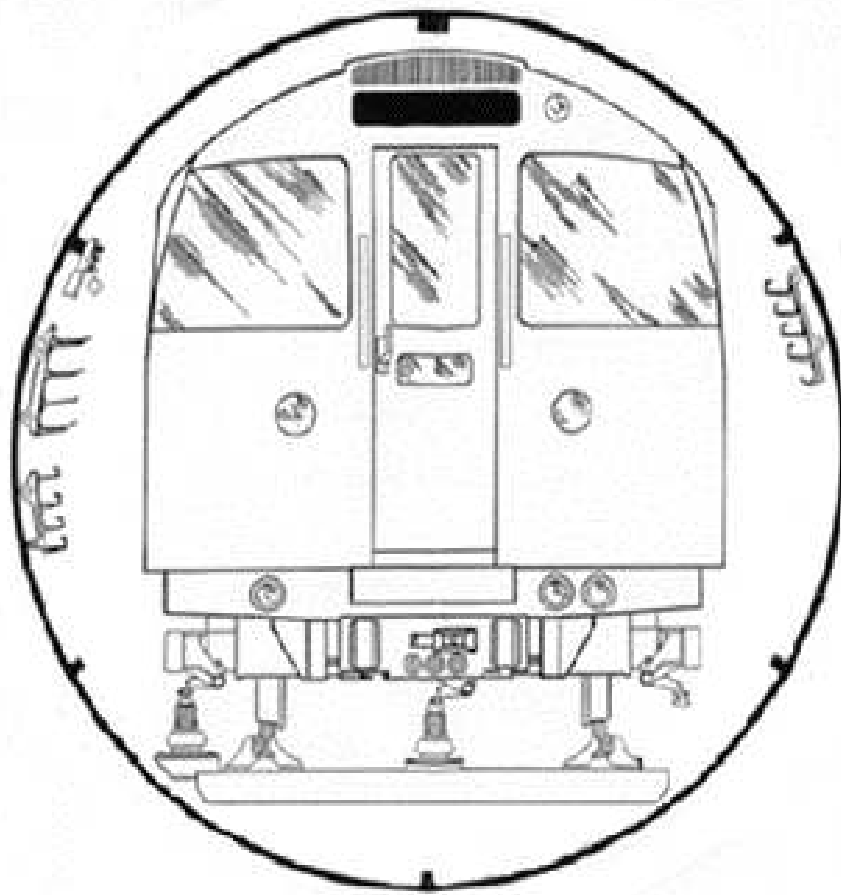
$f_0 \approx 30$ Hz

Limitations on High Mass



Pandrol Rail Fastenings

*Current Concerns
Current Solutions*

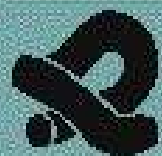
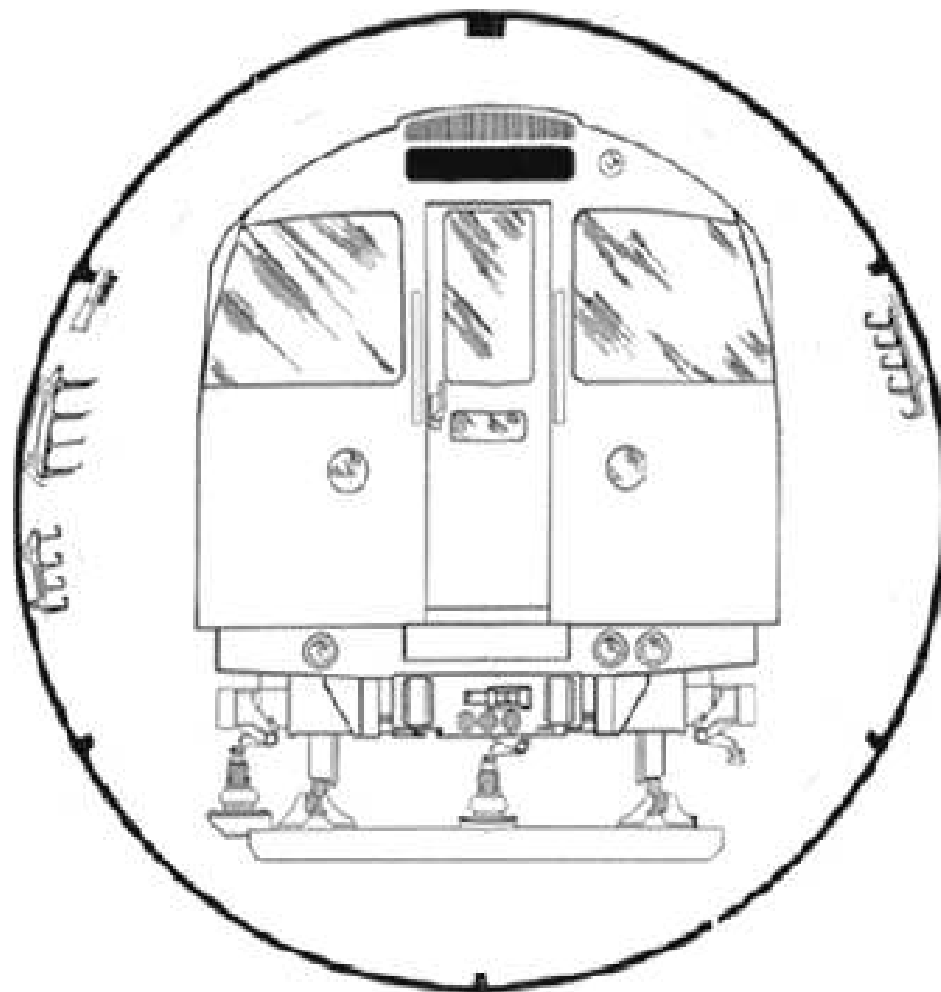


Pandrol Rail Fastenings

*Current Concerns
Current Solutions*

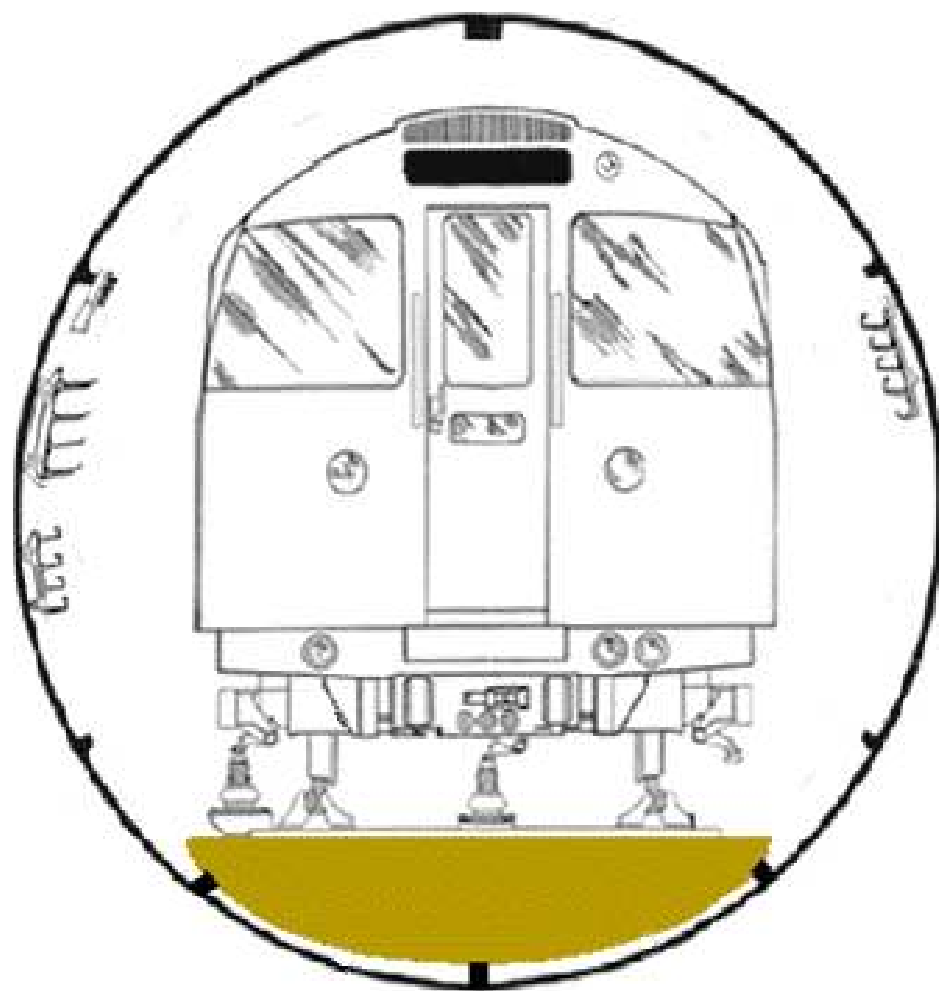
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14 Empujes
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METROFERROVIARIA
13ª SEMANA DE TECNOLOGIA
METROFERROVIARIA





Pandrol Rail Fastenings

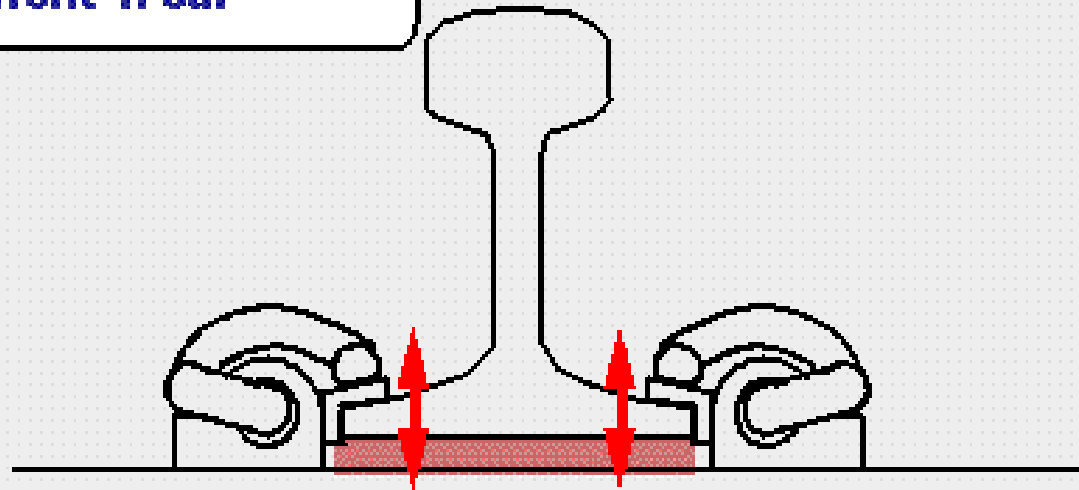
Current Concerns
Current Solutions



Pandrol Rail Fastenings

Current Concerns
Current Solutions

**Fastening Fatigue Limit
Component Wear**



Limitations on Low Stiffness

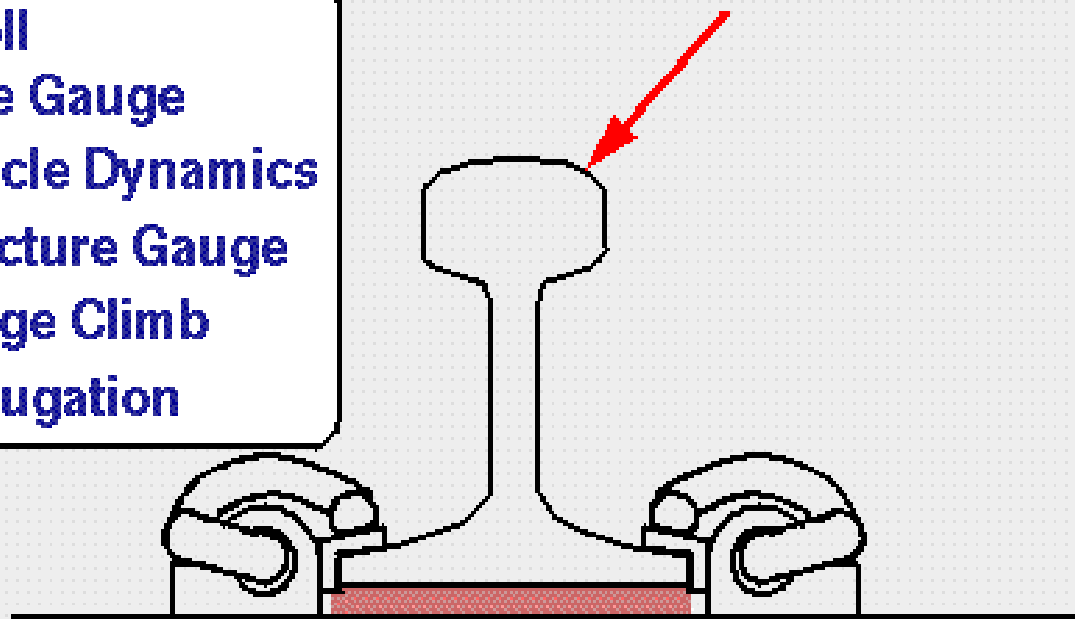


Pandrol Rail Fastenings

*Current Concerns
Current Solutions*

Rail Roll

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

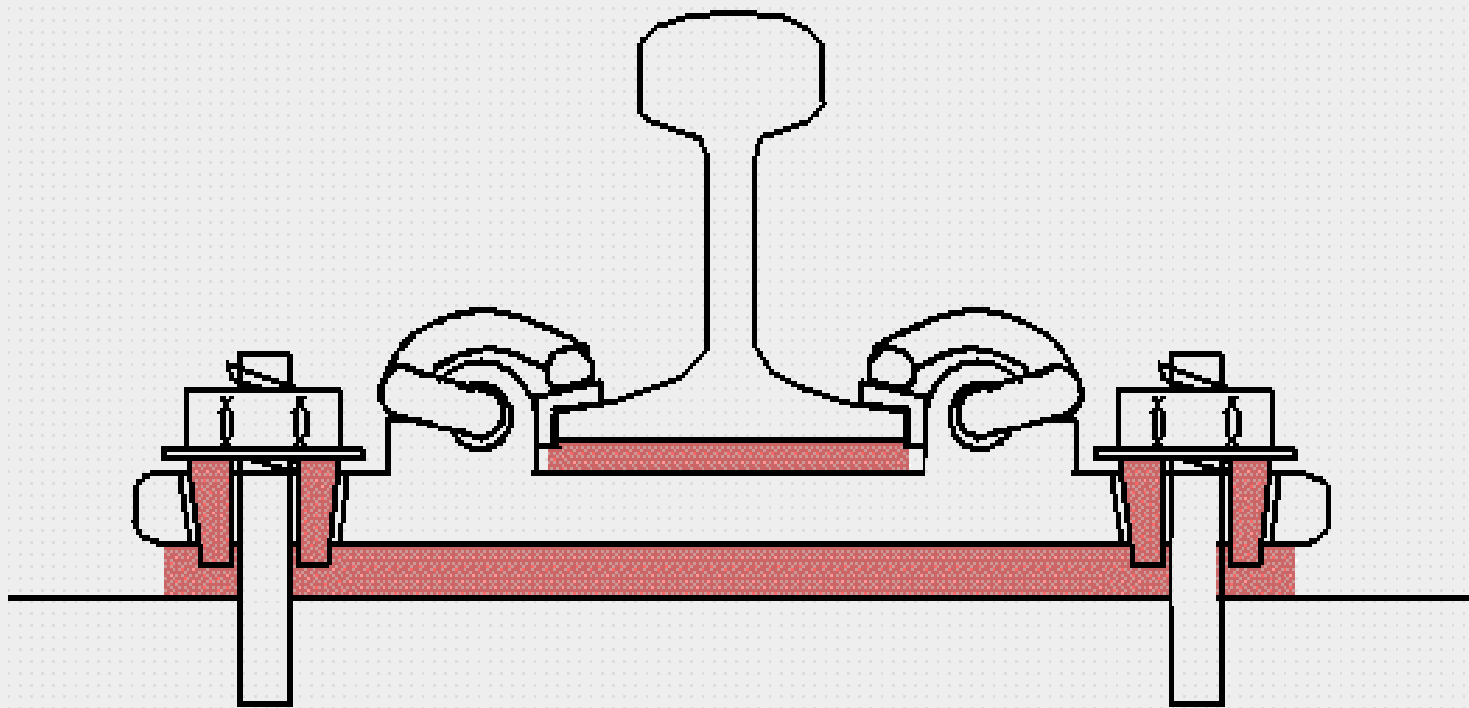


Limitations on Low Stiffness



Pandrol Rail Fastenings

Current Concerns
Current Solutions



Limitations on Low Stiffness



Pandrol Rail Fastenings

Current Concerns
Current Solutions

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13th SEMANA DE TECNOLOGIA
METROFERROVIARIA



Noise & Vibration

Resilient baseplate

Vanguard

Construction

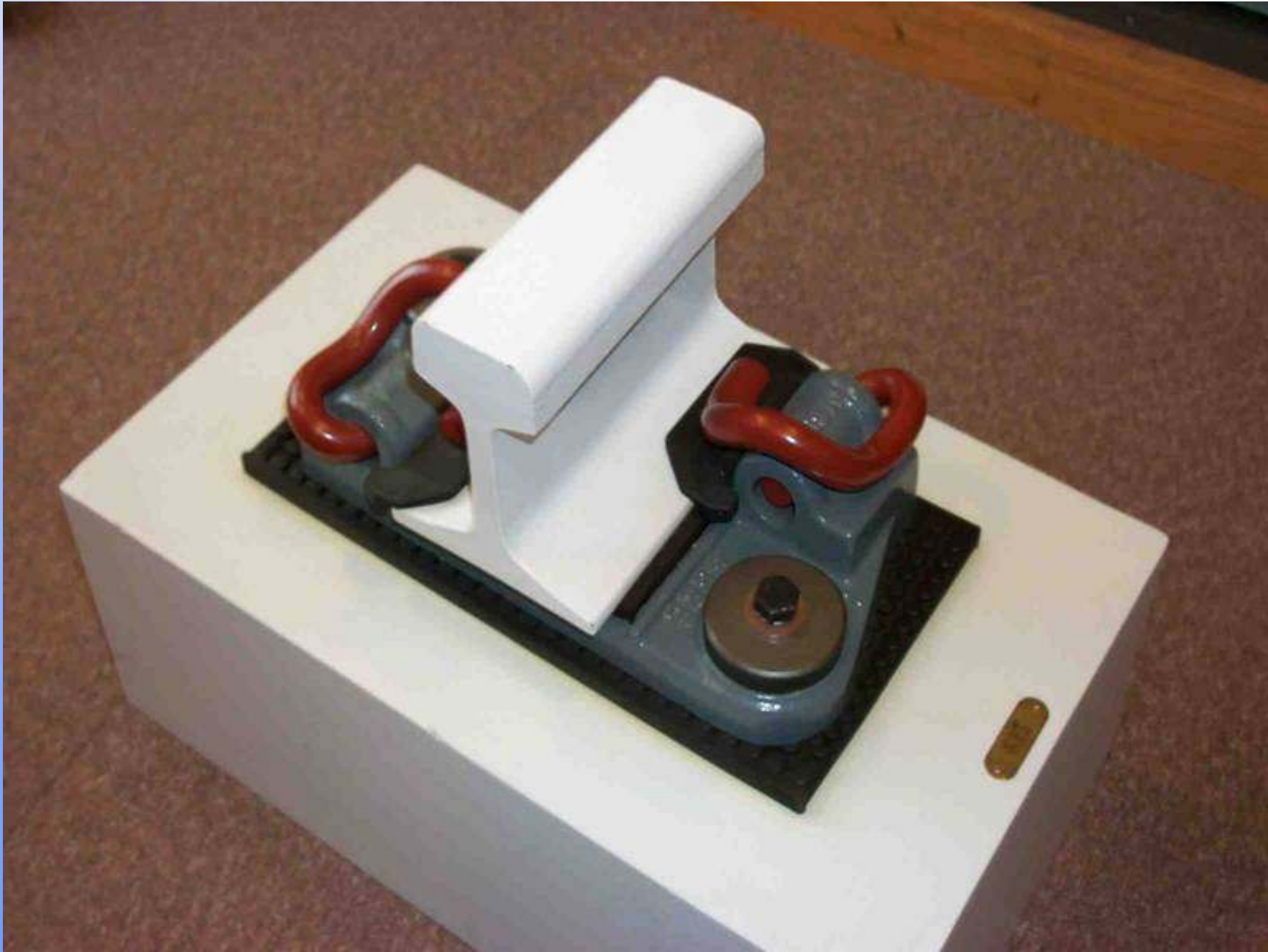
Conclusion





Docklands Light Railway, London: 1989.





2007



14

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13ª

Exposición Internacional de España, Zaragoza y Madrid



Sao Paulo Metro

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Klara Bridge – Sweden.



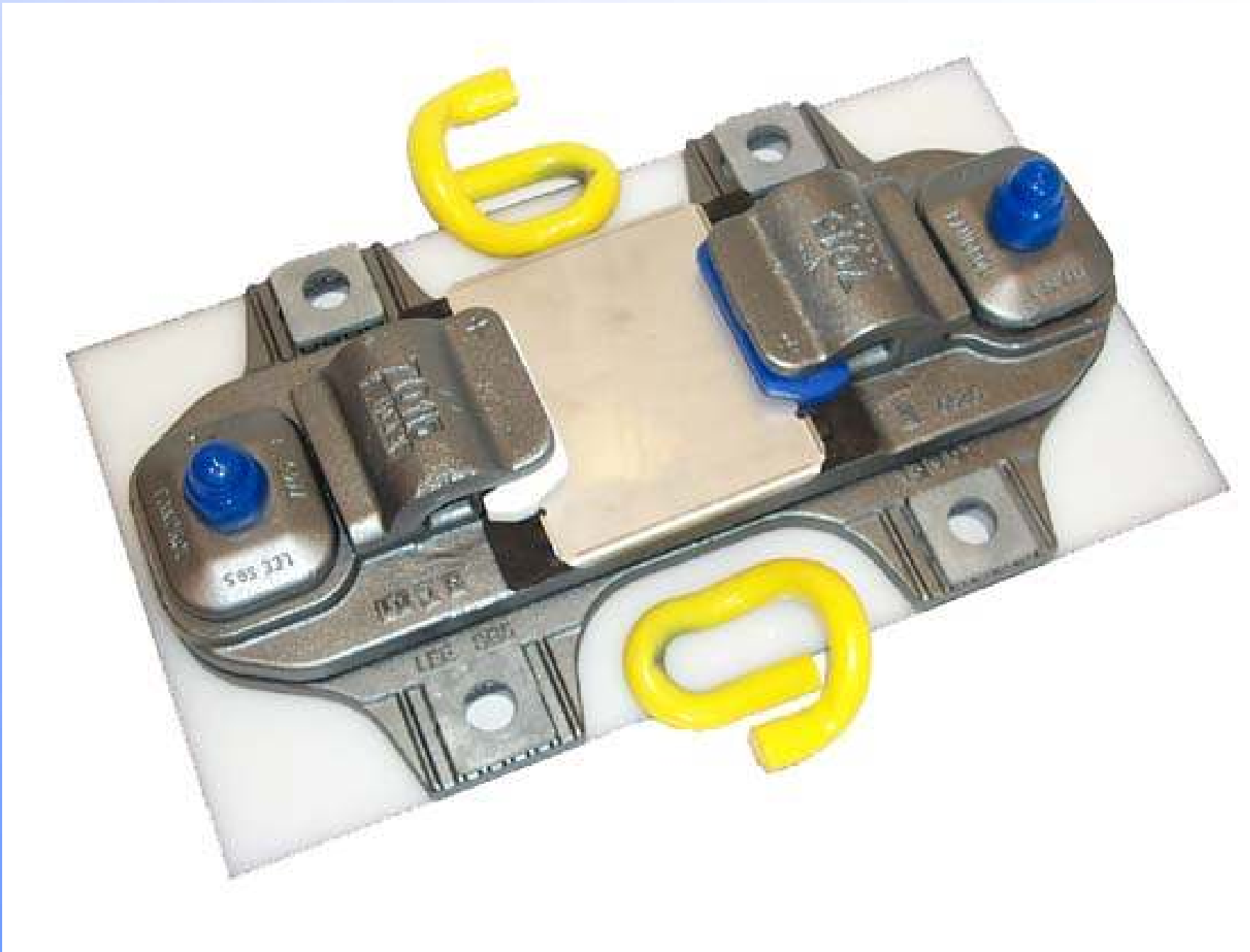


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METROFERROVIARIA
Transporte Metropolitanos, Española, Integrada y Nacional





Normal, full toe load assembly



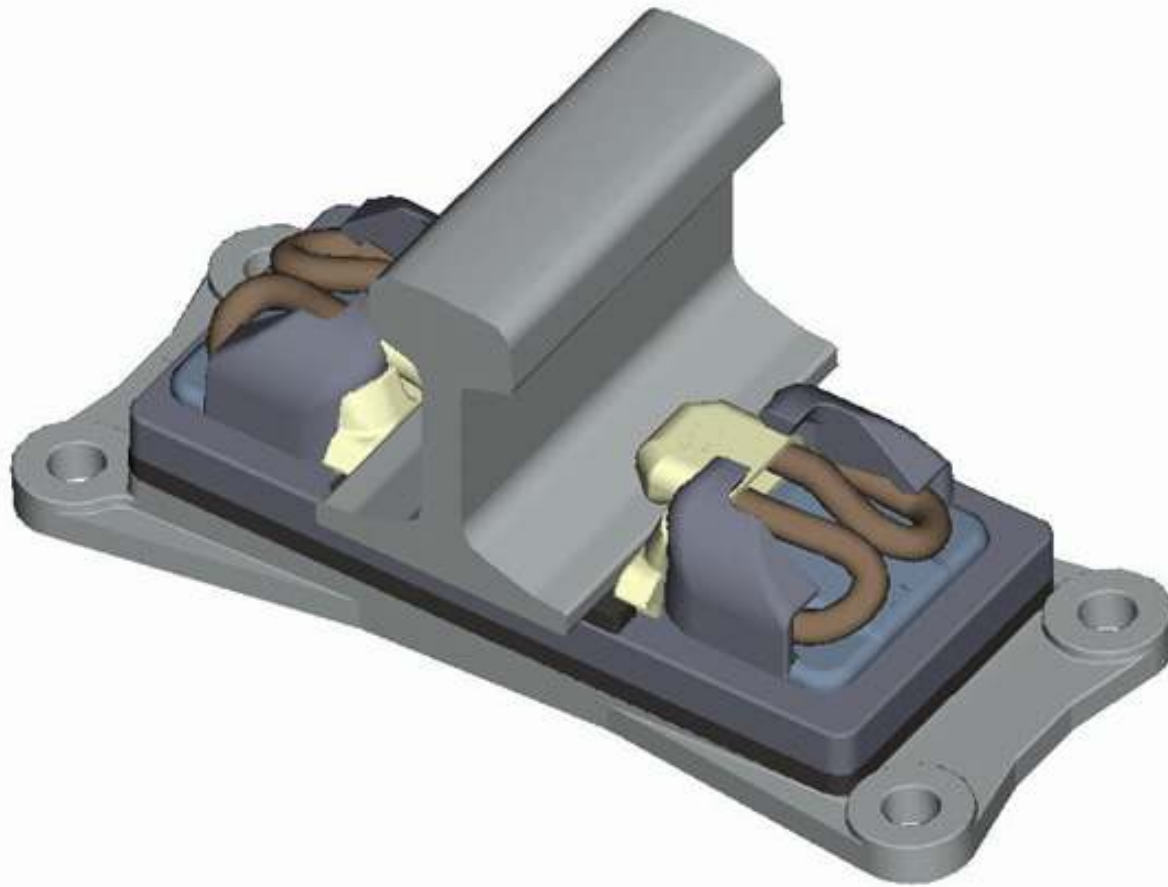
Rail free or ZLR assembly



Changi Airport Line, Singapore







PANDROL VIPA SP

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Barcelona, Manufacturas de España, Ingeniería y Maquinaria


AEAMESP



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14 años de experiencia
13ª SEMANA DE TECNOLOGÍA
METROFERROVIARIA
Ingeniería Manufacturadora, Operativa, Integrada y de Servicio



Nidelv - Norway

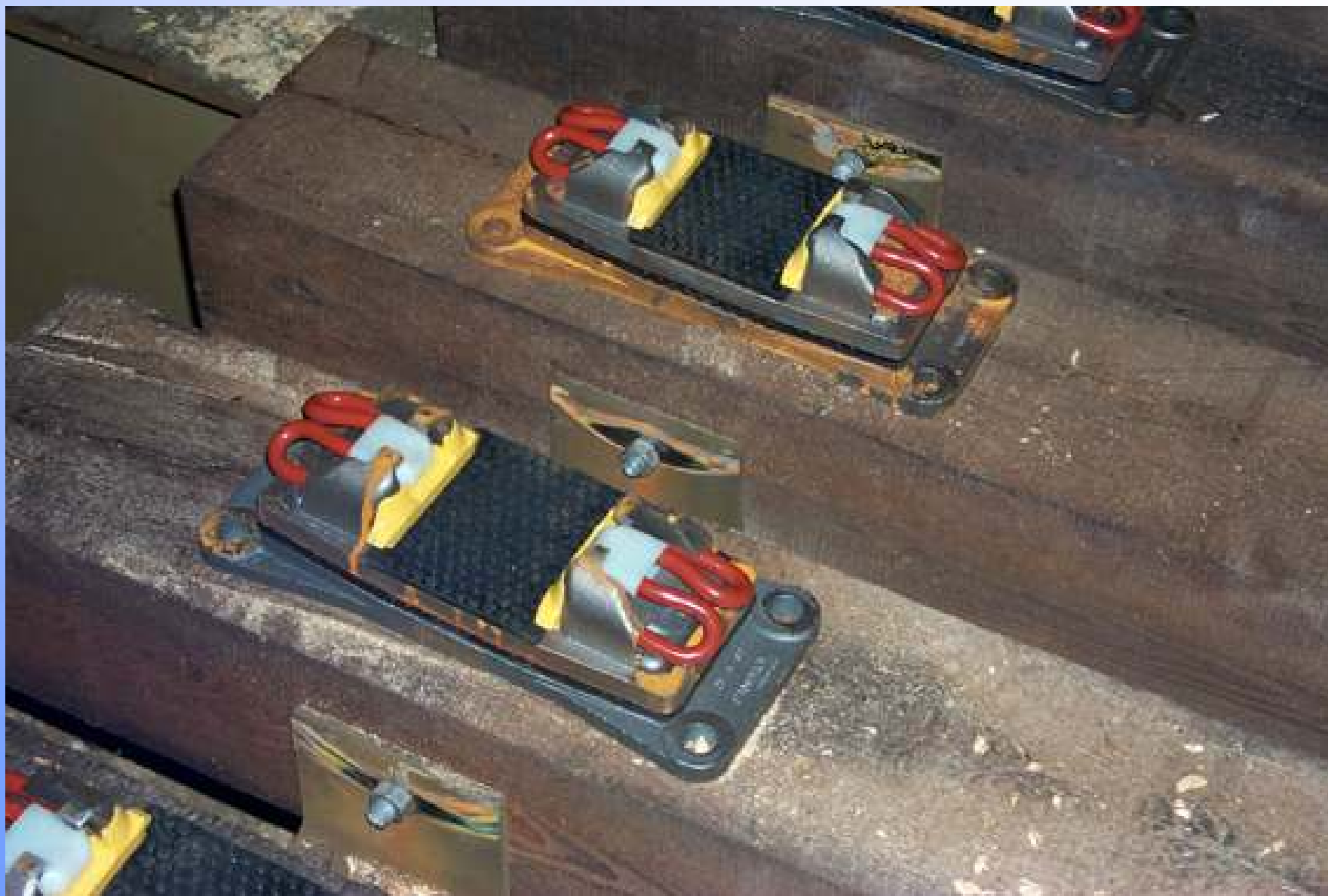


2007

14 empassos
de 100 metros

13ª SEMANA DE TECNOLOGIA
METROFERROVIÁRIA

Impulsando Modernização, Eficiência, Segurança e Meio Ambiente







2007
14 años
13ª SEMANA DE TECNOLOGÍA METROFERROVIARIA
Iniciando Manufacturas, Operación, Mantenimiento y Actualización





Valhubert tunnel - Paris



Cosmesti Bridge - Romania

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Tehnologia, Manoperena, Expansiune, Integrare si Inovare







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13th SEMANA DE TECNOLOGIA METROFERROVIARIA
Tecnología, Mantenimiento, Operación, Seguridad y Medio Ambiente



Noise & Vibration

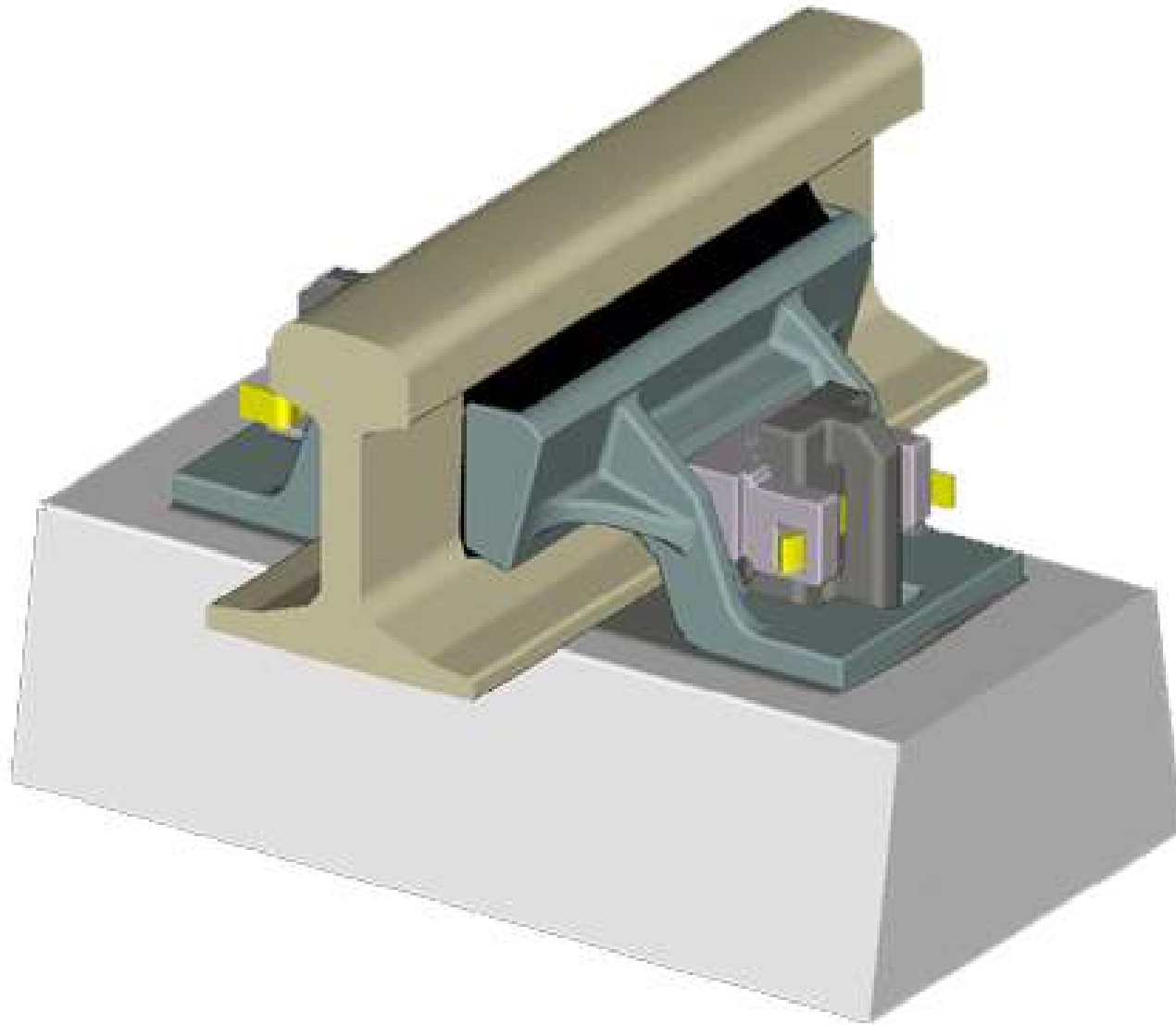
Resilient baseplate

Vanguard

Construction

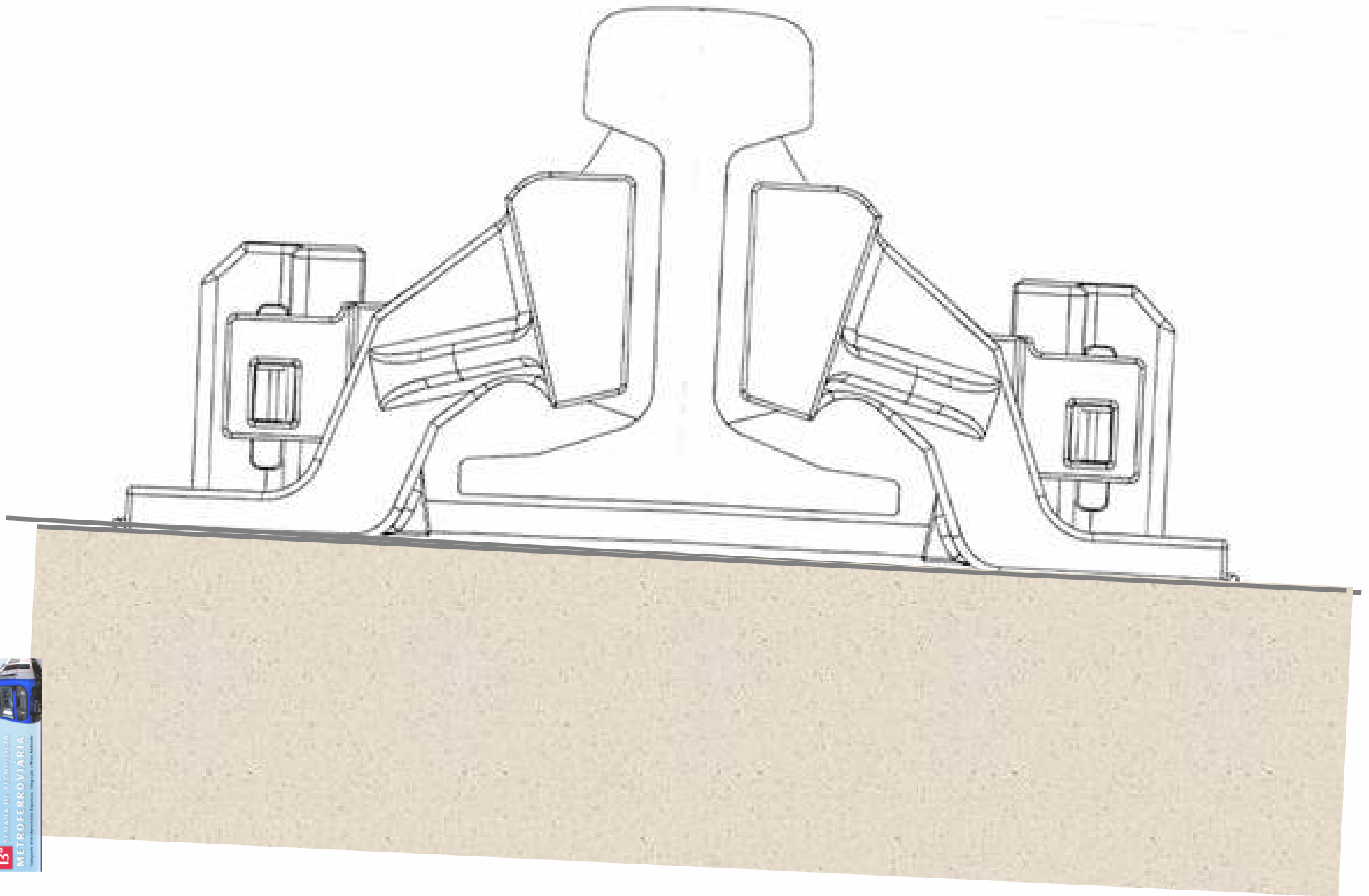
Conclusion



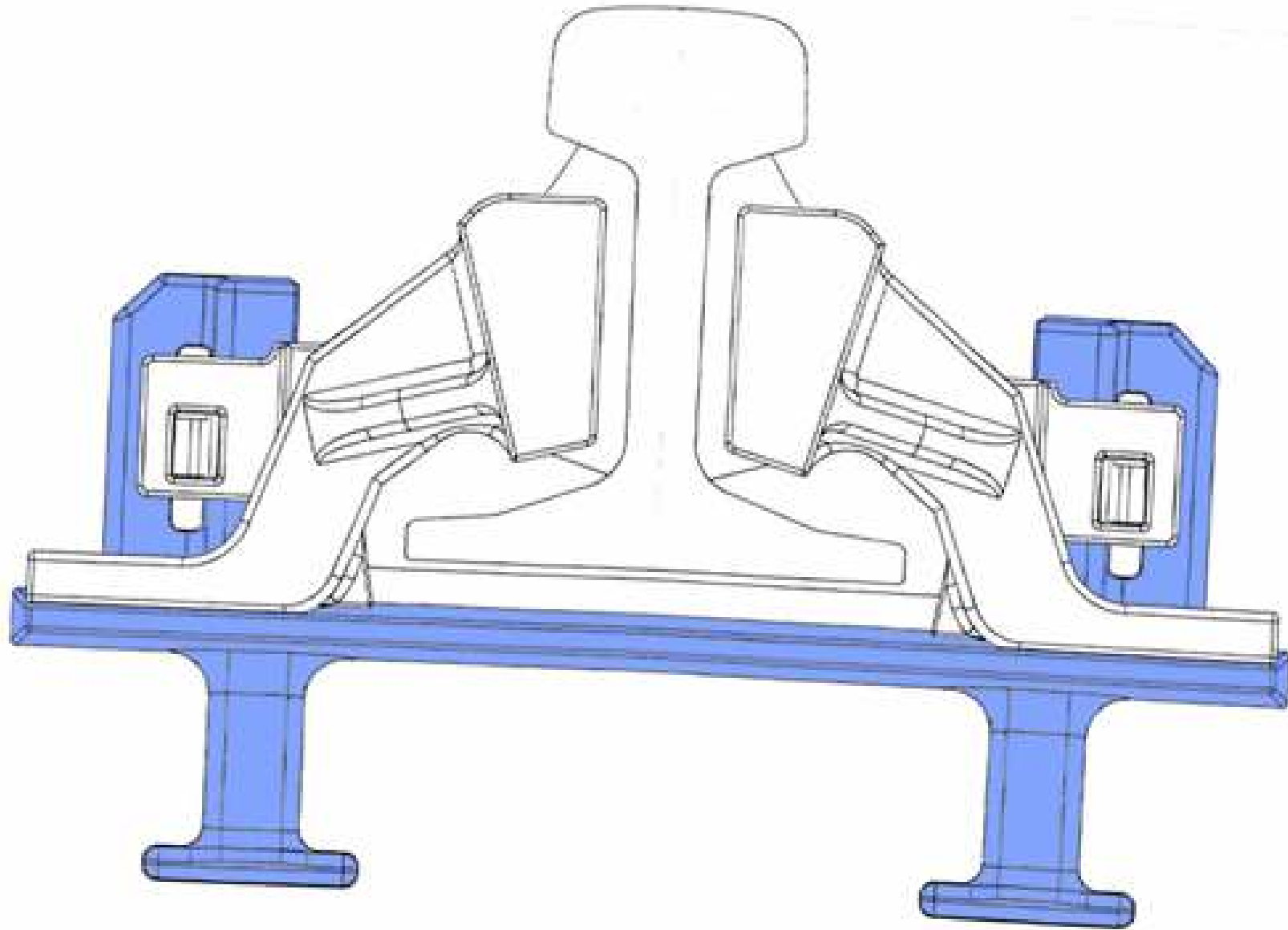


Pandrol Vanguard

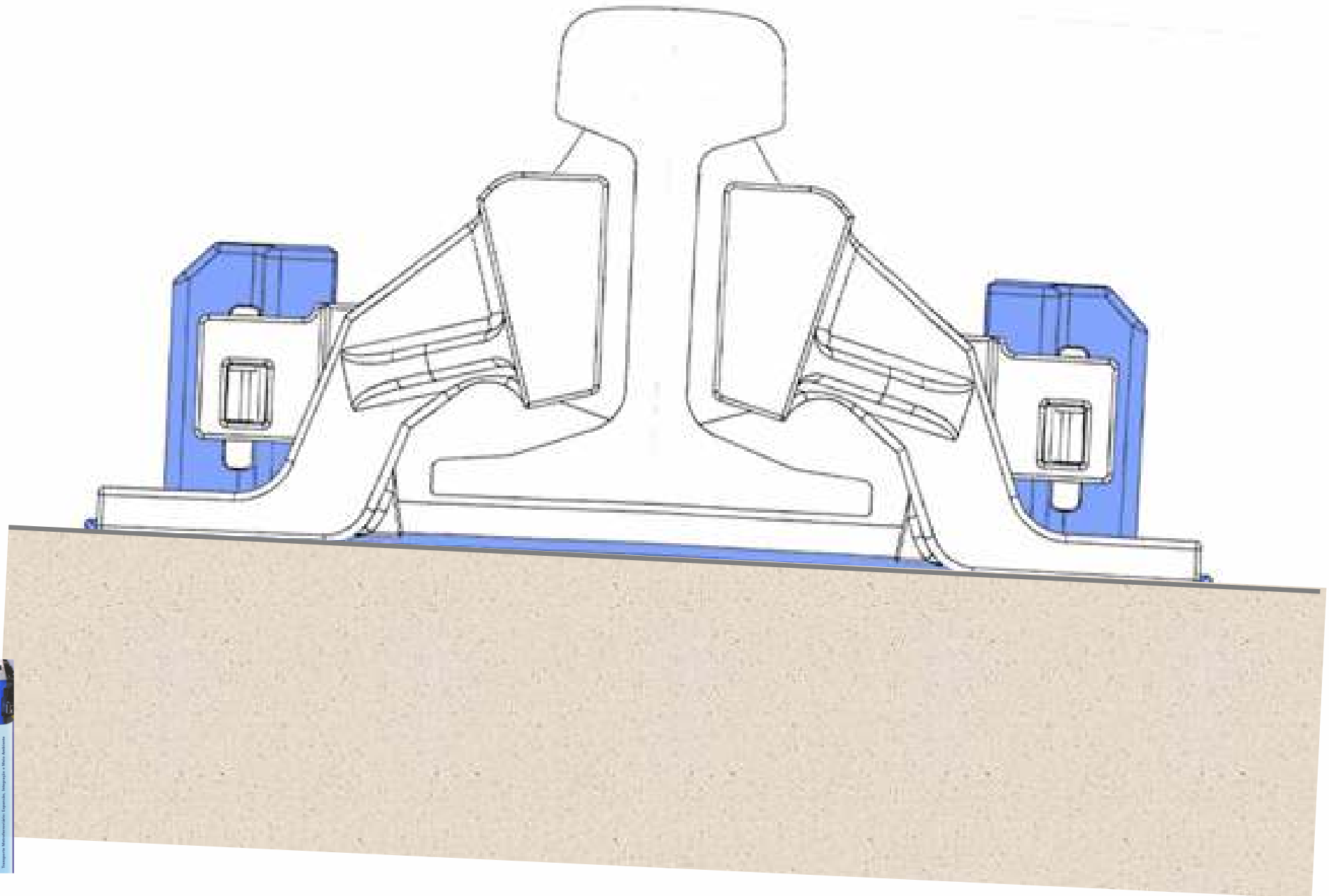
Pandrol Vanguard



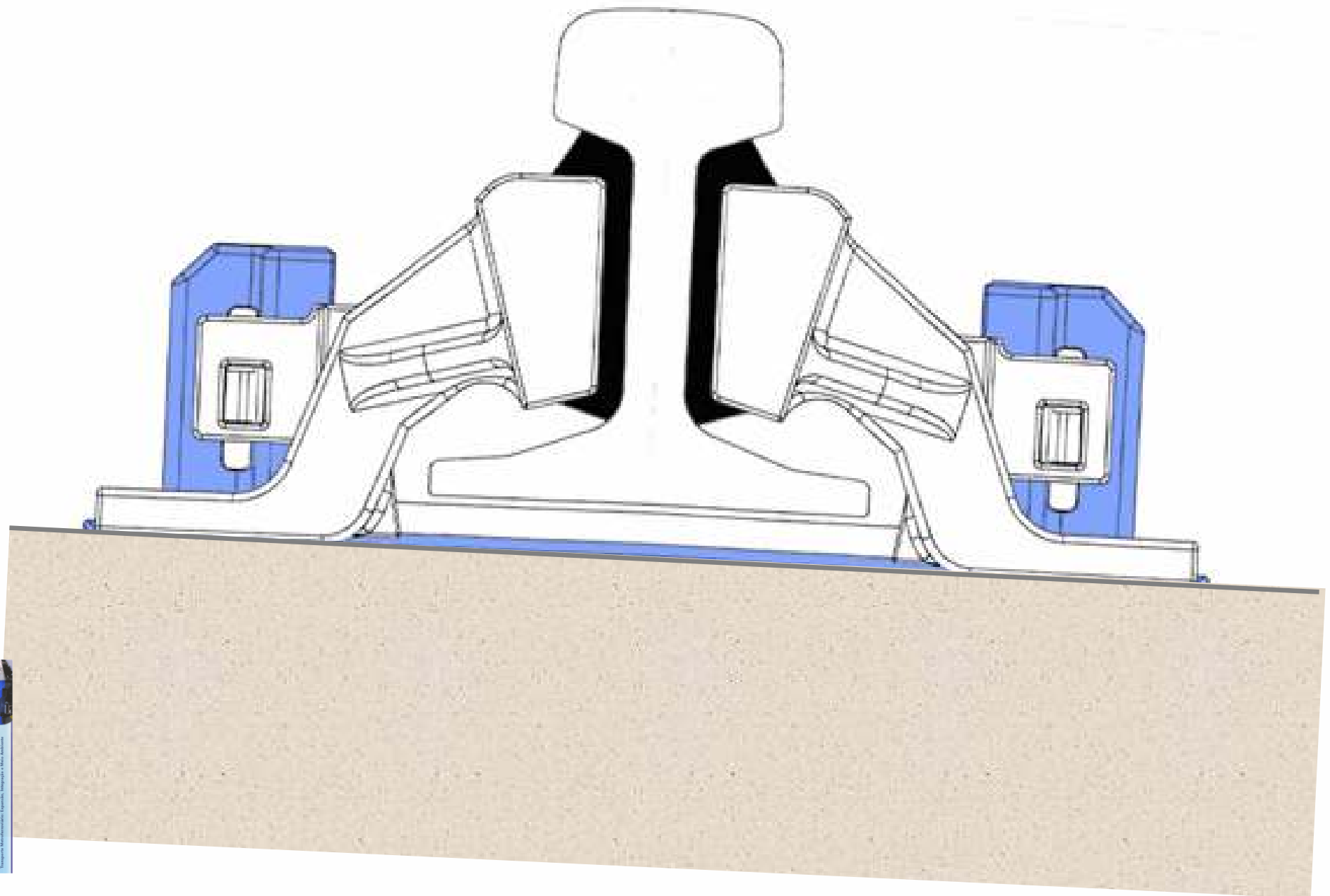
Cast SG iron plate with stems and shoulders ...



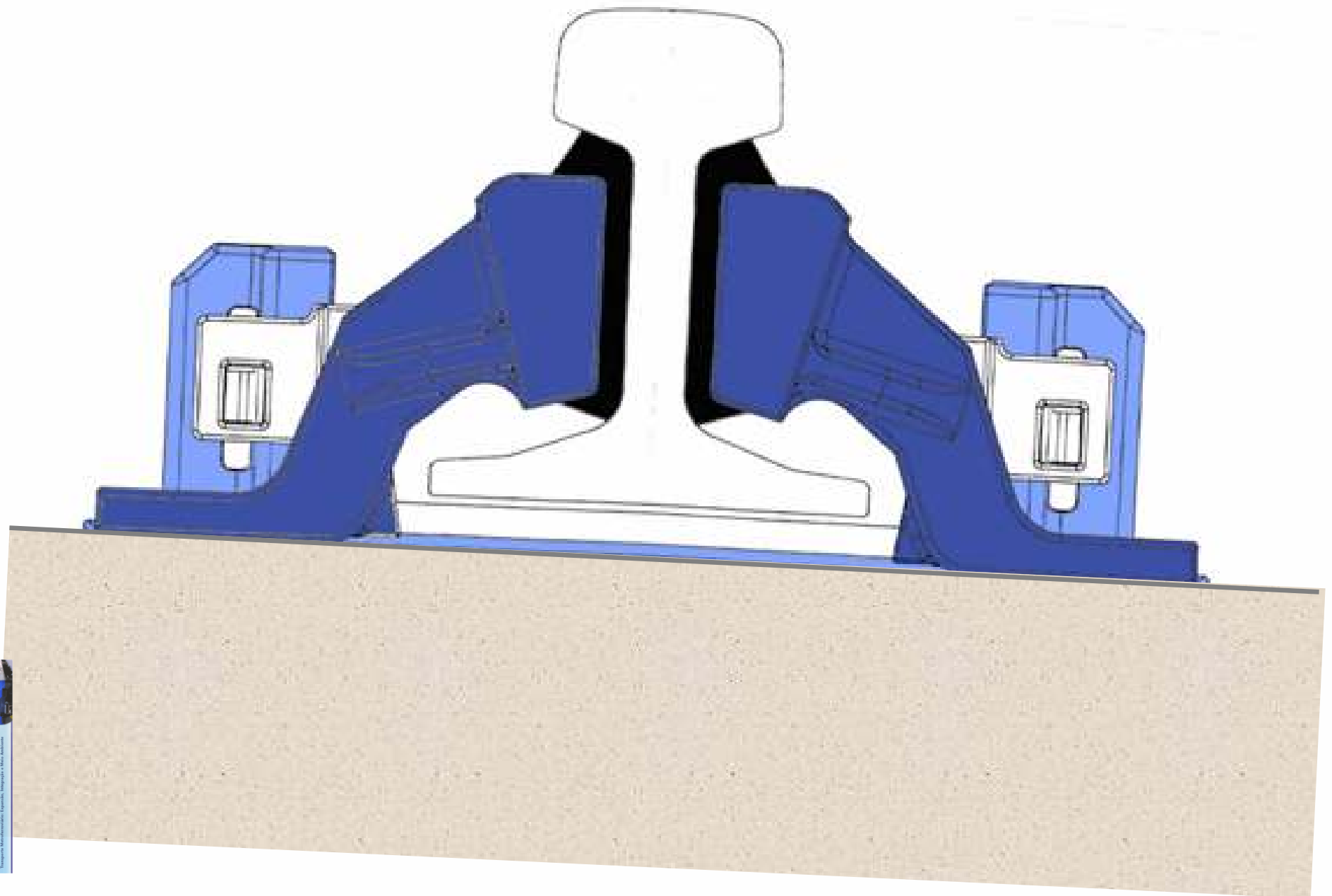
... cast into prestressed concrete sleeper



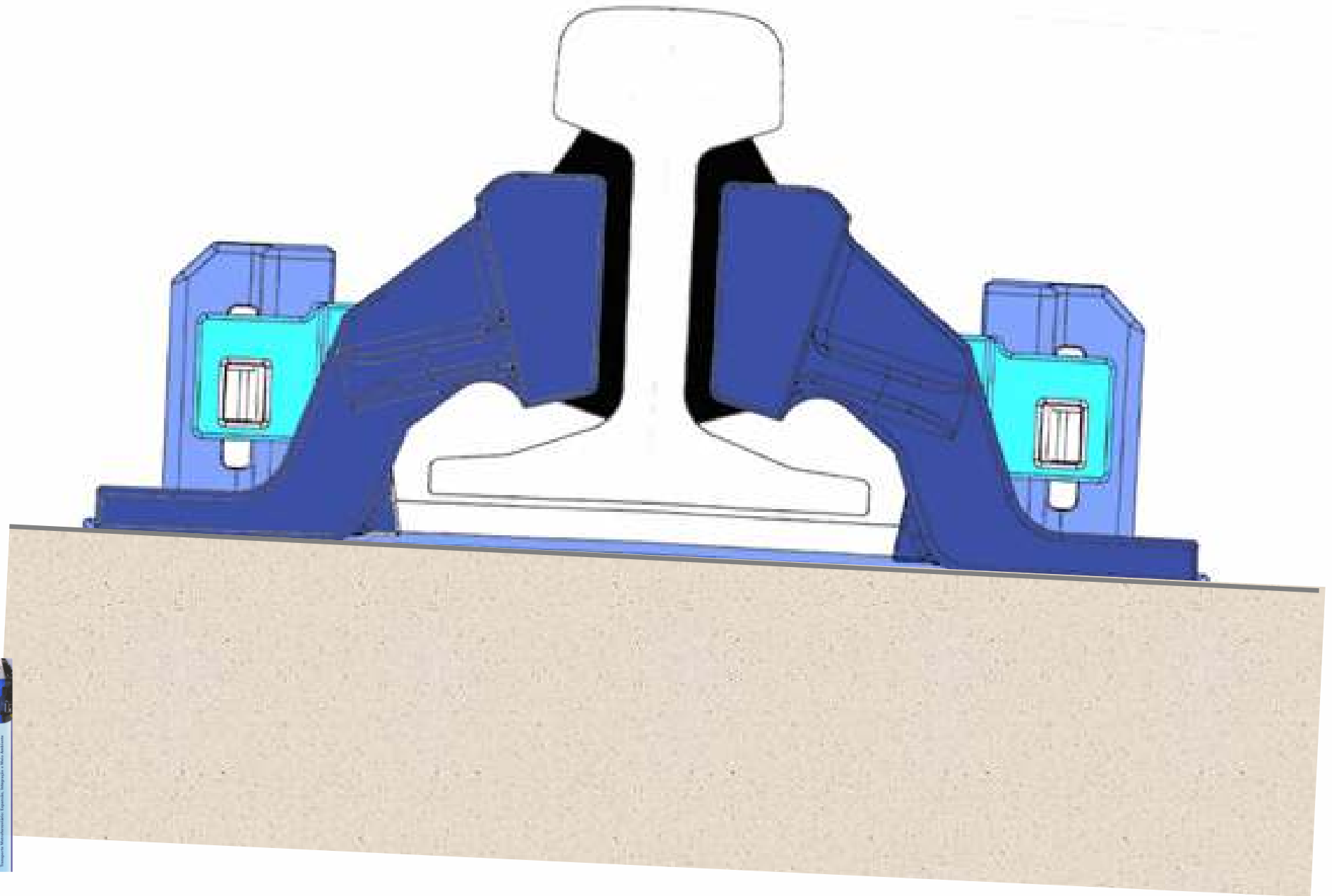
Natural rubber wedges support rail ...



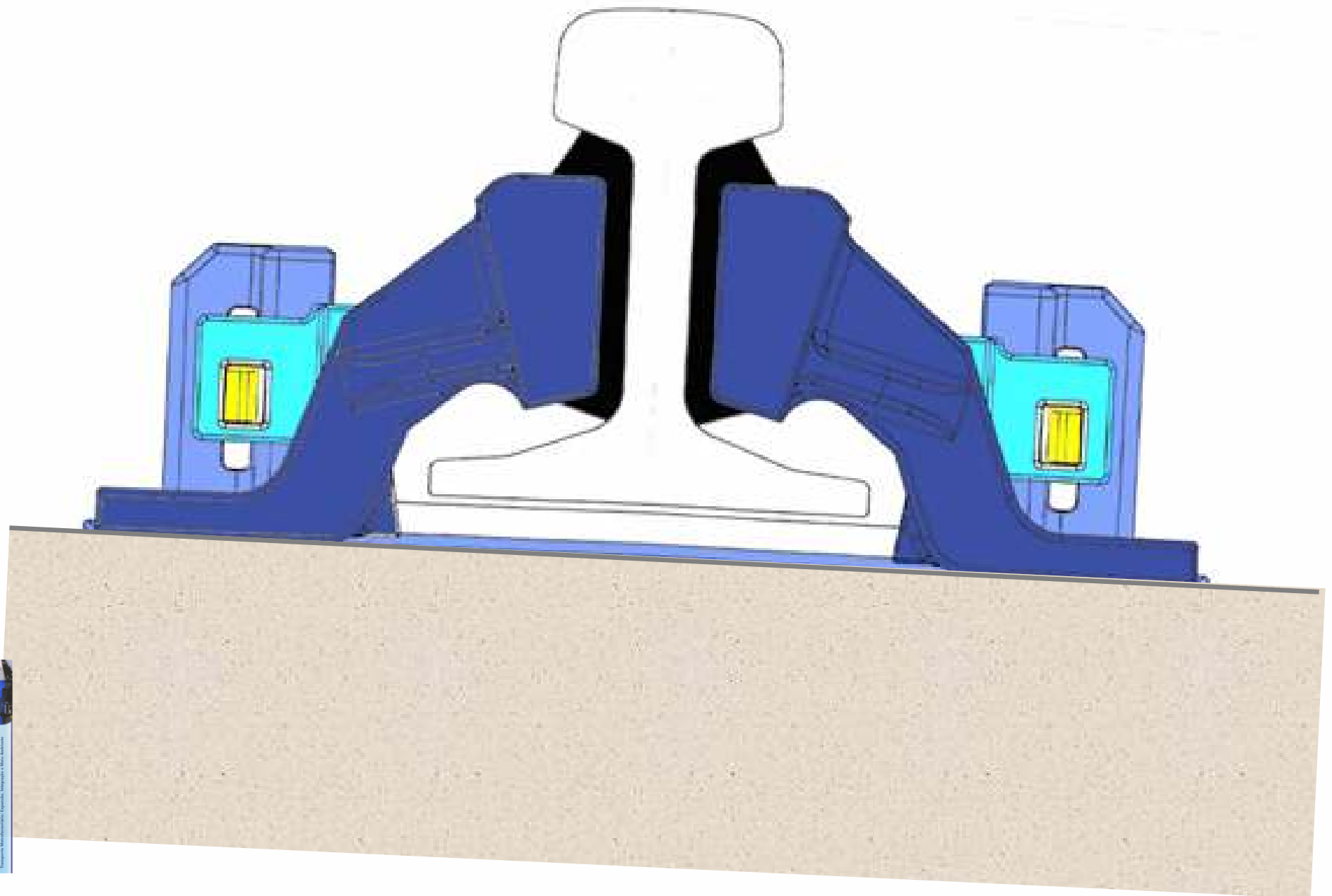
... and are in turn supported by cast SG iron side plates ...



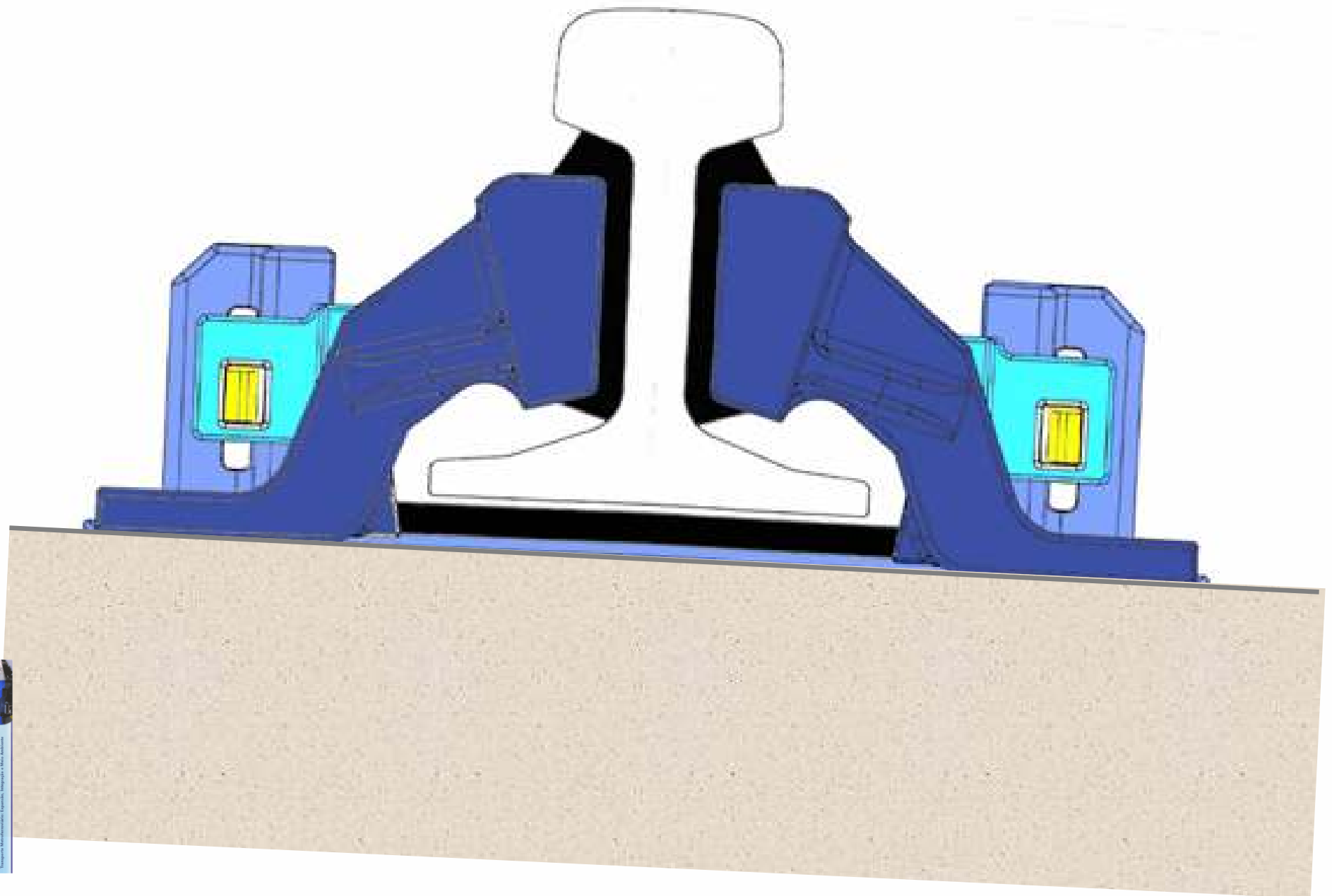
... which are locked in place with cast SG iron wedges ...

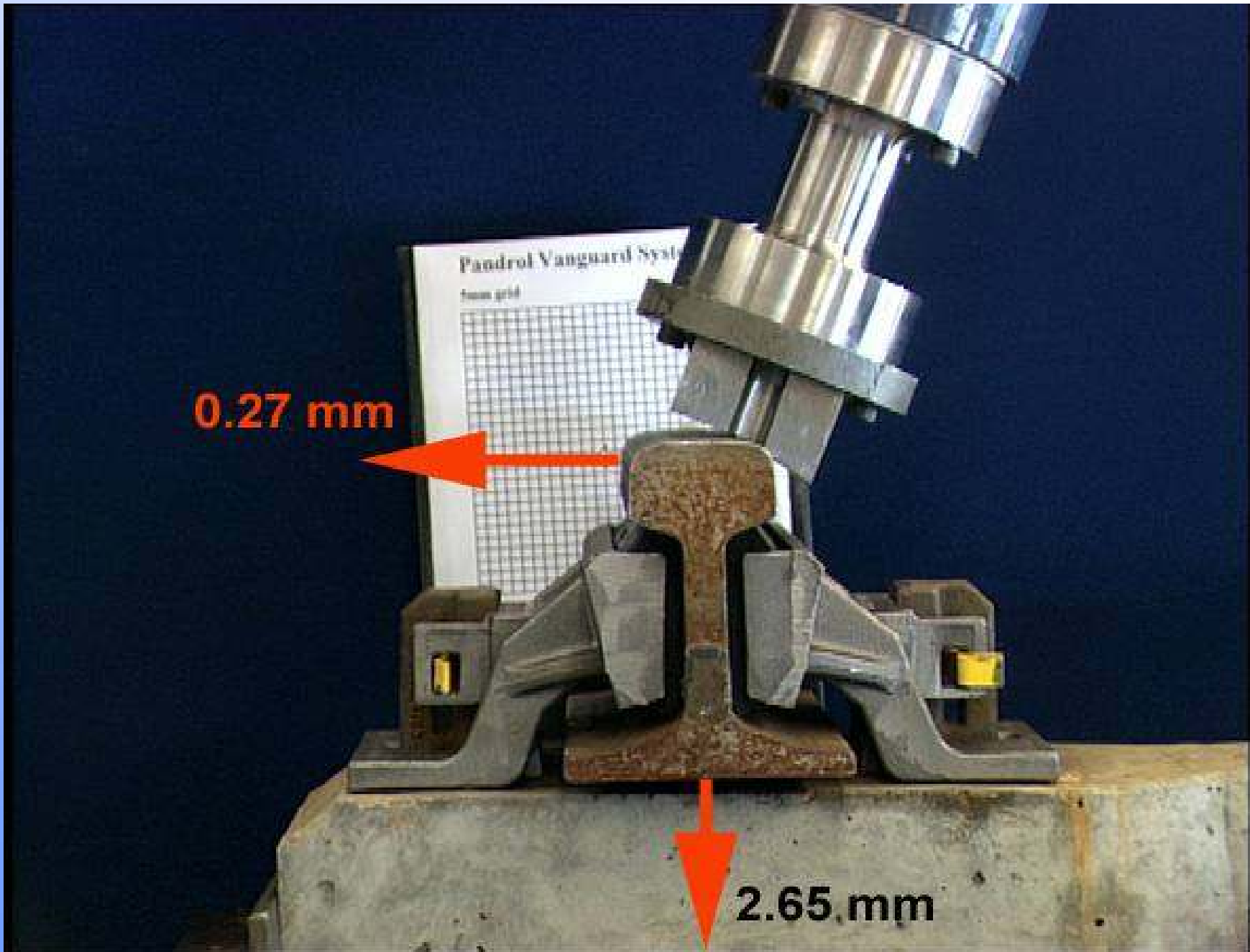


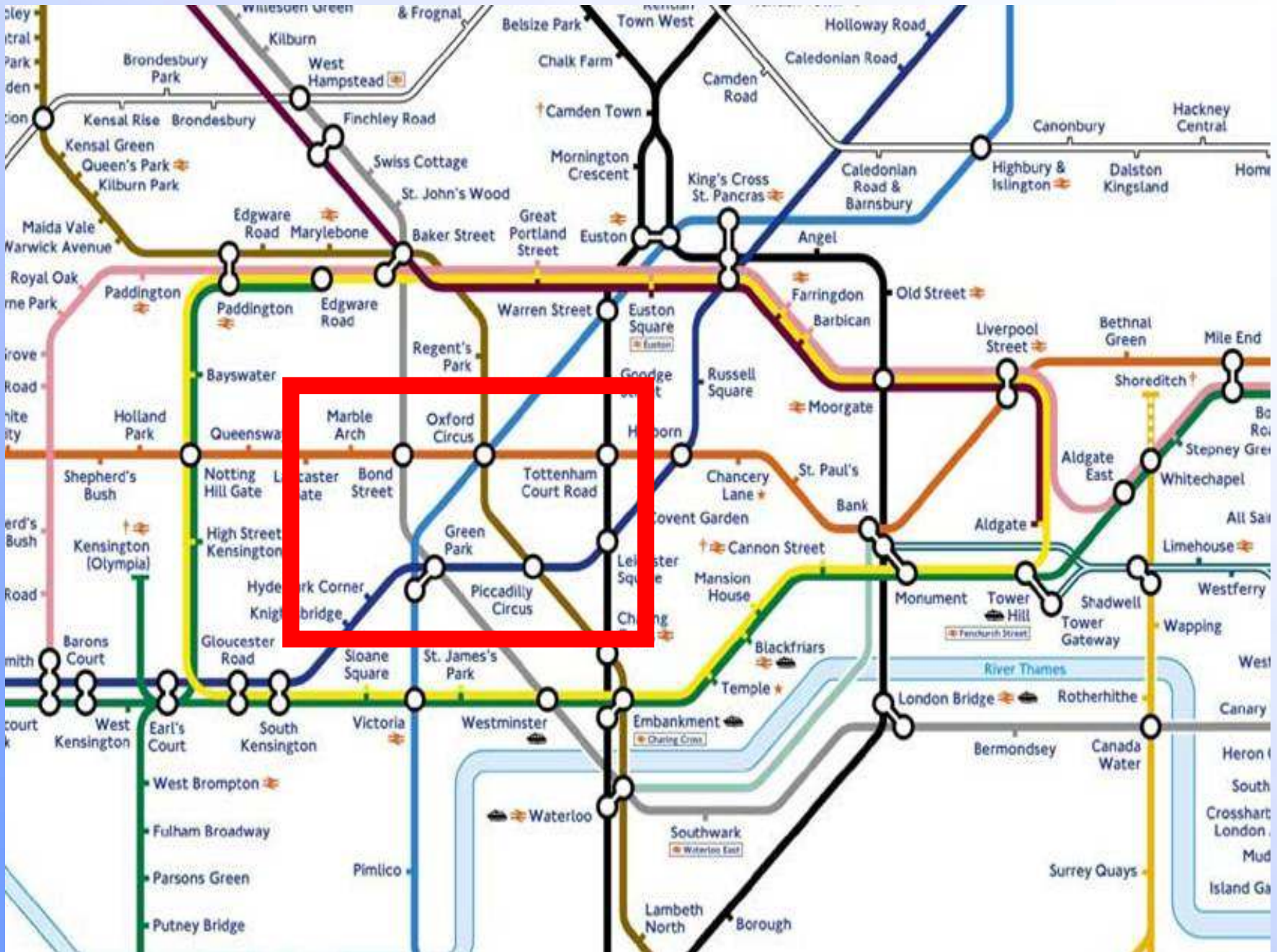
... spring steel clips locate these for added security ...



... and a natural rubber overload pad prevents excessive deflection







London Underground (The Tube)





2007



14 años de experiencia

SEMANA DE TECNOLOGÍA METROFERROVIARIA

13ª

Exposición Internacional de España, Septiembre de Madrid, España



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Ingeniería, Mantenimiento, Operación, Seguridad y Medio Ambiente



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Tecnología, Mantenimiento, Operación, Seguridad y Medio Ambiente



2007



13ª SEMANA DE TECNOLOGIA METROFERROVIARIA
Iniciando el Manifiesto. España, Impulsando la Nueva Andadura



2007



13^a SEMANA DE TECNOLOGIA METROFERROVIARIA
Iniciando el desarrollo de España, llegando a México



2007



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METROFERROVIARIA
European Metrotechnology Congress, September 4-8, Barcelona



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METROFERROVIARIA
Transporte Ferroviario, Español, Ingles y en Audio

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



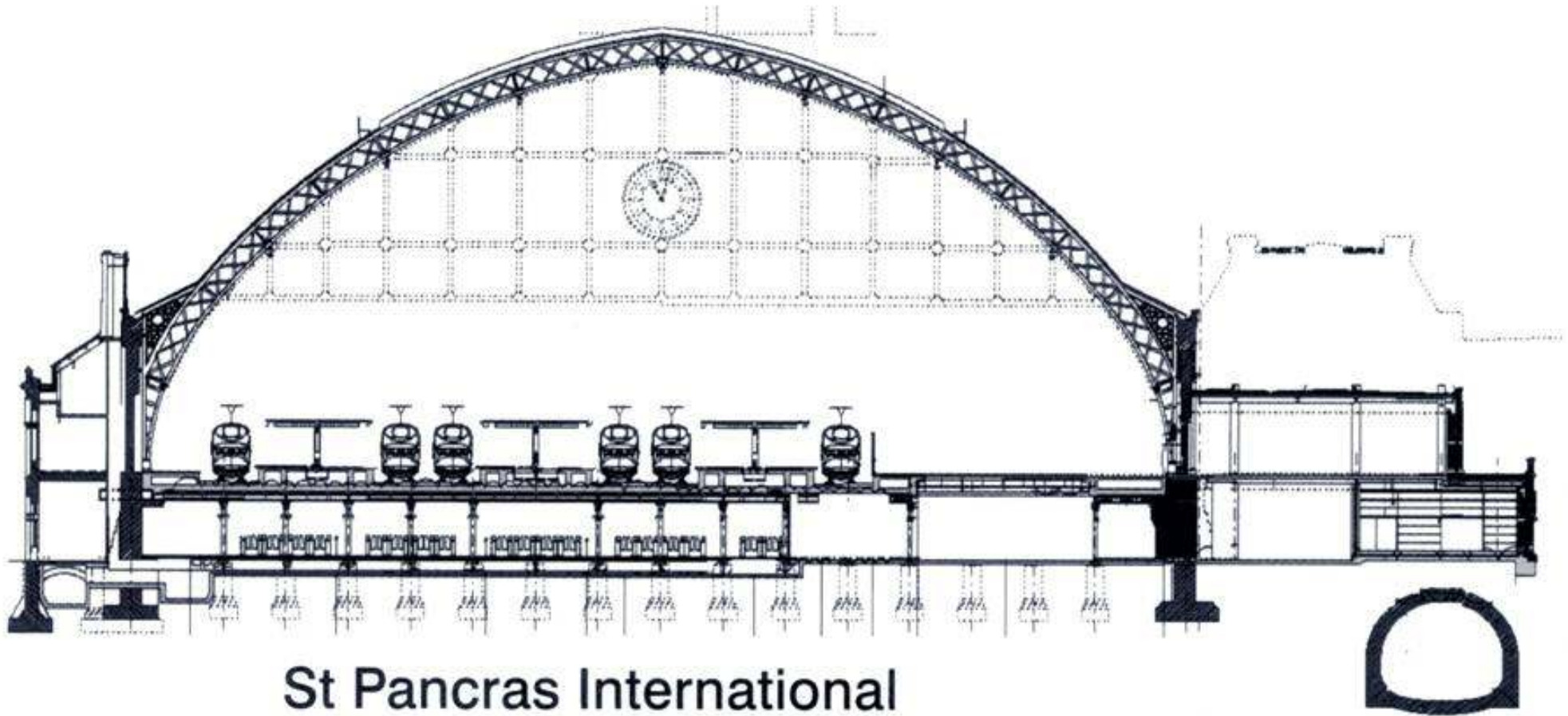


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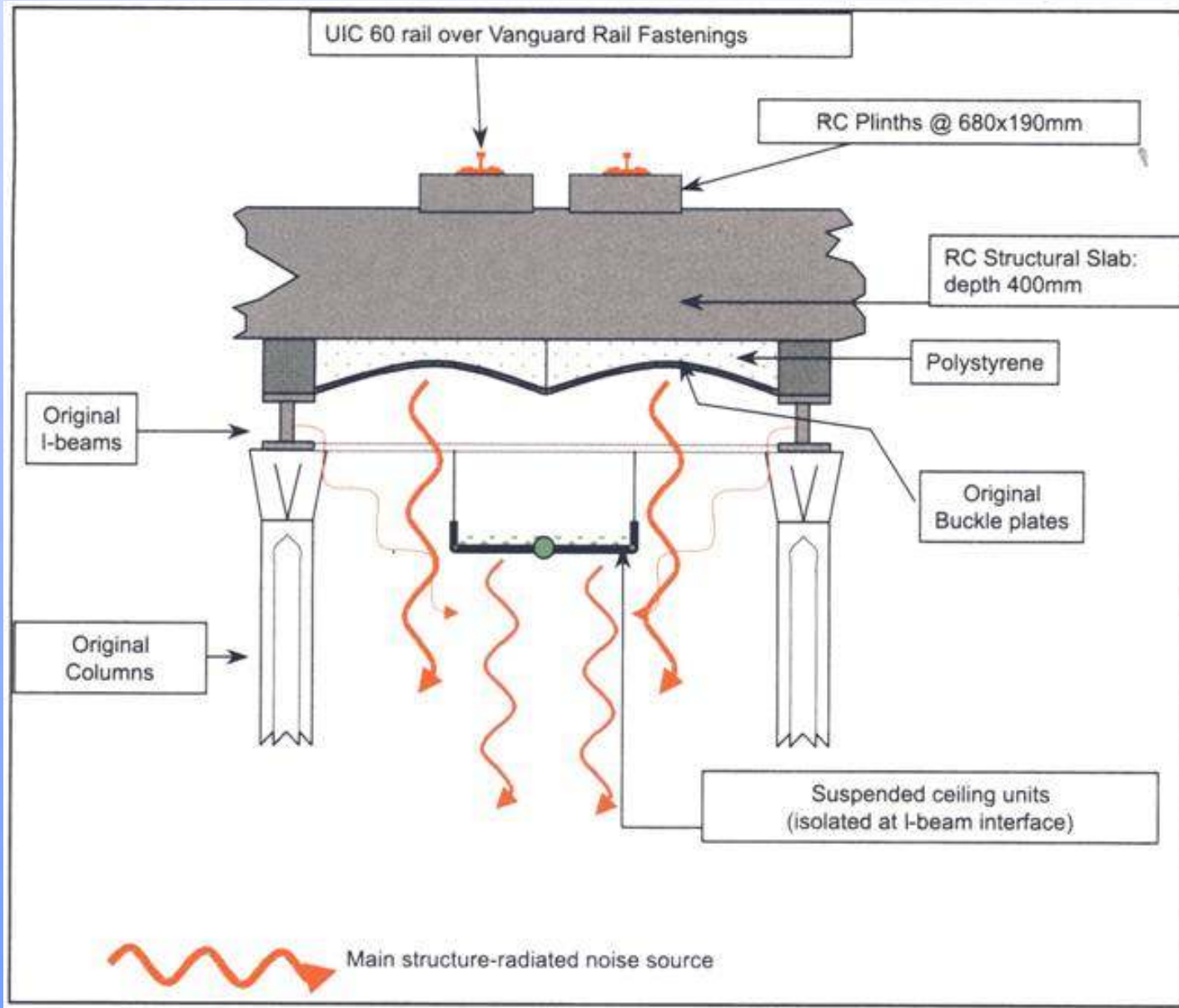
14th European
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METROFERROVIARIA
Barcelona, Madrid, Sevilla, Zaragoza & Valencia





St Pancras International
 (with concourses in undercroft beneath platforms)







2007



14 empresas



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METROFERROVIARIA
Tecnología, Mantenimiento, Operación, Seguridad y Nueva Acción





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METROFERROVIARIA
Tecnología Ferroviaria, Española, Europea y Mundial



St Pancras - London

Noise & Vibration

Resilient baseplate

Vanguard

Construction

Conclusion





CTRL St. Pancras, London.





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Seminario Manutención, Operación, Seguridad y Mantenimiento



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St Pancras - London



Thameslink Box Tunnel





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METROFERROVIARIA
Tecnología Ferroviaria Española, Integrada y Avanzada



2007
14th SEMANA DE TECNOLOGIA METROFERROVIARIA
13th SEMANA DE TECNOLOGIA METROFERROVIARIA
Iniciativa: Manufacturas, Equipos, Materiales y Mantenimiento





2007



14 años

SEMANA DE TECNOLOGÍA

METROFERROVIARIA

13ª

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Departamento de Manufactura, Operación, Integración y Mantenimiento



2007



14 años

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Tecnología Ferroviaria Española, Integrada y Avanzada



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Noise & Vibration

Resilient baseplate

Vanguard

Construction

Conclusion



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 ----- >



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

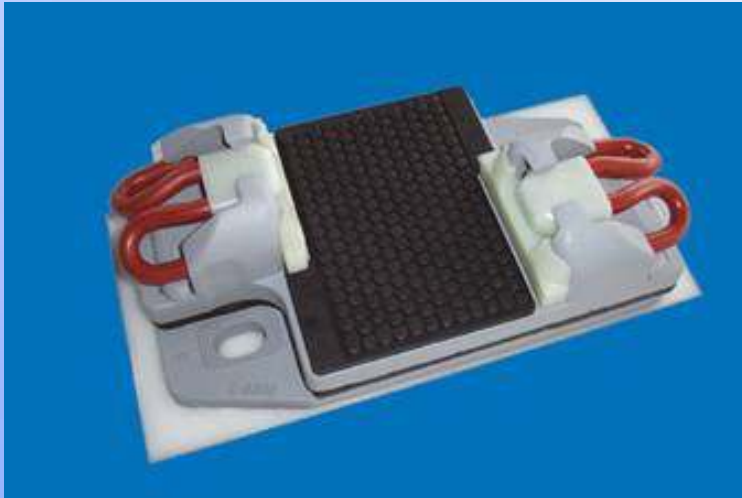
Floating slab track

Base isolation of structures

Increasing performance ---->

Increasing cost ----->



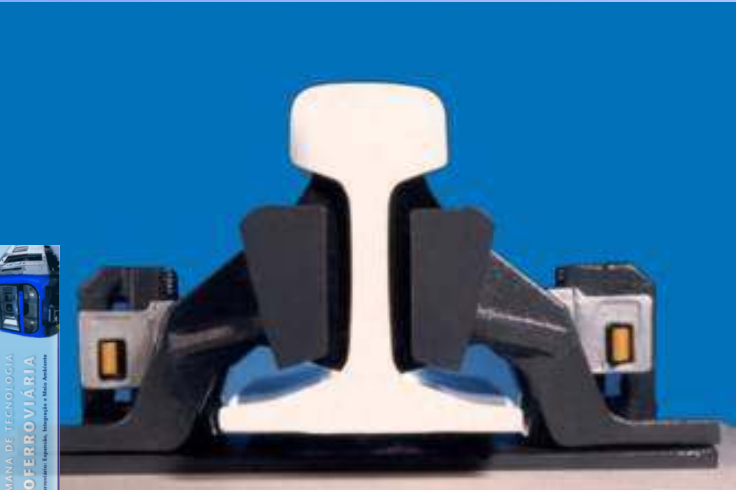


Pandrol Vipa resilient baseplate

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





The End