Conventional and new generation vibration mitigation solutions and their performance

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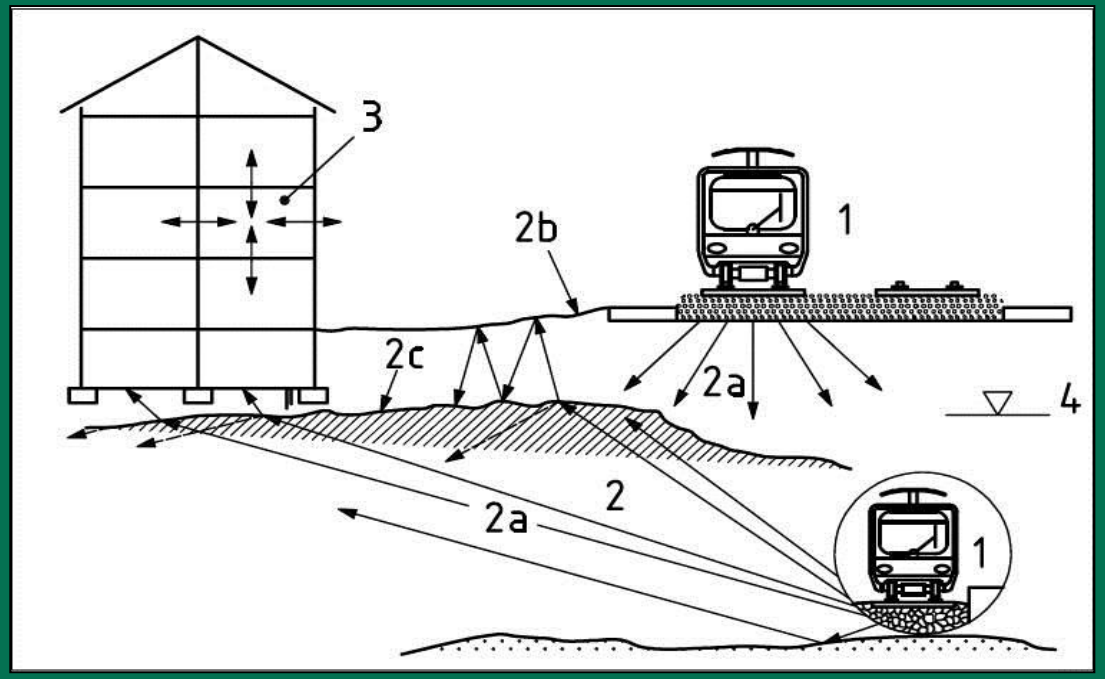
Contents
Key Presentation Take-Aways

- Introduction
- Mitigation requirements
- Mitigation solutions for wheel and rail related issues
- Mitigation solutions for turnouts
- Mitigation solutions for rolling noise
- Conclusions

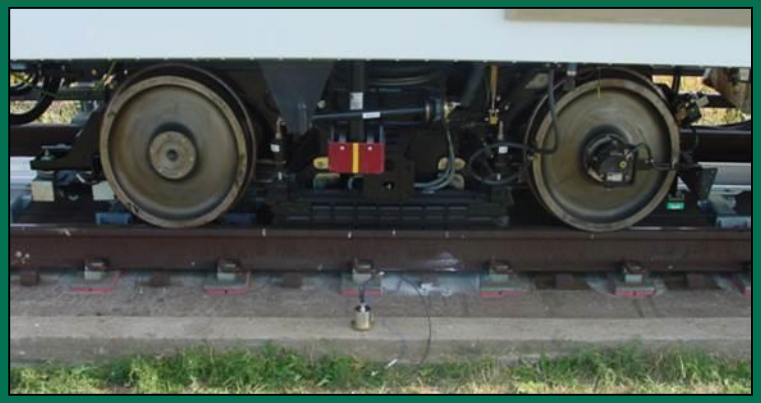
Introduction : overview of mitigation possibilities

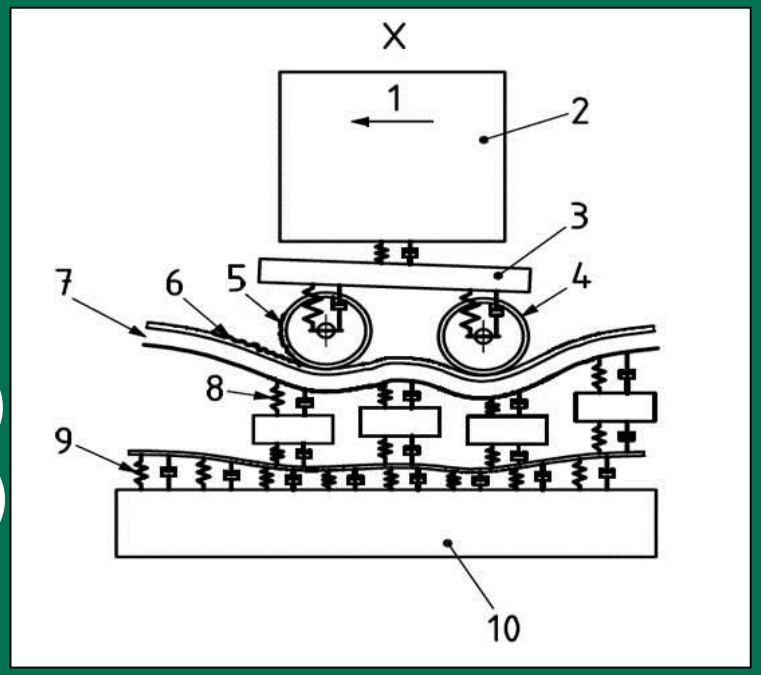
- At the source (1)
- In the propagation path (2)
- At the receiver (3)



Example: Influencing parameters at the source

1. train speed (operational)
2. vehicle mass (design)
3. truck mass (design)
4. non-suspended mass (design)
5. wheel roughness (maintenance)
6. rail roughness (maintenance)
7. rail characteristics (design)
8. rail support stiffness (design)
9. track bed mass/stiffness (design)
10. soil impedance (local parameter)

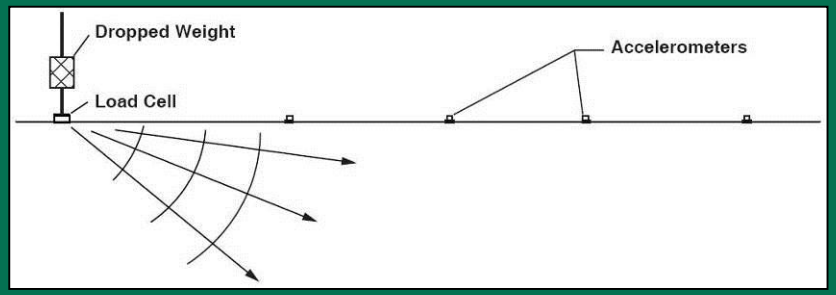


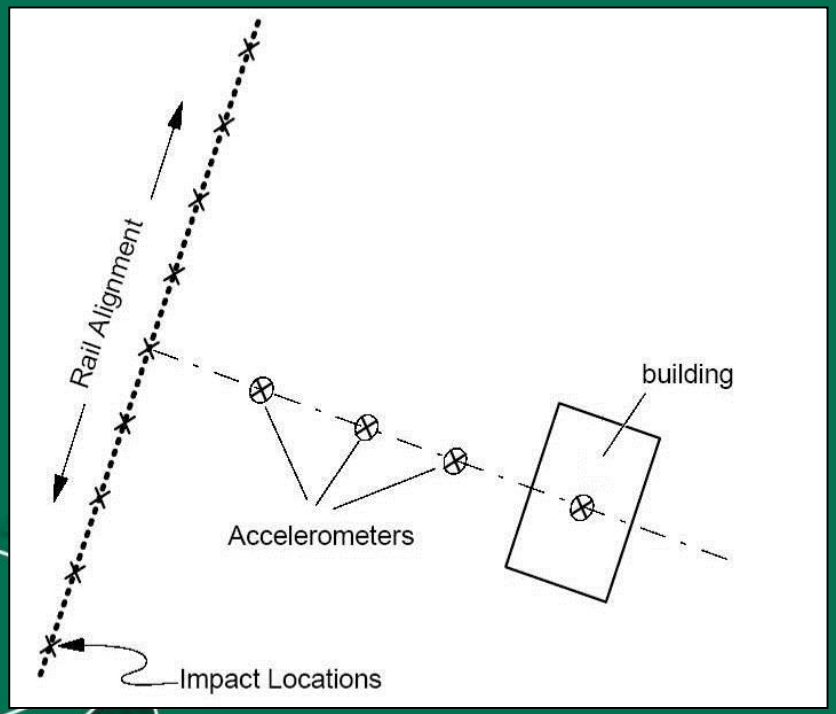


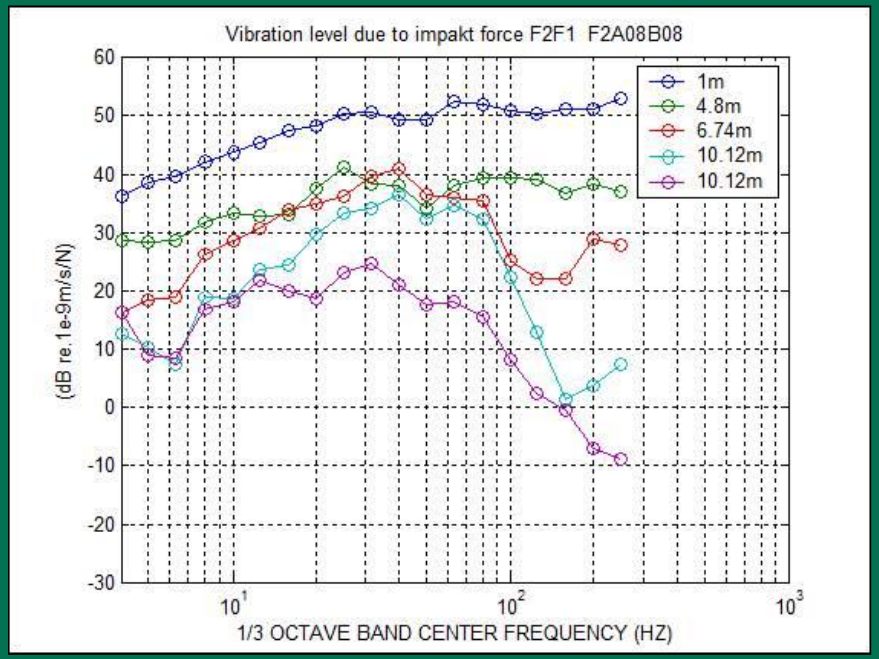
Mitigation requirements : distance based criterion for urban transit at grade (example)

Distance track/buildings	Vibration isolation requested in comparison with stiff track on concrete slab
≥ 12 m	-
> 7 m - < 12 m	10 dB
≤ 7 m	20 dB

Mitigation requirements : based upon detailed vibration assessment (FTA)







Overview of vibration mitigation solutions

- Specific wheel and rail related issues
- Turnout designs for minimal impact
- Normal rolling noise

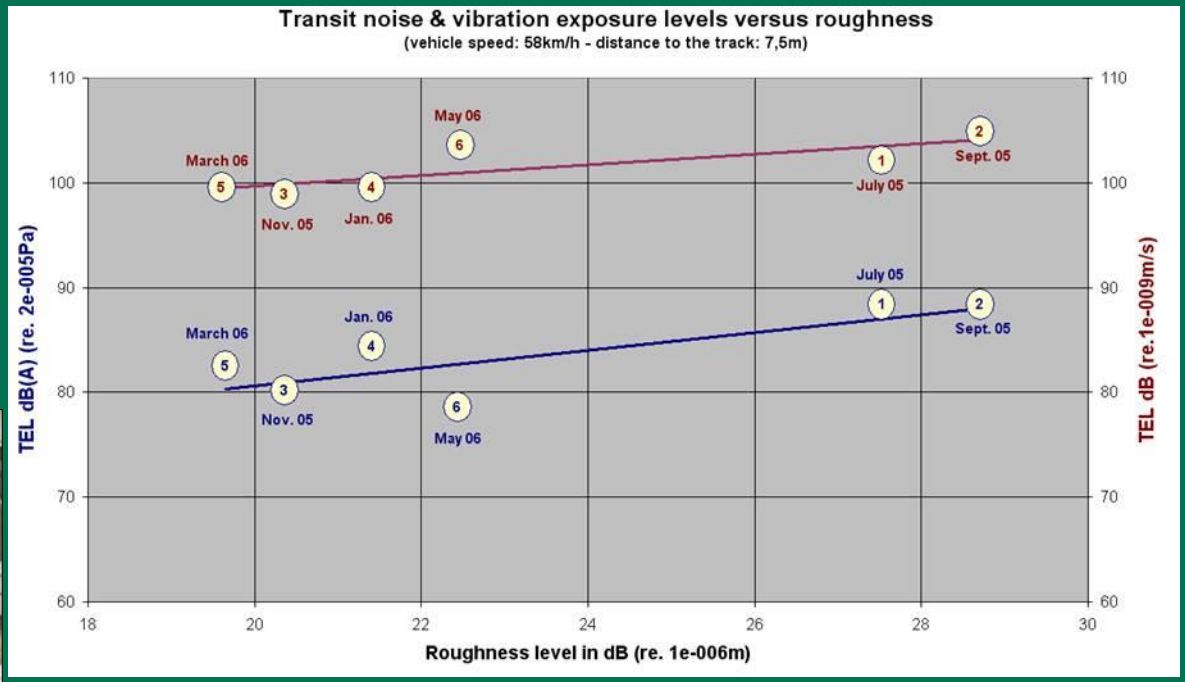
Specific wheel and rail issues

- Wheel
  - wheelflats ➔ truing
  - Out of roundness

Specific wheel and rail issues

- Rail
  - Corrugation or high roughness levels
  - Measurement with Rail Surface Analyzer
  - Solution: grinding

Specific wheel and rail issues



Turnout designs for minimal impact

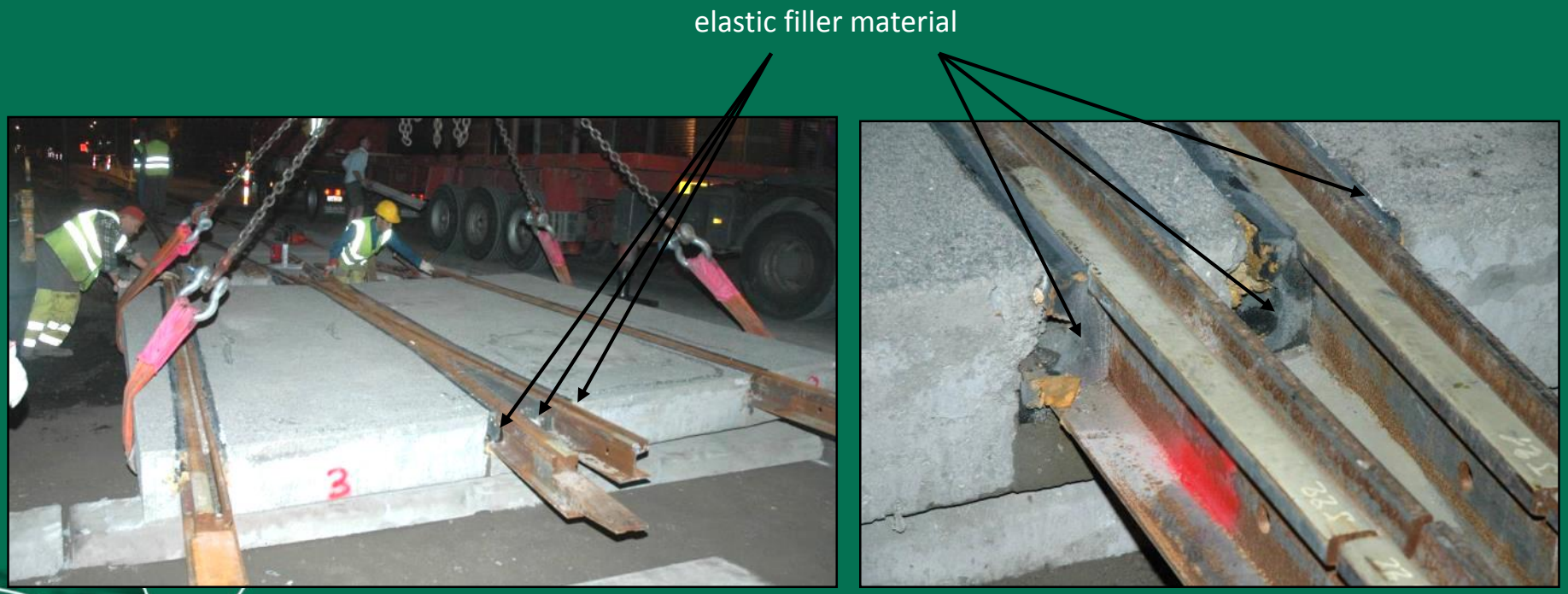
- Turnouts
  - Vibrations +10dB in comparison with tangent track
  - Solutions other than floating slab :
    1. “moveable point frog”

Turnout designs for minimal impact

2. “hybrid” turnouts (embedded with discrete fixation points)

Turnout designs for minimal impact

3. “embedded” turnouts (prefabricated without discrete fixation)



Normal rolling excitation

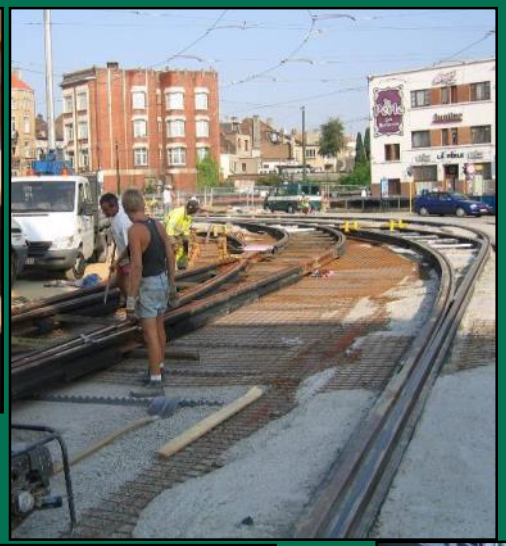
Mitigation solutions for vibrations problems :

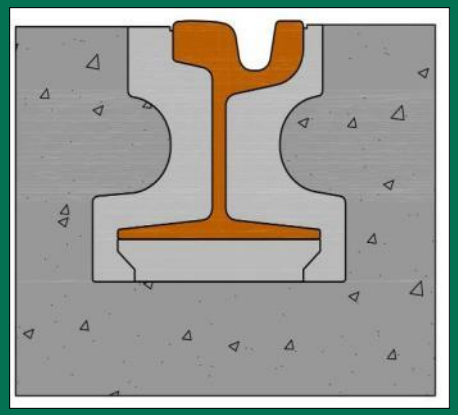
- Elastic rail fixation (ERF)
- Superelastic rail fixation (SERF)
- Under tie pad (UTP)
- Ballast mat (BM)
- Floating slab (FST)
- Measures in the propagation path (soil barrier-wave impeding blocks)

Mitigation performances :

Low (L), Medium (M), High (H), Very High (VH)

ERF – Continuously supported rail Brussels and Athens -Performance Low

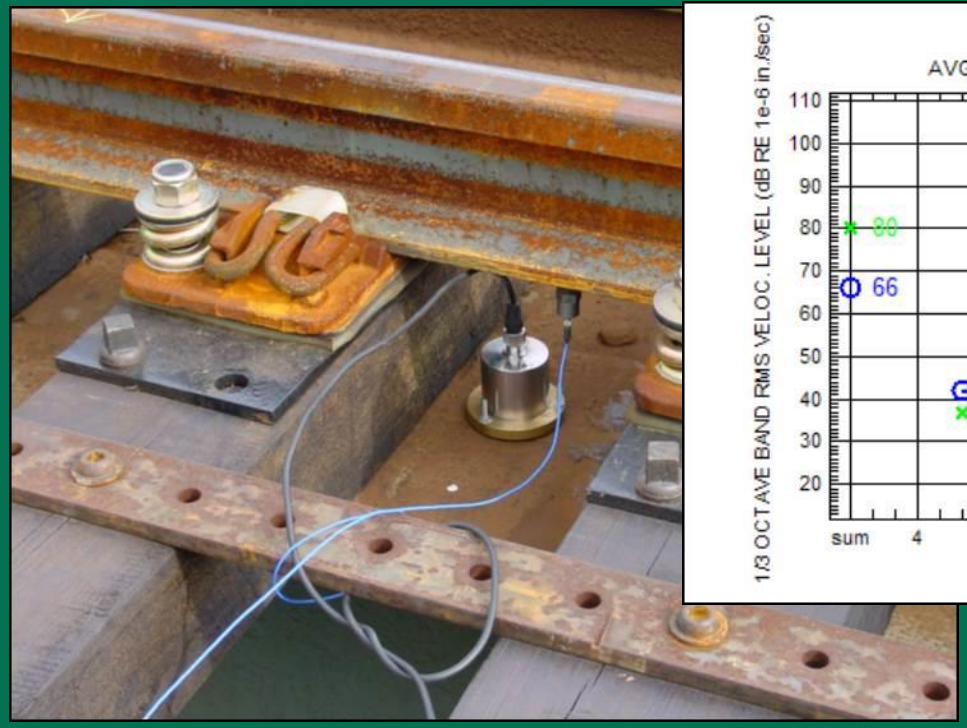


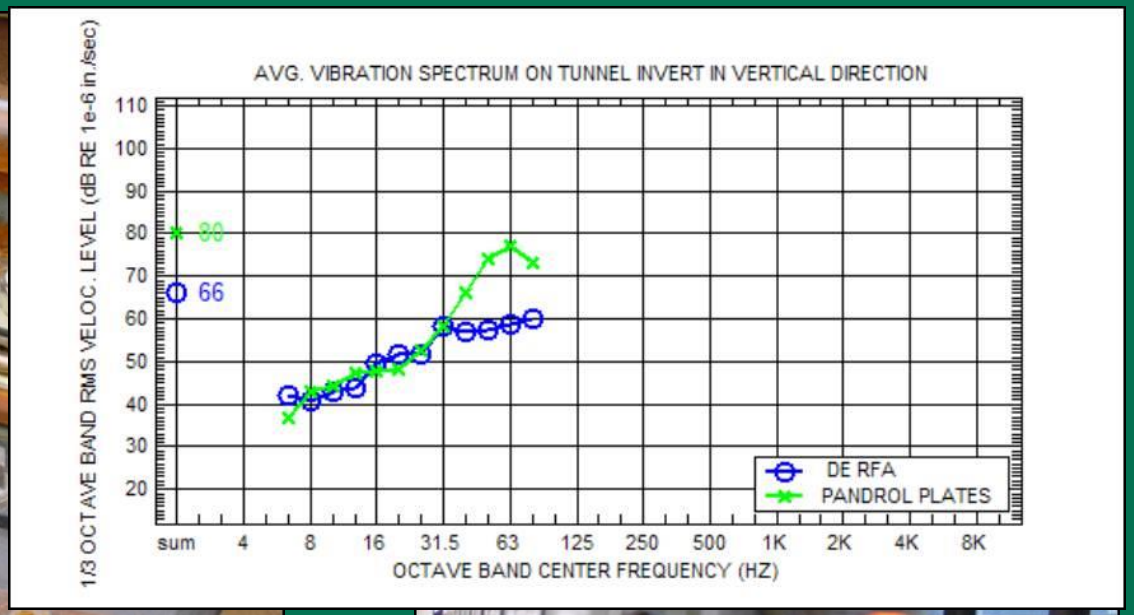


ERF – Discrete Rail Fixation (DS ISO RAIL) Antwerp-Performance Medium to High

ERF –Discrete Rail Fixation (DS ISO RAIL)
San Francisco Muni- Performance Medium

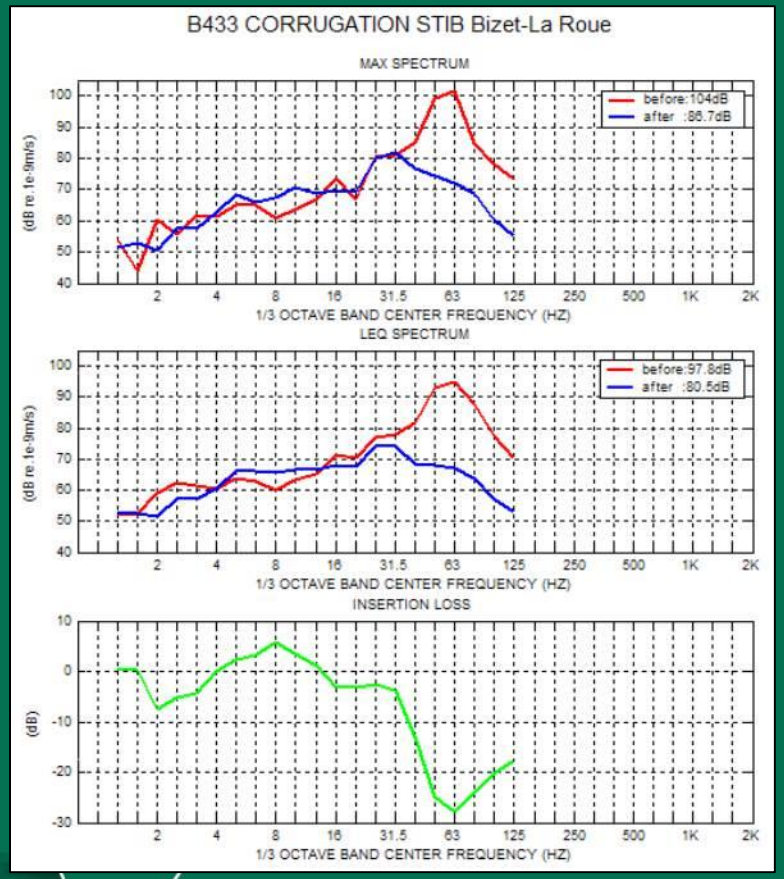
SERF – Super Elastic Direct Rail Fixation
New York City- Performance High to Very High



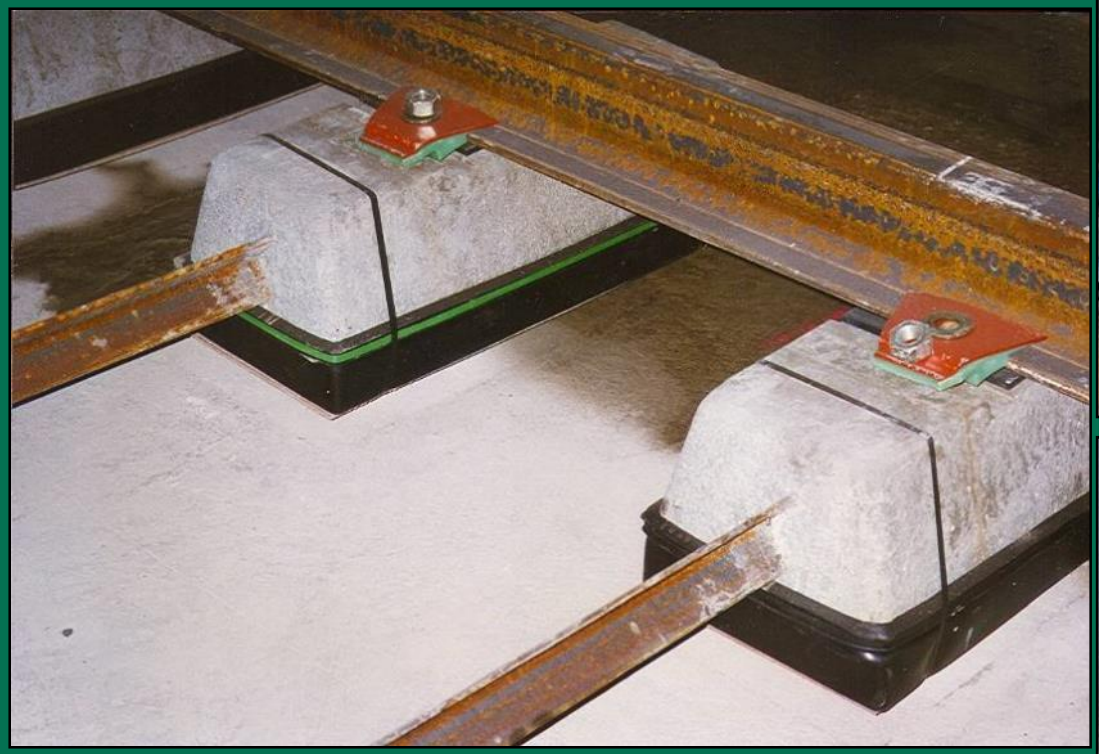


SERF – Super Elastic Direct Rail Fixation
Antwerp-Milan- Performance H to VH

SERF – Super Elastic Rail Fixation
Brussels – Performance H to VH

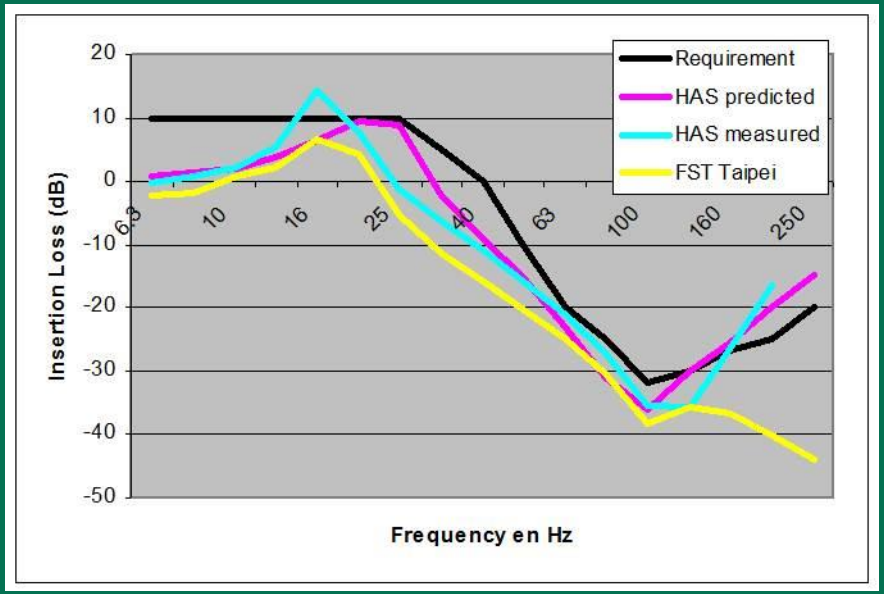


UTP – Booted twin block ties (inside tunnel)
Paris – Brussels metro – Performance Medium



UTP – Booted twin block ties (outside)
Manila – Performance Medium

UTP – Booted monoblock concrete ties
France – Performance Low-Medium-High



UTP – Preloaded ties - elastic undertie pads
Paris – Performance High

Before

After

UTP – Preloaded ties - elastic undertie pads
Charleroi (Belgium) – Performance High

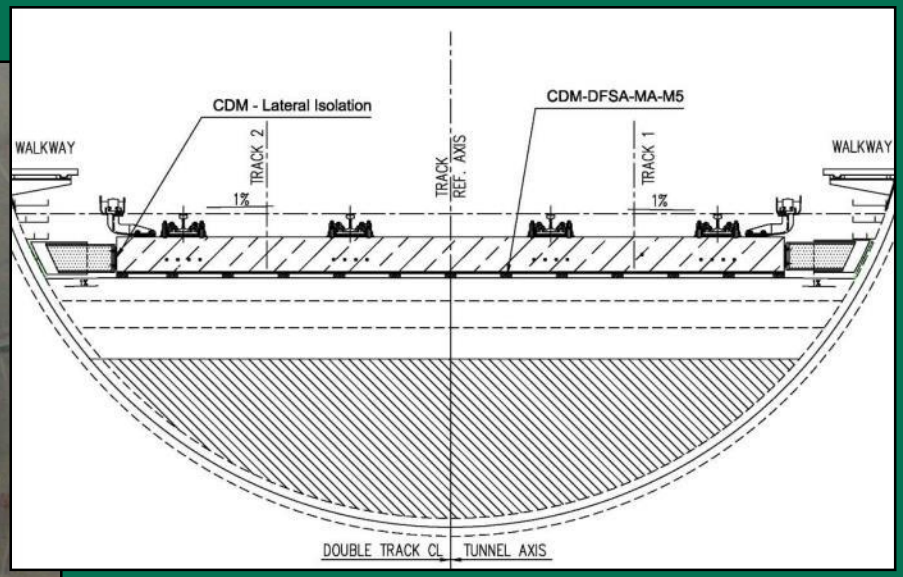
Before

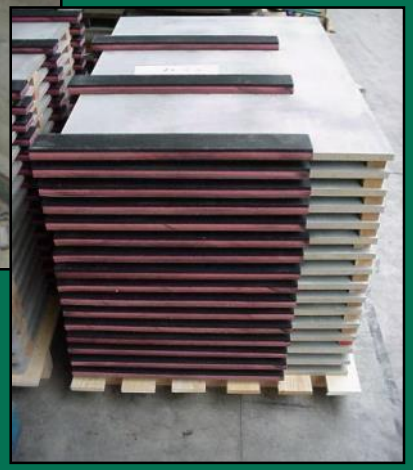
After

BM : Ballast mat (high speed train)
Performance High

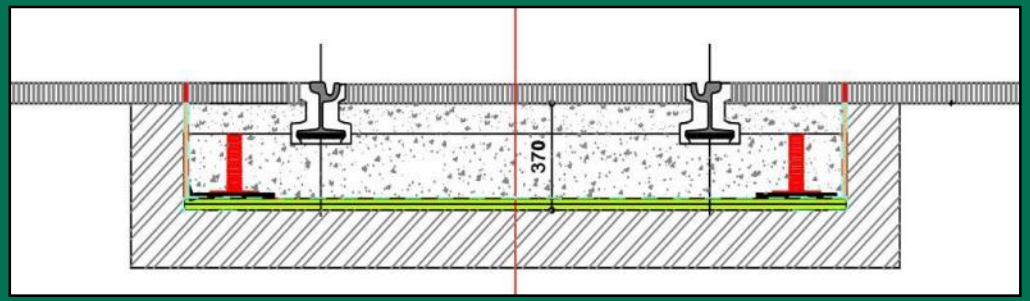
UTP and BM- Under tie pads and ballast mat Brussels- Performance Very High

FST – Floating Slab – Longitudinal elastomer strips
Athens metro- Performance Very High

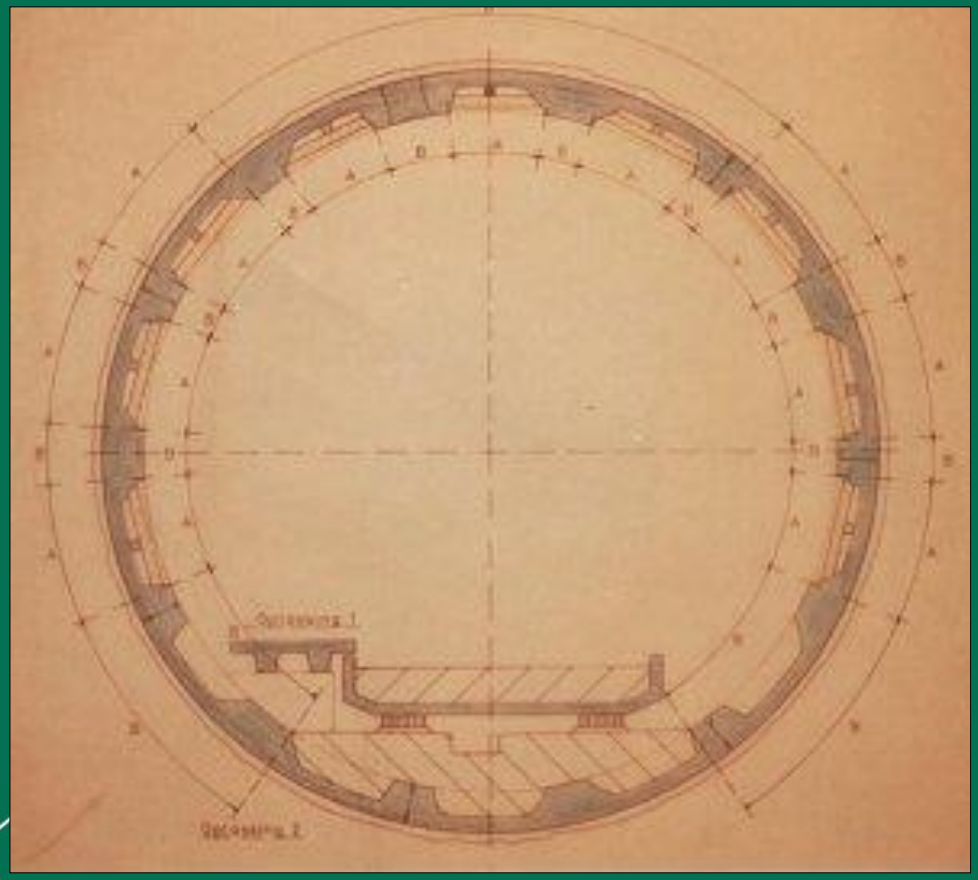


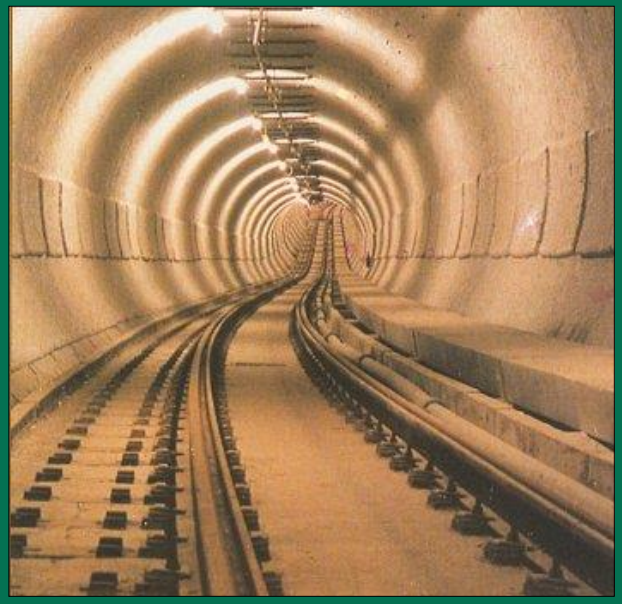


FST – Floating Slab – Continuous elastomer mat
Athens tram- Performance High

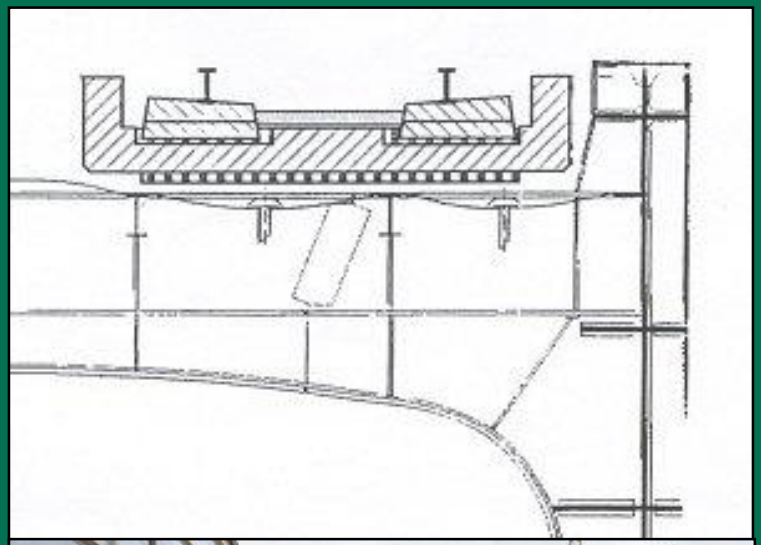


FST – Floating Slab – Discrete elastomer pads
Antwerp tram- Performance Very High



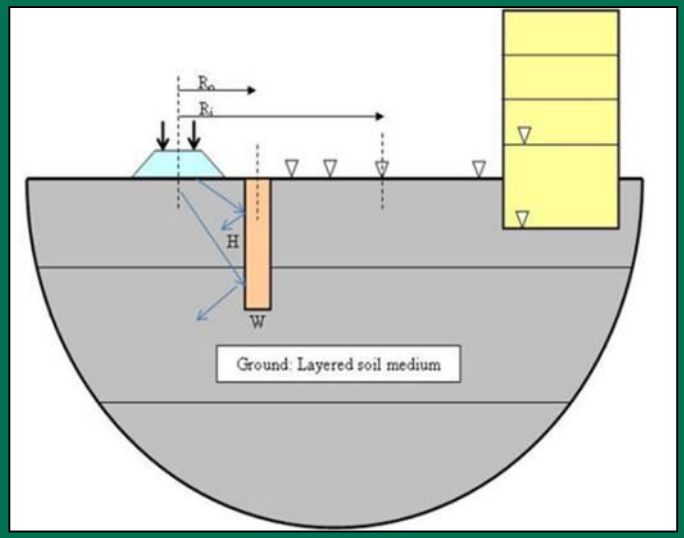


FST – Floating Slab – Transversal elastomer strips
Brussels - Performance Very High



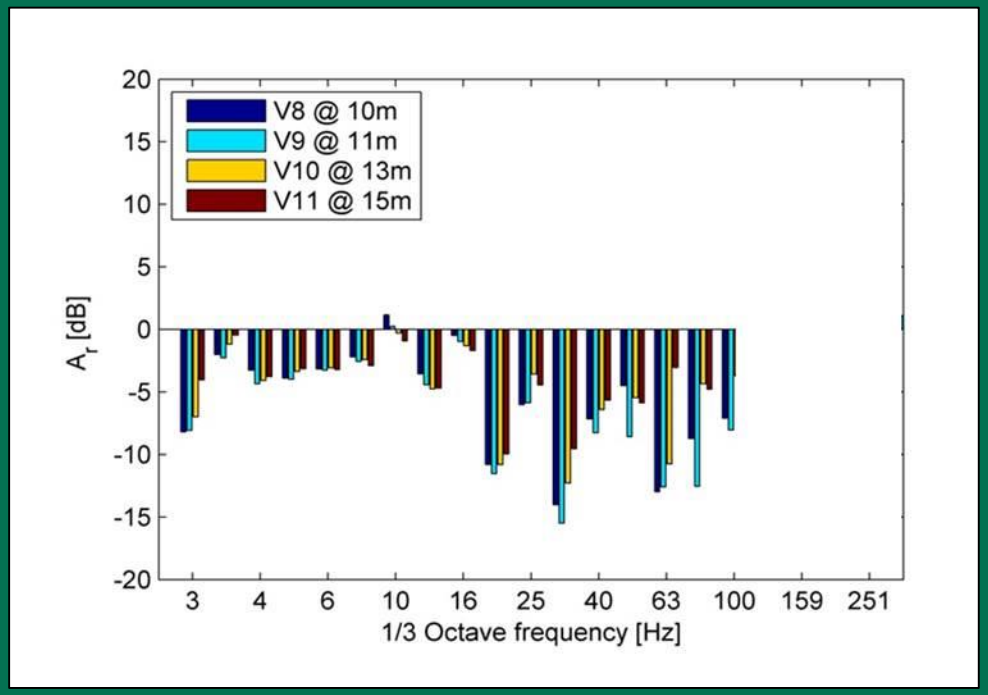
Layered soil barrier
Performance Medium to High

- Layered soil barriers
  e.g. concrete layer/softer resilient layer
  Manual excavation method
- Examples of execution:
  - Arnhem (Prorail, NL)
  - Brussels (Infrabel, BE)
- Results: reduction of vibrations
  with 6 dB in lower frequency bands
  and more than 10 dB in higher frequency bands



Wave impeding blocks in the propagation path Performance Medium to High

- Wave impeding resonance blocks: large indeformable blocks close to the tracks put on the ground
- Results: reduction of vibrations with 6 dB in lower and 10 dB in higher frequency bands



Measured insertion loss during ICE passage

Wave impeding blocks
2.4 m wide – 1 m high @ 7 m from track

Websites

- qcity.org
- urbantrack.eu
- corrugation.eu
- aptrail.com
- d2sint.com

Conclusions

- Reliable and durable vibration mitigation solutions are available for rail transport infrastructures, from low performance to very high performance solutions.
- In many cases alternatives are availble to bypass the use of the expensive floating slab : super elastic rail fasteners or super elastic undertie pads with a dynamic stiffness as low as 6 kN/mm.
- It is important to quantify exactly the vibration mitigation requirements in order to select the optimal (least expensive) vibration mitigation solution.