

THE LOW-NOISE POTENTIAL OF LOW-VIBRATION TRACK

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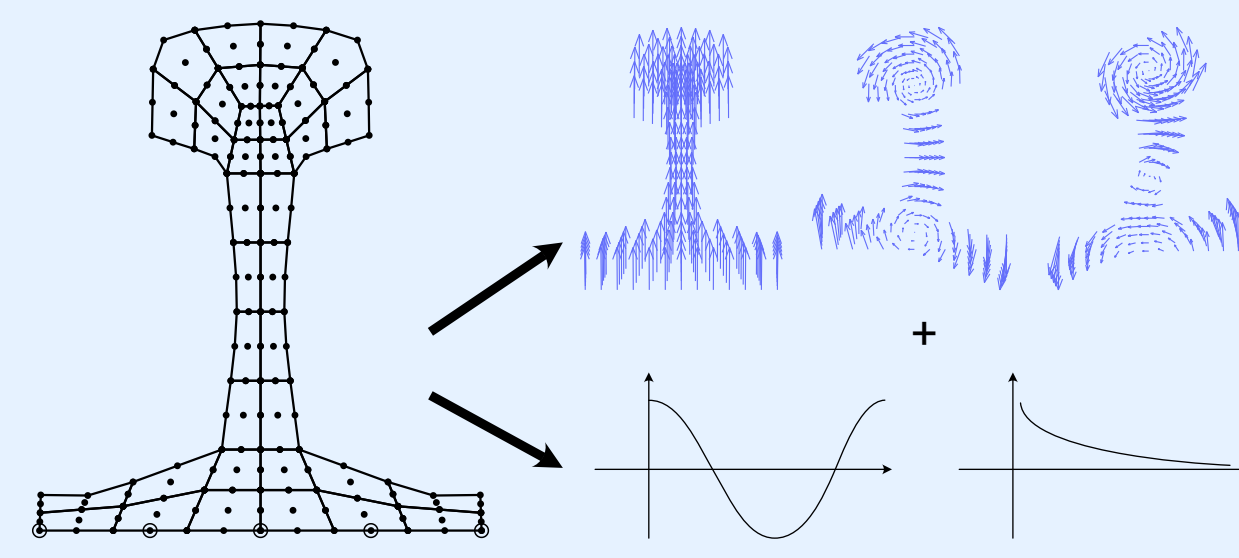
INTRODUCTION

- Low-vibration track (LVT) is a non-ballasted (slab) track developed for reducing ground vibrations
- Vibration and noise are excited by wheel and rail roughness in rolling contact
- Slab tracks produce higher rolling noise than ballasted tracks
- Why? Lower rail pad stiffness in slab tracks → decoupling of the rail
- LVT has a two-stage elastic support → allows tuning involved elasticities

Can we tune the two elasticities to preserve low ground vibration and reduce radiated airborne noise?

METHODS

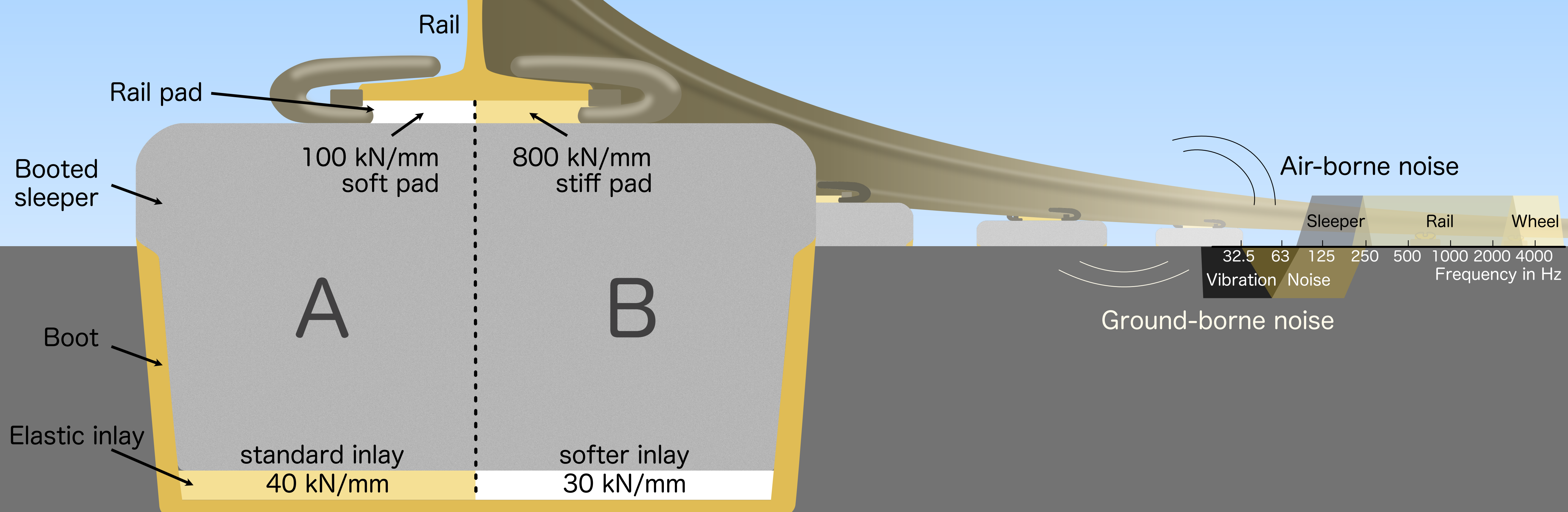
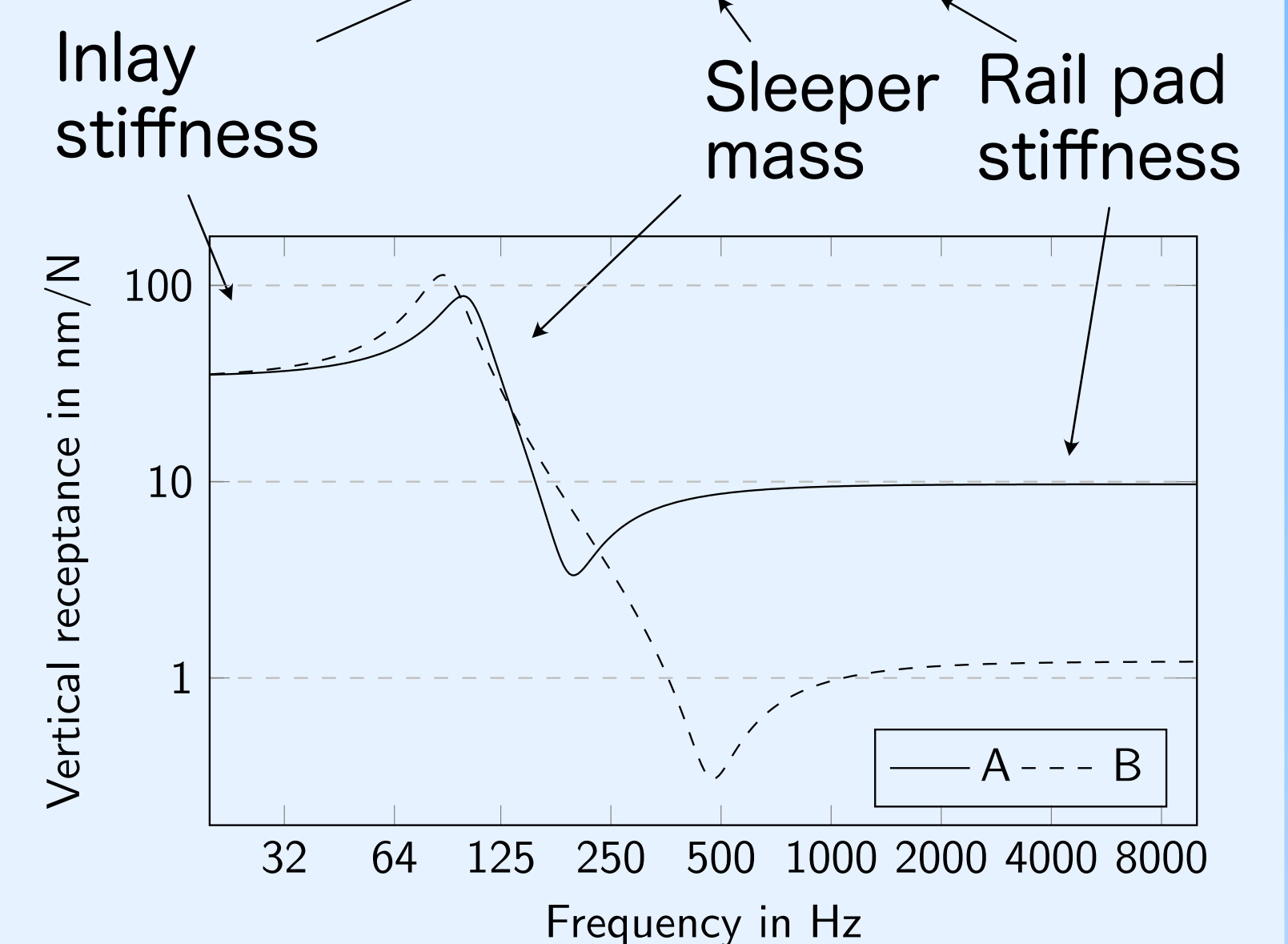
- Track decay rate (TDR) is noise indicator
- Higher decay → shorter rail section radiates
- Rail modeled as infinite waveguide (WFEM)



- WFEM coupled to spring-mass-spring system at each rail seat

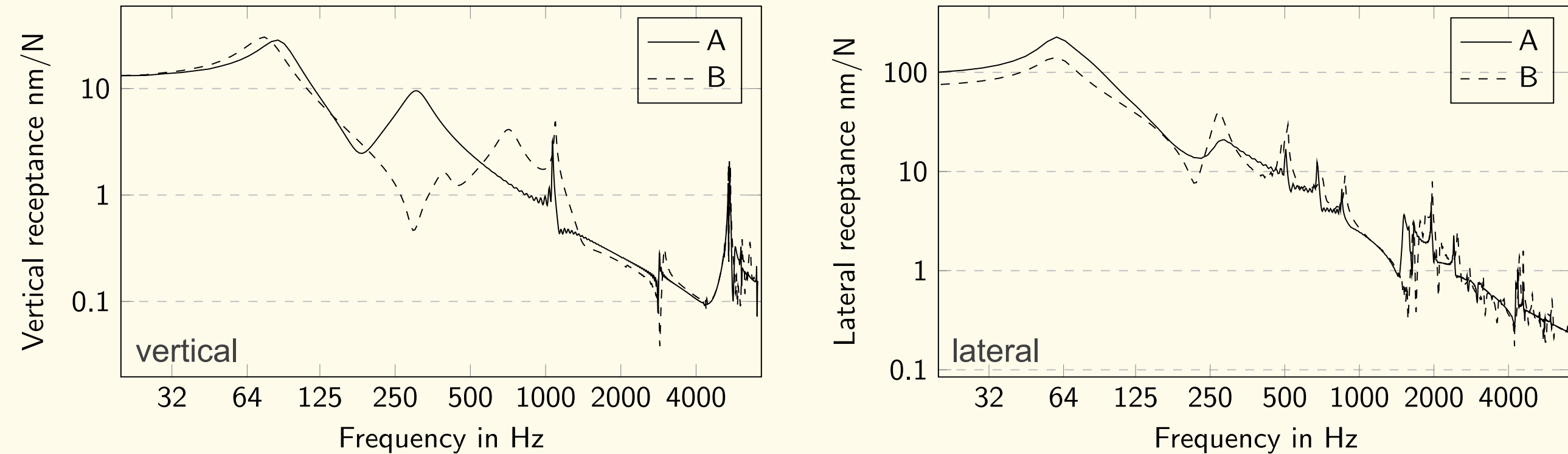
- Receptance R under the rail foot is modeled as

$$R = \frac{1}{s_i - \omega^2 m} + \frac{1}{s_p}$$

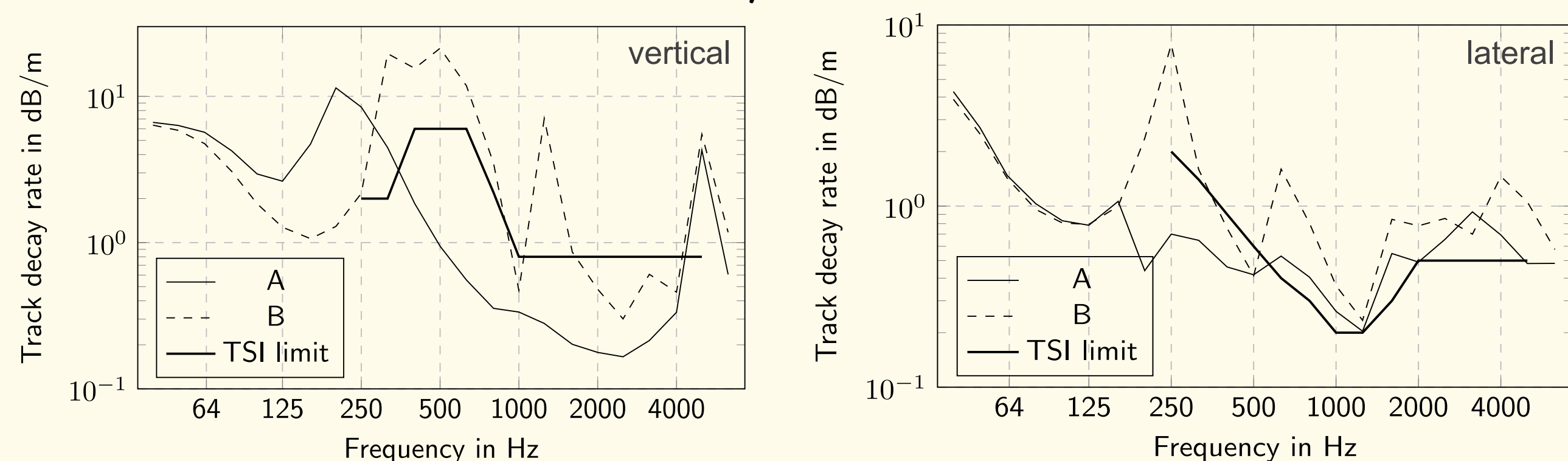


RESULTS

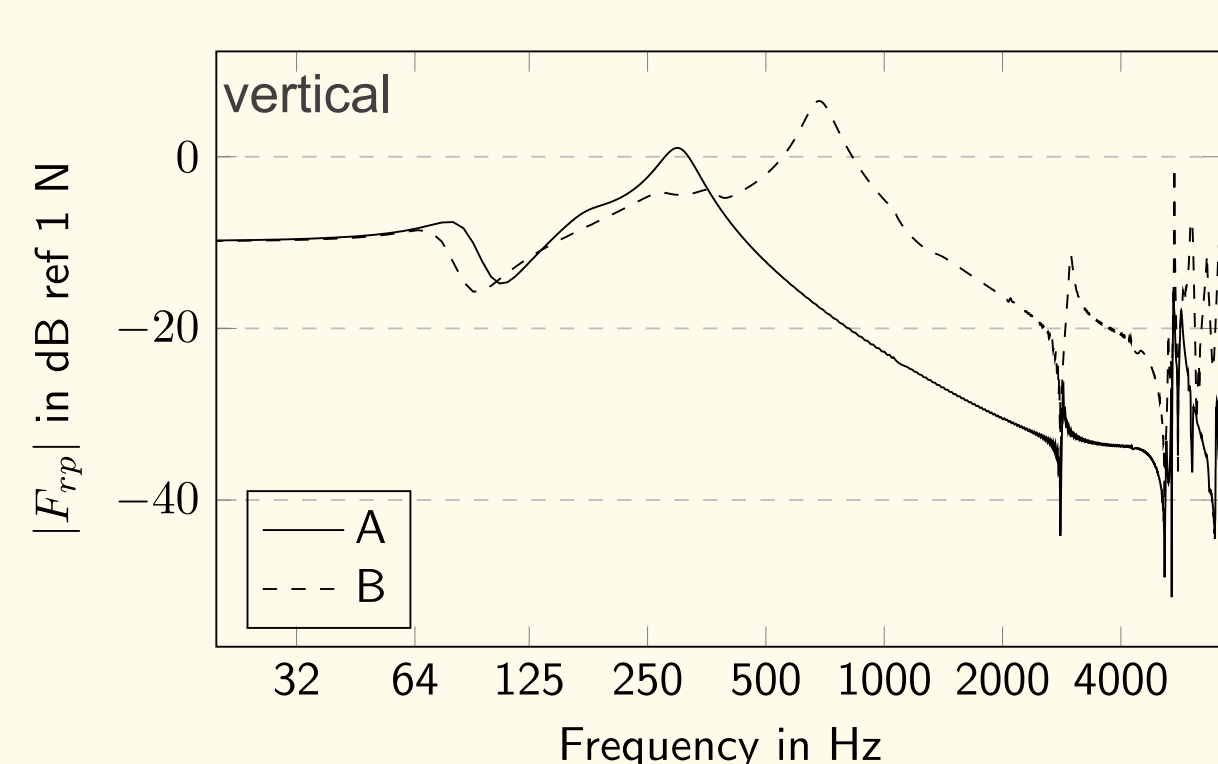
- Receptance at the top of the rail is maintained below 100 Hz



- TDR increased in significant frequency range
- Fulfills the TSI limit in more 1/3 oct bands



- Increased forces on the rail seats and sleepers



The increased TDR between 250 Hz and 2000 Hz indicates a lower sound radiation from the track.

The stronger coupling between the rail and the sleeper leads to higher forces on the sleeper and indirectly on the wheel-rail contact.

DISCUSSION

- Soft suspension at low frequencies maintained
- Increasing pad stiffness is known to reduce radiated noise from track
- Problem: increasing contact forces → higher chance of corrugation → noise
- Possibly higher costs for rail grinding
- However, comparatively low investment costs compared to noise barriers, etc.
- Could be used on tracks where other noise reduction methods are unfeasible
- Further research: quantifying sound pressure difference and comparing to actual measurements in cooperation with SBB

CONCLUSIONS

- Developed a model for predicting TDR on LVT
- Increasing rail pad stiffness and compensating by decreasing inlay stiffness → higher TDR in relevant frequency range while maintaining soft response at low frequencies
- Further investigation into the effect of increased contact forces recommended

Thompson, D. J. (2009). Railway noise and vibration: Mechanisms, modelling and means of control (1st ed). Elsevier.
 Nelson, J. T. (1996). RECENT DEVELOPMENTS IN GROUND-BORNE NOISE AND VIBRATION CONTROL. JSV, 193(1), 367-376.
 Nilsson, C.-M., Jones, C. J. C., Thompson, D. J., & Ryue, J. (2009). A waveguide finite element and boundary element approach to calculating the sound radiated by railway and tram rails. Journal of Sound and Vibration, 321(3-5), 813-836.
 Zhang, X., Jeong, H., Thompson, D., & Squicciarini, G. (2019). The noise radiated by ballasted and slab tracks. Applied Acoustics, 151, 193-205.
 Gautier, P.-E. (2015). Slab track: Review of existing systems and optimization potentials including very high speed. Construction and Building Materials, 92, 9-15.
 Lombaert, G., Degrande, G., Kogut, J., & François, S. (2006). The experimental validation of a numerical model for the prediction of railway induced vibrations. Journal of Sound and Vibration, 297(3-5), 512-535.
 Diehl, R. J., Nowack, R., & Hölzl, G. (2000). SOLUTIONS FOR ACOUSTICAL PROBLEMS WITH BALLASTLESS TRACK. JSV, 31(3), 899-906.

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