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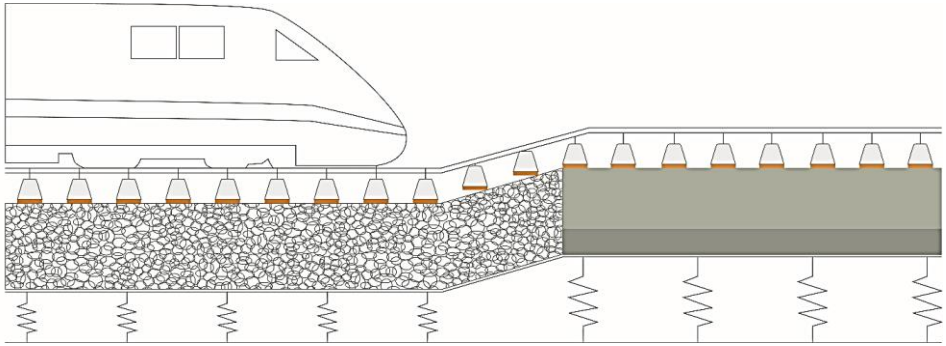
Elasticity in Railway Superstructure:

Managing Track Stiffness in Transition Zones and Turnouts

Martin Quirchmair

What is the Problem?

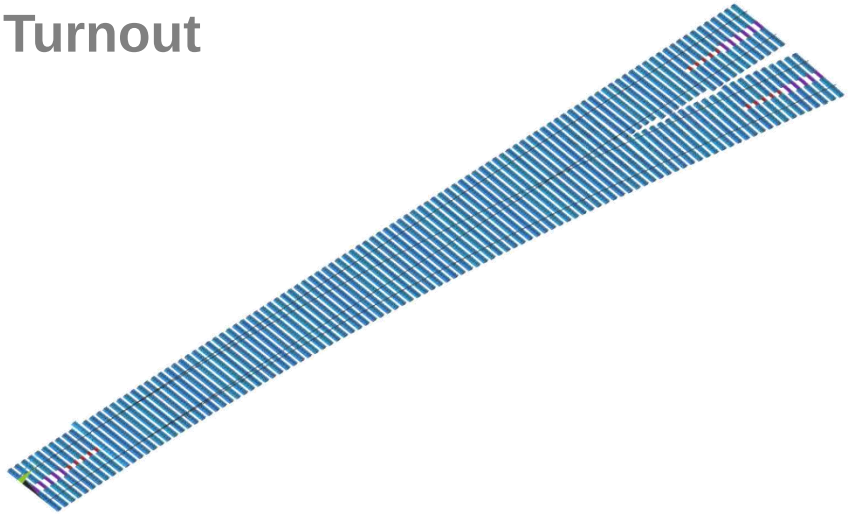
Transition Zone

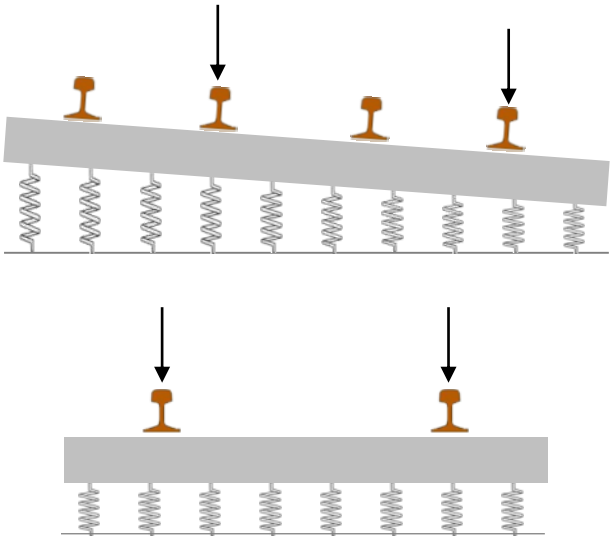


→ Change of track parameter because of different superstructure

(Stiffness, Settlement,…)

Turnout





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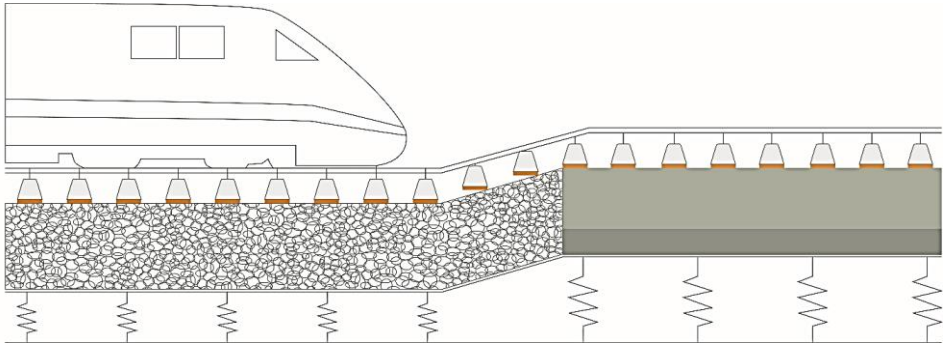

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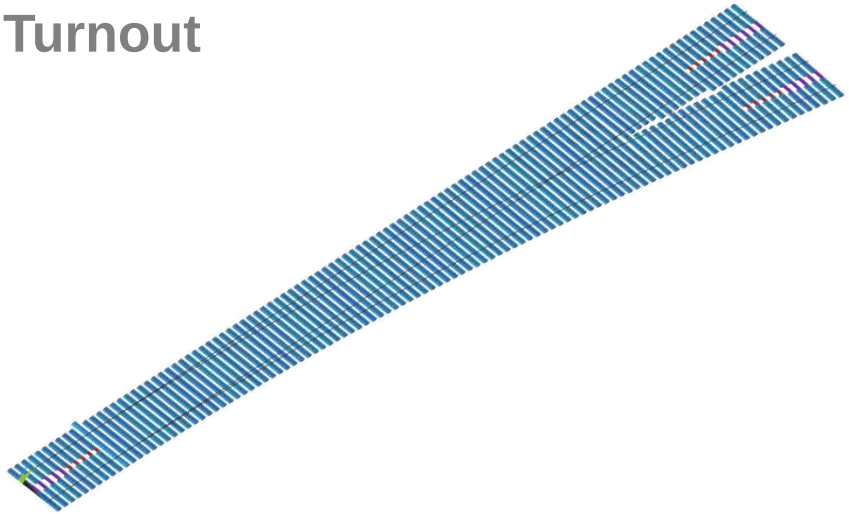
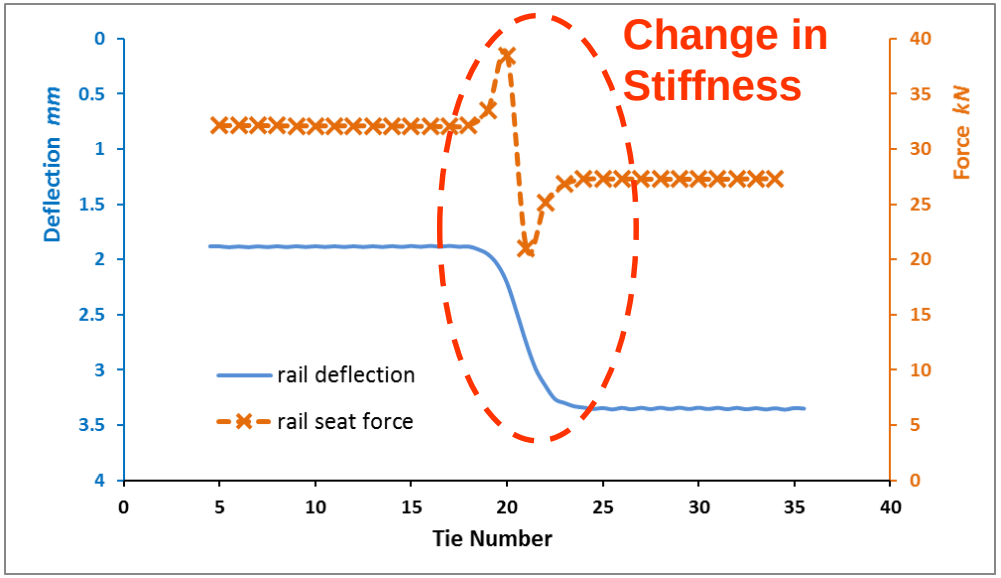


- Change of stiffness because of change in track geometry
  (Ties, frog,…)
- Tilting of turnout ties because of off-center loads
- Turnouts cause much higher maintenance expenses (minimum 5 times higher compared to regular track)

Effects

High dynamic forces cause defects and damages!



Broken clips

Settlement

Tie hollowness

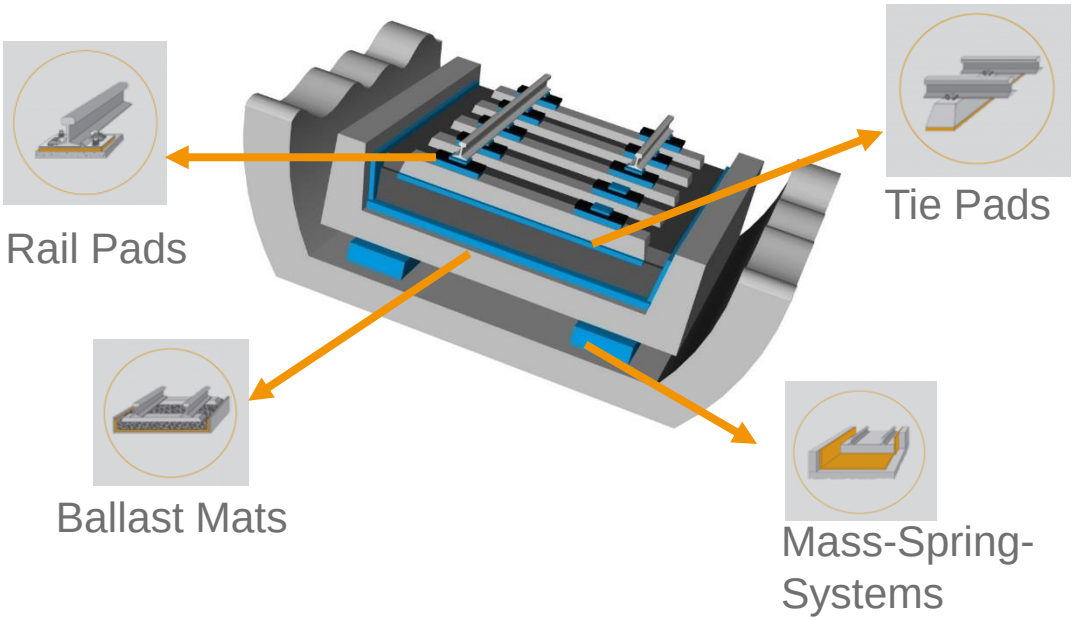
Deterioration of ties and ballast

Reduced Forces

Why elasticity? → To reduce dynamic forces and prevent damages!

Additional elastic elements help to adjust stiffness between different superstructures!

- → lower the forces on the superstructure
- → prevent damages
- → prolong lifetime of all components
- → reduce settlement
- → reduce maintenance



Guidelines for Designing

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Possible Design Approach:

- Given dynamic rail deflection during train passage

↓

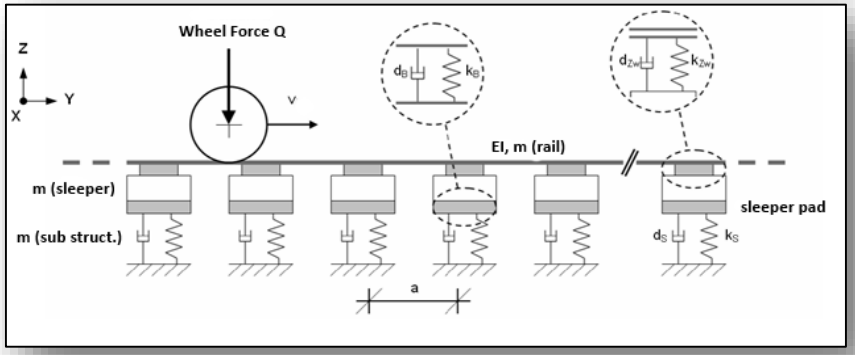
Adjustment of the overall track stiffness using sleeper pads, baseplate pads, rail pads or ballast mats with designed stiffness

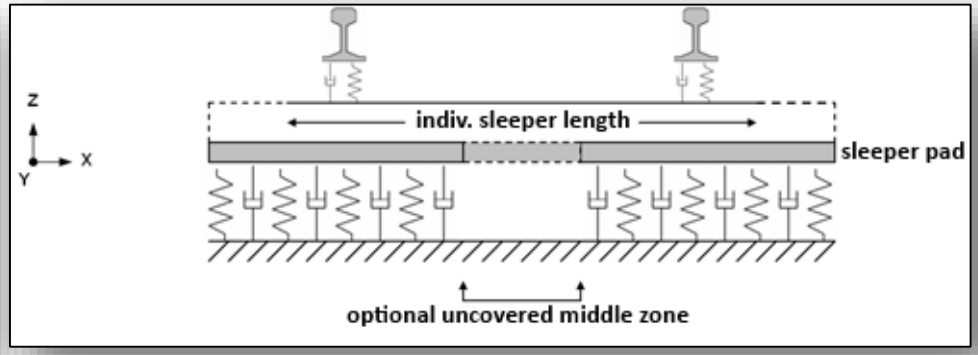
- Long term settlement of the track

↓

Reduction due to elastic elements e.g due by increasing the contact surface between ballast and substructure

Calculation Model / FEM





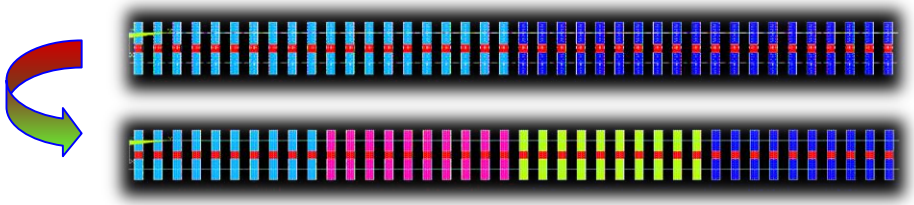
- **Different elastic layers**
  - Substrucure
  - Under ballast mats / Tie Pads
  - Ballast
  - Rail pads
- **Different designs**
  - Ballasted track
  - Slab track / Transition Slabs
  - Mass spring systems
  - Ties

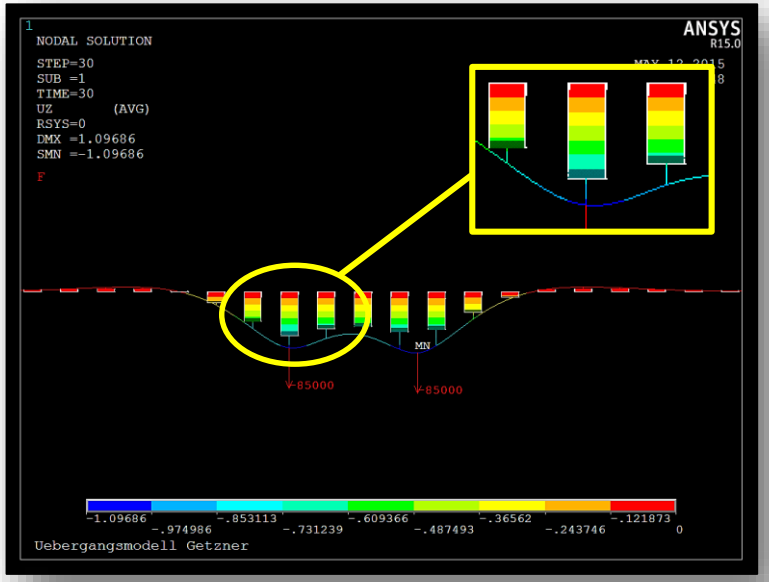
Advantage of finite element method (FEM) compared to analytic calculation modells (*"infinite continously bedded beam"*):

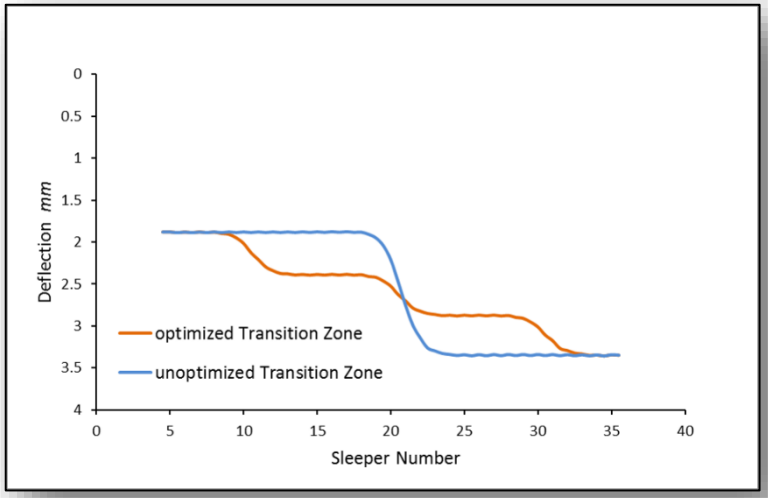
- FEM allows to compute track sections with spontaneously changing parameters (tie pads, ballast mat, tie spacing, ballast height, substructure,...)
- Calculation of static and dynamic loads also where stiffness changes

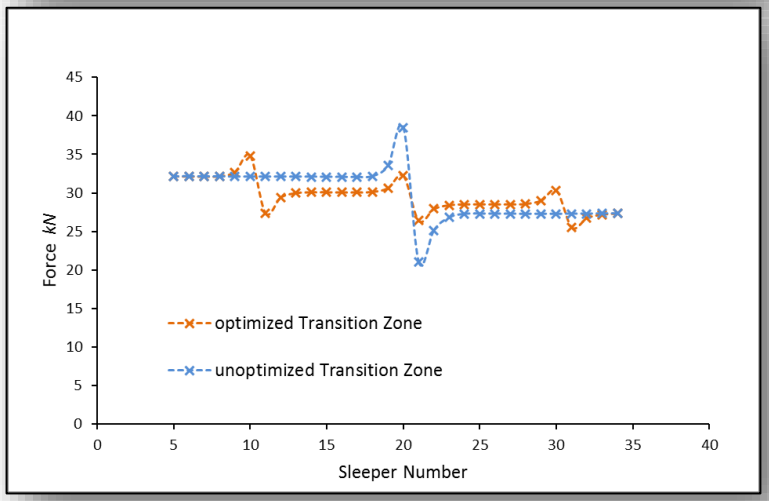
Calculation Transition Zone

- Calculation of different track parameters
  - Deflection (rail pad, TP,...)
  - Rail seat forces
  - etc.



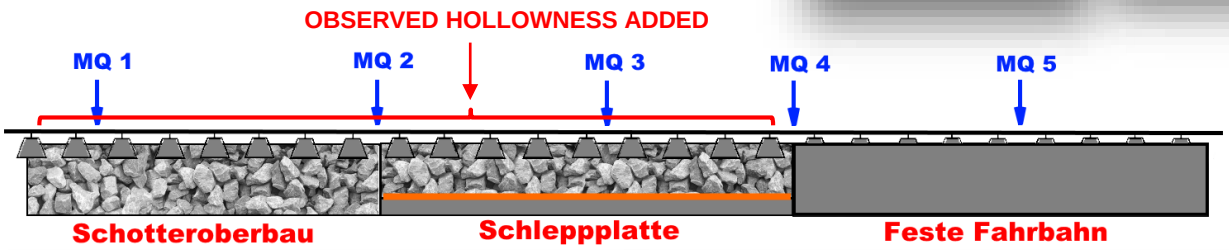


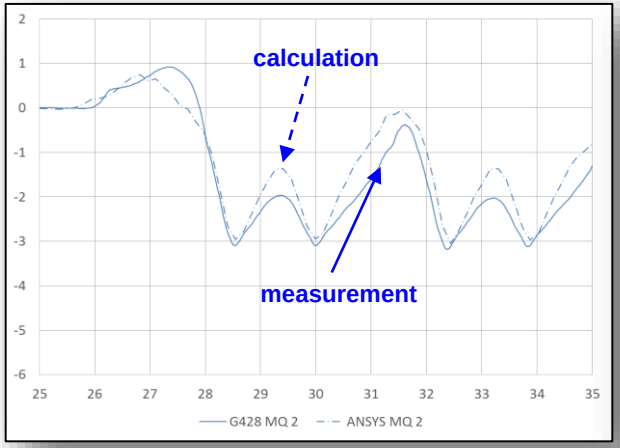


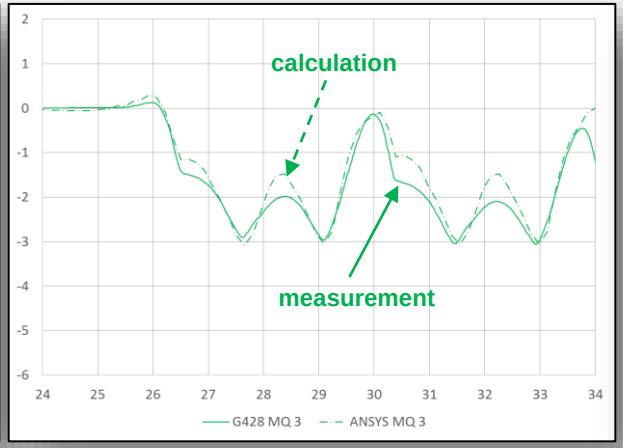


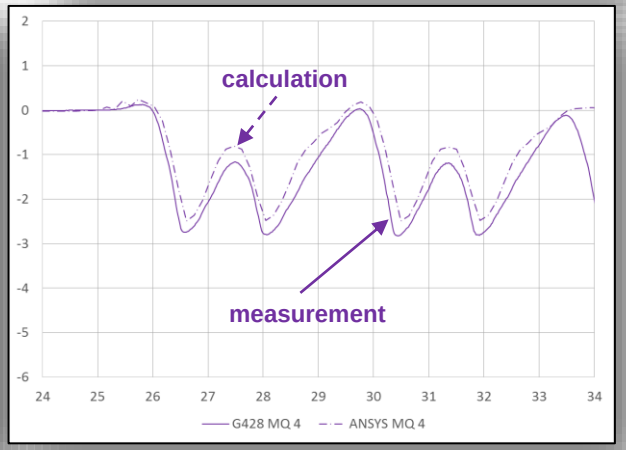
Calculation Transition Zone

- Example: Heavy Haul
  - Rail deflection measurements
  - Slab track → ballasted track
  - 45to axle load
  - Potenial of FEM-Model



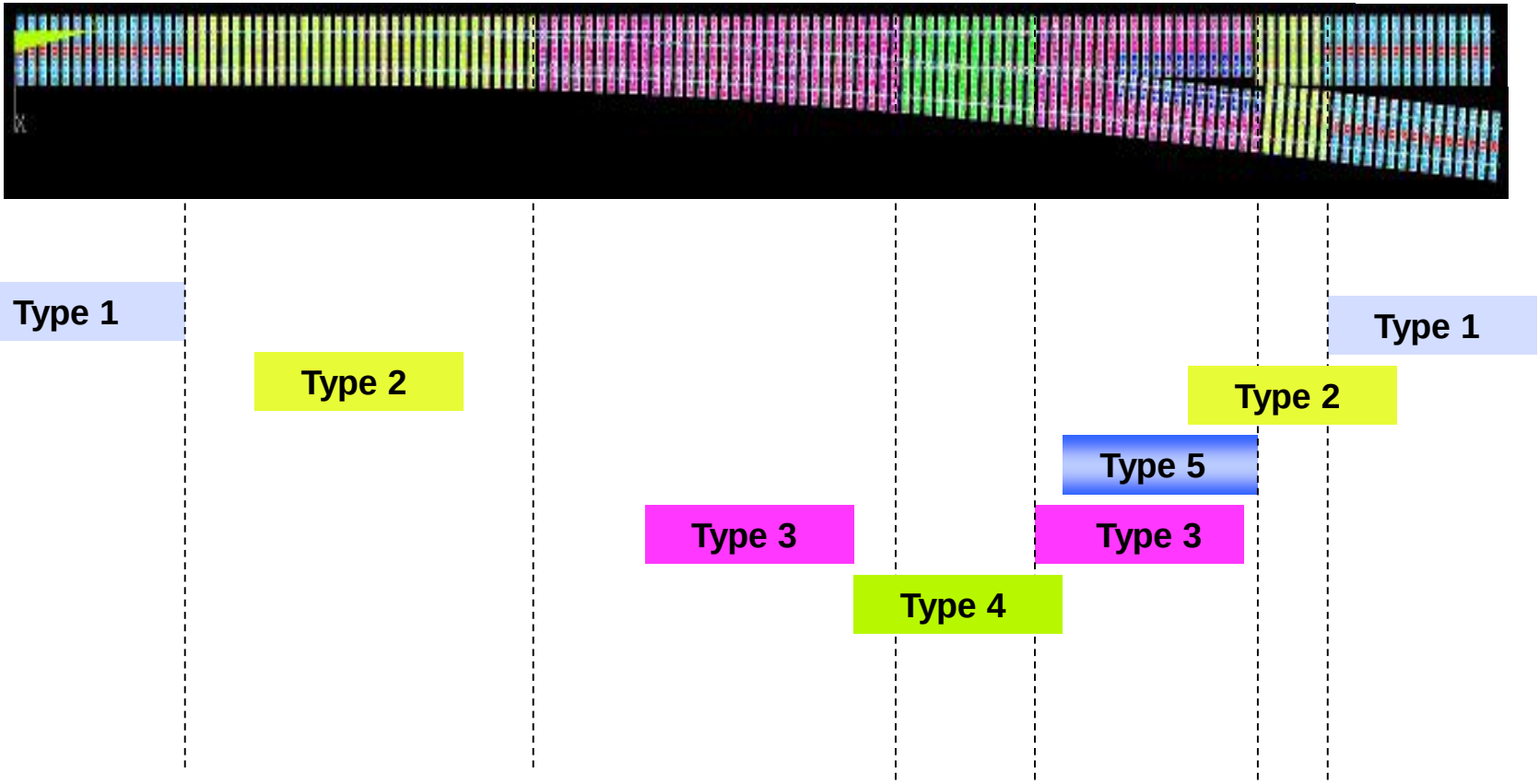






Calculation Turnout

High Speed Track - Solution with → Tie Pads



Different bedding modulus and behavior

Calculation Turnout

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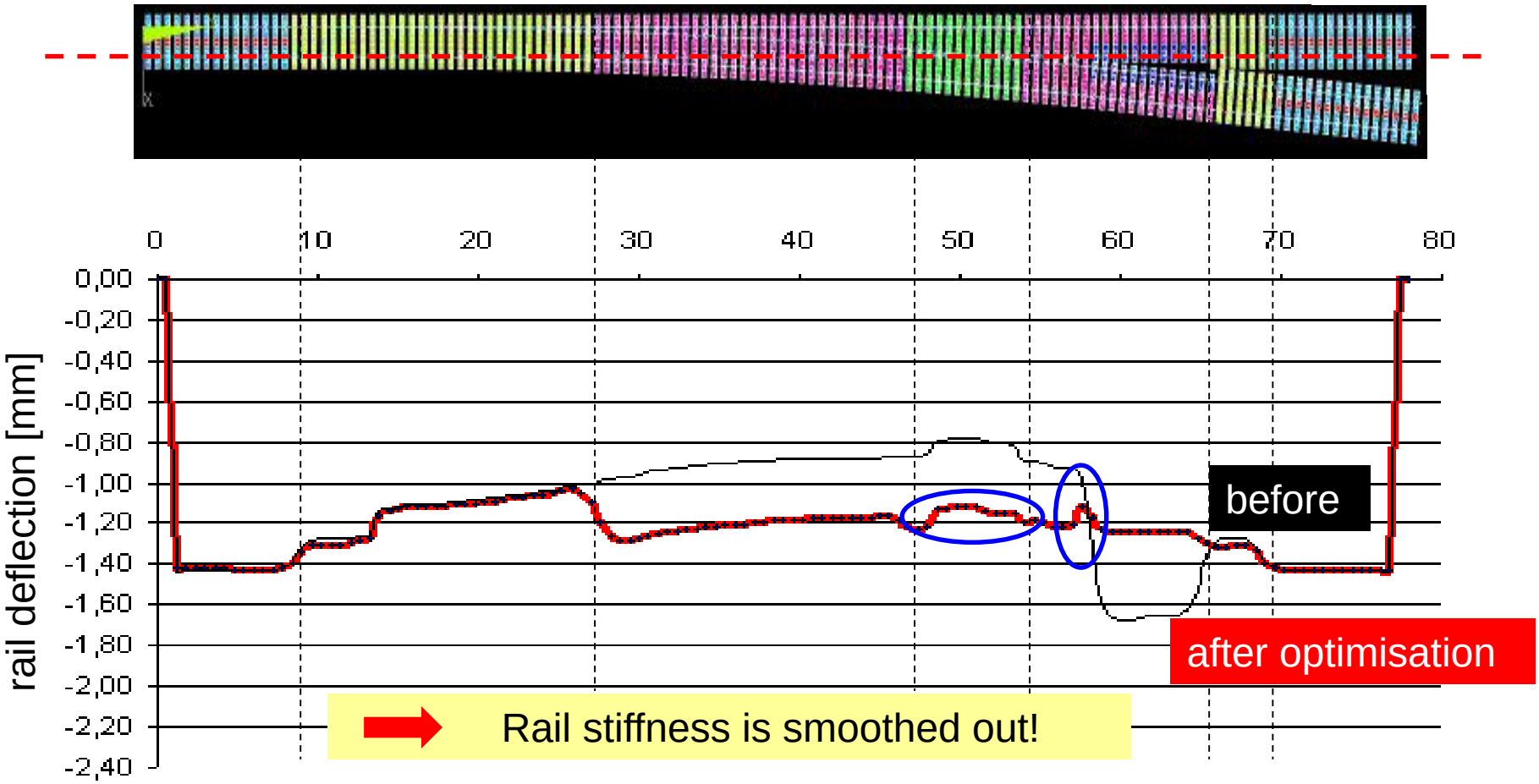
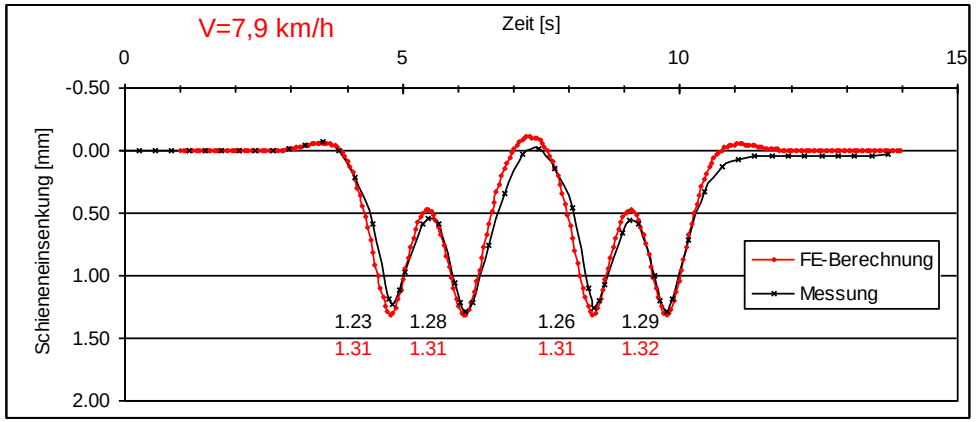
Results of optimisation



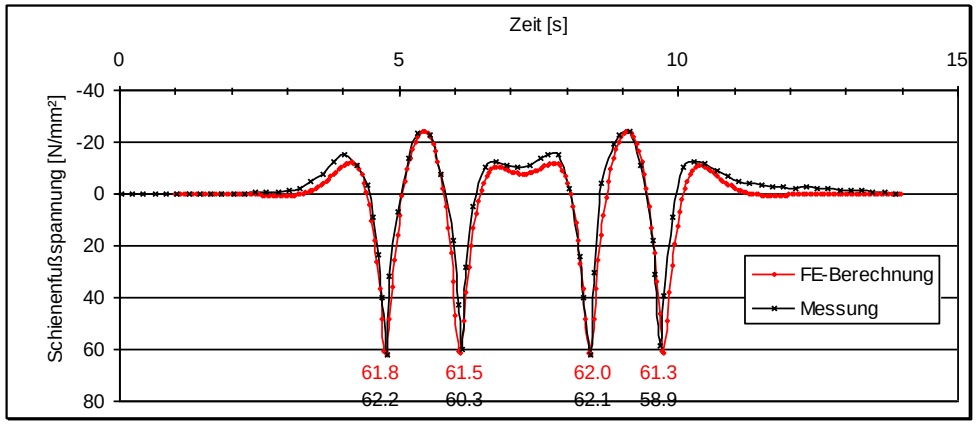
Calculation Turnout

Sector 1: Verification of the dynamic structural behavior on part model

Turnout bearers with Under Sleeper Pads in slab of Sittenbergtunnel



Rail deflection



Railfoot stress

Calculation Turnout

Sector 1: Verification of the dynamic structural behavior on part model

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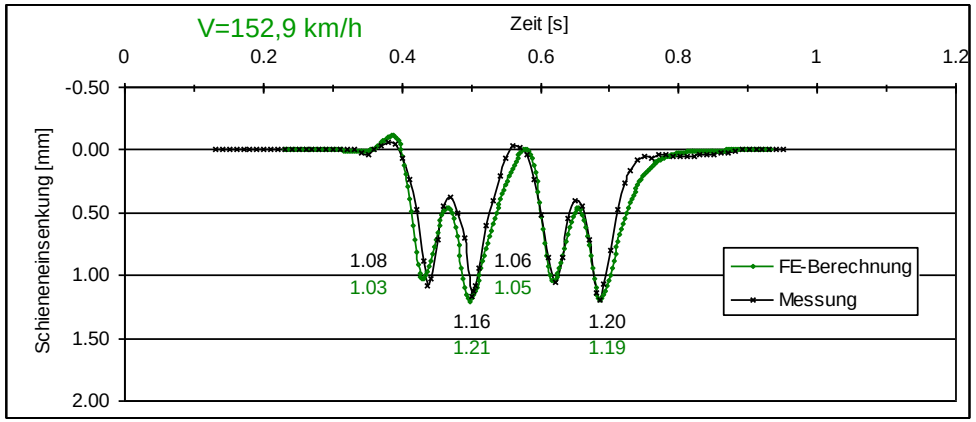

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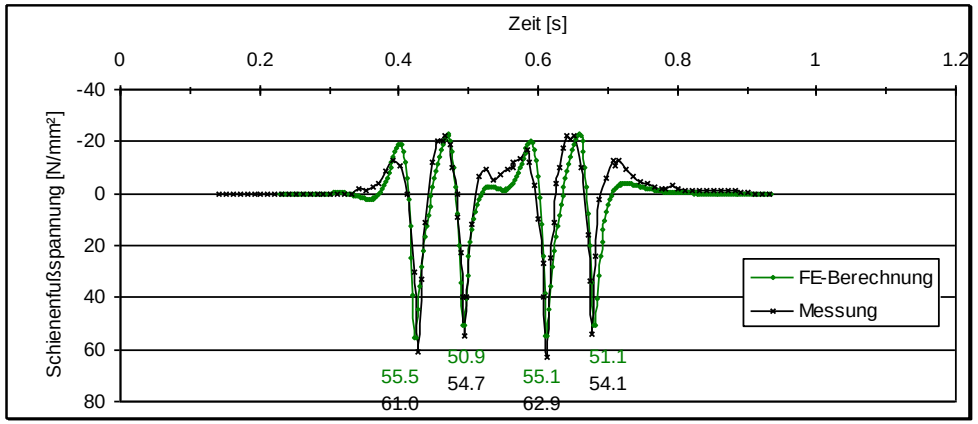
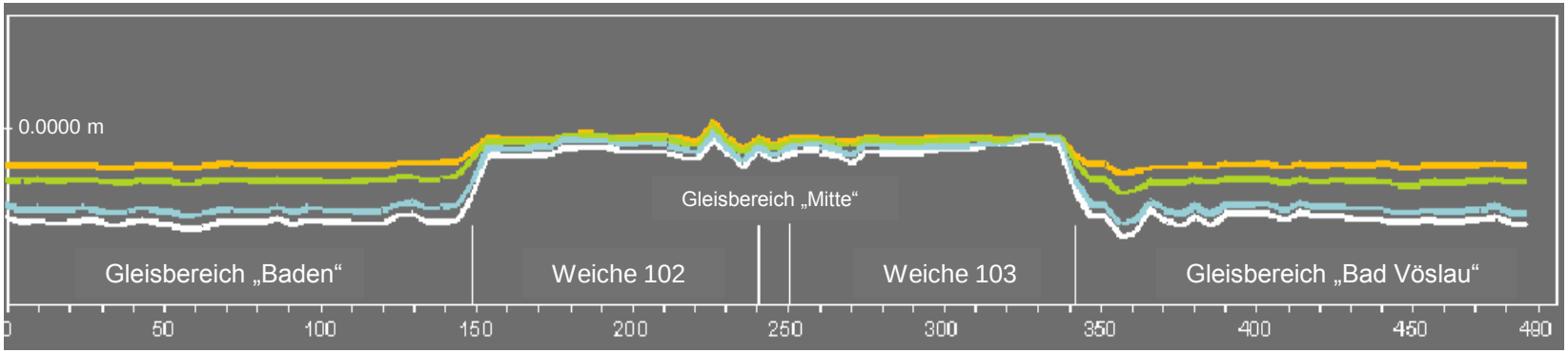


Railfoot stress

Experience gained in the track

Nullmessung vom 21. Oktober 2002
Erstmessung vom 4.,5. und 6. November 2002
Zweitmessung vom 2.,3.,4. Dezember 2002
Drittmessung vom 1. und 2. April 2003
Viertmessung vom 22. und 23. Juli 2003

Settlement



EW UIC60-1200-1:18,5 Fz(Be)Li EW UIC60-1200-1:18,5 Fz(Be)Re

Regular Track
Turnouts with Sleeper Pads
Transition Zones with adjusted stiffness

Benefits of Solution

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Benefits of Solution with elastic Elements:

- Reduction of dynamic influences
  under local change in track stiffness
- Lowering of large stiffness gradients
  in the track
- Reduction of settlement
  especially at transitions to fix points
- Reduced maintenance
  due to lower stress for all components
- Less sloworders and hindrances
  ability of keeping track quality high over a longer timeframe

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