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Behaviour of slab track under extreme stress conditions

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Proposed advantages of slab track for high-speed railways

- ⇨ Durability
- ⇨ Low maintenance costs
- ⇨ Economical selection of route elements

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Slab track development in Germany accompanied by BAUGRUND DRESDEN

- ⇨ Slab track field test (e.g. Breddin-Glöwen, Waghäusel, Eckartshausen)
- ⇨ High-speed line from Hannover to Berlin
- ⇨ High-speed line from Cologne to Frankfurt/Main
- ⇨ High-speed line from Nuremberg to Ingolstadt

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Influences on the load-bearing behaviour of slab track

- ⇨ Dynamic axle loads, depending on static axle loads, train velocity, vehicle and track component quality, properties of the substructure
- ⇨ Temperature effects
- ⇨ Cyclic behaviour of slab and substructure
- ⇨ Building process

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Characteristics of the standard calculation method for slab tracks in Germany

- ⇨ Design leads to safe tracks and durable slab structure under standard stress conditions
- ⇨ Determination of behavioural reserves of slab track under standard stress conditions is not possible
- ⇨ Determination of the behaviour of slab track under extreme stress conditions is not possible
- ⇨ Simplified approach to the underground reaction, the dynamical behaviour and the interaction between the layers of the slab structure

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Model aspects of the load-bearing behaviour of slab track

- ⇨ Splitting temperature and axle loads
- ⇨ Safety factors for loads (UIC) and material properties
- ⇨ Simplified approach to the mechanical model concerning interval and width of cracks
- ⇨ Substructure model as ground reaction

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Model aspects of the load-bearing behaviour of slab track

- ⇨ No failure but suggested reduction of serviceability and shortening of life cycle
- ⇨ Many influence factors and the time dependent behaviour of slab track make general approaches very difficult
- ⇨ Work on special parts and calibrate the calculations with test results, observations and measurements

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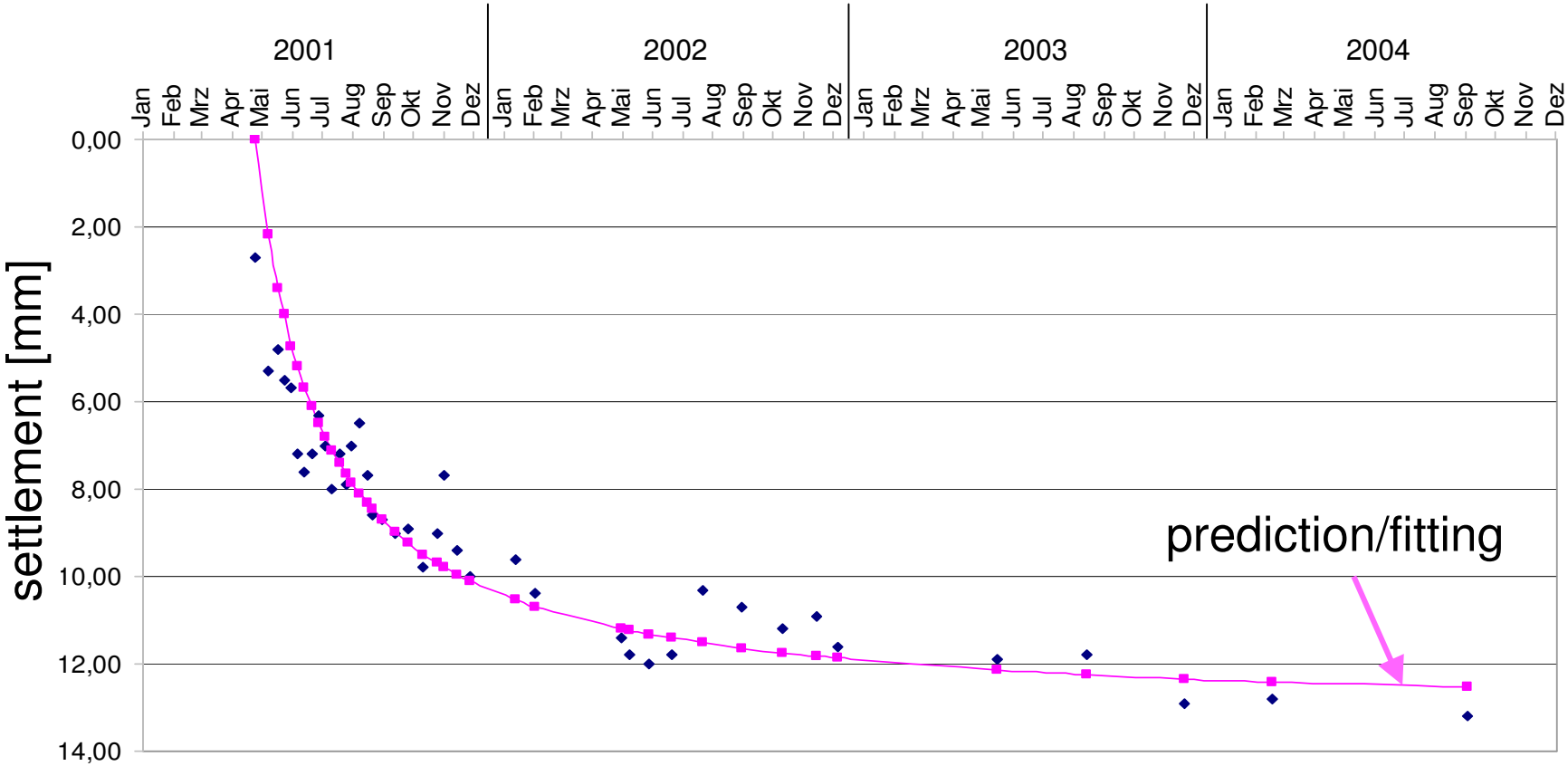

Time depending settlement at so called white dam (high speed line from Colongne to Frankfurt/Main, km 121,841-122,070)

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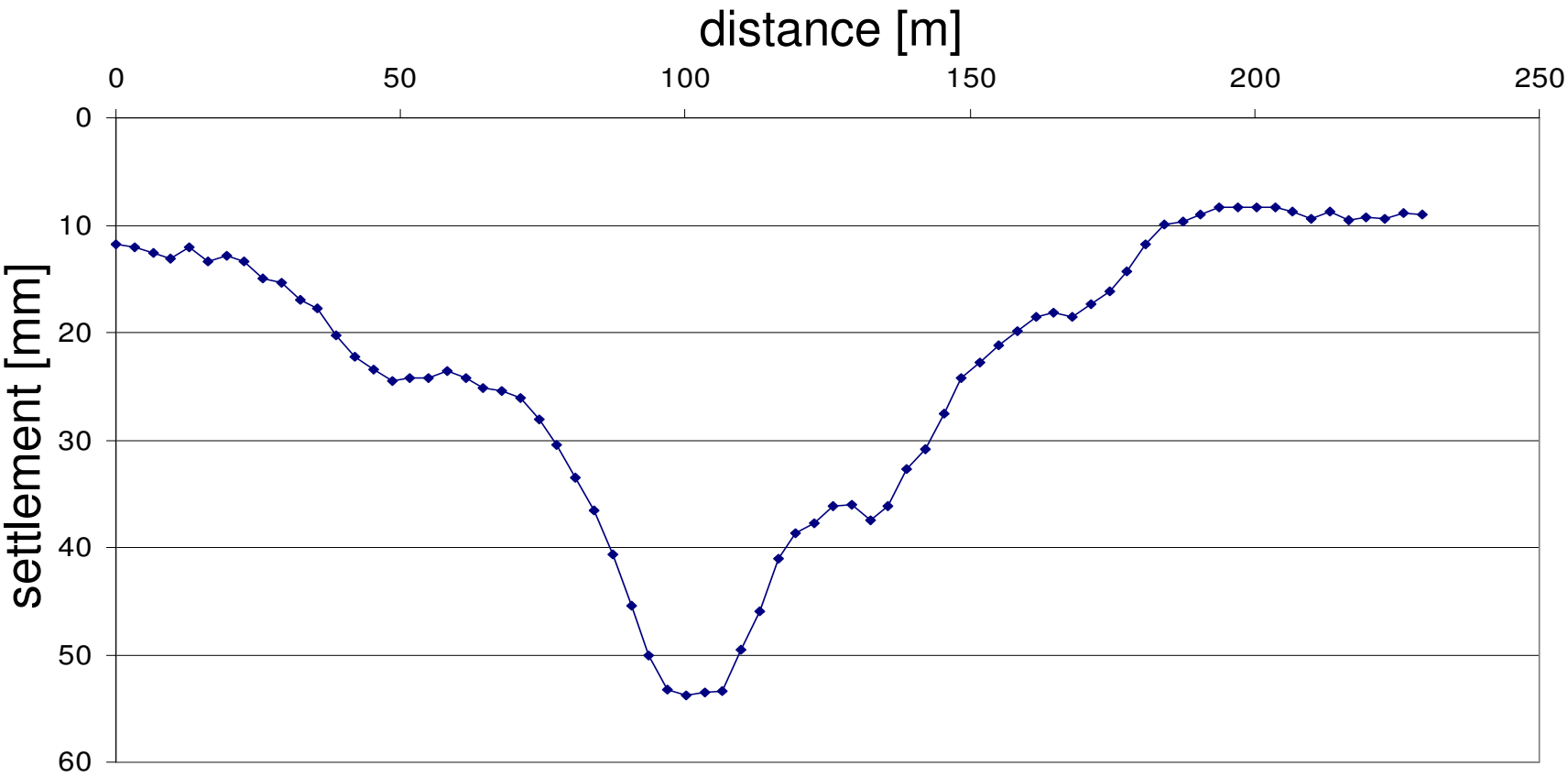

Settlement under the rail at so called white dam (high speed line from Colongne to Frankfurt/Main, km 121,841-122,070)

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Dam with extreme settlement (high speed line from Colongne to Frankfurt/Main, km 72,602-72,692)

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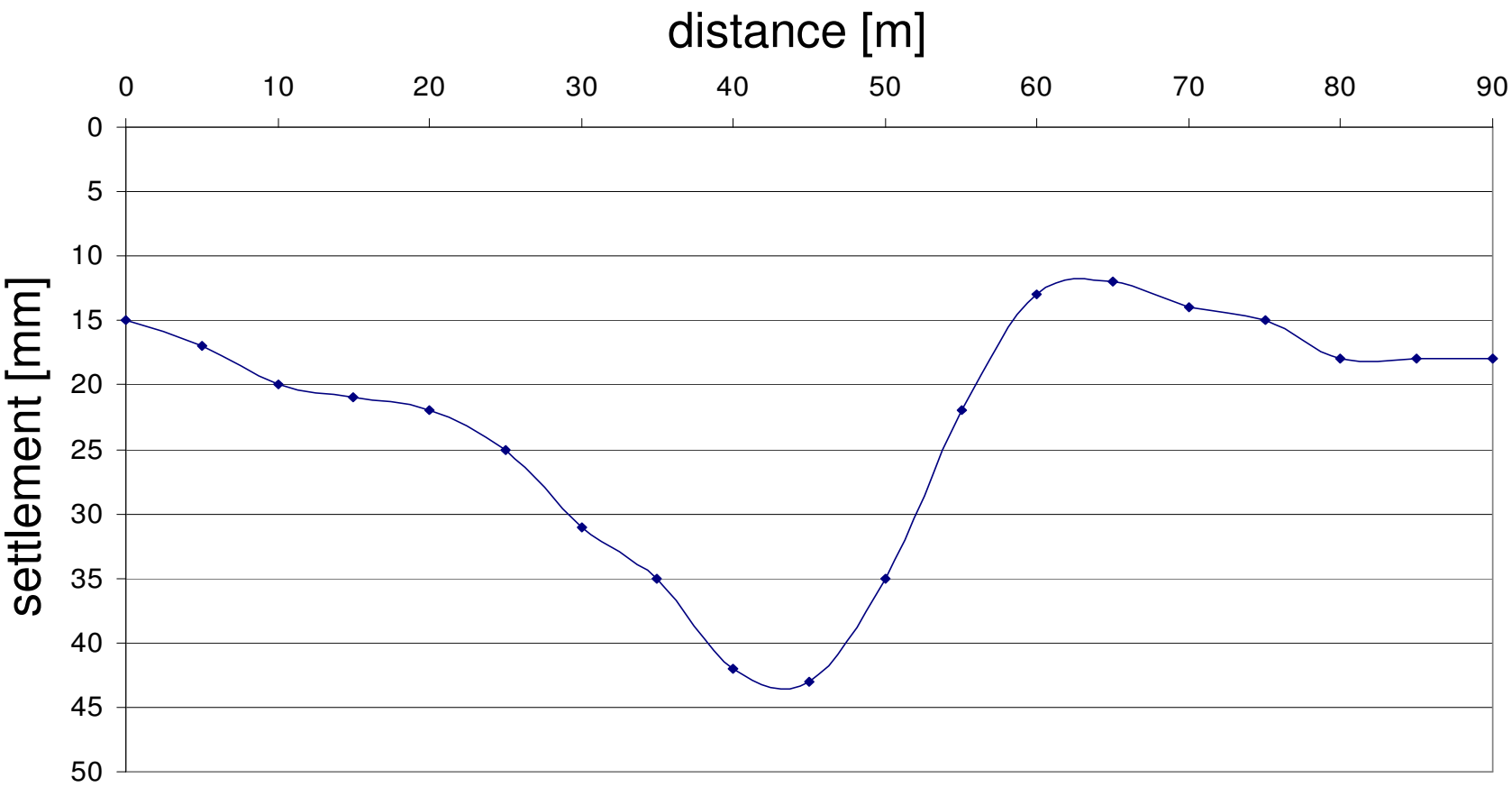

Settlement till February 2004 (high speed line from Colongne to Frankfurt/Main, km 72,602-72,692)

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Slab track without visible defects (high speed line from Colongne to Frankfurt/Main, km 72,602-72,692)

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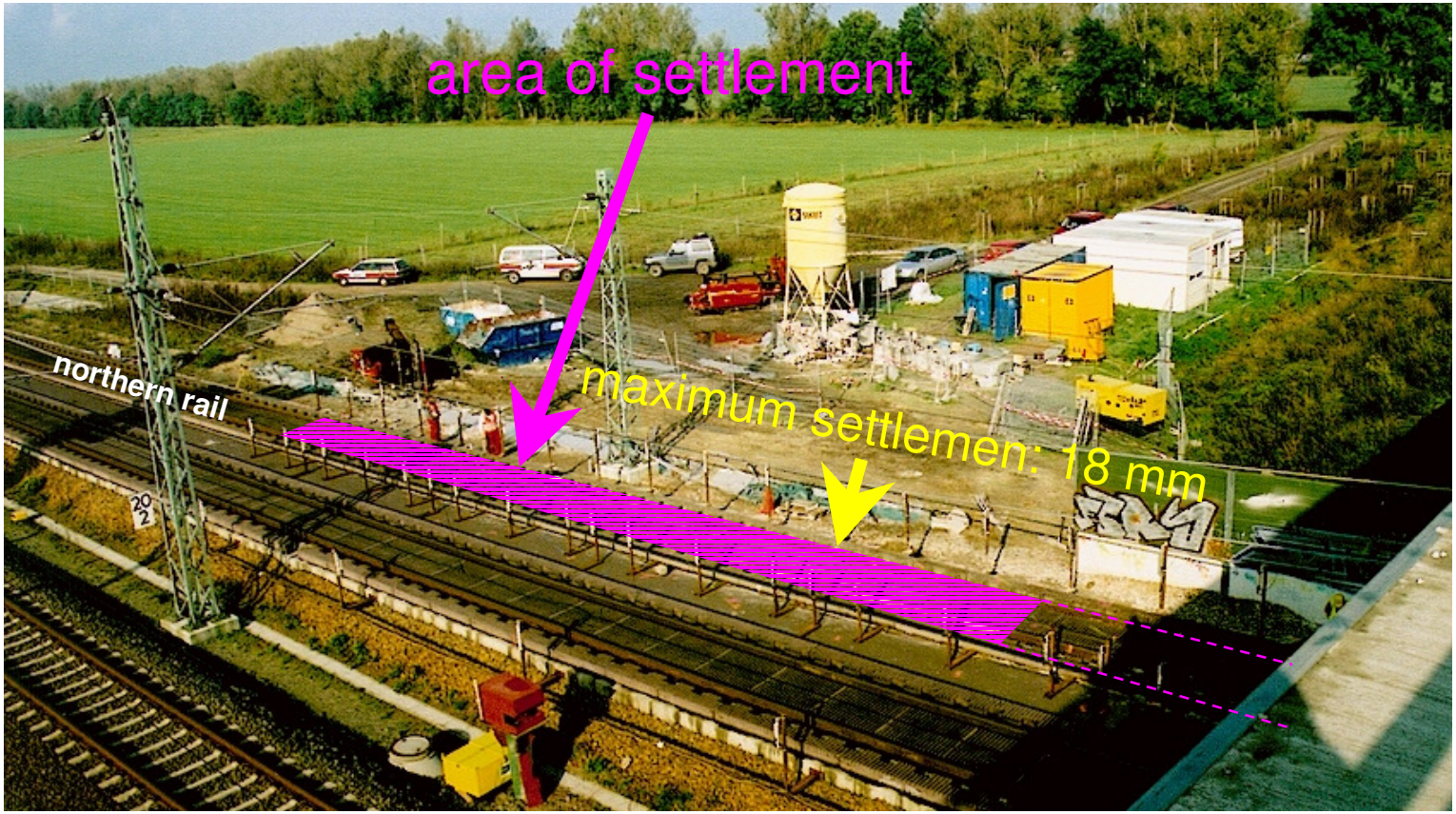

Settlements at high speed line from Hannover to Berlin, Dallgow

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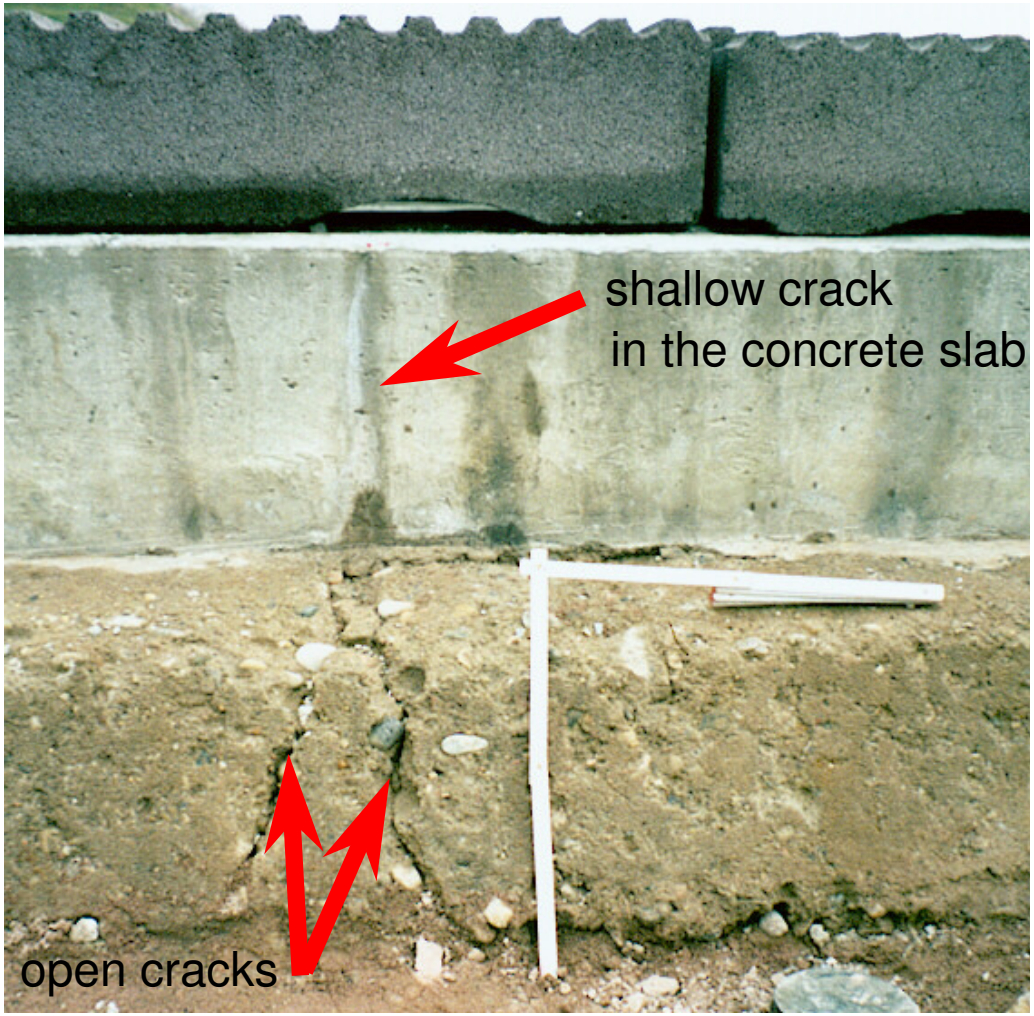

Cracks in the slab structure at high speed line from Hannover to Berlin, Dallgow

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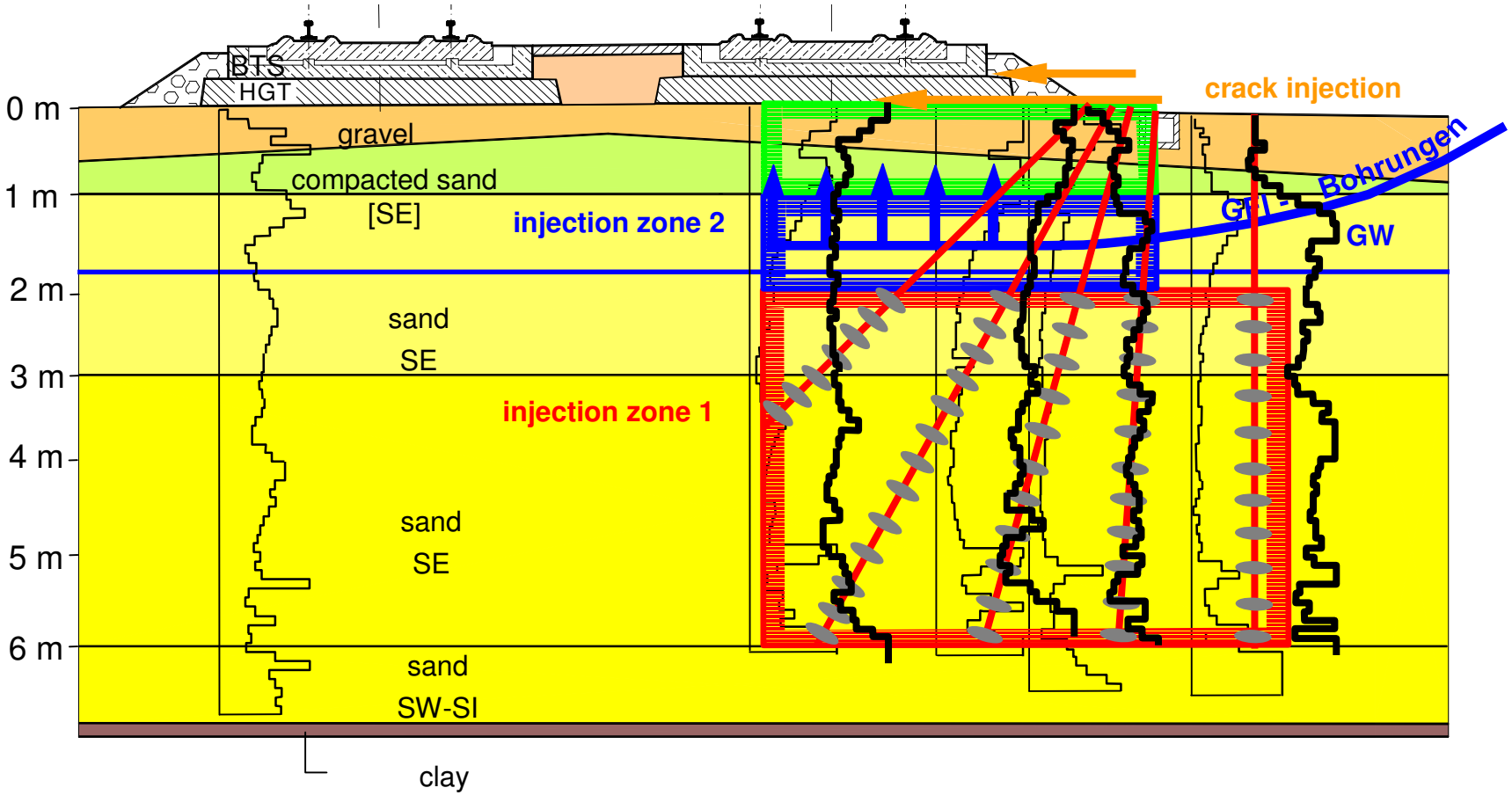

Underground situation and restoration method at Dallgow

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Injection between the layers of the slab structure at high speed line from Hannover to Berlin, Dallgow

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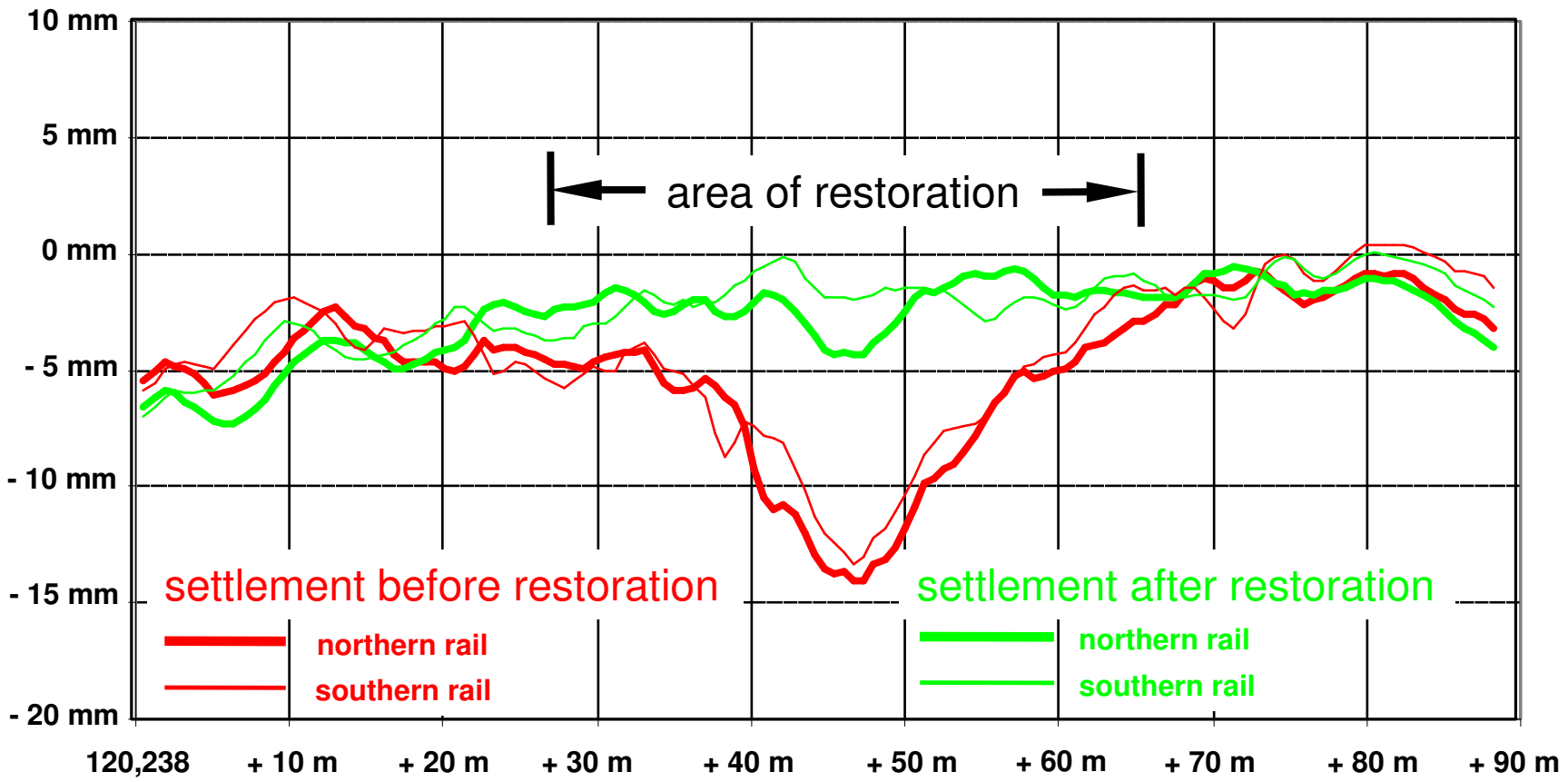

Restoration by injection at at high speed line from Hannover to Berlin, Dallgow

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Experiences with extreme settlements under slab track

- ⇨ Settlements caused by substructure compaction due to predominant static load have only little effect on slab structure and can be readjusted
- ⇨ Settlements caused by dynamic overload of the substructure lead to extreme stress conditions of the slab track and require underground as well as slab structure restoration
- ⇨ Slab track-underground-interaction is essential for the stress conditions of the slab track and can be verified by dynamic response of the underground

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Investigation of slab track behaviour

- ⇨ Accompanying field tests (underground investigation, measurements, laboratory tests)
- ⇨ Calculations using the Finite Element Method to investigate the realistic behaviour of slab track
- ⇨ Calibrate the calculations using measurement results
- ⇨ Parameter studies for extreme conditions

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Field test with slab track in Eckartshausen

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Results of the field test in Eckartshausen

- ⇨ Very high dynamic loads (vibrating 2 axle loads each 200 kN) caused settlements up to 20 mm
- ⇨ Slab track spanned over settlement hollow but did not break
- ⇨ Adhesion losses between concrete slab and hydraulic bonded layer
- ⇨ Fibre reinforced concrete increases elasticity and load bearing capacity

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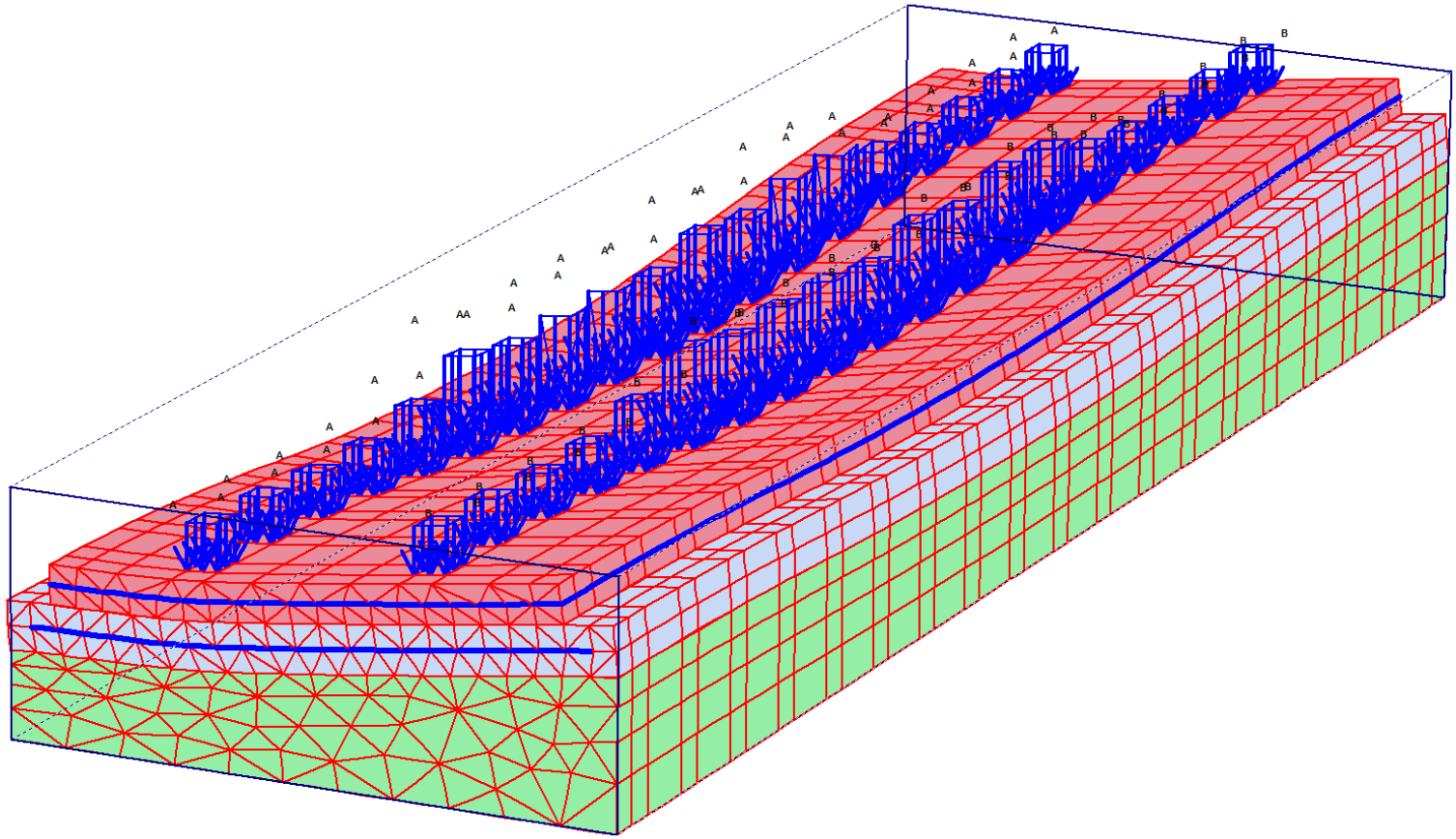

Modelling slab track using the Finite Element Method

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Analysis results

- ⇨ Bending stresses in the hydraulic bonded layer are smaller than the stresses derived from standard calculation method in Germany
- ⇨ Adhesion losses between concrete slab and hydraulic bonded layer cause comparatively little stress increase because of friction preservation
- ⇨ Calibration of the Finite Element Model using measured vertical deflection due to dynamic loads (0,1 – 0,4 mm) leads to very rigid material behaviour
- ⇨ Change of underground stiffness in longitudinal direction up to 10 times causes change of stresses up to 2 times

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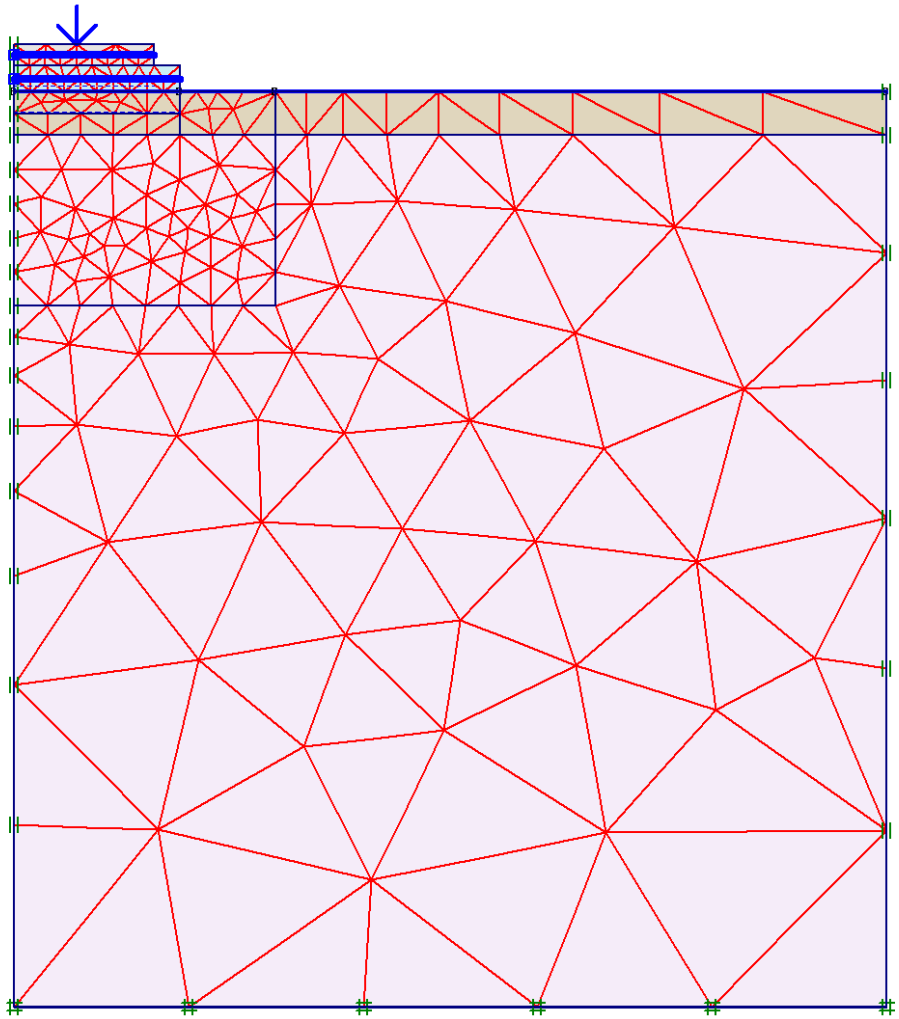

Outlook:
Realistic prediction of settlements due to rail loads

Finite Element Model of the substructure using a constitutive law with intergranular strain (hypoplasticity)

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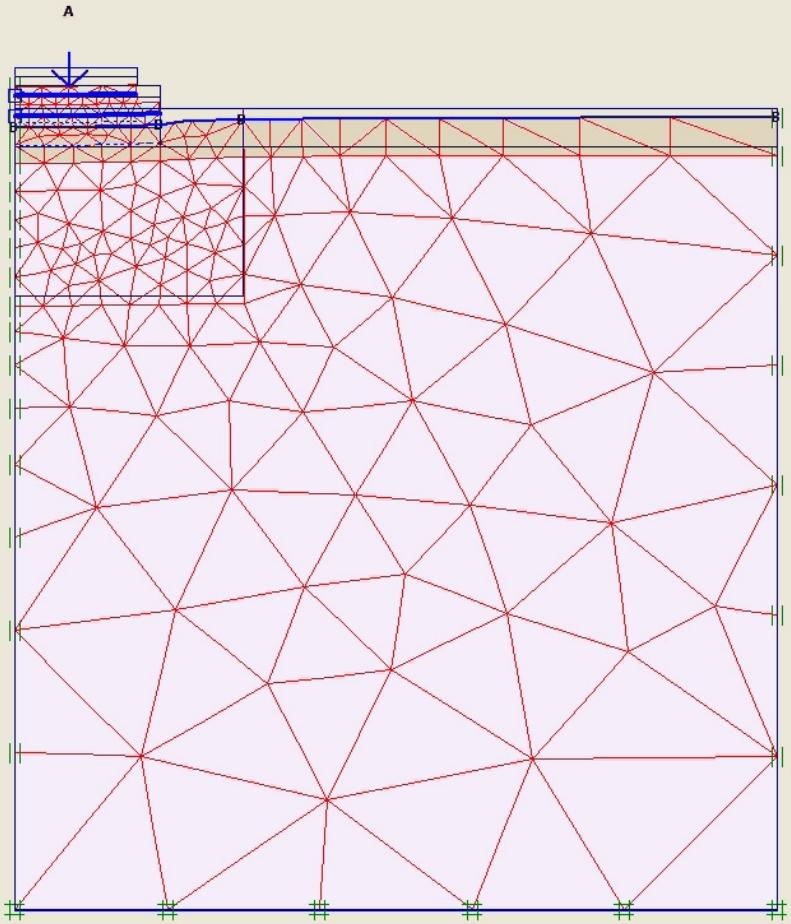

Deformed mesh
(Step 94)

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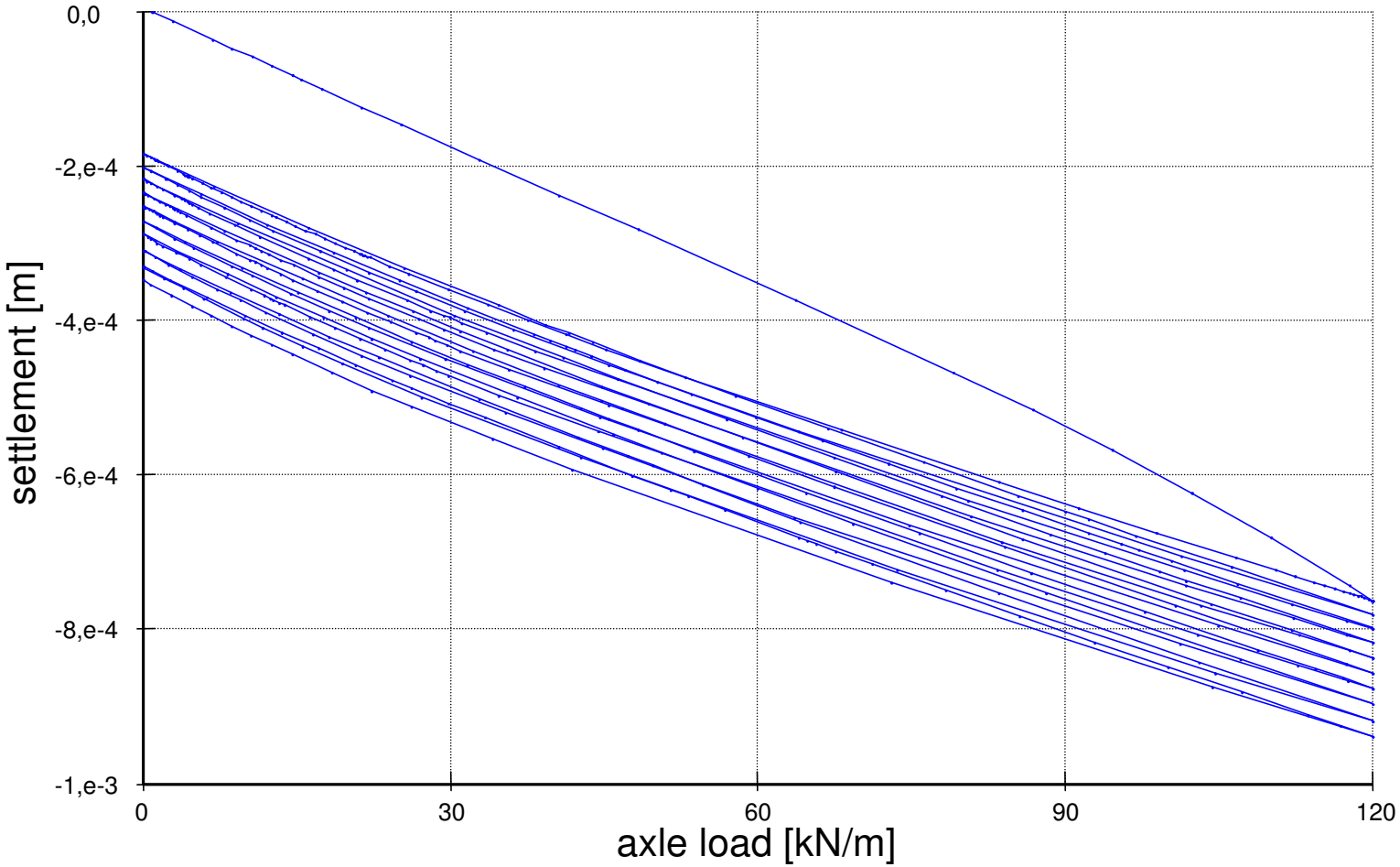

Settlement after 10 load cycles

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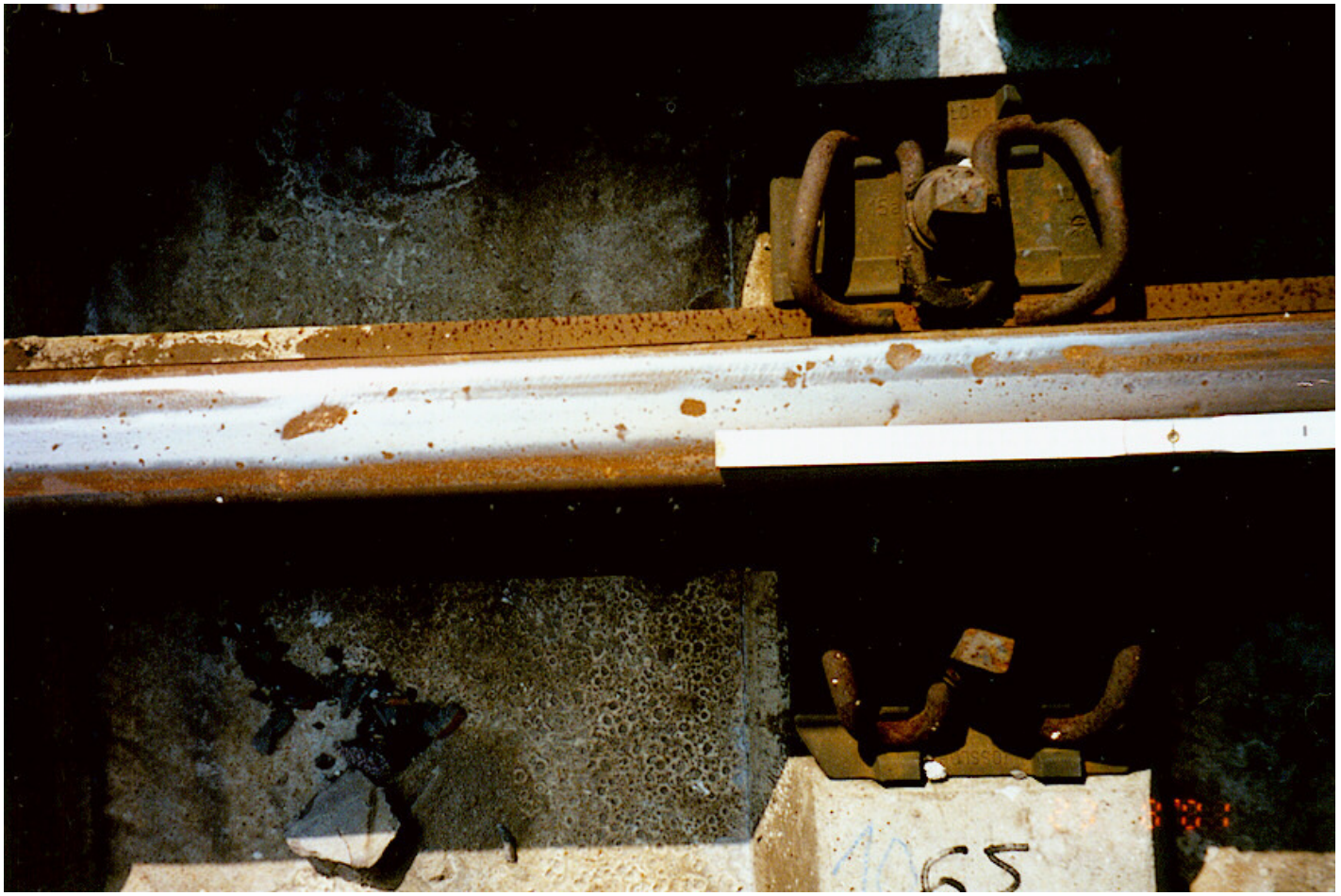

Rail head deterioration after grinding

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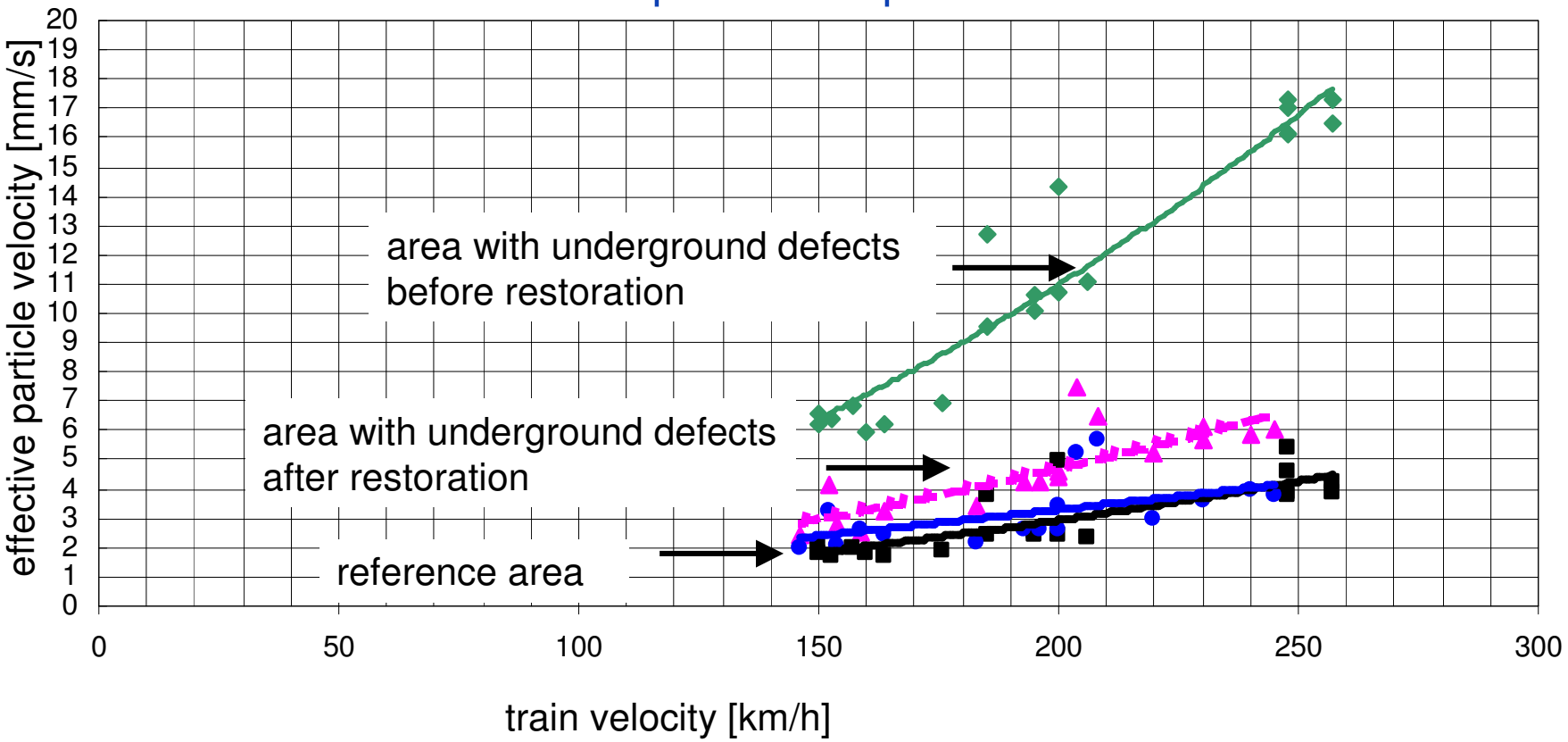
measurement position: top of concrete slab



Measurement of particle velocity for various train velocity