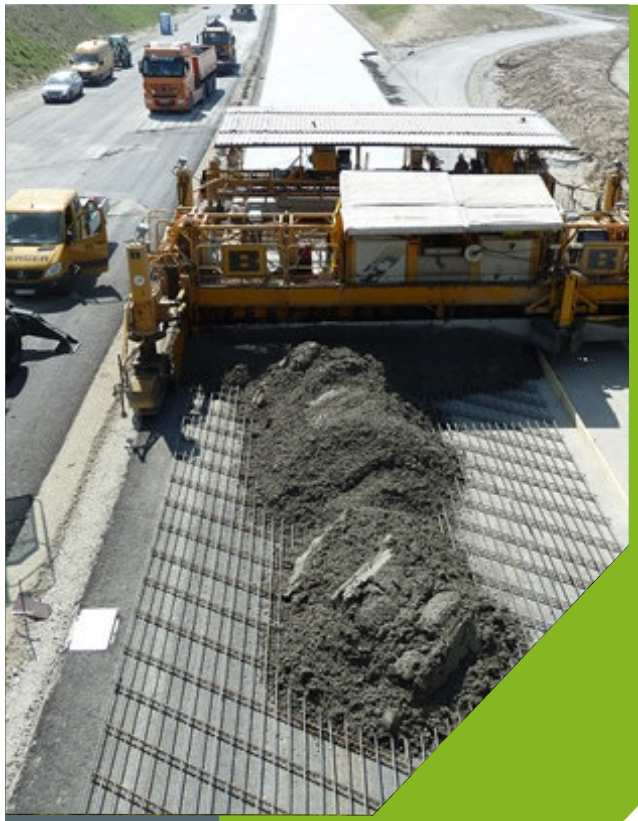


bast
Bundesanstalt für Straßenwesen

Falling Weight Deflectometer on Concrete Pavements - current situation and perspective

Dipl.-Ing. Stefan Höller
Federal Highway Research Institute (BASt)

EUPAVE Best Practices Workshop

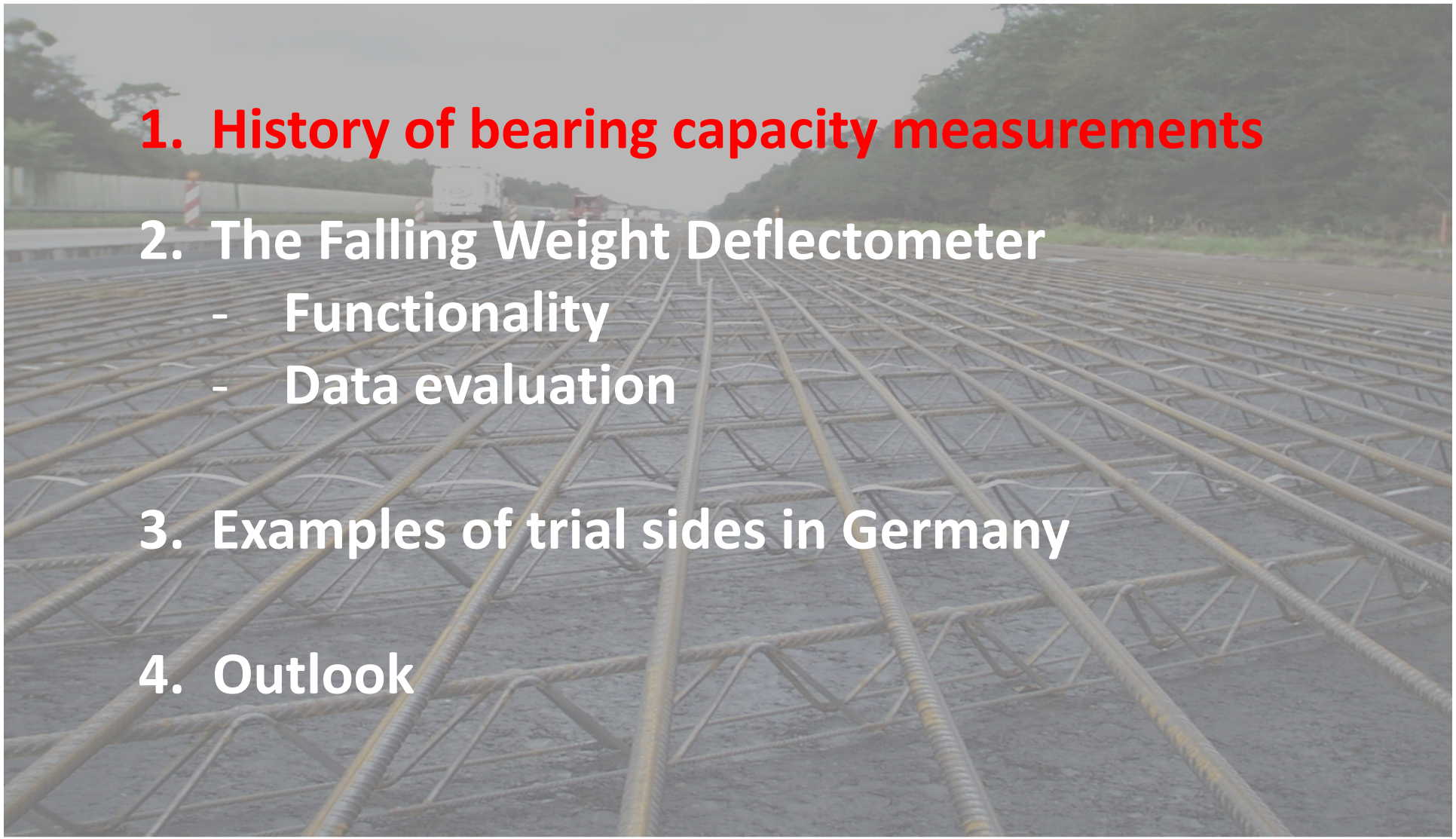
"Non-Destructive Auscultation and Monitoring Techniques for Concrete Pavements“

22.05.2024 in Brussels

Inhalt

1. History of bearing capacity measurements
2. The Falling Weight Deflectometer
   - Functionality
   - Data evaluation
3. Examples of trial sides in Germany
4. Outlook

Inhalt



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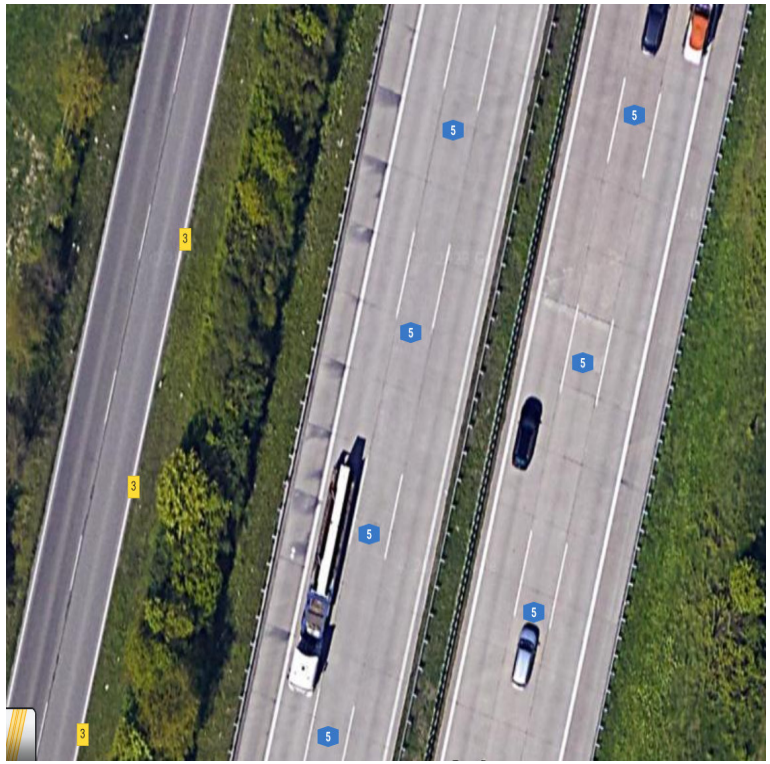
Damages to the structures of concrete pavements: here some examples from the application of Jointed Plain Concrete

Water leakage

Erosions
(here: Bitumen from interlayer)



Longitudinal Crack

Damages to infrastructure due to heavy rain events, current example A61, flooding in the Ahr valley

Autobahn destroyed

And here? First no visible Damage

Possible maintenance measures for concrete pavement

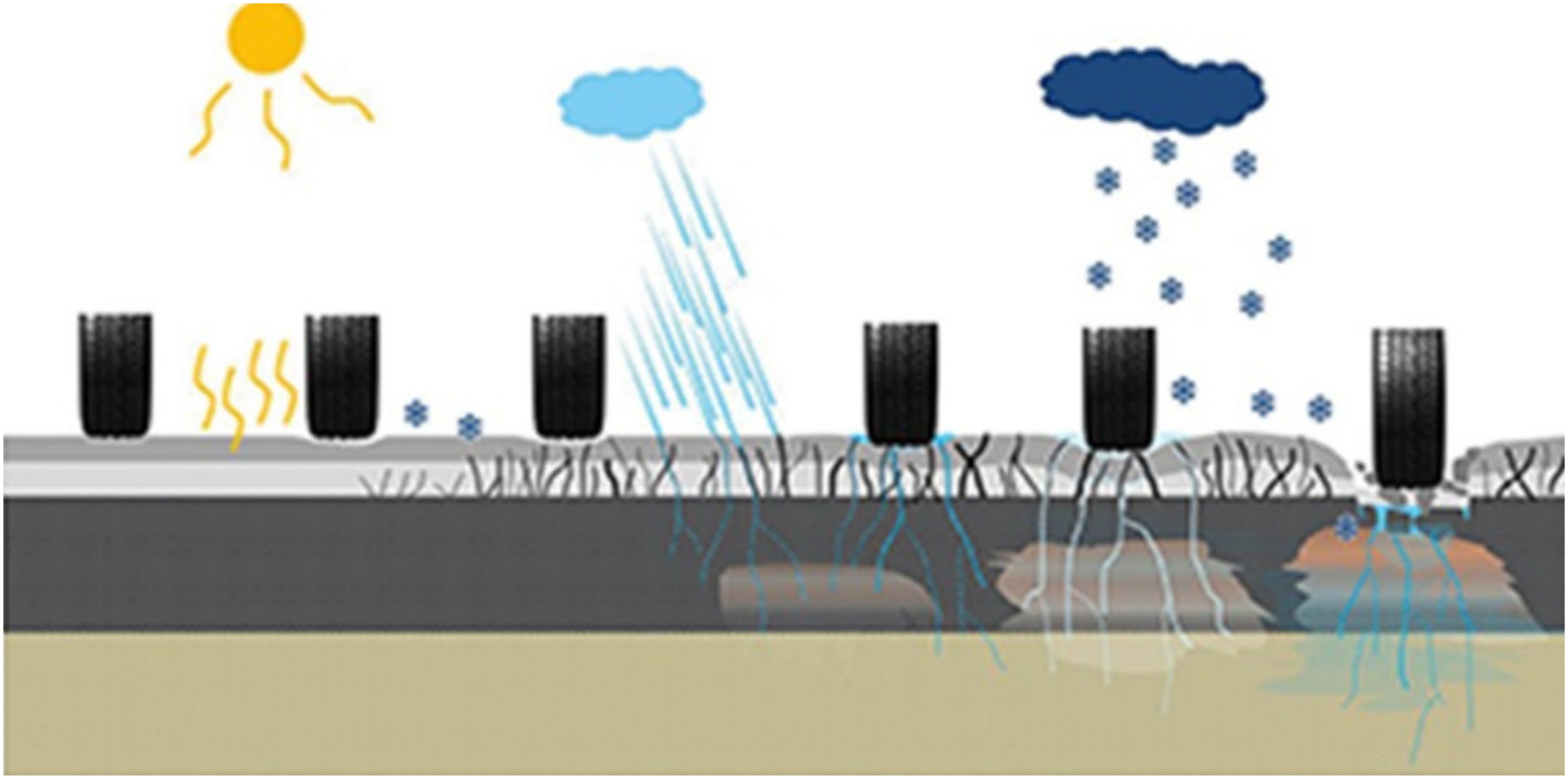
Stabilising of slabs

stiching of cracks

Replacement of single slabs

Complete reconstruction

What phase are we in?



Destructive investigations:
Here an example of taking samples (drill cores)

Advantages:
- Accurate information about the road construction and the current performance (adhesion, cavities, erosions)

Disadvantages:
- High effort
- Traffic restrictions
- Selective statements

Benkelman Beam / Modified Benkelman Beam

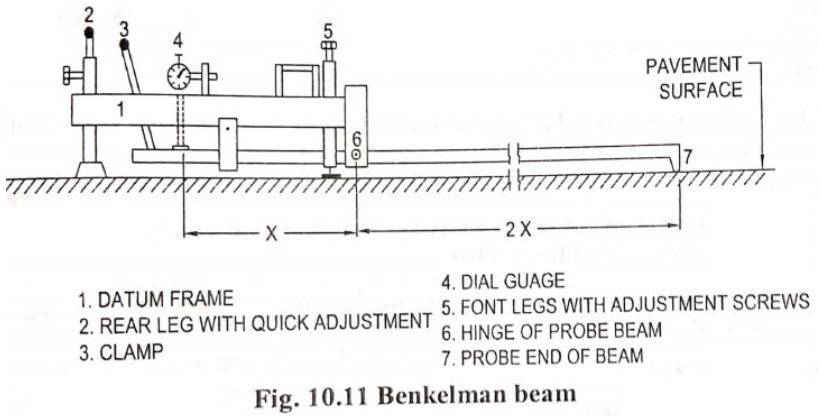


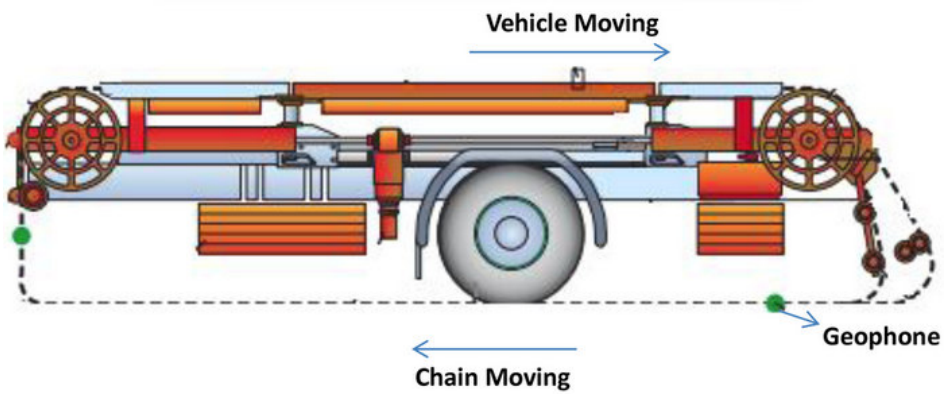
Fig. 10.11 Benkelman beam

developed in 1952

advantages:
- Easy to handle

disadvantages:
- Measurement is time-consuming
- Truck axle as a load is not precisely defined
- Individual measurements
- output selective values
- Traffic restrictions required

Lacroix / Curviametro



Developed in 1964

advantages:
- Low cost monitoring
- Fewer traffic restrictions
- required

disadvantages:
- Distribution of the device is limited

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Falling Weight Deflecometer

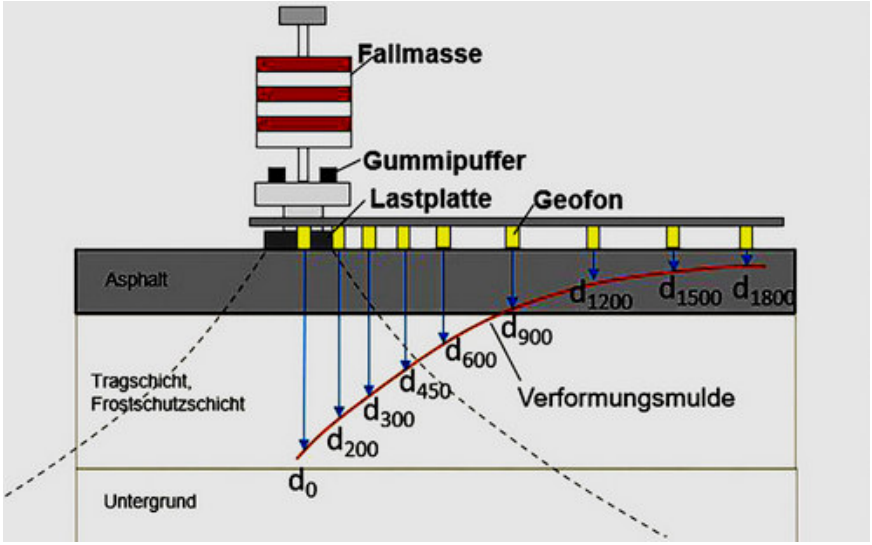
Developed in 1964

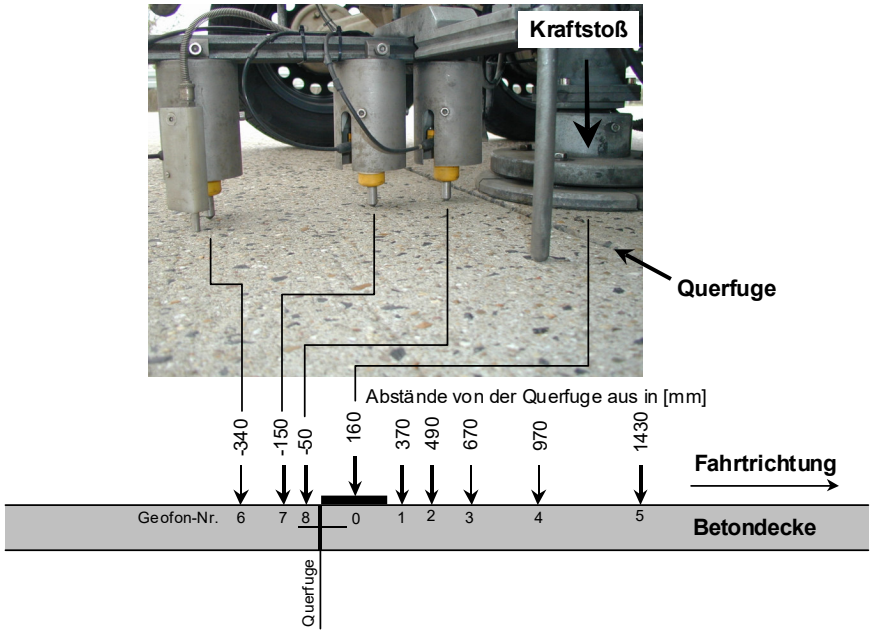
advantages:

- distribution of the device is high
- Easy to handle
- Load-plate is precisely defined

Disadvantages:

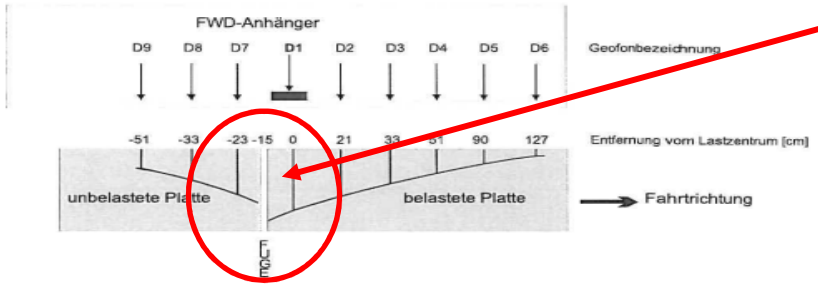
- Traffic restrictions required

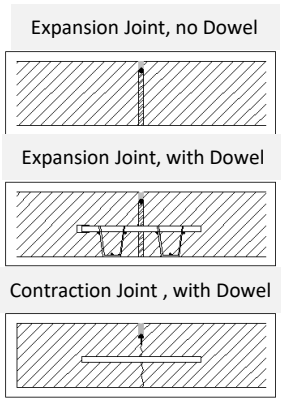


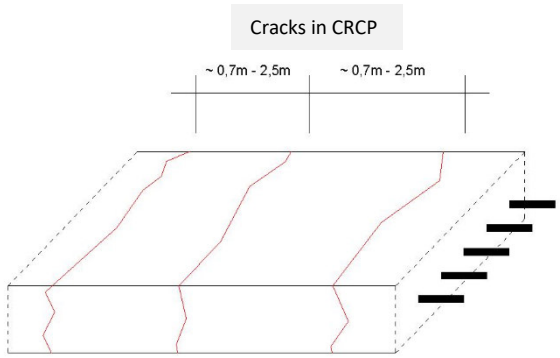


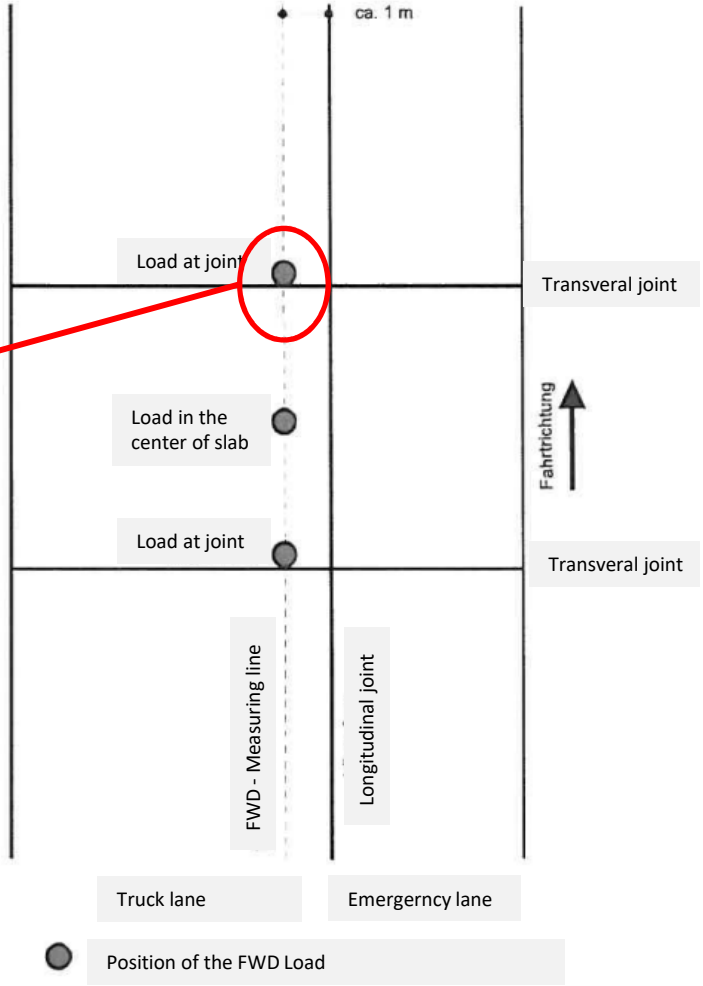
Falling Weight Deflectometer
- Boundary conditions for the measurements on concrete pavement

- Force impact 30 – 300 kN (50 kN)
- Diameter of the load plate 300 mm
- Duration of the force impulse 25 – 30 ms
- Temperature range from + 5°C to + 30 °C
- No frost in the subsoil/substructure







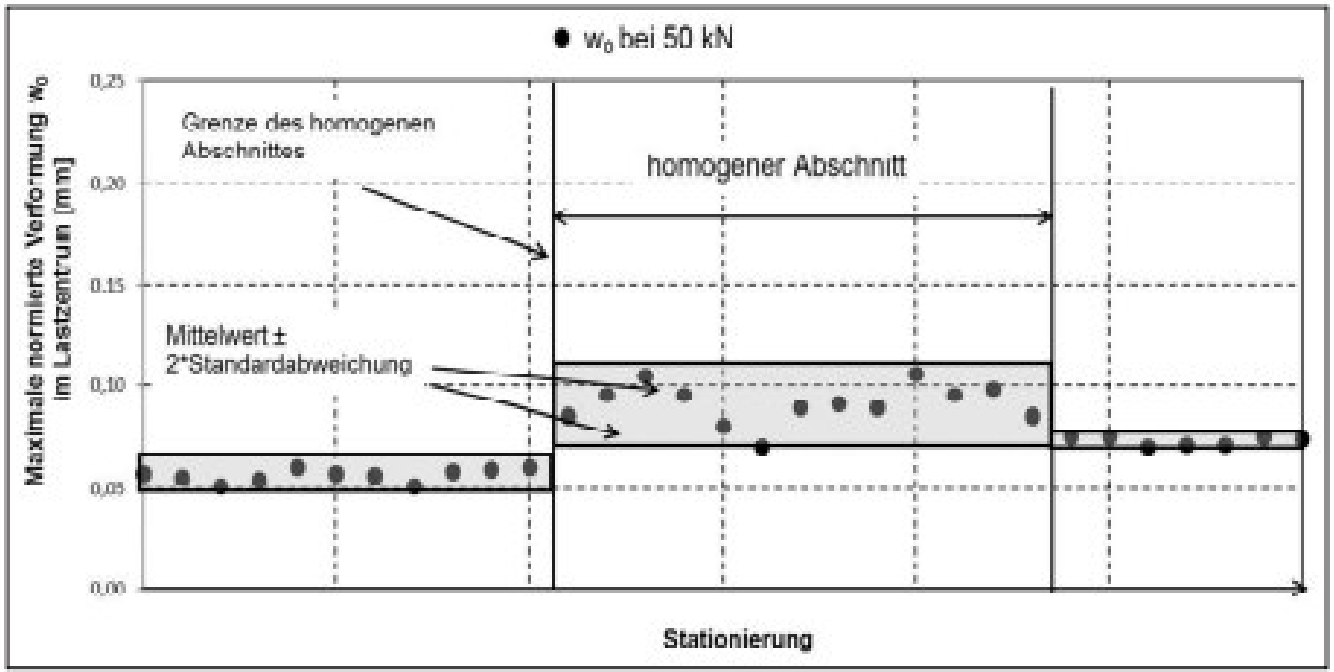


Evaluation of the FWD raw data

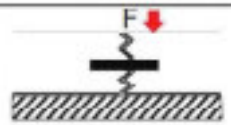
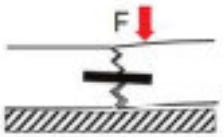
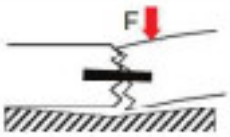
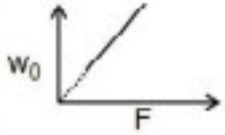
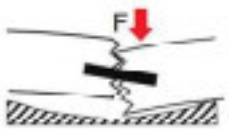
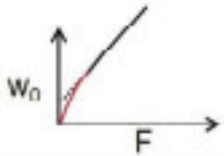
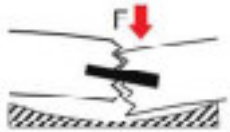
- Maximum measured deflection
- Relative vertical joint movement
- Effectiveness index
- Standard deviations of the maximum measured deformation
- Standard deviations of relative joint movement
- Regression parameters or fictitious deformation
- Equivalent deformation modulus
- Bearing capacity ratio

the next steps in planning maintenance measures:

Identification of homogeneous sections

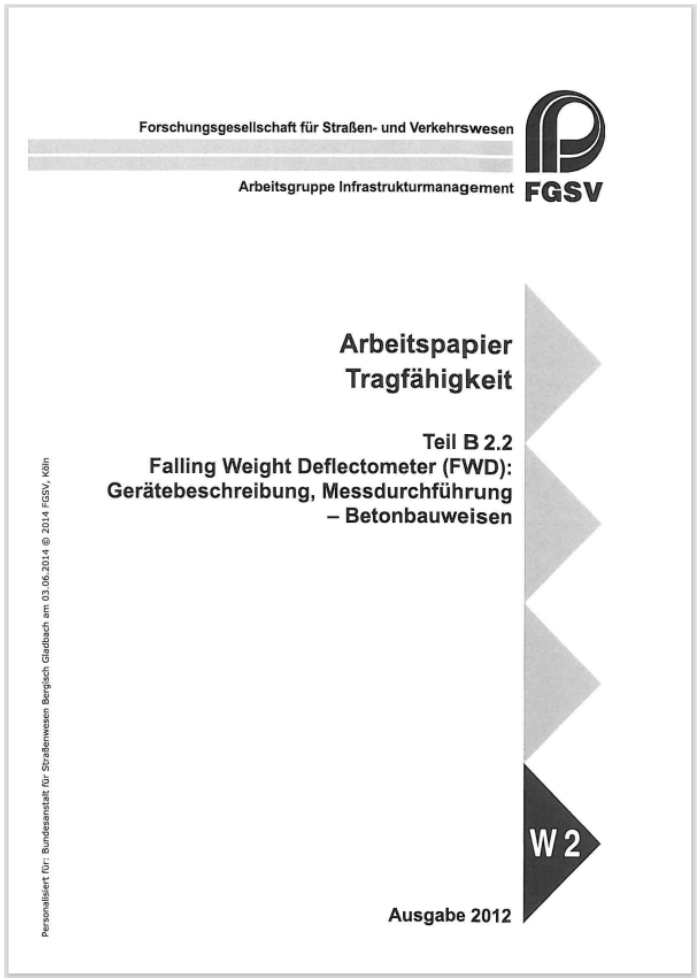


the next steps in planning maintenance measures: Dividing of the homogeneous sections into categories

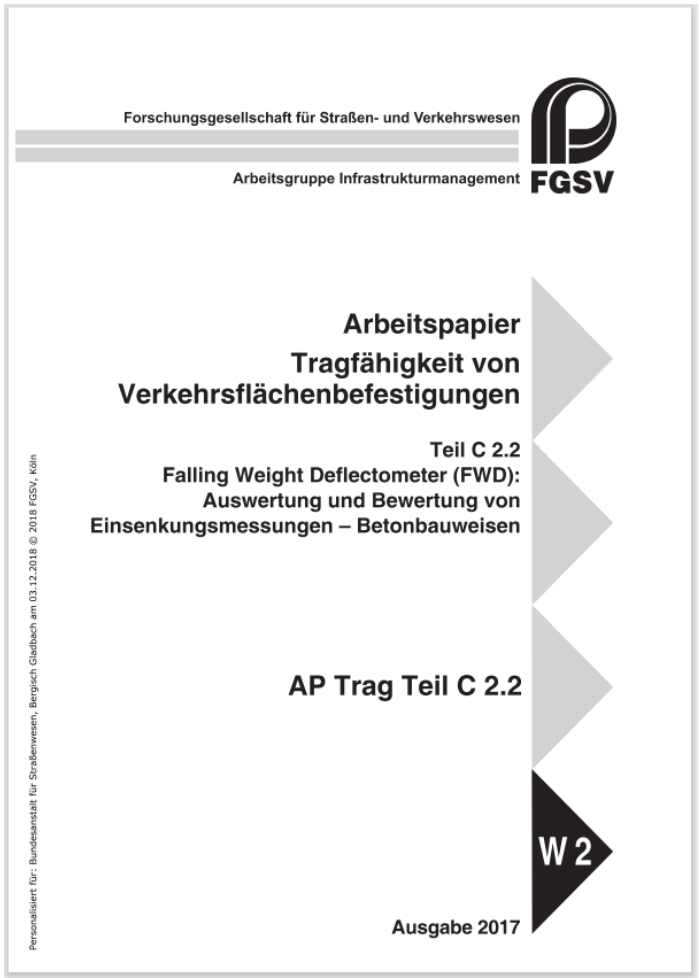
Kate-gorie	Regressions-Parameter	System	F/w_0 Diagramm	Erläuterung
I	a ≤ 0,00175 b ≤ 0,015mm b ≥ 0,010mm			- Flach verlaufende Reg.- Gerade; die linear extrapolierte Gerade schneidet oder tangiert den Ursprung. - Neubau; neuwertige Konstruktion; Konstruktion nach erfolgreicher Unterpressung
II	a ≤ 0,00175 b < -0,010mm			- Flach verlaufende Reg.- Gerade, die linear extrapolierte Gerade schneidet oder tangiert den Ursprung. - Bereits ein geringer Kraftimpuls erzielt eine vergleichsweise hohe Einsenkung. Bei weiterer Laststeigerung wird jedoch der Endzustand schnell erreicht. - Beginnende Verschlechterung der Auflagerverhältnisse.
III	a > 0,00175 b ≤ 0,015mm b ≥ -0,010mm			- Steil verlaufende Reg.- Gerade; die linear extrapolierte Gerade schneidet oder tangiert den Ursprung. - Selbst bei max. Kraftimpuls wird der Endzustand nicht erreicht. Gestörte Auflagerverhältnisse bei noch vorhandener Querkraftübertragung. i.d.R. keine Schädigung erkennbar
IV	a > 0,00175 b ≥ 0,015mm			- Steil verlaufende Reg.- Gerade; die linear extrapolierte Gerade schneidet oder tangiert den Ursprung - Bereits ein geringer Kraftimpuls erzielt eine hohe Einsenkung. Endzustand wird nicht erreicht. - Gestörte Auflagerverhältnisse bei reduzierter Querkraftübertragung.
V	a > 0,00175 b < -0,010mm			- Steil verlaufende Reg.- Gerade; die linear extrapolierte Gerade schneidet die y- Achse im negativen Bereich - Bei geringem Kraftimpuls noch gute Querkraftübertragung. - Bei Laststeigerung nehmen die Einsenkungen stark zu. - Endzustand wird nicht erreicht. Vermutlich ausgeprägte Hohlstelle bei geringer Querkraftübertragung.

FGSV Manuals on FWD

How to measure?



How to evaluated?

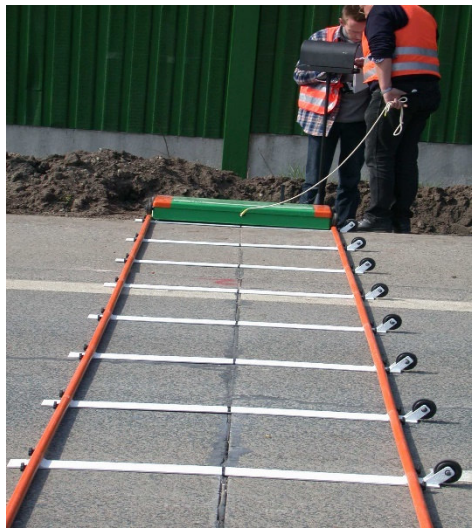


Annual comparative measurement of FWD in Europe at BASt

(here: April 2024)

To analyze the overall performance of the concrete pavement additional measurements will be needed, for example:

Position of the dowel bars



Georadar

Eveness
(longitudinal and transverse)

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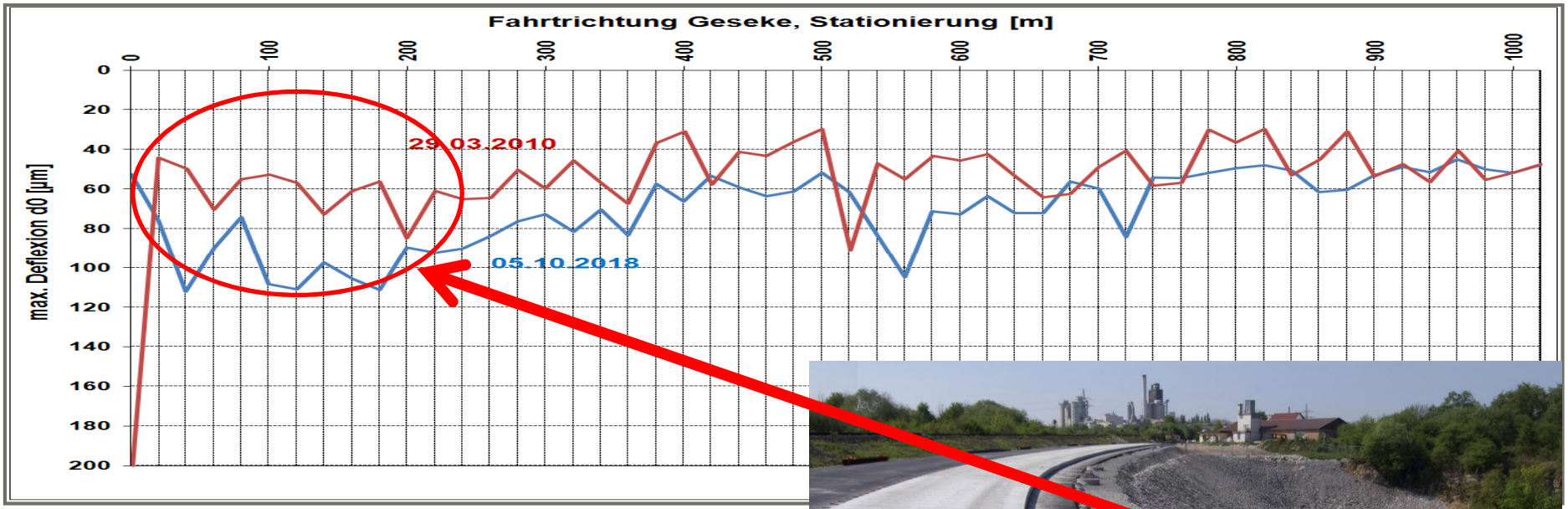
CRCP, Access road near Geseke – after 11 years of service (with heavy trucks)

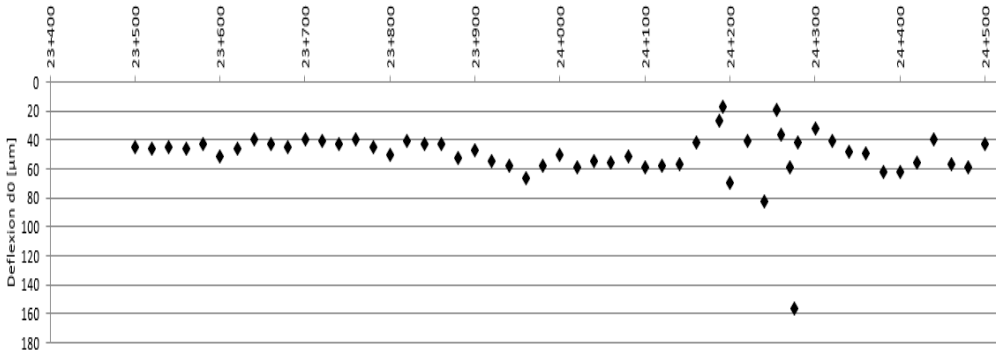


newly filled embankment

CRCP, E 313 Grobbendonk

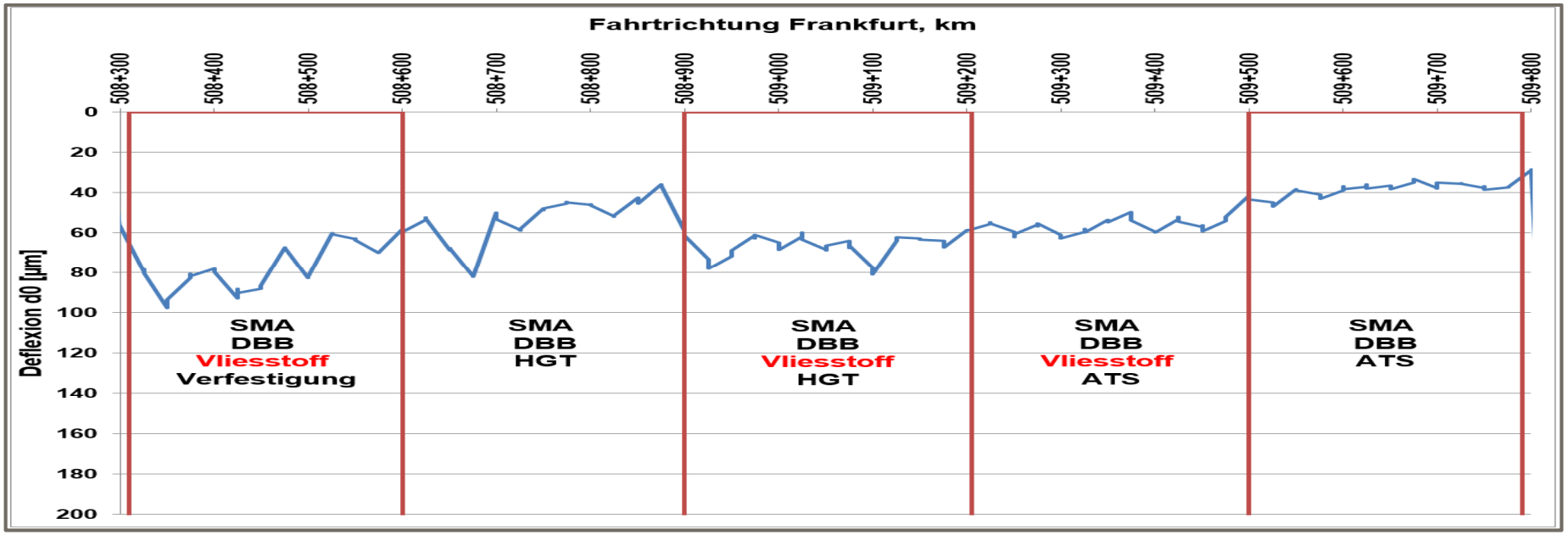
Small water leakage at the longitudinal joint
after 8 years of service

FWD Results in the load center

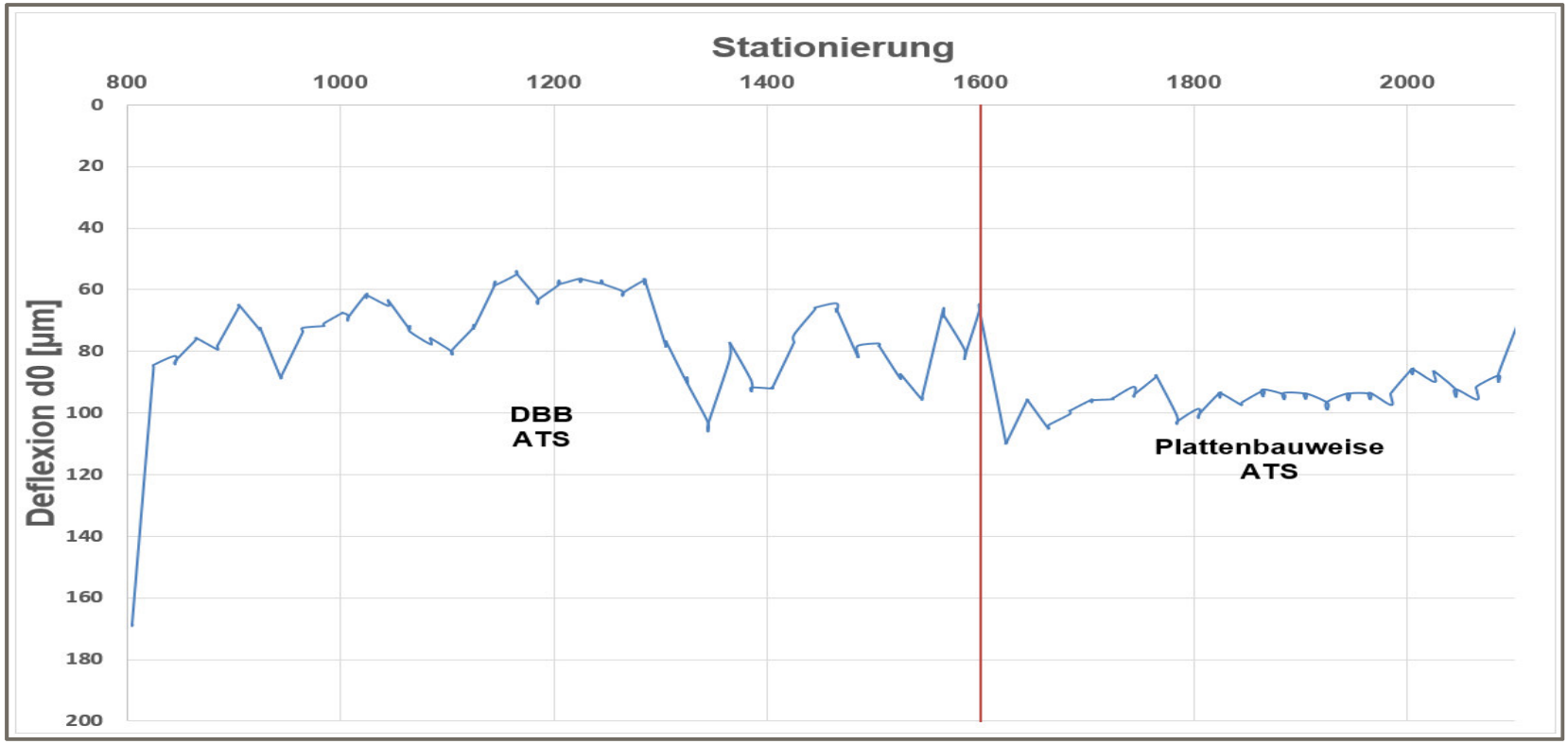


CRCP on Autobahn A5 near Darmstadt

FWD results after 15 years in service with heavy traffic

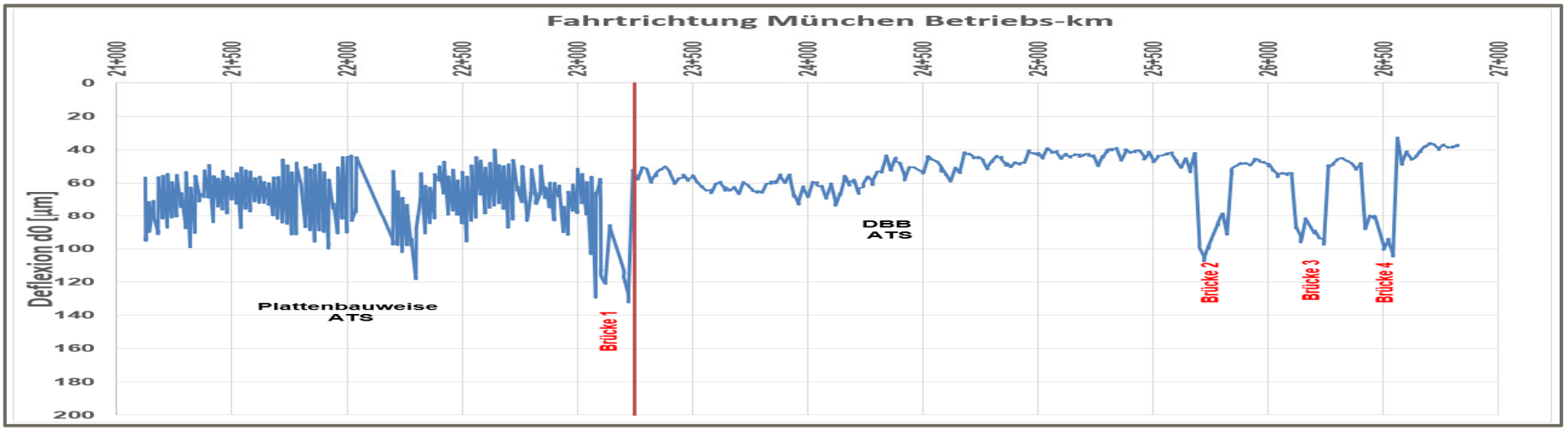


FWD – Results after 22 years in service



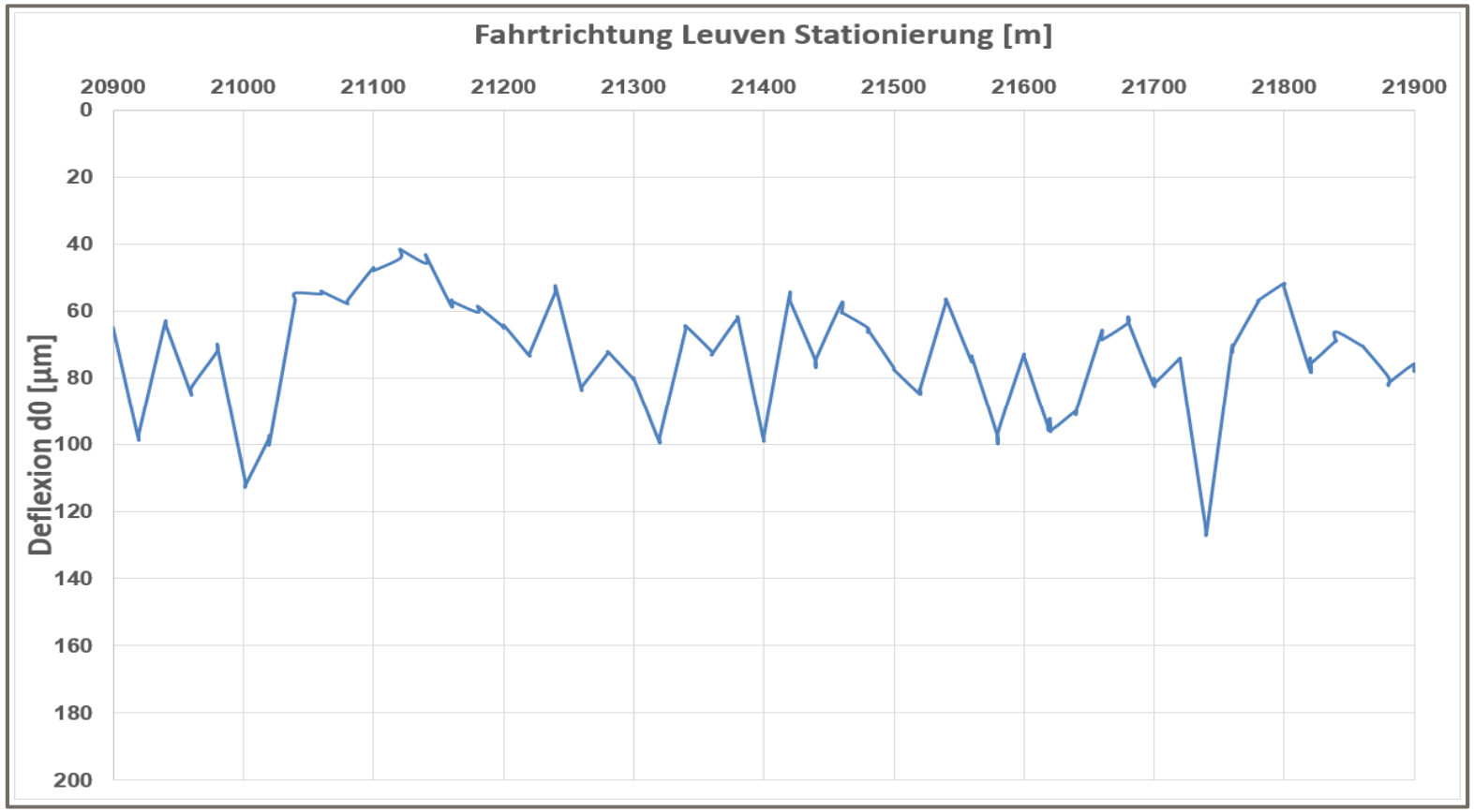
CRCP, JPC and Asphalt on bridges on Autobahn A94 near Forstinning

FWD results after 8 years in service



CRCP on E40 near Leuven

FWD results after 48 years in service with heavy traffic



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Multifunctional assessment tool for the structural evaluation and the design of pavements (MESAS)

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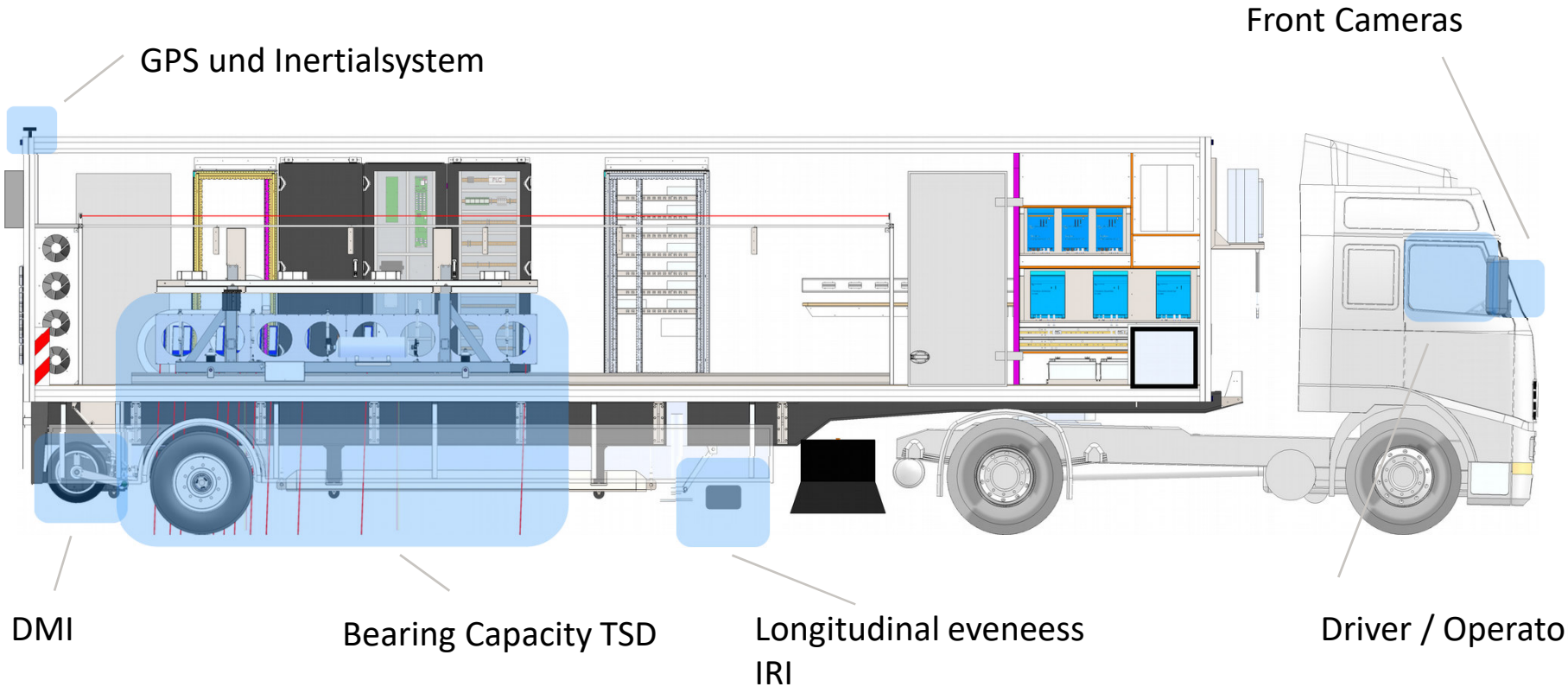
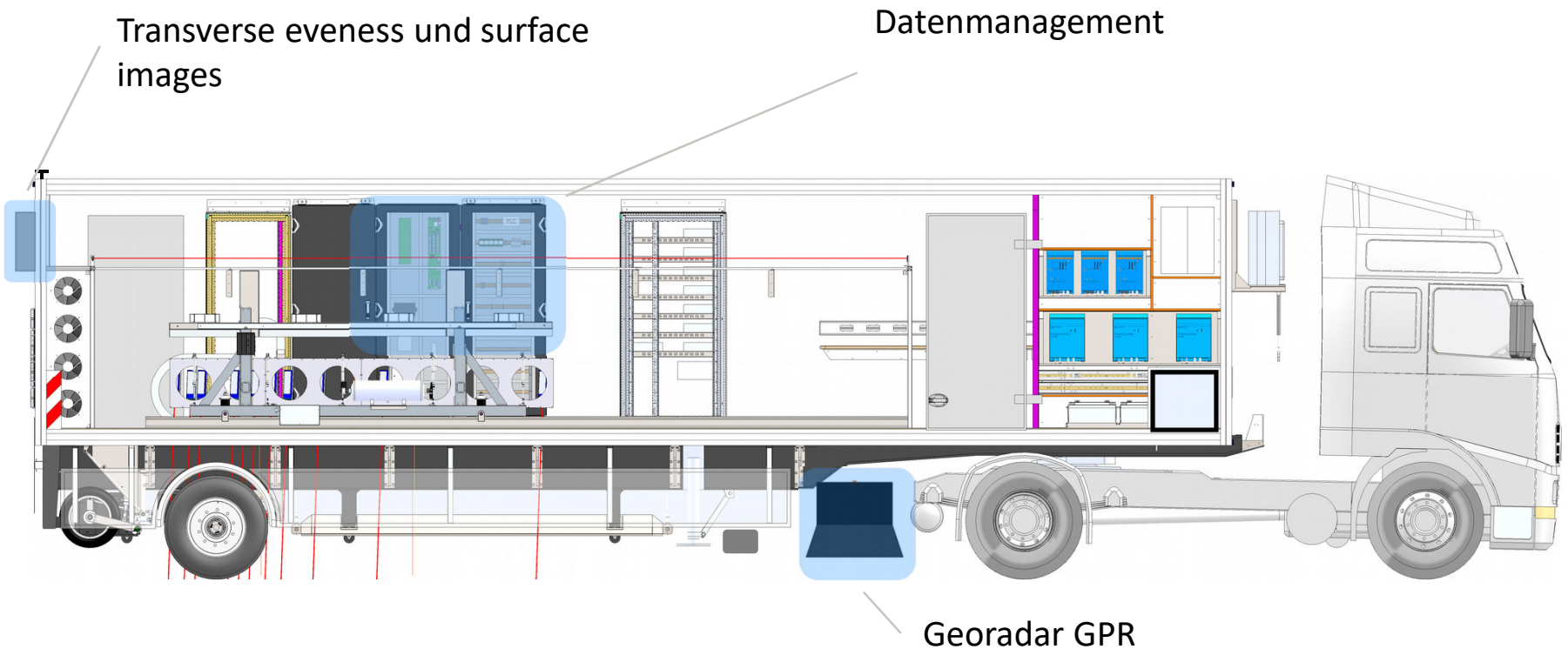


Multifunctional assessment tool for the structural evaluation and the design of pavements (MESAS)



Thank You

for Your

Kind

Attention!