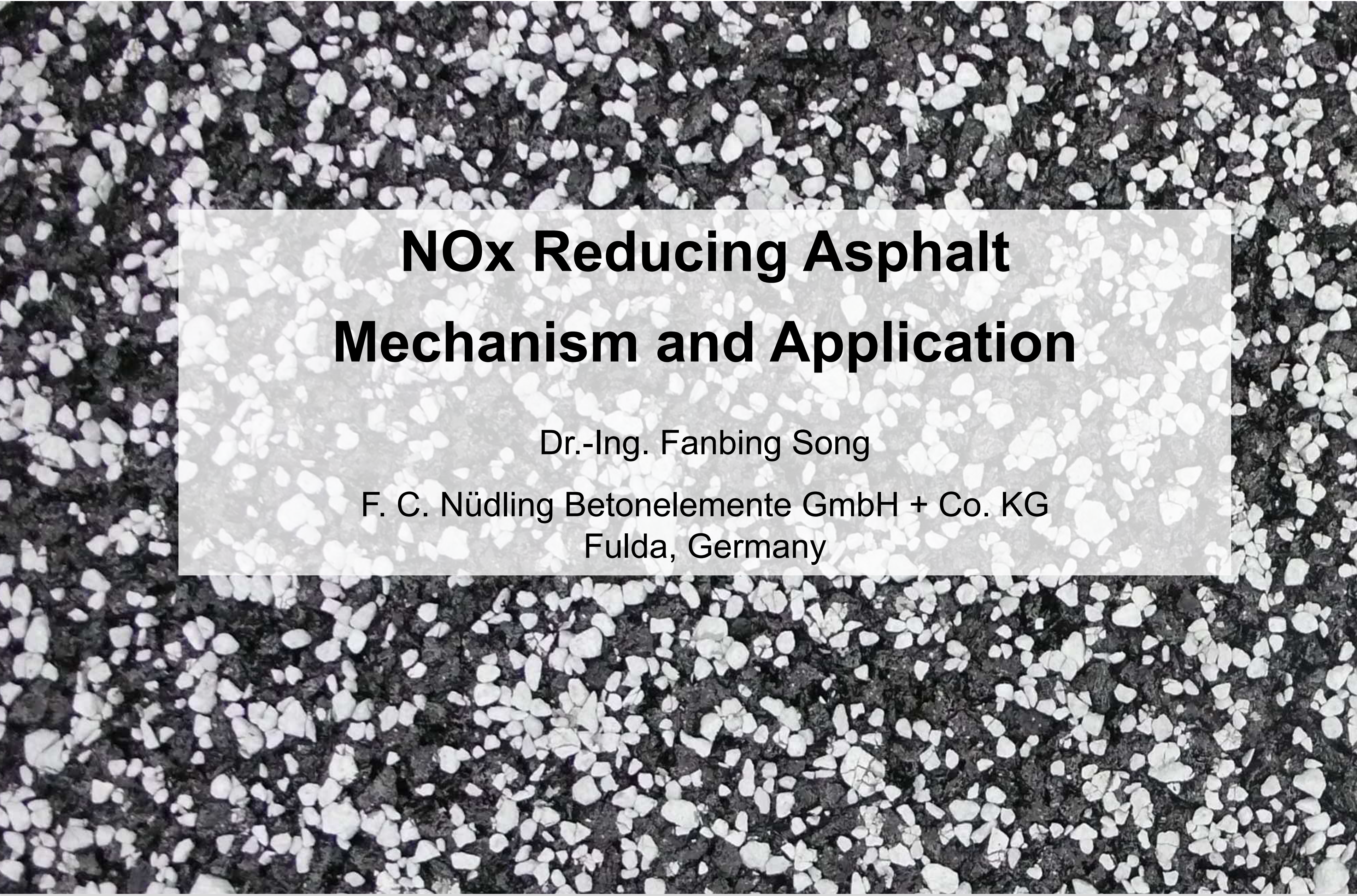


NOx Reducing Asphalt

Mechanism and Application

Dr.-Ing. Fanbing Song

F. C. Nüdling Betonelemente GmbH + Co. KG
Fulda, Germany

Air pollution in urban areas

Nitrogen oxide

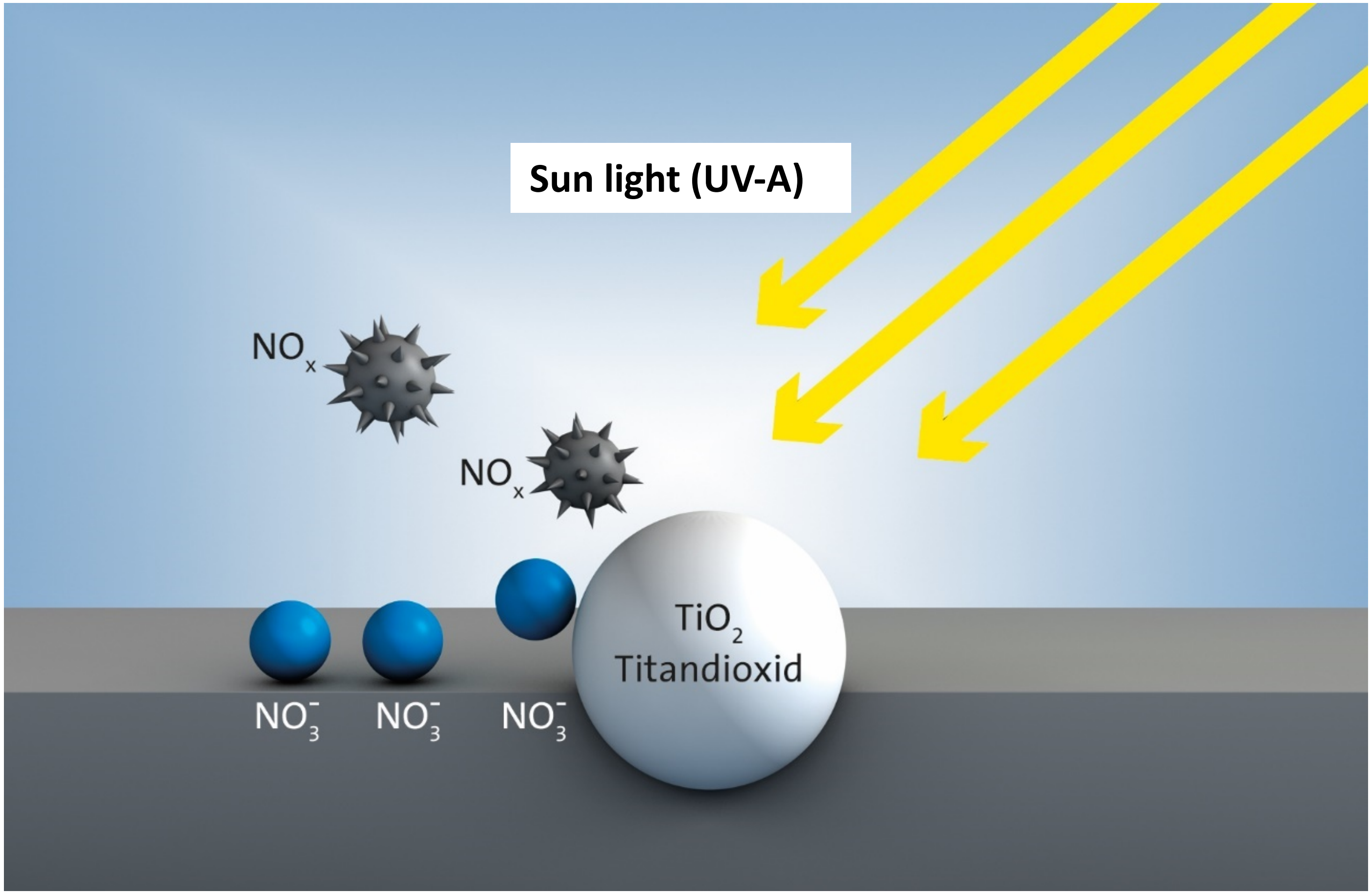
VOC

Ozone

Summer smog …

Solution to air pollution

Mechanism of photocatalysis



FCN - Strong competence in photocatalysis

Over 14 years experience in developing and applying of photocatalytic concrete:

1. Paving stone with photocatalytic active surface (DBU project with Fraunhofer IME,)
2. Developing of UHPC for diverse applications (research project with Uni Kassel)
3. Photocatalytic active granule for asphalt surface (research project with TU Darmstadt)
4. PureBau: Investigation on material systems for photocatalytic high efficient building materials (BMBF collaborative project)
5. NaHiTAs (Substainable HighTech Asphalt): Pollution and noise reducing asphalt with innovative new material processing and monitoring (BMBF collaborative project)

DBU Deutsche Bundesstiftung Umwelt

UNIKASSEL VERSITÄT

Bundesministerium für Bildung und Forschung

Fraunhofer IME

TECHNISCHE UNIVERSITÄT DARMSTADT

Photocatalytic Granule for asphalt surface

Photocatalytic Granule (AirClean® Granule):

- ✓ **Asphalt road**
- ✓ **Bicycle lane**

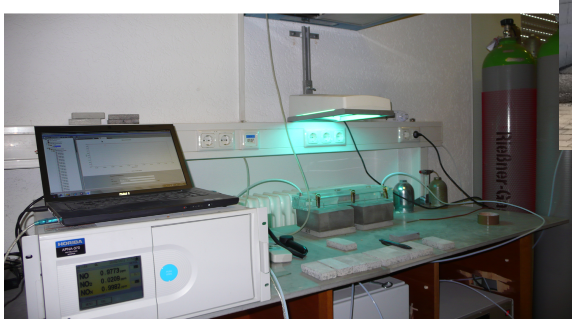
→ particularly effective in urban areas

- made of UHPC (Ultra High Performance Concrete, > 150 MPa)
- industrial production through patented processes (grain size 1-3 mm)
- practical application through asphalt paver (innovative) or chips spreader (conventional) directly on the hot asphalt surface (spreading amount about 1.3 - 1.5 kg/m²)

Verification of photocatalytic activity

Three-step strategy:

- Laboratory standard test (ISO 22197-1)
- FCN-Canyon measuring trial
- In-situ street measuring campaign



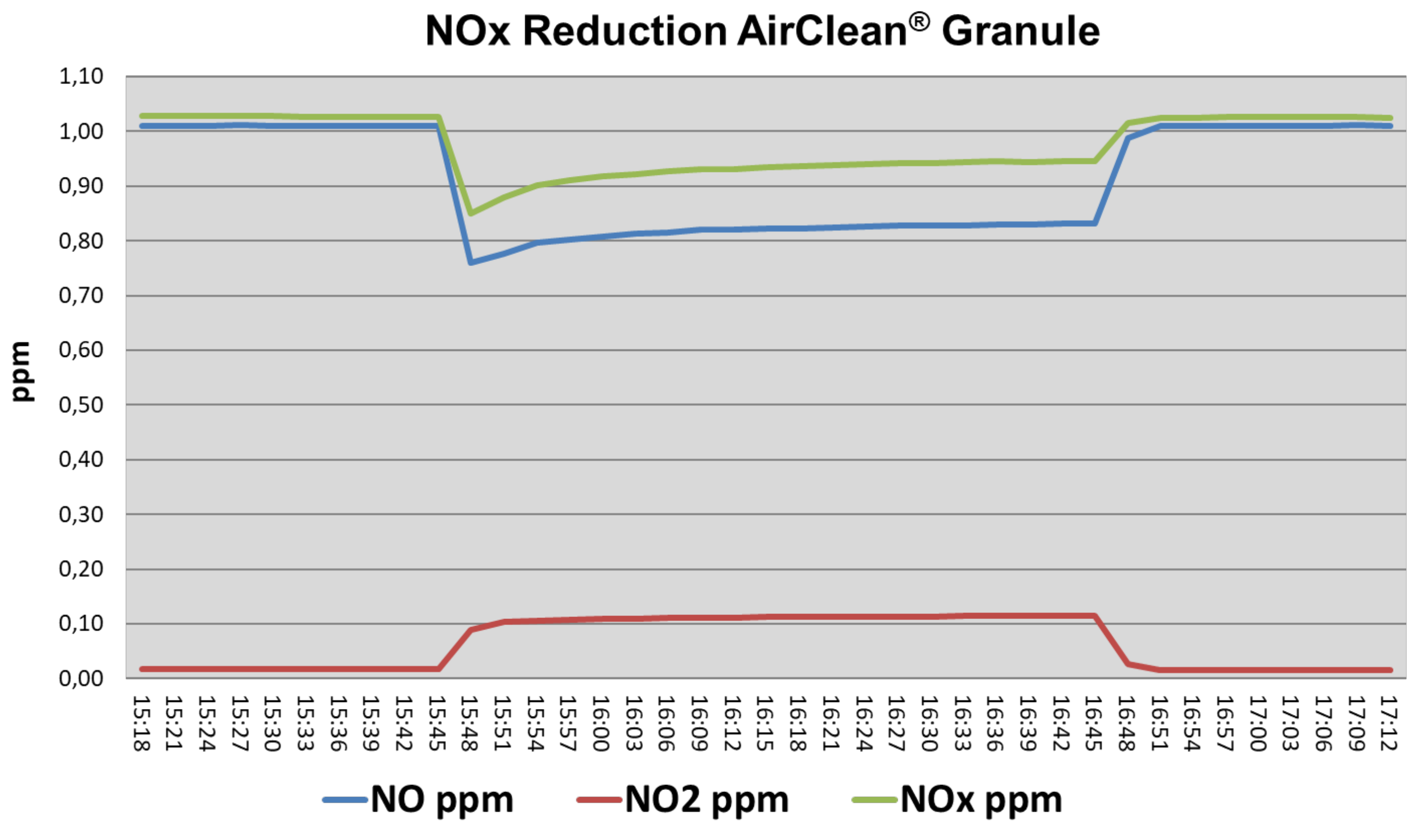
Method	NOx Degradation
laboratory (pure Granules)	10 - 15 %
laboratory (asphalt sample)	4 - 7 %
canyon trial	max. ≈ 25 %
street trial	≈ 18 %

Verification of photocatalytic activity

- Laboratory standard test (ISO 22197-1)

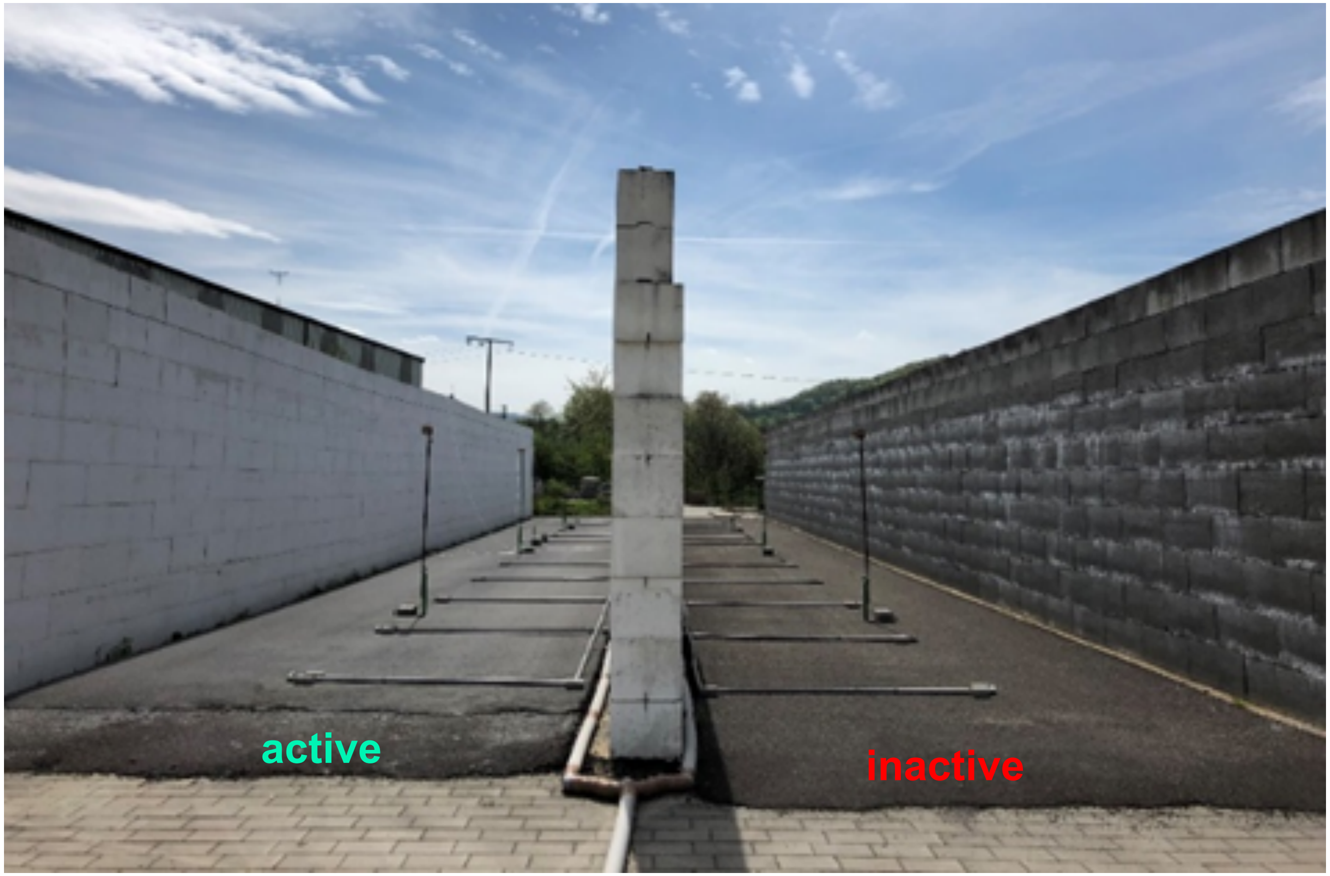
Verification of photocatalytic activity

- Laboratory standard test (ISO 22197-1)



Verification of photocatalytic activity

- FCN-Canyon measuring trial

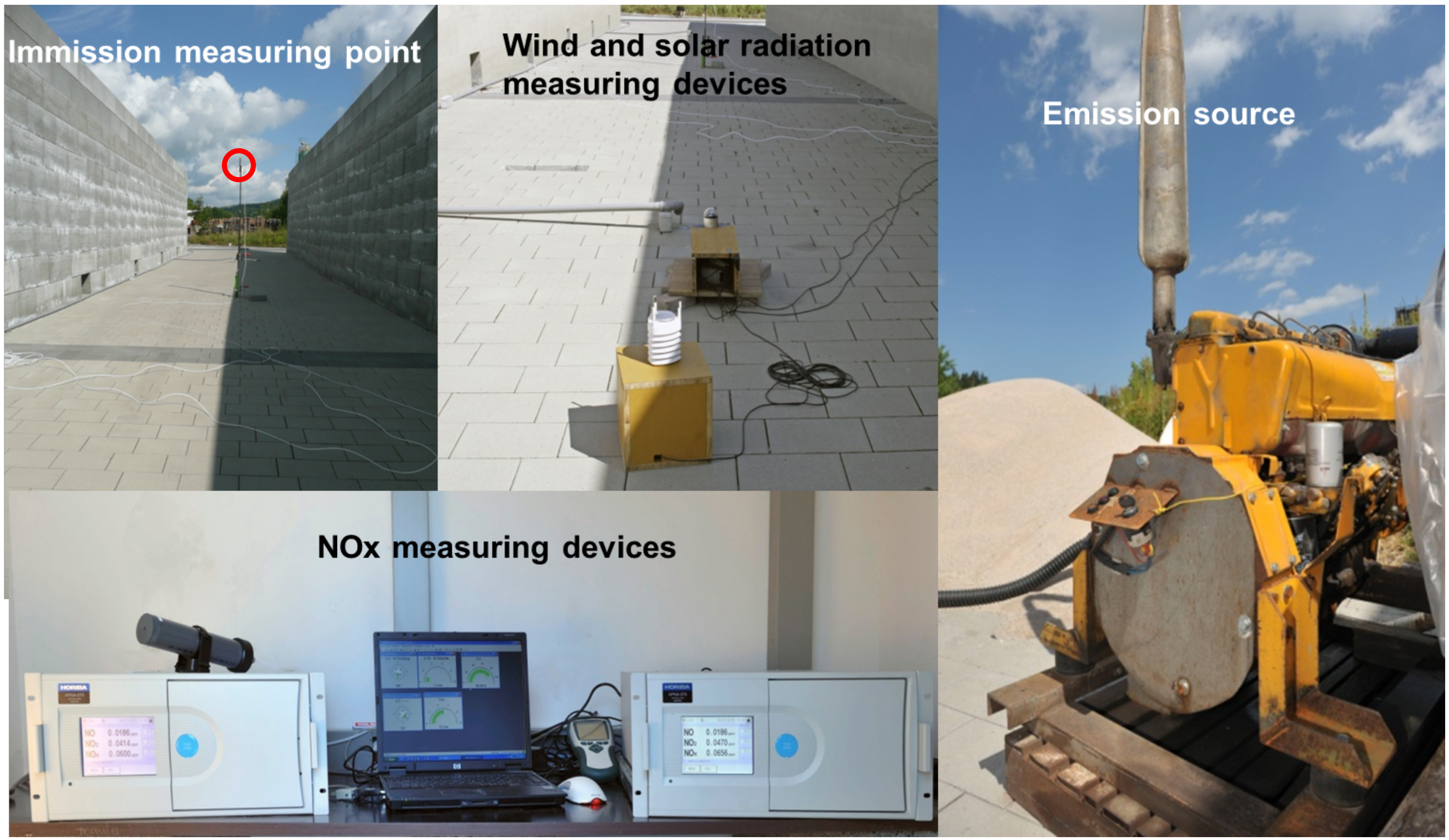


Verification of photocatalytic activity

- FCN-Canyon measuring trial

Verification of photocatalytic activity

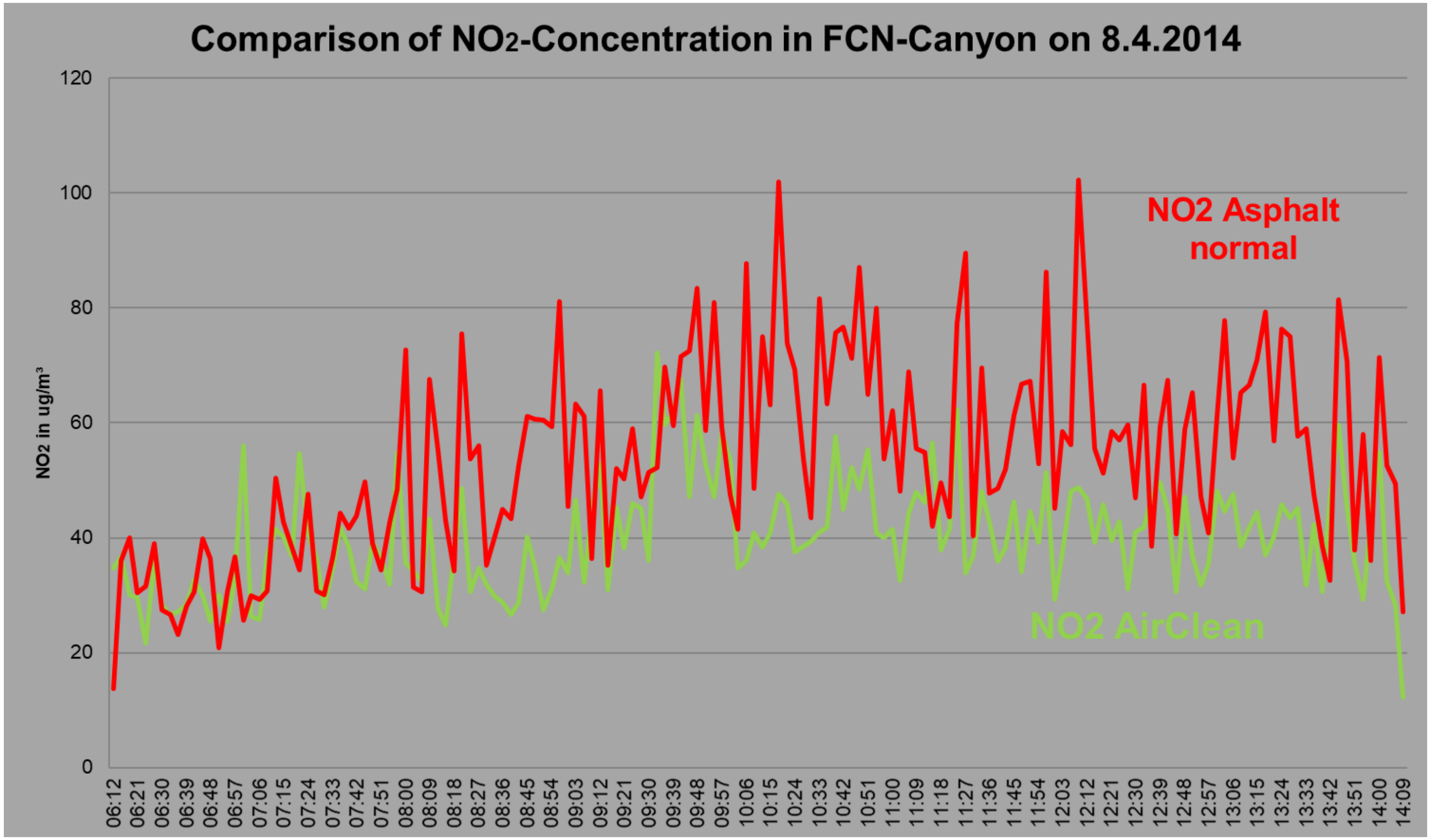
- FCN-Canyon measuring trial



Verification of photocatalytic activity

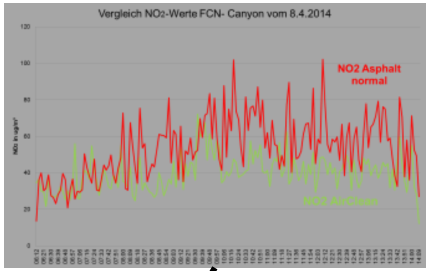
- FCN-Canyon measuring trial

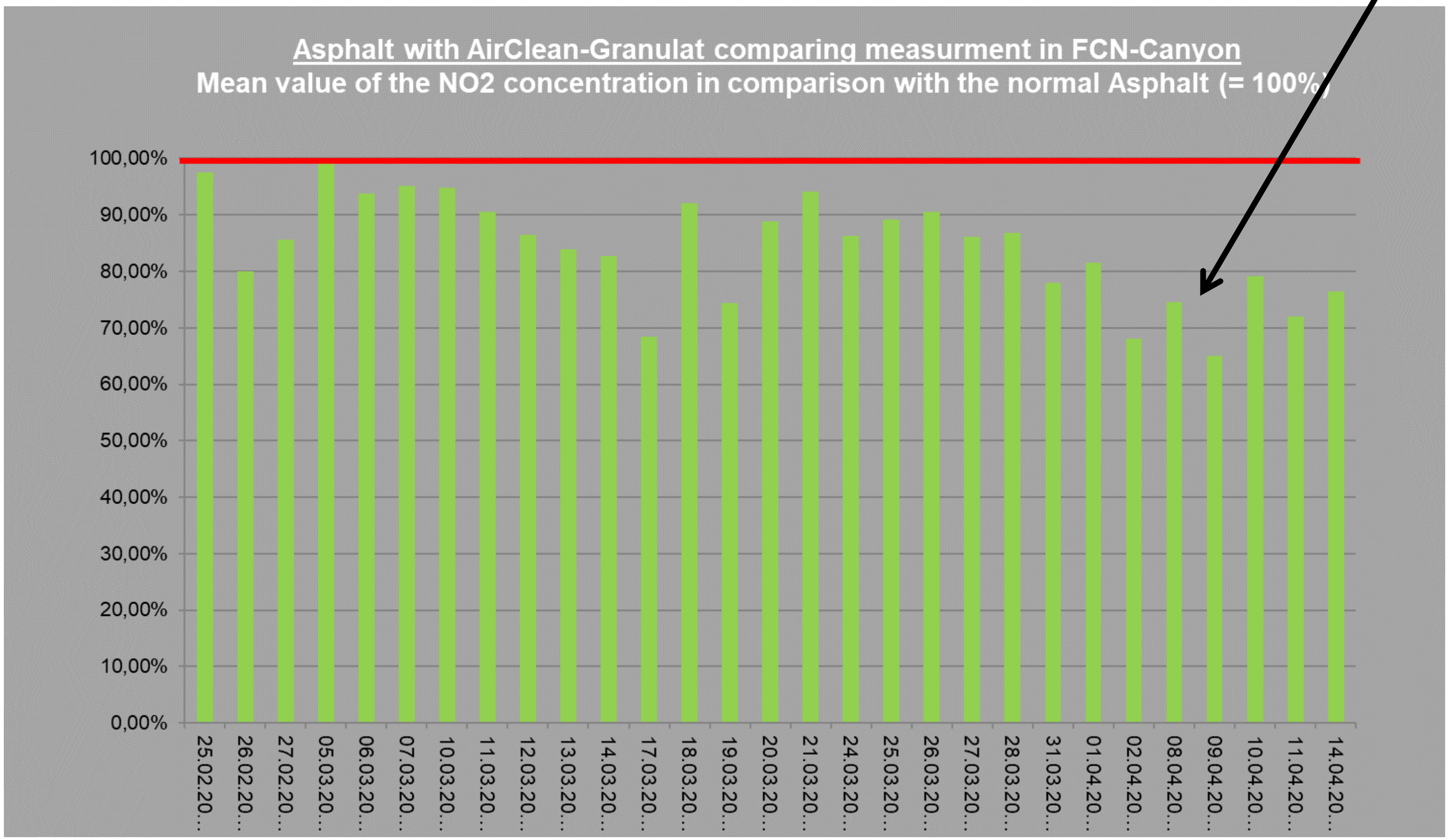
NO2 reduction about 25 %



Verification of photocatalytic activity

- FCN-Canyon measuring trial





Verification of photocatalytic activity

- In-situ street measuring campaign

Verification of photocatalytic activity

- In-situ street measuring campaign

Trial road: 600 m long, 3 measuring stations, AirClean® Granule 1/3 mm, 1.4 kg/m²

Reference road: 650 m long, 3 measuring stations

Total measuring duration: about 4 weeks (before and after)

Verification of photocatalytic activity

- In-situ street measuring campaign

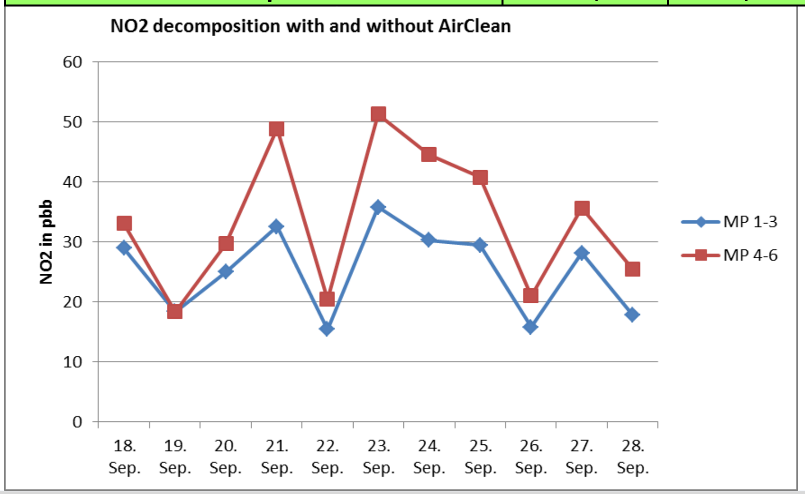
Variante 1 **no2 decomposition before and after AirClean**

concentration: ppb time period: 7:00-18:00		before	
		MP 1-3	MP 4-6
		no2	no2
08.09.2017	Fri	38,55	37,49
09.09.2017	Sat	32,61	30,99
10.09.2017	Sun	25,81	29,02
11.09.2017	Mon	14,79	18,35
21.09.2017	Thu	32,74	48,94
22.09.2017	Fri	15,24	20,33
23.09.2017	Sat	35,89	51,67
24.09.2017	Sun	30,01	43,98
25.09.2017	Mon	29,34	40,44
26.09.2017	Tue	15,75	21,32
27.09.2017	Wed	28,09	35,75
28.09.2017	Thu	17,67	25,25
		25,10	**33,47**

	MP 1-3	MP 4-6
Δ after-before	- **5,72**	- **0,24**
correction MP 4-6 (-0,24)	- 0,24	
Δ after-before (corr.)	- 5,49	
Δ after-before in %	**-17,8%**	

no2 decomposition with and without AirClean

concentration: ppb time period: 7:00-18:00		**with**	**without**
		MP 1-3	MP 4-6
		no2	no2
18. Sep.	Mon	28,93	33,06
19. Sep.	Tue	18,41	18,35
20. Sep.	Wed	24,98	29,7
reduction in pbb and %		**5,43**	**17,7%**



Comparison **before and after**:
NO2 reduction = **17.8 %**

Mean values of 3 measuring stations (07:00-18:00)

Comparison **active and inactive**:
NO2 reduction = **17.7 %**

Mean values of 3 measuring stations (07:00-18:00)

NaHiTAs

Research Project - Substainable HighTech Asphalt (NaHiTAs):
Pollution and noise reducing asphalt with innovative new material processing and monitoring

Funded by Federal Ministry of Education and Research (BMBF)

Bundesministerium
für Bildung
und Forschung

In cooperation with

Project duration:
01.07.2015 - 31.12.2018

NaHiTAs

Goal: Conception of a multifunctional road surface made of asphalt

Pollutant decomposition: Photocatalytic properties

Innovative paving technology: Processing and monitoring technology

Subtainability: Methods to maintain noise and NOx reducing properties

Noise reduction: Noise-reducing texture

Results

NaHiTAs
Nachhaltiger HighTech-Asphalt

Performace test for the application as spreading material according to TL Gestein StB (Technical delivery conditions for aggregates in road construction)

<u>Assessment in terms of traffic safety and durability:</u>

- Resistance to polishing
- Resistance to mechanical loading
- Resistance to weathering, freeze-thaw attack
- Resistance to abrasion
- Affinity to bitumen

AirClean® Granule	**!!! excellent !!!**

Results

Experiments on Bitumen

Influences of TiO_2 and photocatalysis on the **aging process of bitumen**

- 2x Road bitumen 50/70
  1x Polymer modified bitumen
  - Softening point
    Penetration
    Break point
  - DSR and BBR
  - Chemical Analysis
    - Asphalt seperation
    - Latroscan (TLC-FID)
    - Infrared spectroscopy
    - Waste product
    - Reporter molecules

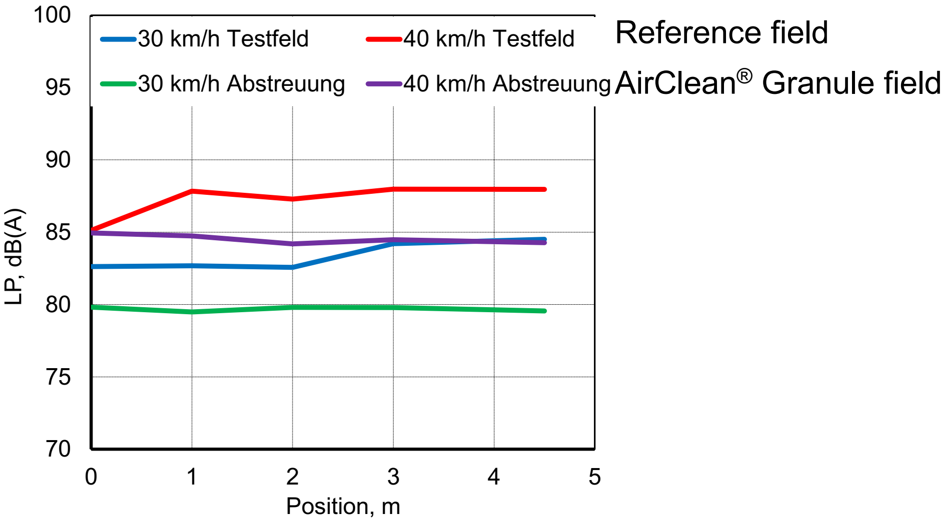
→ **No negative effect through TiO2 and photocatalysis was found!!!**

Results

NaHiTAs
Nachhaltiger HighTech-Asphalt

Evaluation of the **noise reducing effect** (CPX-Method):

- Trial road in Bad Hersfeld (AirClean® Granule 1/3 mm, 1.4 kg/m², Asphalt SMA 5)
- Reduction of noise from 3 to 5 dB(A) on asphalt surface with **AirClean® Granule**



Practical application

- **road paver (innovative)**
  mounted with chips spreader

→ Simultaneously paving the asphalt surface and spreading the granules

- **chips spreader (conventional)**
  mounted on roller

→ spreading the granules after paving the asphalt surface and before the first compaction procedure

References

- **Completed field trials:**
  - STRABAG/TPA test field, Bad Hersfeld, 2016 and 2018
  - BASt test field, Köln, 2017
  - Sanhe test field, China, 2017

- **Completed projects:**
  - Project Darmstadt, Rheinestr., April 2019
  - Project Stuttgatt, am Necktor, April 2019

- **Ongoing projects**
  - Project Denmark, Port Skagen, Summer 2019
  - Project Darmstadt, Hügelstr., May 2019
  - Project Herne, Hauptstr. + Bismarkstr.+ Rottbruchstr., Summer 2019
  - Project Potsdam, Summer 2019 …

References

Project Darmstadt: Rheinestraße → through conventional method

References

Project Darmstadt: Rheinestraße → through conventional method

References

Project Darmstadt: Rheinestraße → through conventional method


40-42
8
HAMM
Wz.5
PETER RUDOLPH
STRASSEN- UND TIEFBAU
Lofty
»Top Trends
einmalig
günstig!«
www.lofty.de

References

Project Darmstadt: Rheinestraße → through conventional method

References

Project Darmstadt: Rheinestraße → through conventional method

References

Project Stuttgart: am Necktor → through innovative method

References

Project Stuttgart: am Necktor → through innovative method

References

Project Stuttgart: am Necktor → through innovative method

References

Project Stuttgart: am Necktor → through innovative method

References

Project Stuttgart: am Necktor → through innovative method

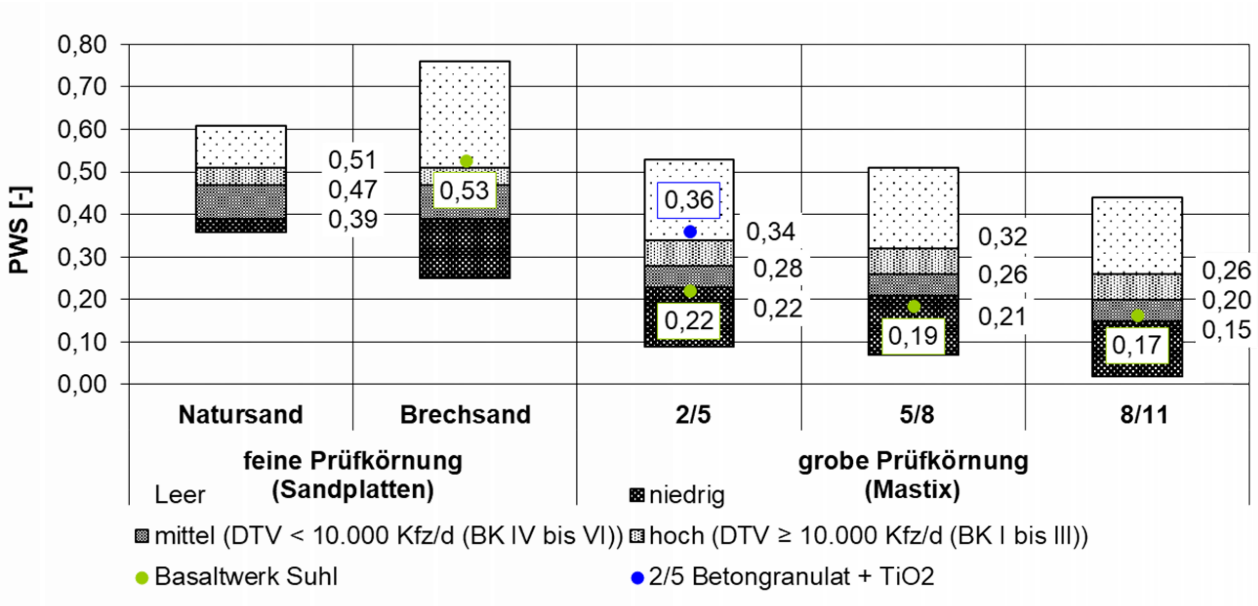

STRABAG
8

Thanks for your attention !

Results

AirClean® Granule in comparison with natural aggregate (Greywacke and Basalt):

- According to the specification FE-Nr. 06.0098/2012/DGB **AirClean® Granule** is quit suitable for roads even under extreme heavy traffic load (up to load class 32/100)



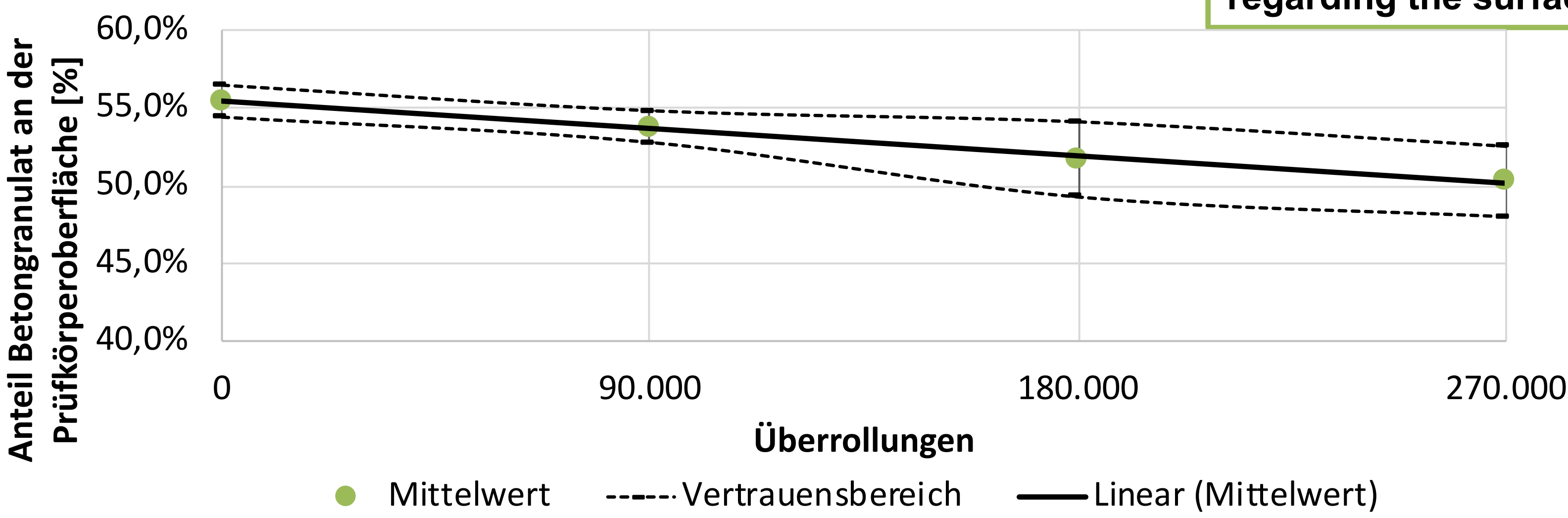
<u>Resistance to polishing</u>

Wehner/Schulze-Method

Results

- **<u>Abrasion test</u>** of **AirClean® Granule** spread on asphalt surface (sample taken from the trial field in Bad Hersfeld)
- **AirClean® Granule**: 1/3 mm, 1.4 kg/m², Asphalt SMA 5
- Average grip reduction of 0.01 unit after 270.000 overrolling

Average areal loss of 1.7% per 90.000 overrolling regarding the surface area



Practical application

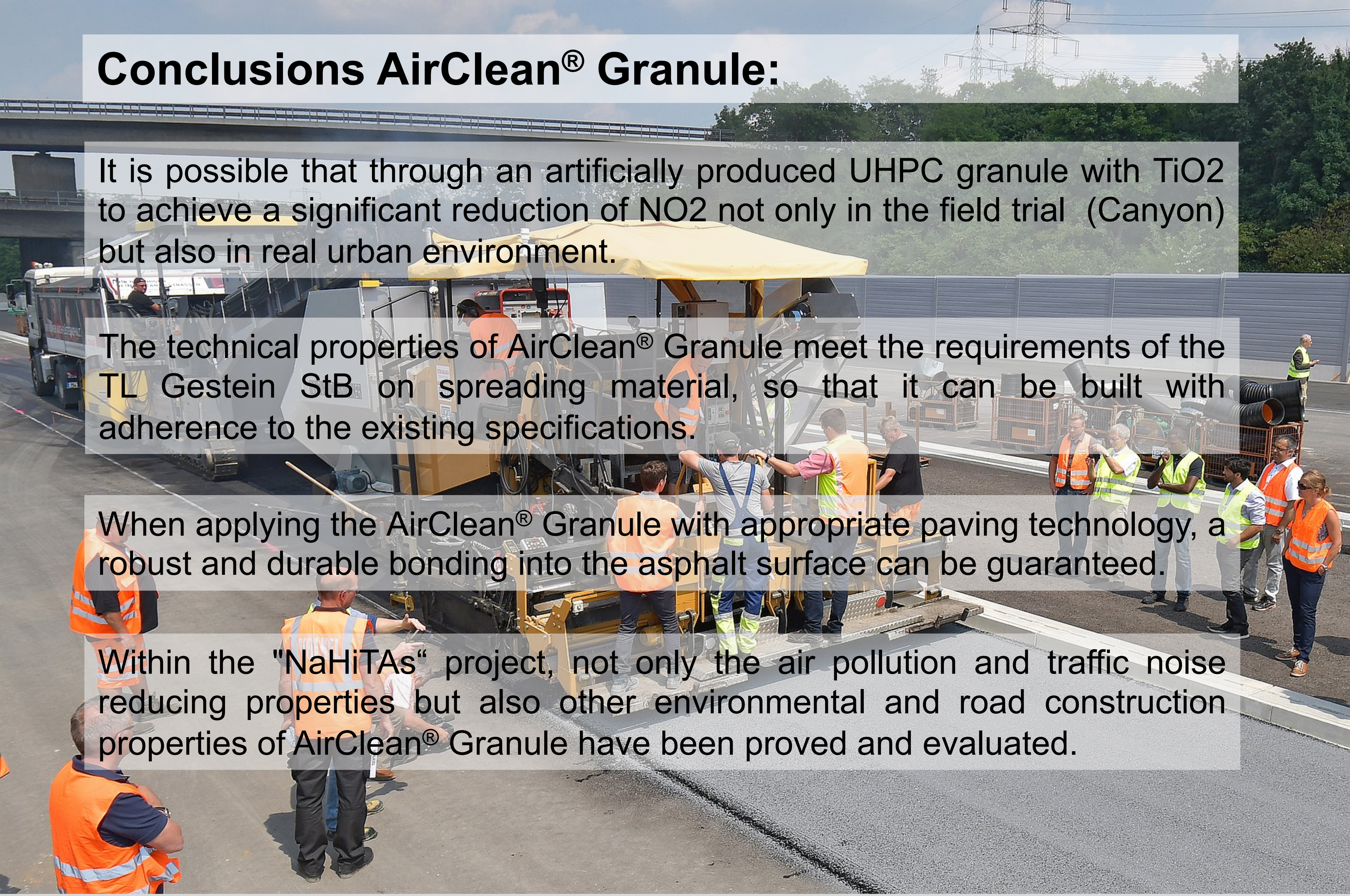
Application sequence (for conventional method):

- The granules shall be spread before the first rolling procedure onto the hot asphalt surface directly behind the paving screed of road paver.
- The spreading work shall be executed through a precision chips spreader mounted on a roller.
- The granules should be pressed and rolled into the asphalt surface with a smooth roller with vibration.

Technical requirements:

- Maximum grain size of the asphalt overlay 8 mm → SMA 5, AC 5 or SMA 8, AC 8
- Application of granules exclusively for air temperature > 15 °C, no application in rain
- The temperature of asphalt mixture at the time for the spreading and rolling procedures > 140 °C
- …

Conclusions AirClean® Granule:



It is possible that through an artificially produced UHPC granule with TiO2 to achieve a significant reduction of NO2 not only in the field trial (Canyon) but also in real urban environment.

The technical properties of AirClean® Granule meet the requirements of the TL Gestein StB on spreading material, so that it can be built with adherence to the existing specifications.

When applying the AirClean® Granule with appropriate paving technology, a robust and durable bonding into the asphalt surface can be guaranteed.

Within the "NaHiTAs“ project, not only the air pollution and traffic noise reducing properties but also other environmental and road construction properties of AirClean® Granule have been proved and evaluated.