SolDuGri

For sustainable reinforcement of infrastructures with glass fiber grids

X Carbonneau

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V Krakowskie Dni Nawierzchni 2018

- Background
- Collaborative research
- Objectives
- Work Programme
- Status
- Conclusion

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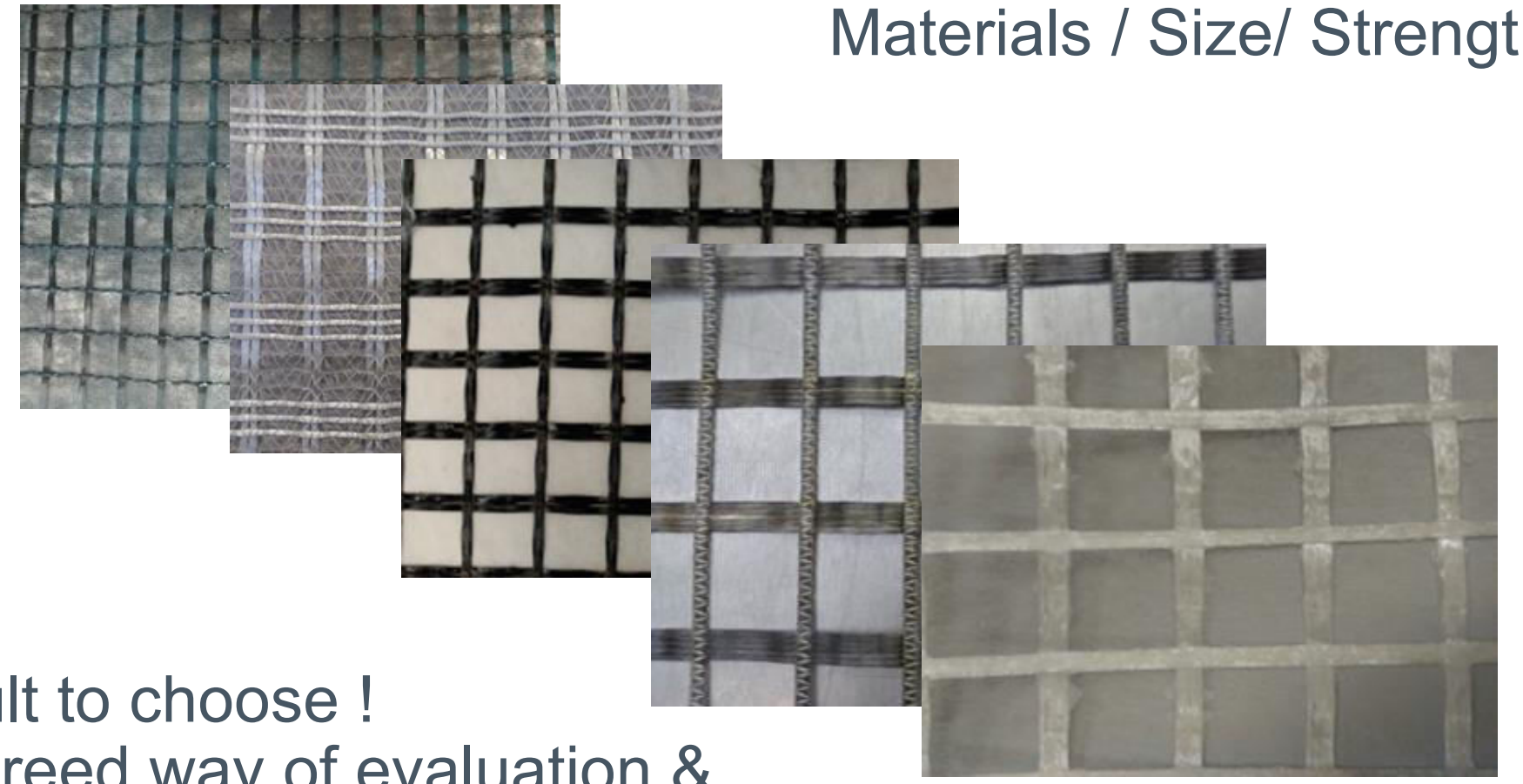
Background

Lots of grids
Materials / Size/ Strength



Difficult to choose !
No agreed way of evaluation & implementation in road design

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Collaborative research

Project Leader INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES STRASBOURG

- Epsilon Private R & QC laboratory for civil works
- 6 D Solutions Fiber glass grids supplier
- Colas Construction & Maintenance transport infrastructure

- Ifsttar
- INSA ICUBE
- ICS

Starting 01/01/2015 For 60 months
Budget : 2 M€

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Objectives

- Efficient and durable solutions for maintenance and reinforcement
- More rational assessment method of the grids
- Understanding and quantification of damage during paving
- Mechanical behaviour of interfaces
- Tool for adapted pavement design with grids
- Data on LCA

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Objectives

› Main results at the end of the project

– Test methods for grids assessment

- Effect of geogrids on bonding

- Optimisation of glass grids characteristics

- Pavement design methodology (including glass grid contribution)

- Impact of glassgrids on recycling

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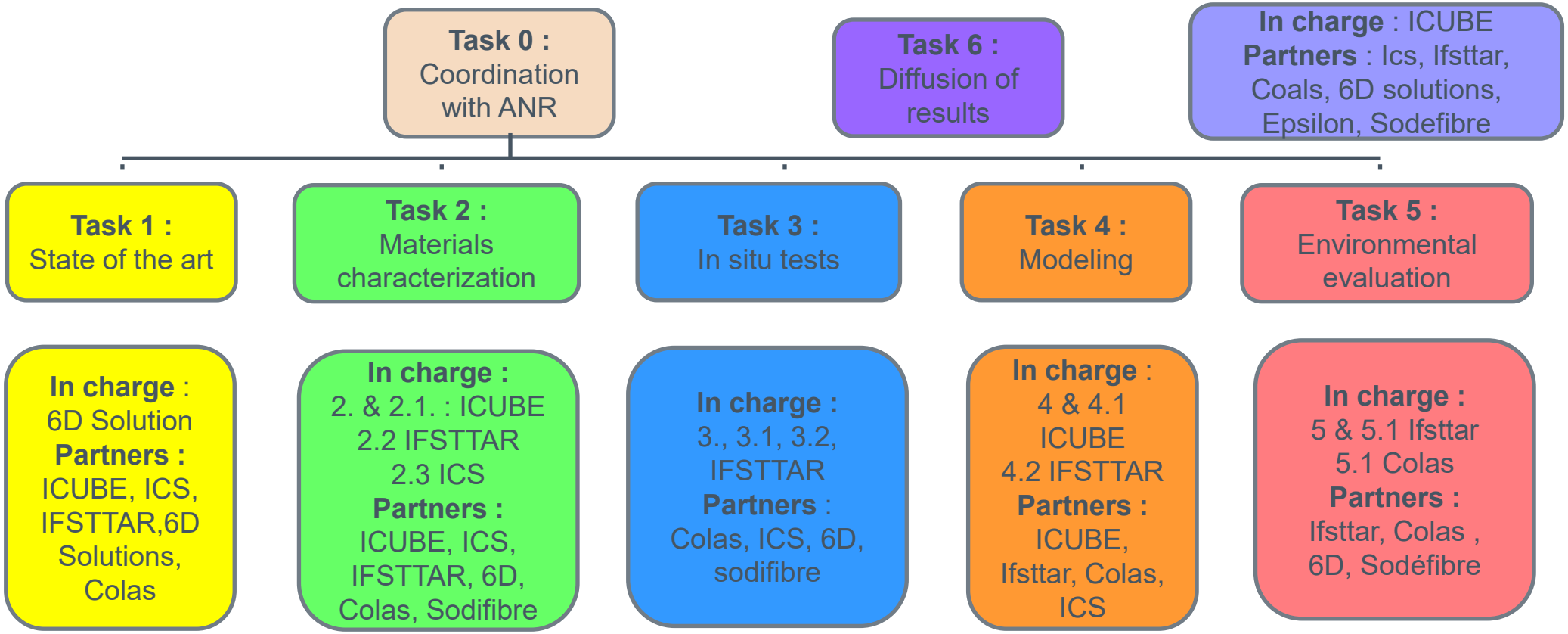
Work programme



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Status – Damaging of geogrids

› Evolution of the grids with AC Laying and compaction

How the grids evolve ?
Tools to simulate and select grids

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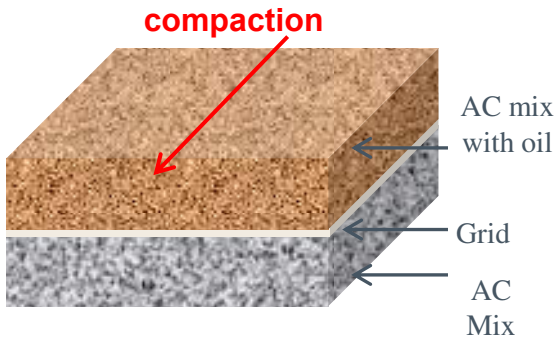
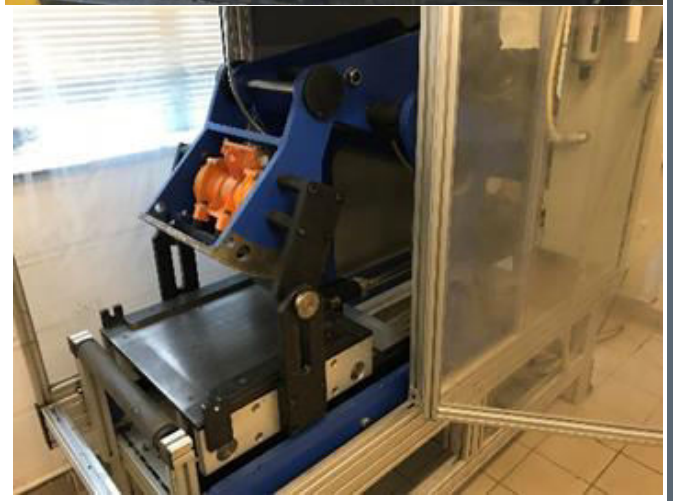
Status – Damaging of geogrids

Effect of the traffic
Grids over AC mix
large rutting device
500 cycles





Simulation of compaction
Compacted @ room temperature
Grids available for characterization

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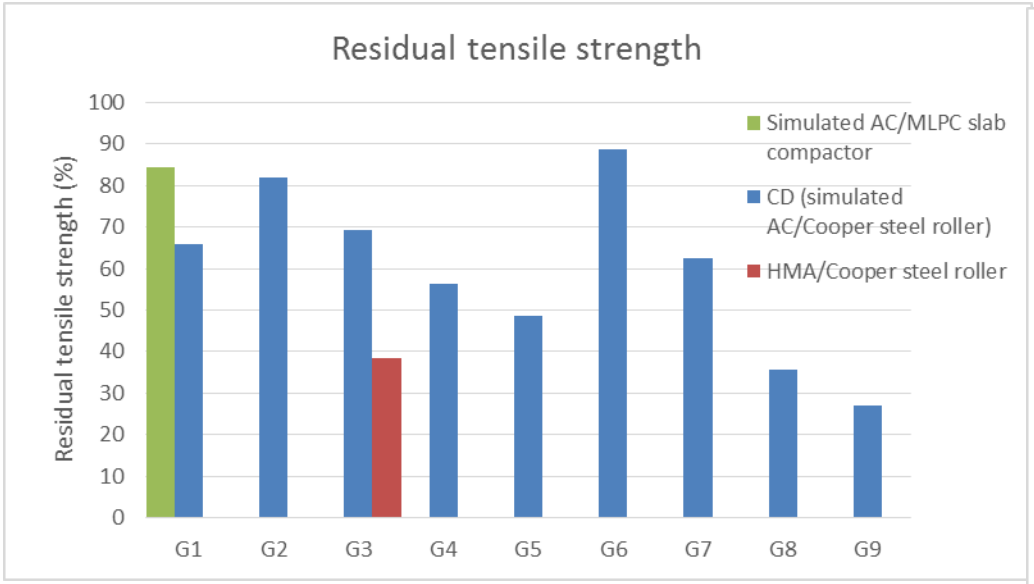
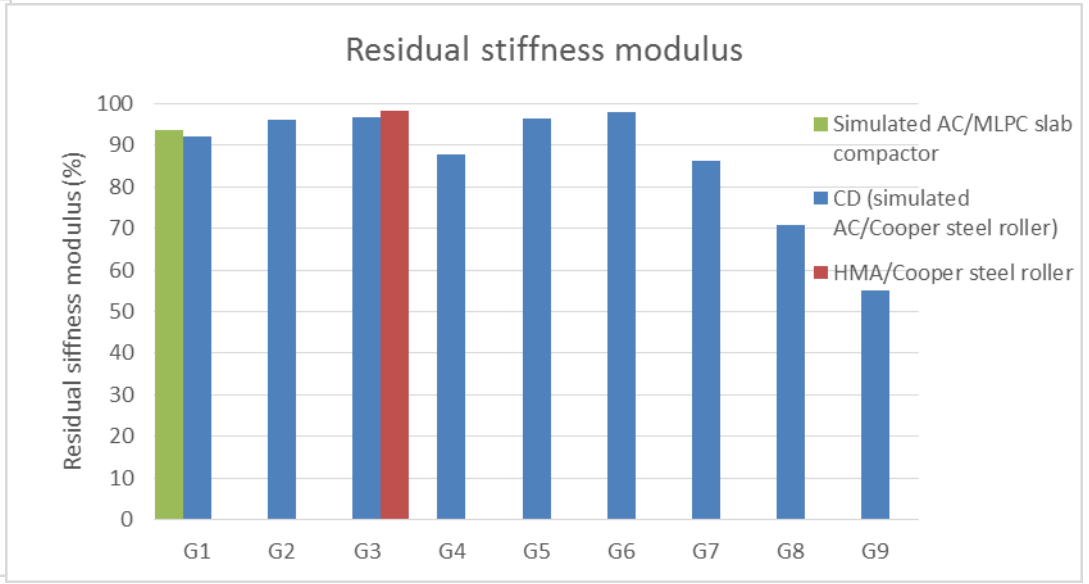
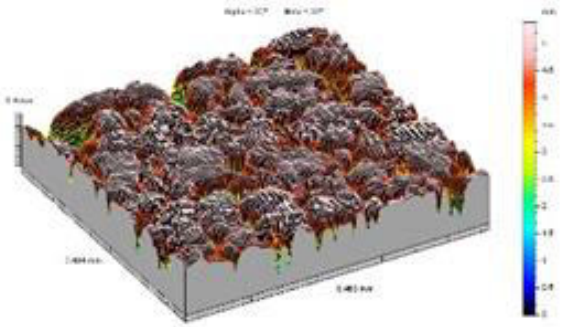
Status – Damaging of geogrids

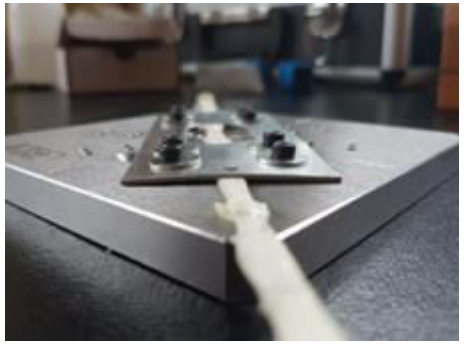
Measurement of residual mechanical characteristics





Status – Damaging of geogrids





Simulate damaging with indentors
Quicker selection of glass grids

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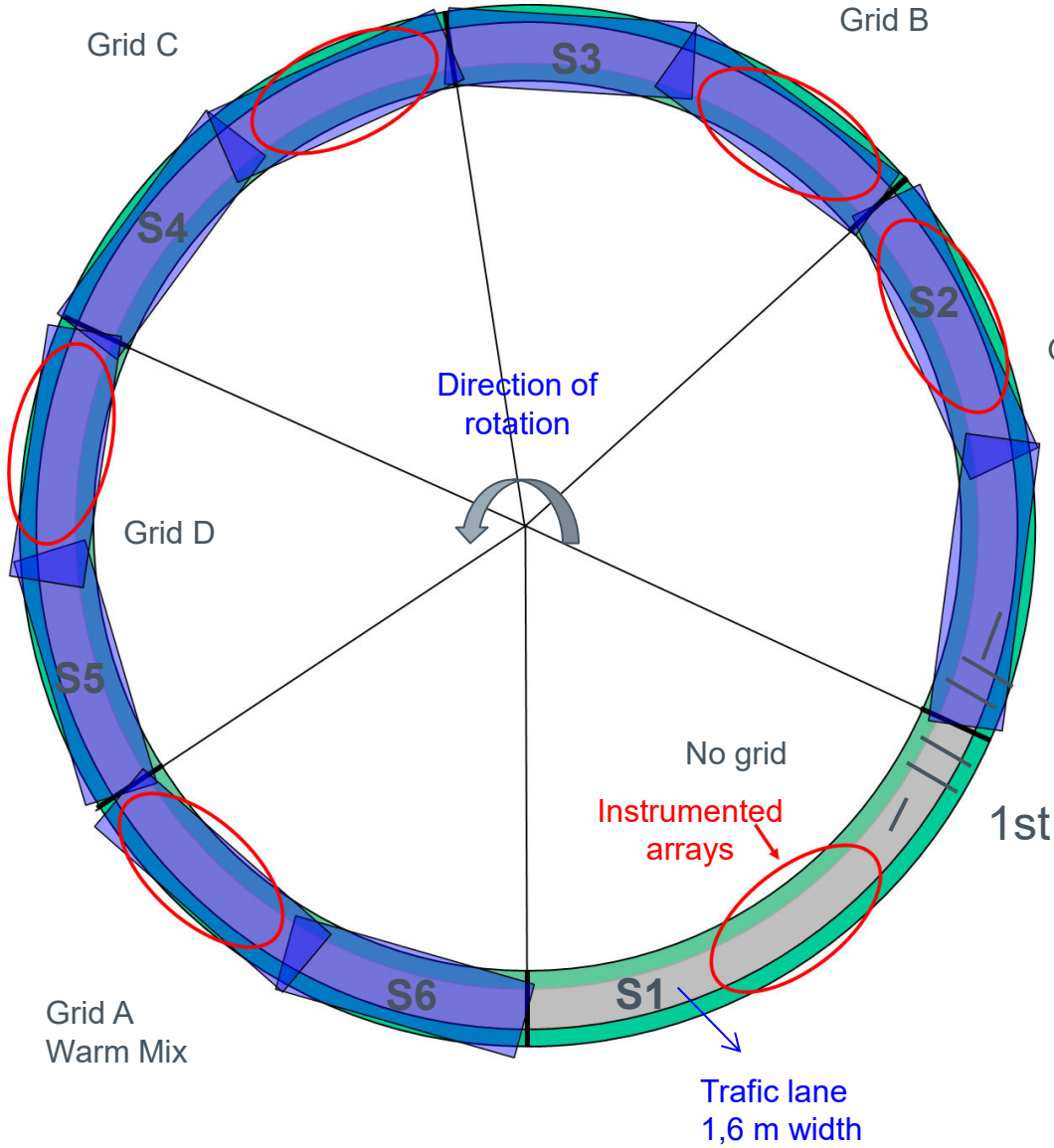
Status Full scale experiment Fatigue Carrousel

S1	**BBSG référence**	11 cm
S2	BBSG + grid A	5+6 cm
S3	BBSG + grid B	5+6 cm
S4	BBSG + grid C	5+6 cm
S5	BBSG + grid D	5+6 cm
S6	BBSG Warm +grid A	5+6 cm



Cracks in 1st AC Mix layer

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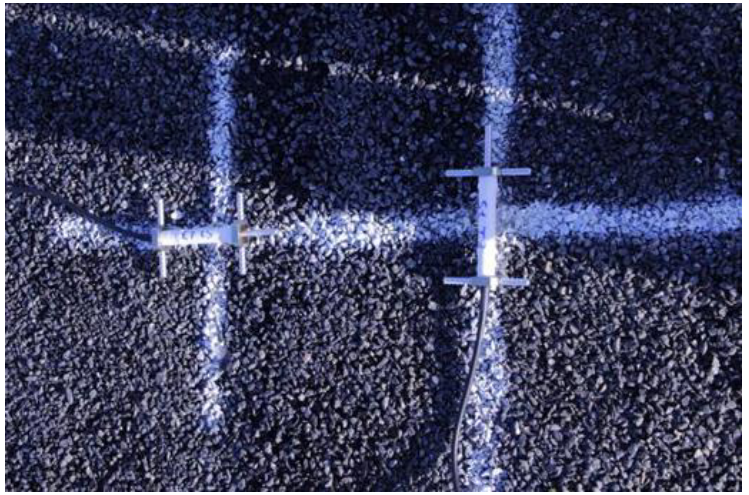
Status Full scale experiment Fatigue Carrousel

1,5 Millions loadings @ 70 km/h /January – June 2018



Strains in AC mix , in grids, vertical strain basement, temperature

Comparison between Modeling and Carrousel results
Deconstruction environmental measures (dust)

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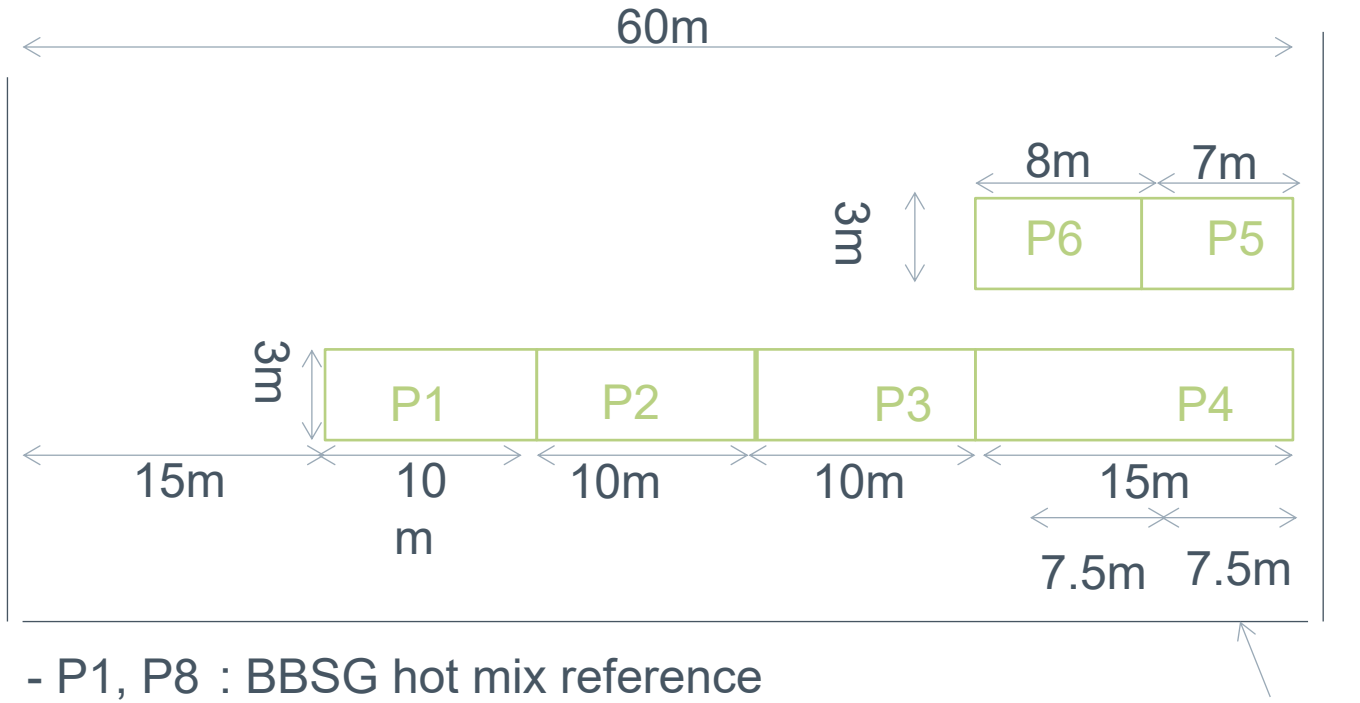
Status Full scale experiment



- P1, P8 : BBSG hot mix reference
- P2, P6 : BBSG hot mix, grid A
- P3 : BBSG hot mix, grid D
- P5 : BBSG warm mix, grid D
- P7 : BBSG hot mix grid B

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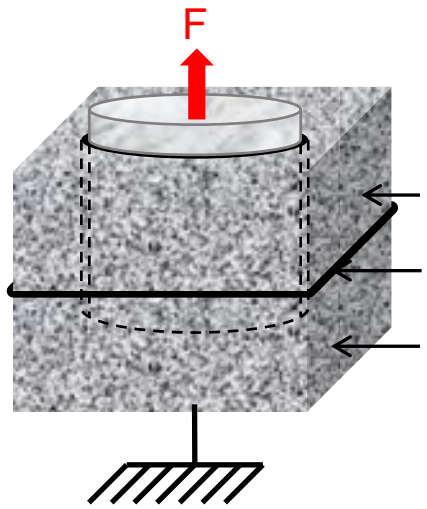
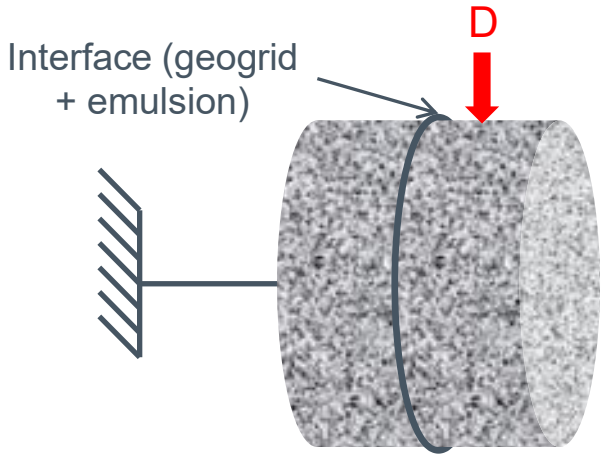
Status : bonding between layers

- According to EN 12697-48
  - Tension Test
  - Shear Bond test





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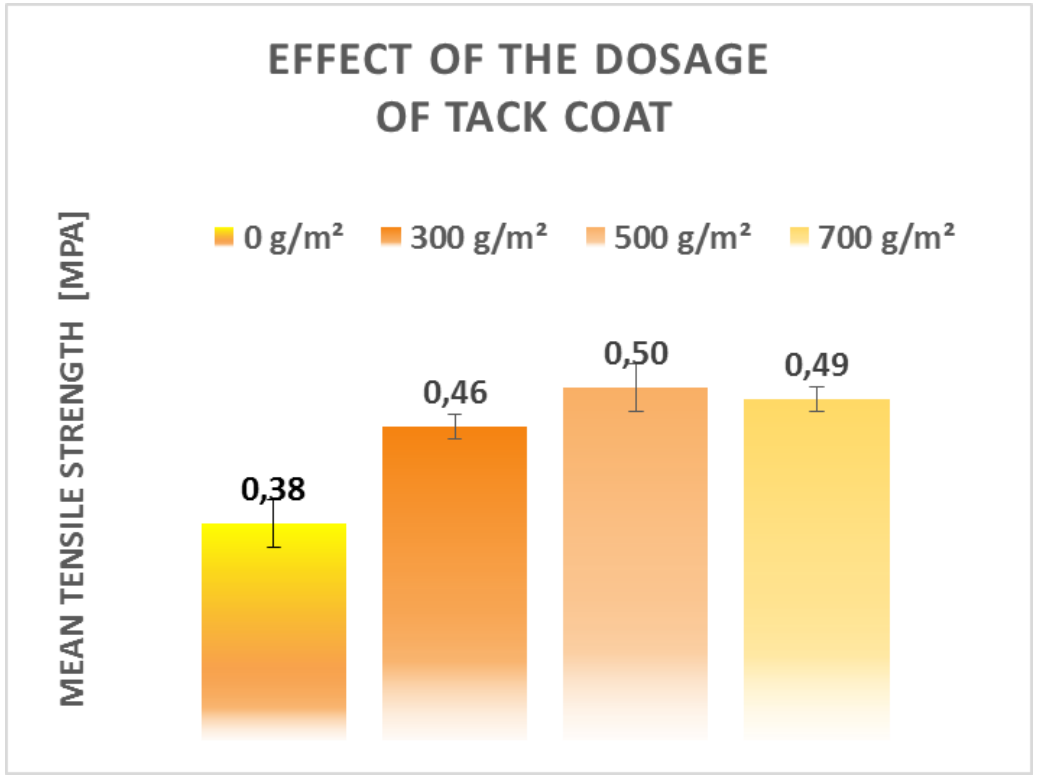
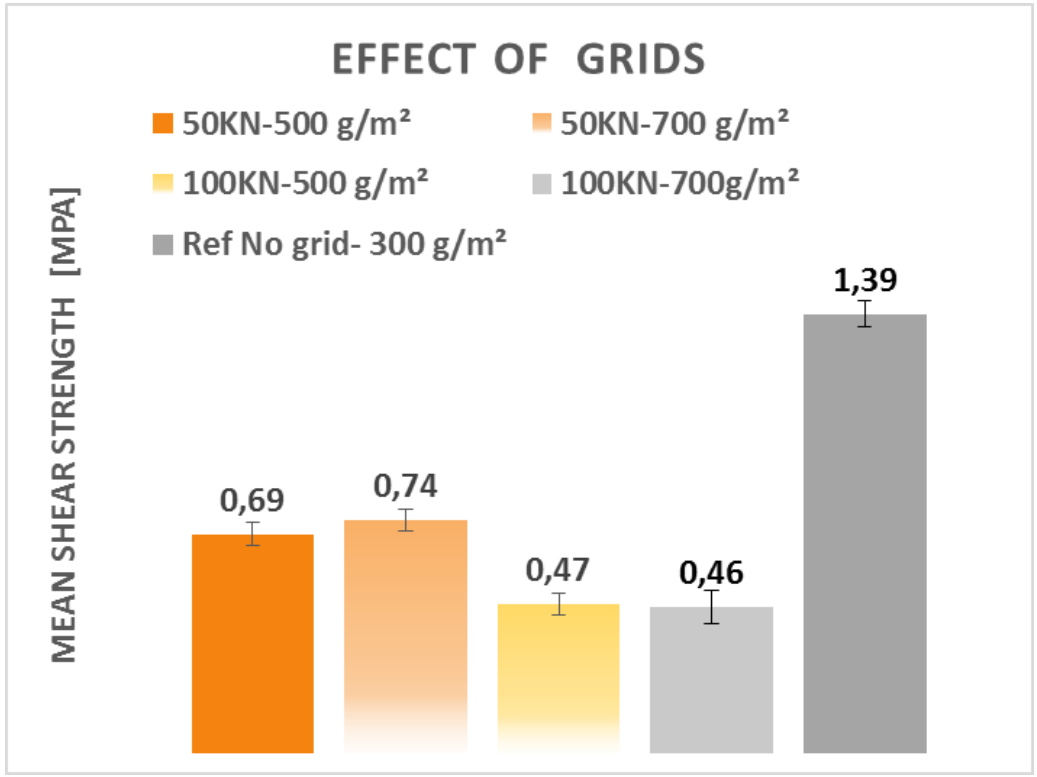
Status : bonding between layers

Tensile test



Shear Test



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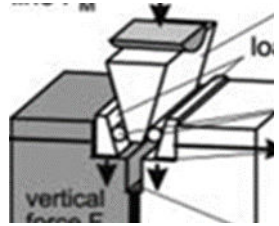
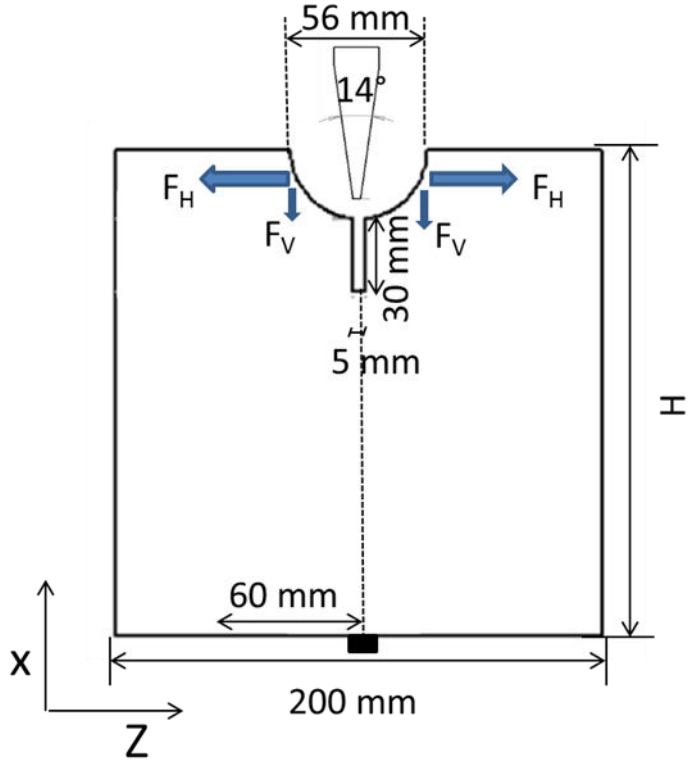
Status : bonding between layers



(Tschegg et al., 2012)

Selection of WST Wedge splitting test
Pure mode I
Adaptation
- Sample size
- Notch
- Work on site samples

Development of test under water



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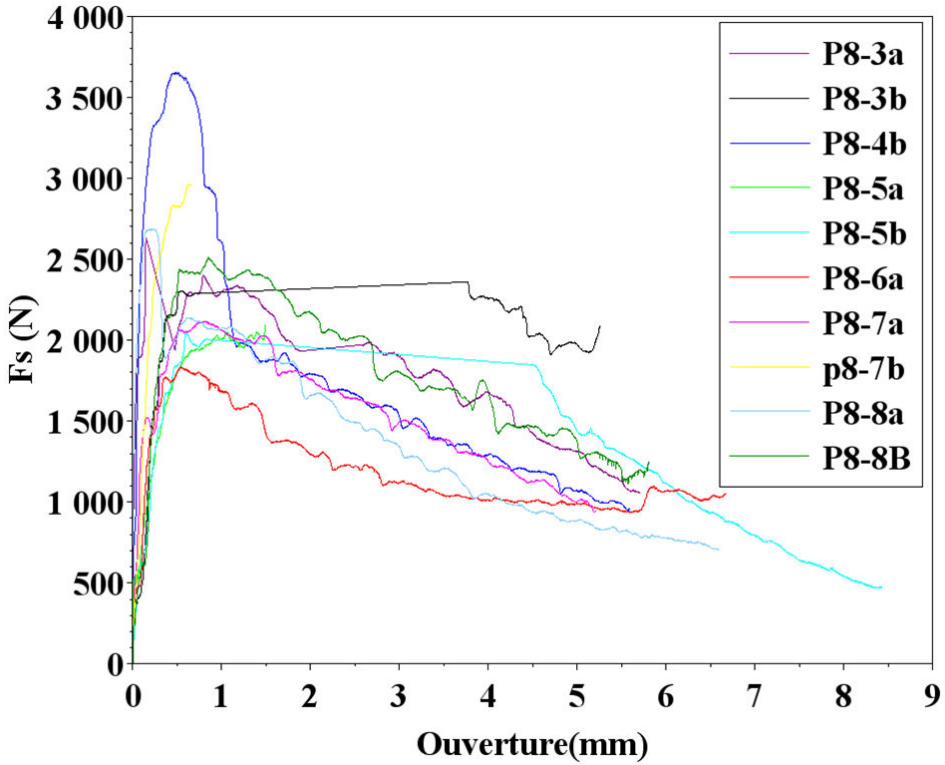
Status : bonding between layers

Test on field samples



Grid : reduction of the bonding

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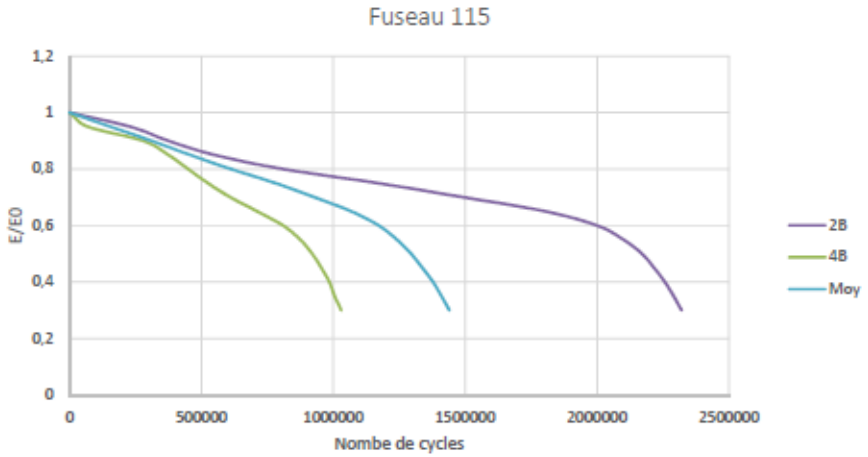
Status Mechanical characteristics

› Evaluation of AC mixes

	Warm mix (135 °C)	Hot mix (160°C)
Modulus 15°C 10hz (MPa)	12400 (12600*)	11970 (12900*)
Fatigue 10°C 25Hz (µm/m)	118 (111*)	118 (109*)

Test on the composite : AC MIX + grids



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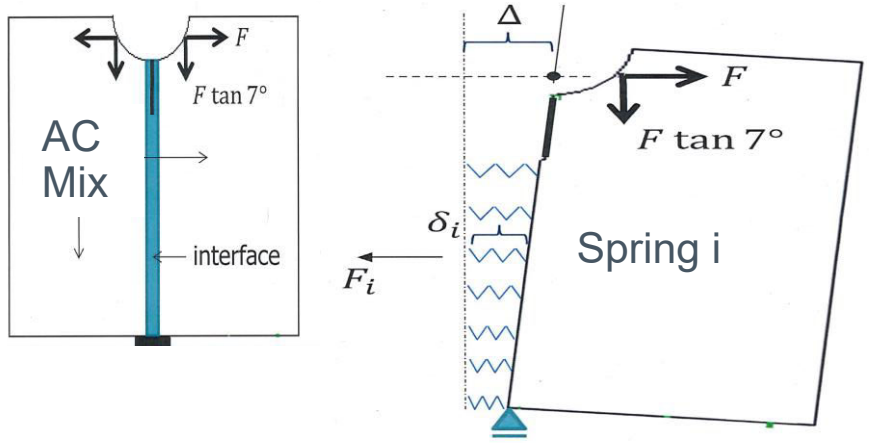
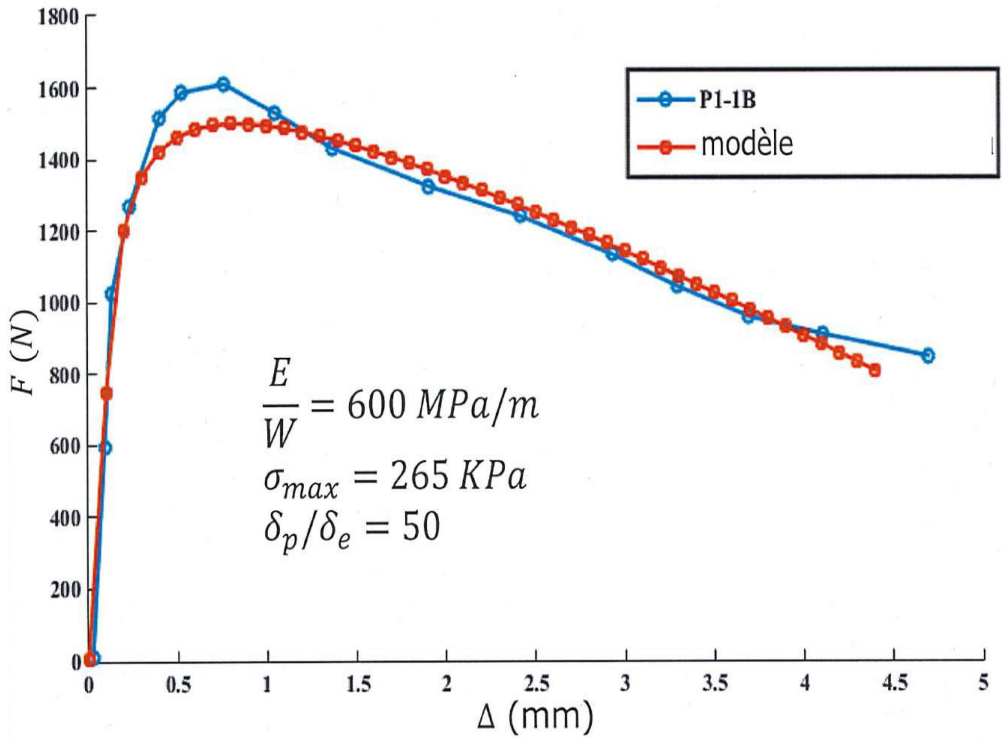
Status Modeling

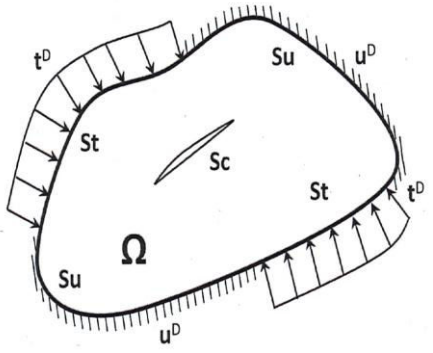
Cracking - WST



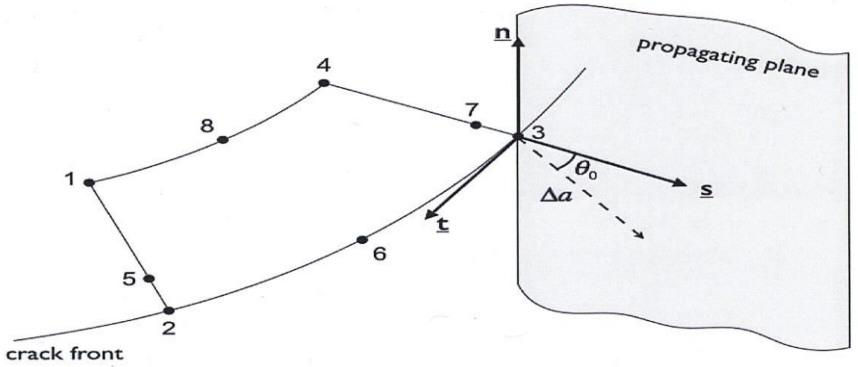


Status Modeling

Crack propagation the pavement

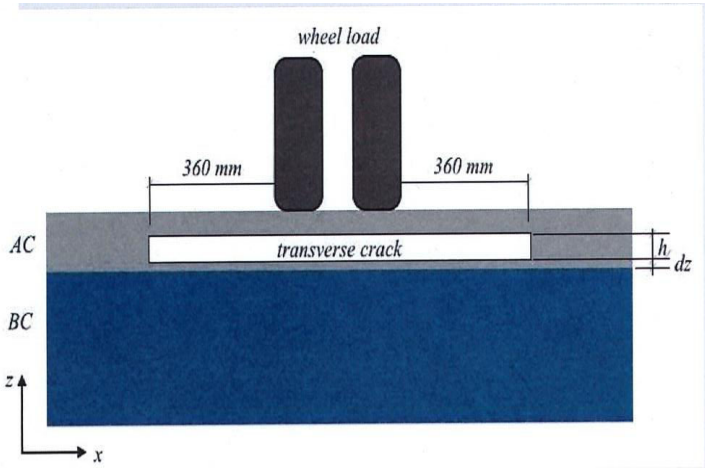


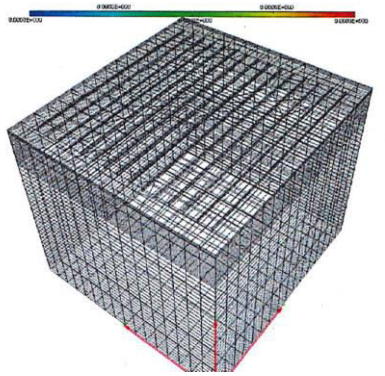
Loading
Crack progagation law
Boundaries state
3D Mesh

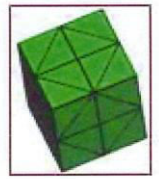


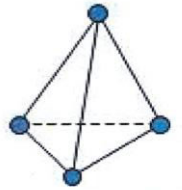
$$\tan\frac{\theta_0}{2} = \frac{1}{4}\left[\frac{K_{Ieff}}{K_{II}} \pm K_{II}\sqrt{\left(\frac{K_{Ieff}}{K_{II}}\right)^2 + 8}\right]$$

$$\frac{\Delta a}{\Delta n} = C(\Delta K_{eff})^m$$









3D maillage

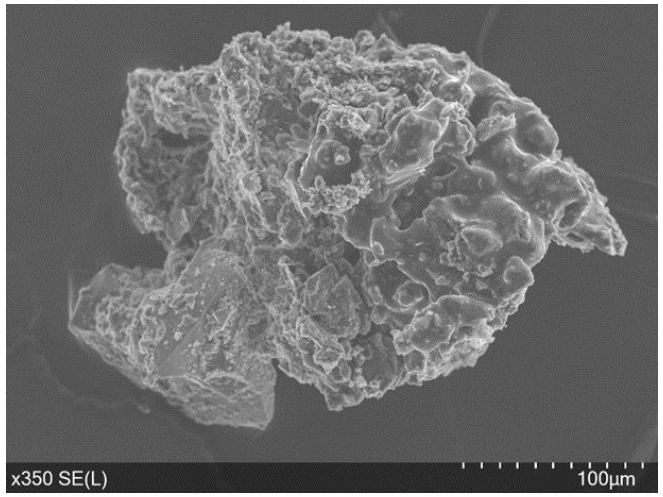
Status – environmental evaluation

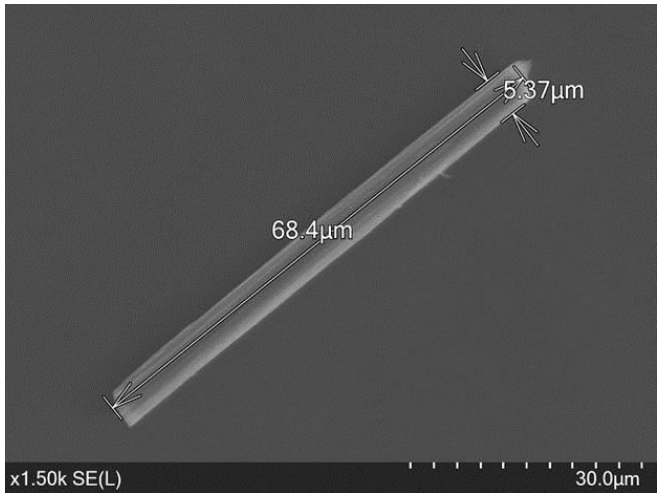
Recycling : Used as RAP

Impact of grids on dust emission with milling

Safety issues with fiberglass particle size ?

In lab milled grids





Dust produced with milling operation

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Status – environmental evaluation

LCA

Lifespan of the pavement

Impact of glass grids on environmental parameters
GEE emission, Energy,..

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Conclusion

- ~ Mid term
  - Development of methodology to characterize grids
  - Good knowledge of damage in the laying step
  - Tools for measuring effect on bonding
  - Full scale trial
    - Measurements to better understand effect of geogrids on mechanical behavior
    - Loading still ongoing in Nantes
  - Modelling
    - New tools to simulate behavior
    - Based on better knowledge of characteristics from components (AC mix & Grids)
  - LCA

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Conclusion

Next step :

- Better pavement design method
- Better selection of grids
- Recommandations for users
- Development of this solution for maintenance

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More details in :

- Godard Eric, Chazallon Cyrille, Hornych Pierre, Nguyen Mai Lan, Doligez Daniel, Pelletier Hervé, Pour une solution durable du renforcement des infrastructures par grilles en fibre de verre, RGRA, 949, Octobre 2017, p24-33
- C Chazallon, T.C. Nguyen, M.L.Nguyen, P. Hornych, D. Doligez, L. Brissaud, E. Godard, “In situ evaluation of geogrid used in asphalt concrete pavement” BCRRA 2017 Athens
- M. Gharbi, M.L. Nguyen, A. Chabot « Experimental evaluation of the interface fracture energy for composite pavements » EATA 2017, 12-14 juin Dubendorf, Switzerland
- M. Gharbi, M.L. Nguyen, S. Trichet, A. Chabot « Characterization of the bond between asphalt layers and glass grid layer with help of a Wedge Splitting Test » BCRRA 2017 Athens
- C. Chazallon, C Barazzutti, H. Pelletier, M.L. Nguyen, P. Hornych, D. Doligez « Laboratory evaluation and reproduction of geogrid in situ damage used in asphalt concrete pavement” ISAP 2018
- M. Gharbi A. Chabot « Characterization of debonding at the interface between layers of heterogeneous materials coming from roads » CFM 2017