Infravation
An Infrastructure Innovation Programme
BioRePavation

BioRePavation: Innovation in bio-recycling of old asphalt pavements

Infravation innovation project

biorepavation.ifsttar.fr

Consortium

- IFSTTAR (France - coordination – has evaluated durability at full scale)
- EIFFAGE Infrastructures (France – has produced an alternative binder & carried out mix design tests)
- IOWA STATE UNIVERSITY (USA – has produced a bioasphalt & carried out mix design tests)
- KRATON chemical (Netherlands – has produced a bio-based performance additive)
- WESTERN RESEARCH INSTITUTE (USA – has carried out non-destructive in-situ evaluation and binder tests)
- UNIVERSITY OF NOTTINGHAM (UK - has conducted life cycle and risk assessment, and binder tests)

Nov 2016 – Avril2018

Main objectives

- Towards a more environmentally friendly **pavement**
  - Increase recycling rate
    - Recycling rate targeted : 50 – 70 %
  - Save natural resources
    - virgin petroleum bitumen
    - virgin aggregate from quarries

Take most advantages from the old brittle bitumen remaining from reclaim materials

At least: same level of quality in comparison to conventional technics

Proposal

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How to prepare actual implementation ?

- Evaluation of 3 alternative bio-materials designed to help recycling (rejuvenators → full replacement)

Sylvaroad™

Biophalt®

Epoxidized methyl soyate

- Technical assessment
  - Demonstrator: IFSTTAR accelerated pavement testing facility
    - Distress mechanism monitoring
    - Innovative non-destructive method
- Environmental assessment
  - Life cycle assessment
  - Fume emission measurements

1st output : an innovative mix

To design mixes with high % of very old RA and biomaterials

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- A new type of base course mix has been designed: GB5 type mix (50 % RAP and 70% RAP) using aggregate packing concept (by maximizing their interlock)
  - Designed according to:
  - » Aggregate availability in the plant
  - » Lab studies of blends with virgin binder and recovered RAP binder in order to determine optimal dosage

- Main mix properties:
  - Very dense mix
  - High modulus with a relatively equivalent « soft binder »
  - Low binder content 4.5%
    - **Only 2.8% added binder at 50%RAP**

2nd output: to lay at full scale these innovative materials

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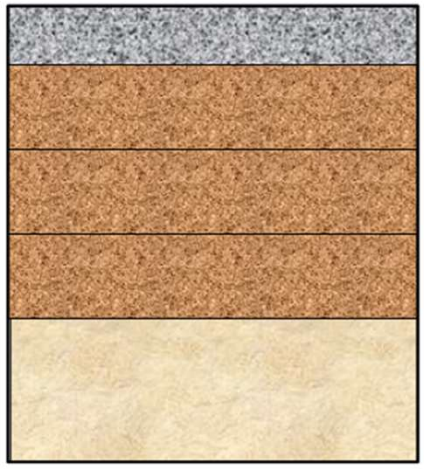
Construction of the demonstration test strip was done in May 2017

MIX1-3: 50% RA / EME: 20 % RA



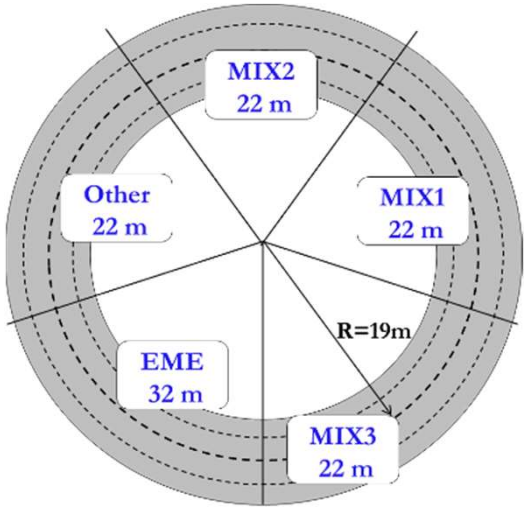
Bituminous surface layer (about 10 cm)

3rd layer Unbound granular base (21 cm)

2nd layer Unbound granular base (25 cm)

1st layer Unbound granular base (30 cm)

Subgrade – stone bed 50/120 mm (1,6 m)



3rd output : high performance in comparison to the conventional mix

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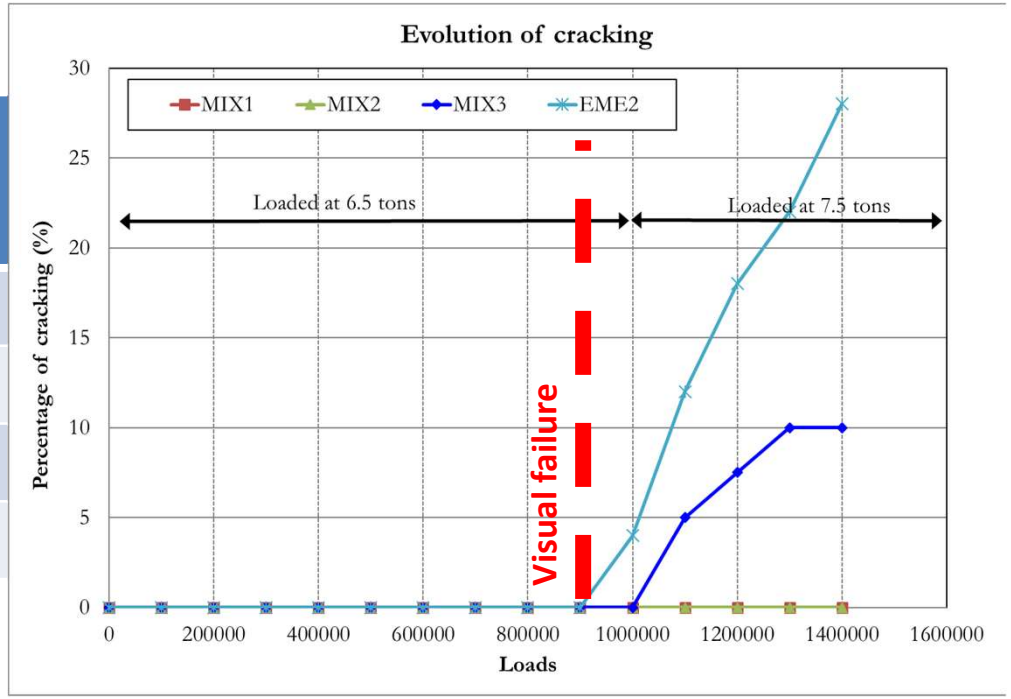
- Low rutting level
- After 1 million cycles: no cracks on the innovative materials, some cracks on the reference material (High modulus mix – EME)
- After 1.8 million equivalent loadings at 65 kN, no cracks on two innovative materials, 10% on one innovative material, 27% on the reference EME
- Results confirmed by FWD measurements and in-situ micro-sampling and testing

MIXES	Air voids	Rutting estimates after initial consolidation
Reference: EME	3.4%	1%
Mix1	3.3%	2%
Mix2	1.6%	2%
Mix3	2.0%	1%



3rd output : high performance in comparison to the conventional mix

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EME2

Mix3

3rd output : high performance in comparison to the conventional mix

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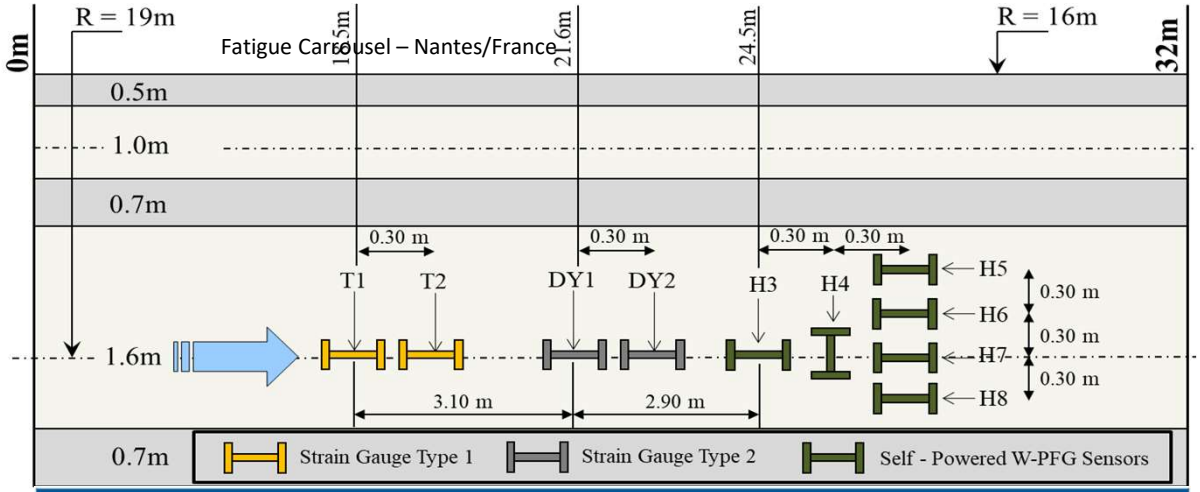
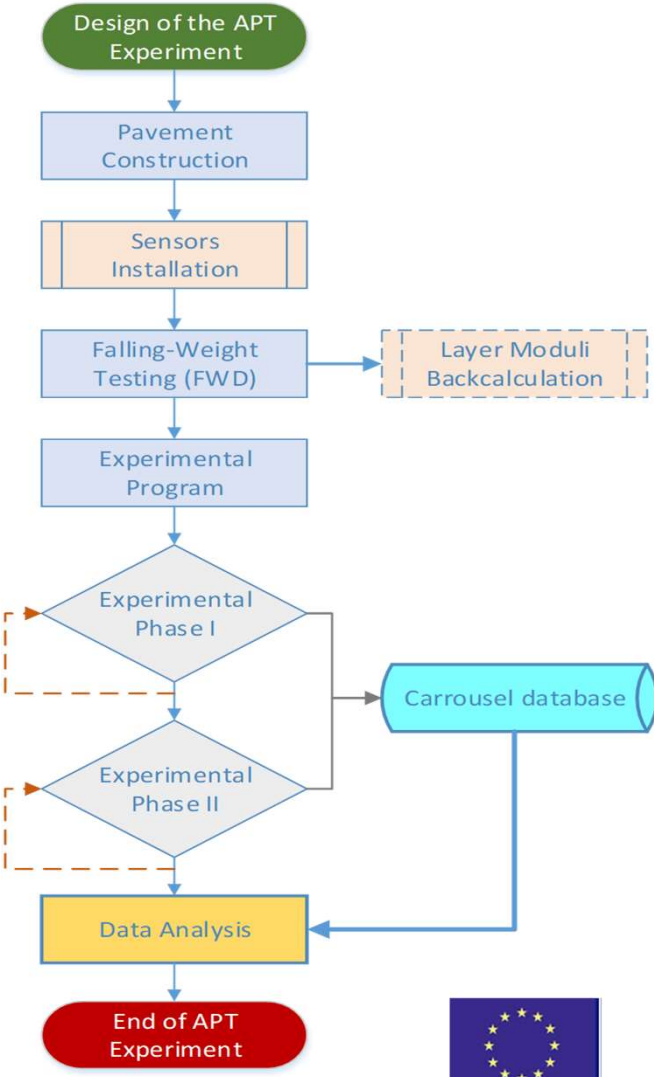


Parameter	Phase I	Phase II
Date	Nov/14/17 to Feb/15/18	Feb/15/18 to Mar/23/18
Number of Loads	Up to 999,200.00	Up to 1,408,000.00
Tyre / Axle	Dual / Single	Dual / Single
Semi-axle load (kN)	65.0	75.0
Speed (rounds/min)	10.0	8.0
Wandering (positions)	11.0	11.0



SMARTi European Training Network 2017-2021 smartietn.eu

3rd output : high performance in comparison to the conventional mix

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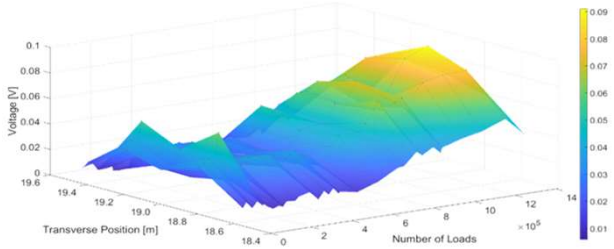
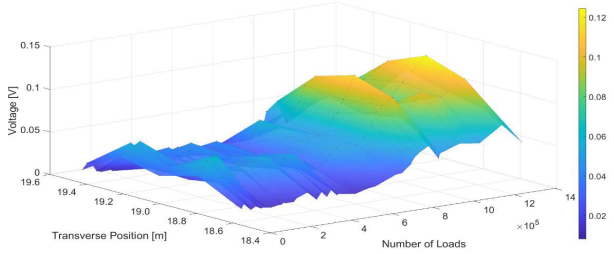
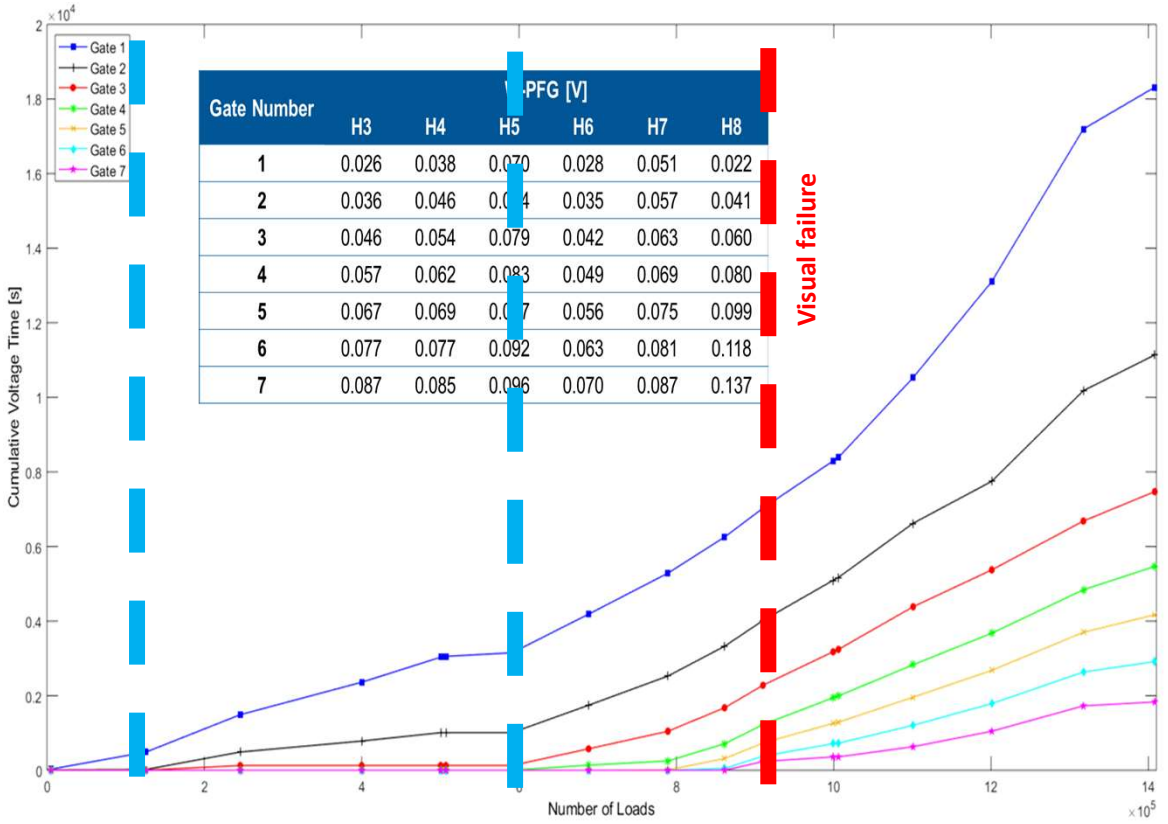
Voltage responses from W-PFG-H3



Voltage responses **(TC)** from W-PFG-H3





Gate Number	W-PFG [V]					
	H3	H4	H5	H6	H7	H8
1	0.026	0.038	0.070	0.028	0.051	0.022
2	0.036	0.046	0.[illegible]4	0.035	0.057	0.041
3	0.046	0.054	0.079	0.042	0.063	0.060
4	0.057	0.062	0.083	0.049	0.069	0.080
5	0.067	0.069	0.[illegible]7	0.056	0.075	0.099
6	0.077	0.077	0.092	0.063	0.081	0.118
7	0.087	0.085	0.096	0.070	0.087	0.137

Predictive maintainance

Davide Lo Presti, 2019

SMARTi European Training Network 2017-2021 **smartietn.eu**

4th output : positive environmental impact

- Measurements of fume emissions in lab
  - Allows defining a limiting mixing temperature in order to remain below organic compound emission of conventional mix for each technology.
- Life Cycle Assessment (cradle-to-gate)
  - The 3 BioRePavation technologies reduce the consumption of non-renewable resources, and even increase the use of renewable resources in the case of the Biophalt mix.
  - Generally the investigated Bio-Asphalt mixtures have lower impact on the environment. In particular, when biogenic carbon is included, the climate change indicator is positively affected. Land Use indicator is significantly negatively affected from BMs if they are not considered as waste. Use of BMs in asphalt mixes is significantly beneficial if these are derived from waste.
  - Environmental control could be carried out by agencies by limiting Transport distances

Conclusion

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- Concept validated!
  - It is possible to manufacture (in conventional asphalt plant) and also to lay (at full scale) a road material with 50% of RA while reducing the amount of fresh bitumen (up to full replacement)
  - Durability: the 3 innovative materials behave better that the reference one which is largely used in Europe for base courses
    - In-situ micro-sampling useful to detect distress mechanism linked to ageing
  - Environmental impact globally positive
- Next step:
  - Deployment of the BioRePavation innovations in various climates and/or local technical policies helped by EU and US lab studies
  - Evaluation of long term durability on the test section
  - Test this concept with other types of mixes including cold mixes

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- Deployment of the BioRePavation innovations
- EMS: in 2017 in Iowa and Emily, Minnesota in August 2019
  - New generation of EMS →SESO is now available at the commercial scale via a batch production process that yields 6 tanks trucks for each production run.
- Biophalt: 2019, 3 main job sites:
  - 3,5 km long cycle path in Rennes. AC with 30% RA and Biophalt as virgin binder
  - 0,5 km long 2x2 lanes road (≈ 850 trucks/day/direction) in Tours. Surface course made with an AC with 60% RA and Biophalt as virgin binder.
  - 1 km long road (≈ 850 trucks/day/direction) in Meau (close to Paris). Surface course made with an AC with 50% RA and Biophalt as virgin binder.
  - 1 another section is planned to be built in the next weeks.
  - Biophalt was awarded in 2019 by the French Ministry of Transportation
- Sylvaroad:
  - trial in Minnesota in August 2019
  - project with RWS in The Netherlands planned by next year

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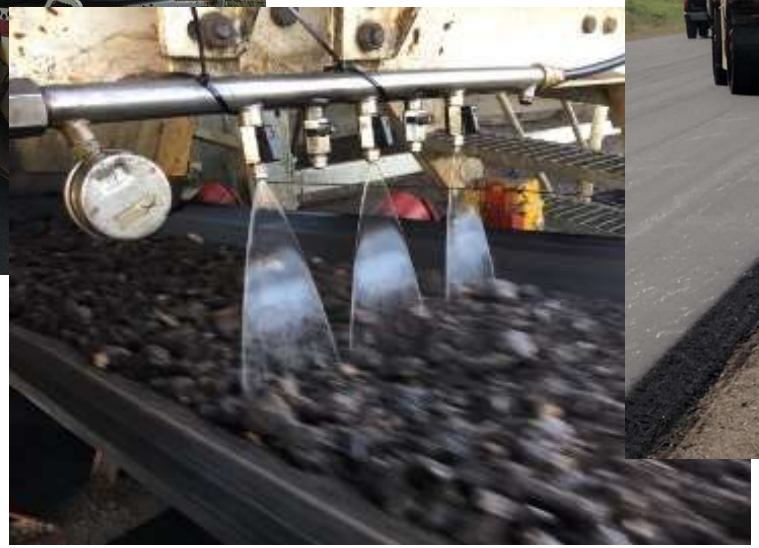
- Deployment of the BioRePavation innovations



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