



Use of rejuvenators in asphalt mixtures

10-11 September 2019
Padova (Italy)



Use of rejuvenators Case study from France

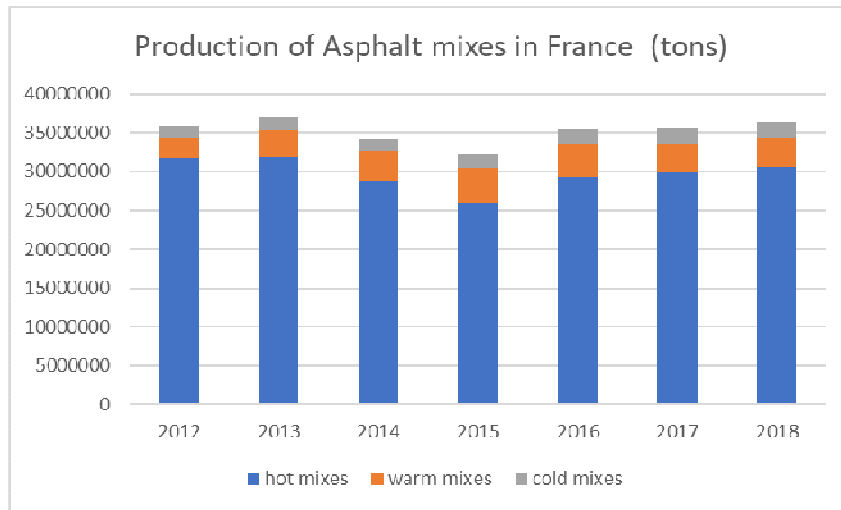
X Carbonneau



- Recycling in France
- MURE Project
- Rejuvenators
- Conclusion

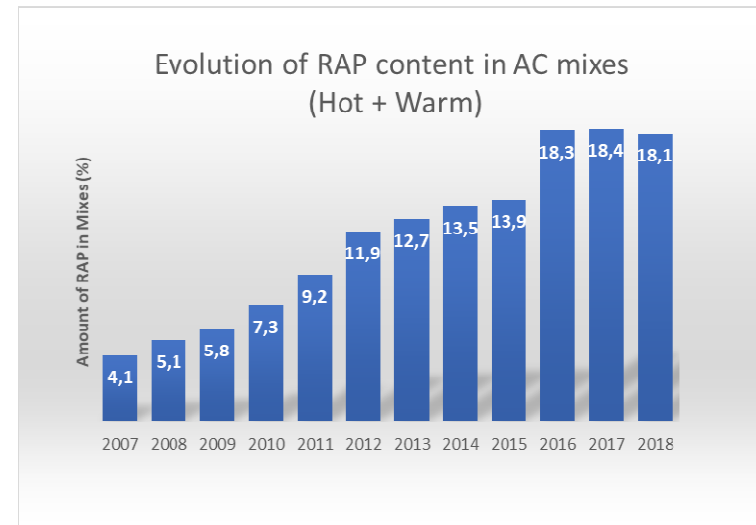


Recycling in France



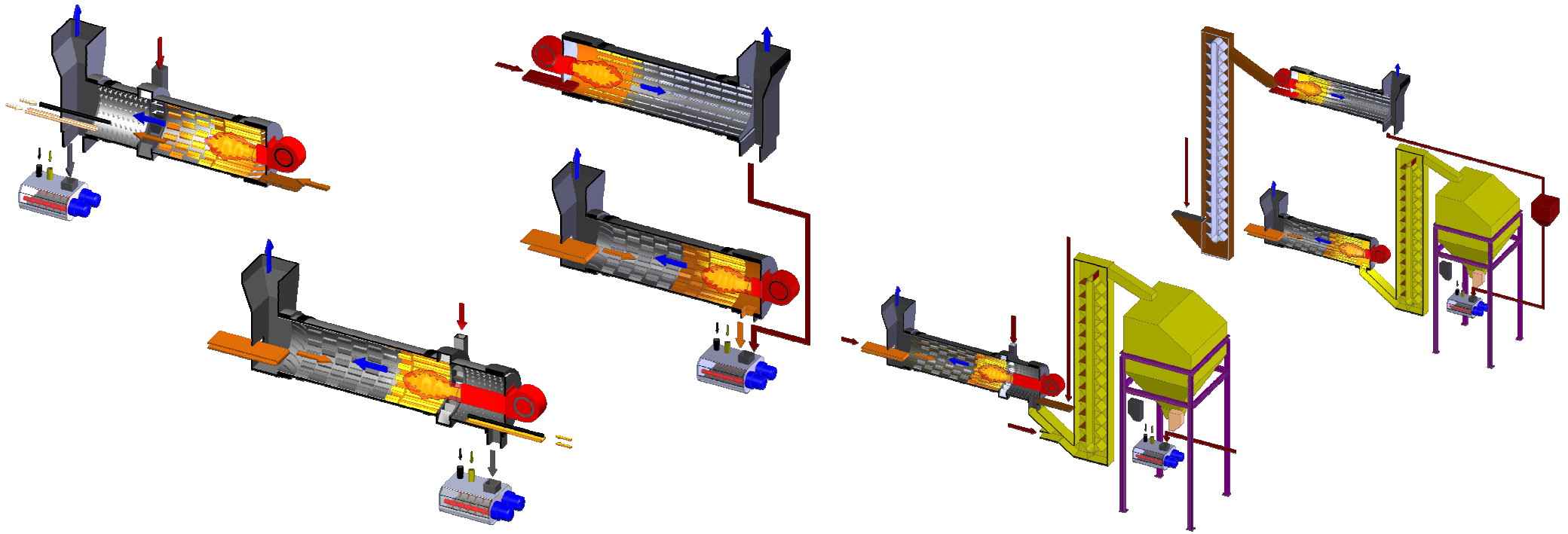
In 2018 84% hot mixes
 10% Warm mixes
 6 % cold mixes

470 plants (433 static+ 37 mobile)



Significant improvment in Recycling
 Strong involvment of Road industry
 « Voluntary commitment agreement » 2009

Recycling in France

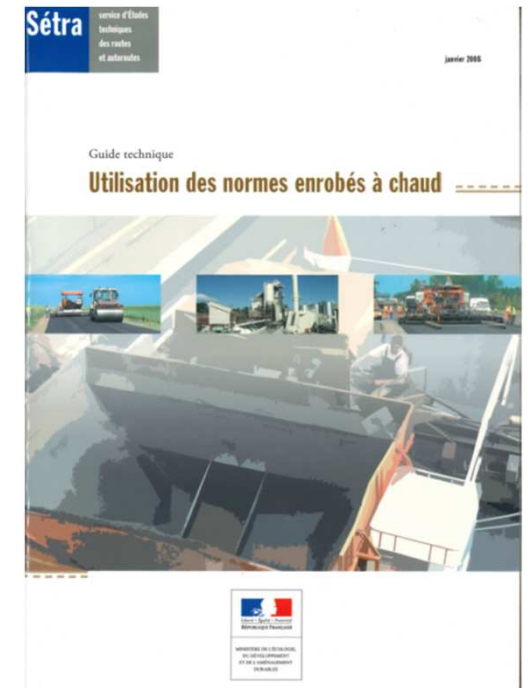


All kind of plants
Main part : RAP 20-40 %
About 20-25 % can go up to 50% (or over)

Recycling in France

The higher the quality of the RAP
the higher the amount allowed

Possible use of RAP						
Use in pavement	Wearing course		0 %	10 %	30 %	10 % 40 %
	Binder course		10 %	20 % 30 %	40 %	
	Base course					
RAP components	binder	Content	TL _{NS}	TL ₂	TL ₁	
		Pen or R&B	B _{NS} B ₂		B ₁	
	Aggregates	grading	G _{NS} G ₂		G ₁	
		Characteristics	R _{NS}		R ₁	R _{NS} R ₁



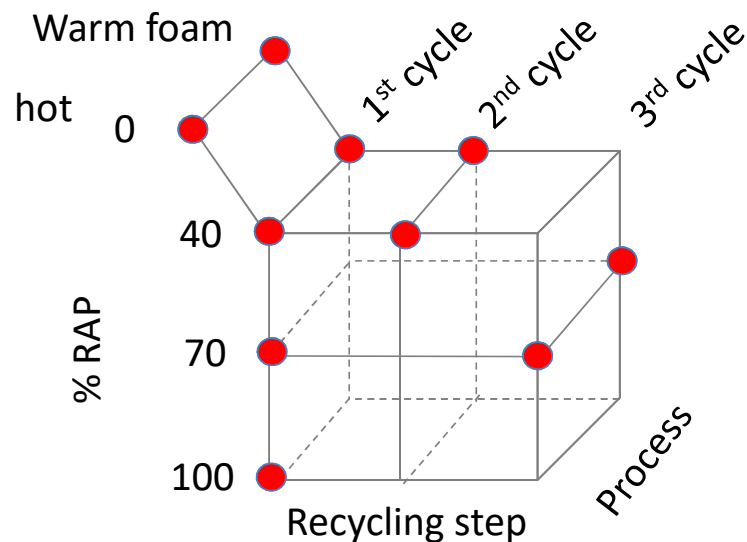
B₁ Pen Min value = 5 & range ≤ 15 1 control / 1000 t
R&B Max 77°C & range ≤ 8 Min 5 tests



- A collaborative research project
- 48 months Total budget ~ 3M€
- Impact of Recycling & Warm technology
- Effect of several recycling steps
- Focus Trials sections
- Accelerated aging
- 1 rejuvenator



- ❖ Scientific part Improvmure
- ❖ Budget 2,3 M€ (Ifsttar, Eiffage, ENTPE, RdF, Cerema DterMed)
- ❖ RAP content 40 and 70 %
- ❖ Warm additive & Foam
- ❖ Rheology , Mechanical , Emissions, Blending, Aging...

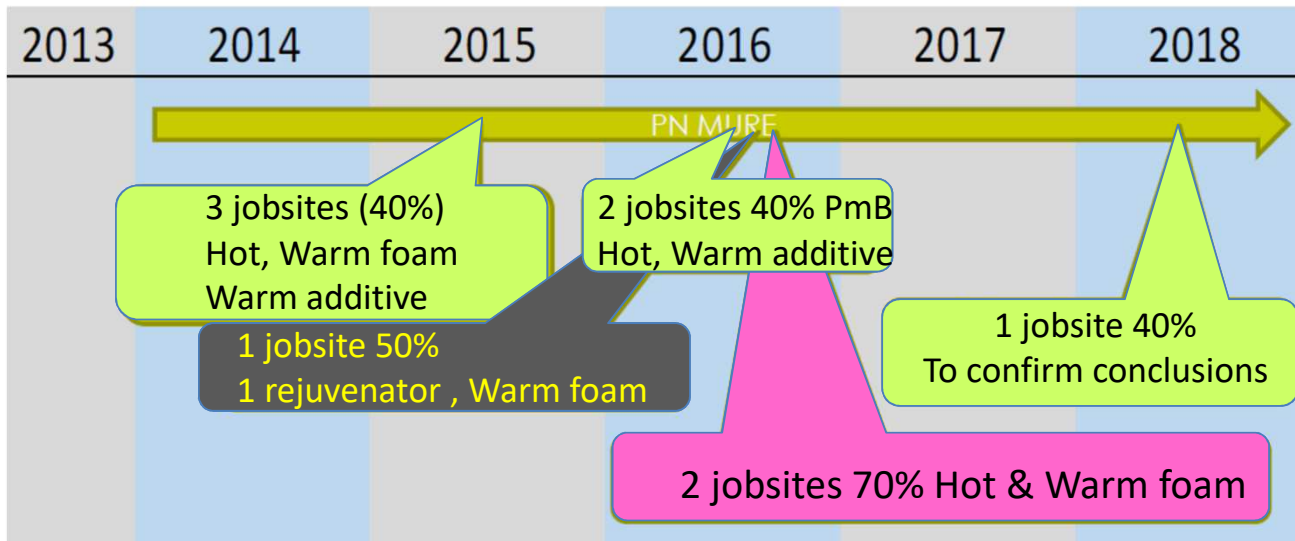


Ref mix 35/50 pen
 Mix 40% RAP 50/70
 Mix 70% RAP 70/100

RAP first cycle Pen 10 R&B 76,2 °C

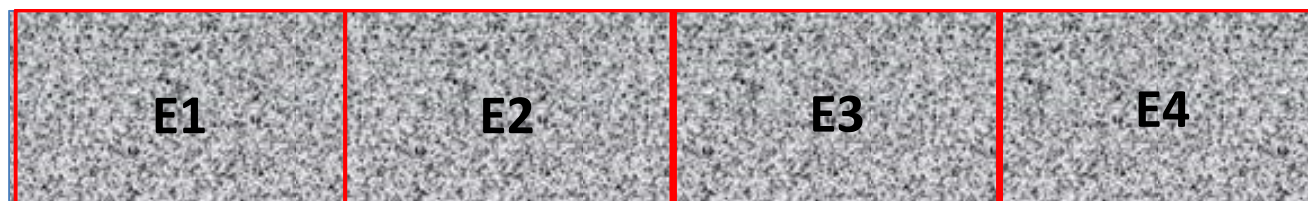
LAB mixes

& samples from jobsites



Mix milled & Aged
RAP for next section in trials

REF mix Mix (40% RAP)



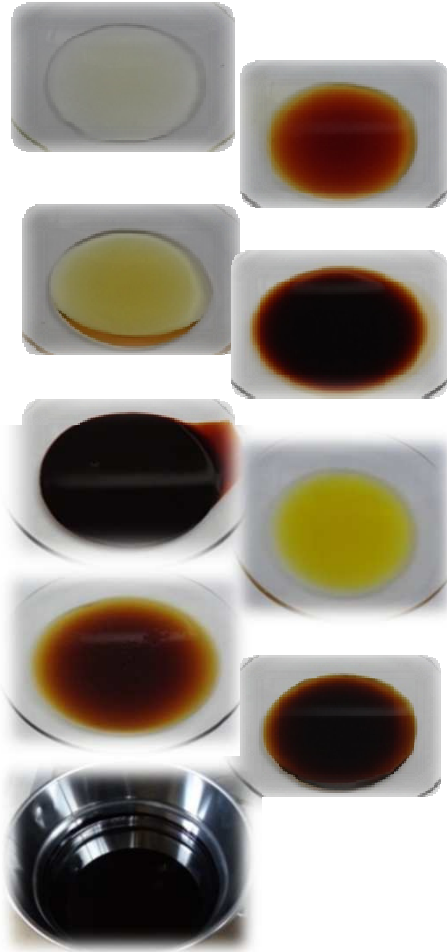
E3 MIX 40% RAP (E2 Milled & Aged)
E4 Mix 40% RAP (E3 Milled and Aged)



MURE project

- Main conclusions
 - Good behavior of mixes with 40% RAP.
 - Possible effect at 70%
 - No effect of multi recycling (3 steps at 40%)
 - No evidence that rejuvenator is needed !
- From Improvmure
 - Slight decrease of water resistance with RAM and Warm process
 - Modulus (Neat binders + binders from RAP) not affected by multi recycling
 - TSRST and Crack propagation : Low effect of RAP content, process, multi recycling
 - Right selection of added binder allow to obtain characteristics
 - Rejuvenator could improve blending between aged and new added binder.
 - Carbonyl index : Major parameter to follow aging. Possible thresholds ?

Rejuvenators



- Many additives
 - No clear definition
 - Lot of R&D and Scientific papers
-
- How to select ?
 - Effect on RAP
 - When use it ?
 - How to use it ?
 - Effect on mixes ?

Rejuvenators

EAPA Position Paper



Rejuvenator

- intended to restore rheological properties of the aged binder from reclaimed asphalt
- Cannot bring back the original composition of the binder

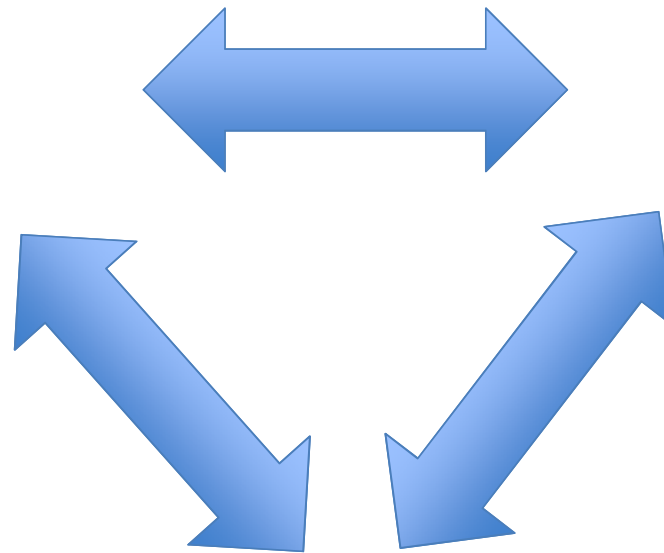
Specifications

- No environmental impact
- No disadvantages regarding Health and Safety
- No change in health and environment classification of the asphalt
- No negative impact on product performances

Rejuvenators

Promises (Suppliers)

Increase RAP content
Value « very aged binder »
Restore initial properties
(flexibility, self healing..)
Increase durability
Long term efficiency



Needs Industry & clients

Ability to use
Rules/ Regulations
Safety/Environment
Answer to questions (blending?)
Low cost
Quick and easy method to use

To be really convinced....

Scientific arguments

Research in labs (but not only..)

Rejuvenators

Needs Industry & clients

Promises

Restore characteristics of the binders

But

Research on blends Additives + RAP binder...

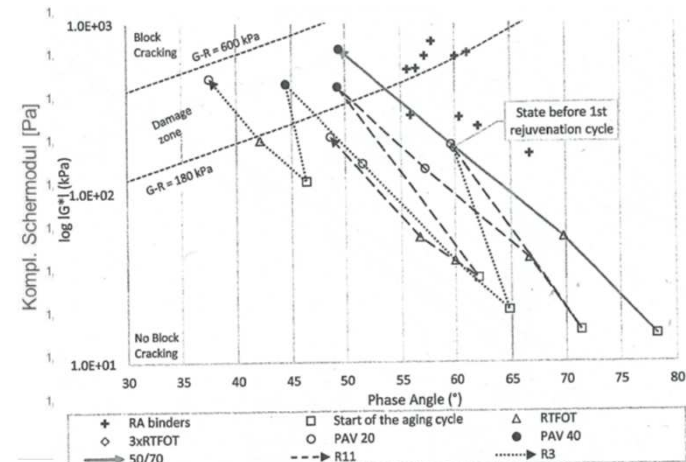
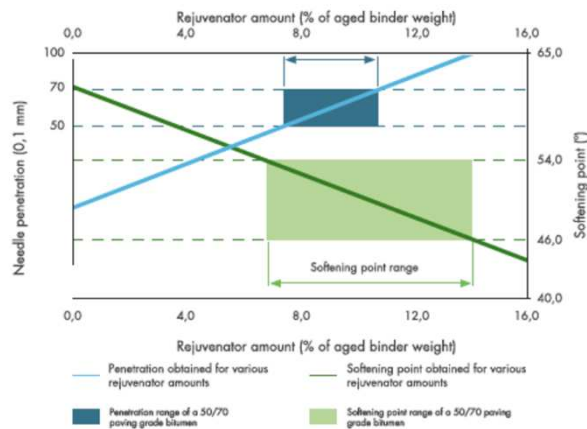
Not always soft binders included for comparison...

Scientific arguments

Rheology

« Effect and efficiency of rejuvenators on aged asphalt binder »
« Rheological evaluation of asphalt binder batches in sedimentation and aging cycles »
, T koudelka, P Coufalik, J Fiedler, I Coufalikova, M Varaus, F yin, RMPD vol 20, N°S1, 2019

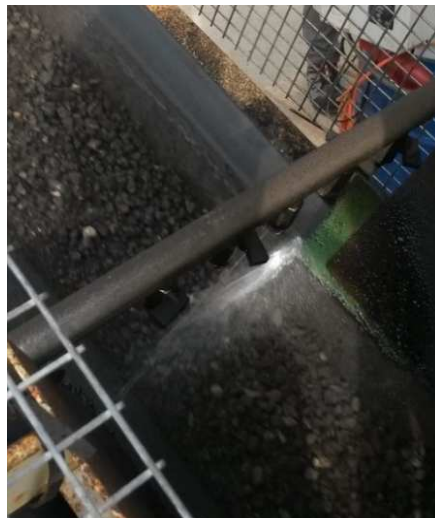
Pen & R&B



Rejuvenators

Promises

Efficiency / Easy to use



About 4kg homogeneously sprayed on 1t of RAP...

Needs Industry & clients

Still questions on quality of the blending between RAP and new binders

Additives should help..

But more convincing arguments needed

« the asphalt mixture was laid and compacted without any silo storage..Because of this , the interaction between Delta S (blended with virgin binder) and recycled binder, especially in the RAS, may not have been complete,... »

NCAT Report 18-04, Phase VI (2015-2017)

NCAT Test tracks findings

Rejuvenators

Promises

Long term Durability

Scientific arguments

Research on Aging methods

Lab research

Low temperature behavior

Cracking resistance

Rheology on binders

Needs Industry & clients

Important topic for industry !

Need link between binders & AC mixes

Try to keep it simple

To be clever

Relevant tests + Right requirements

To be sure of the effect

Conclusion

- Benefit of rejuvenator : No clear evidence
- Soft binders : an existing and efficient solution for usual RAP content
- Proof on H&S issues from suppliers
- But an Important work for the future :
 - What about RAP with PmB ?
 - What about cold mixes ?
 - Tools for decrease in bitumen quality ?
 - Durable high rap content wearing course ?

Conclusion

More information about MURE & Improvmure results in :

- **Comparison of the 3-dim linear viscoelastic behavior of asphalt mixes determined with tension-compression and dynamic tests**

Jean-Claude Carret, Alvaro Pedraza, Hervé Di Benedetto, Cédric Sauzeat

[Construction and Building Materials, Volume 174, 20 June 2018, Pages 529-536](#)

- **Propriétés thermomécaniques d'enrobés multi-recyclés**

Alvaro Pedraza

PhD Thesis in Civil engineering, mars 2018

<https://www.theses.fr/2018LYSET001>

- **Linear viscoelastic behaviour of bituminous mixtures with multi-recycled asphalt pavement**

Pedraza A., Di Benedetto H., Sauzéat C., Pouget S.

[10th Int. Conf. Bearing Capacity of Roads Railways and Airfields \(BCRRA\)](#), p. 8

- **Evaluation of bituminous binders miscibility for warm-mix recycling techniques**

Vassaux S., Gaudefroy V., Soro L.J., Pévère A., Mouillet V., Boulangé L., Barragan-Montero V.

[10th Int. Conf. Bearing Capacity of Roads Railways and Airfields \(BCRRA\)](#)

- **Towards a better understanding of wetting regimes at the interface asphalt/aggregates during warm-mix process of asphalt mixtures**

S. Vassaux, V. Gaudefroy, L. Boulangé, A. Pévère, V. Mouillet, V. Barragan-Montero

[Construction and Building Materials, Volume 133, 15 February 2017, Pages 182-195](#)

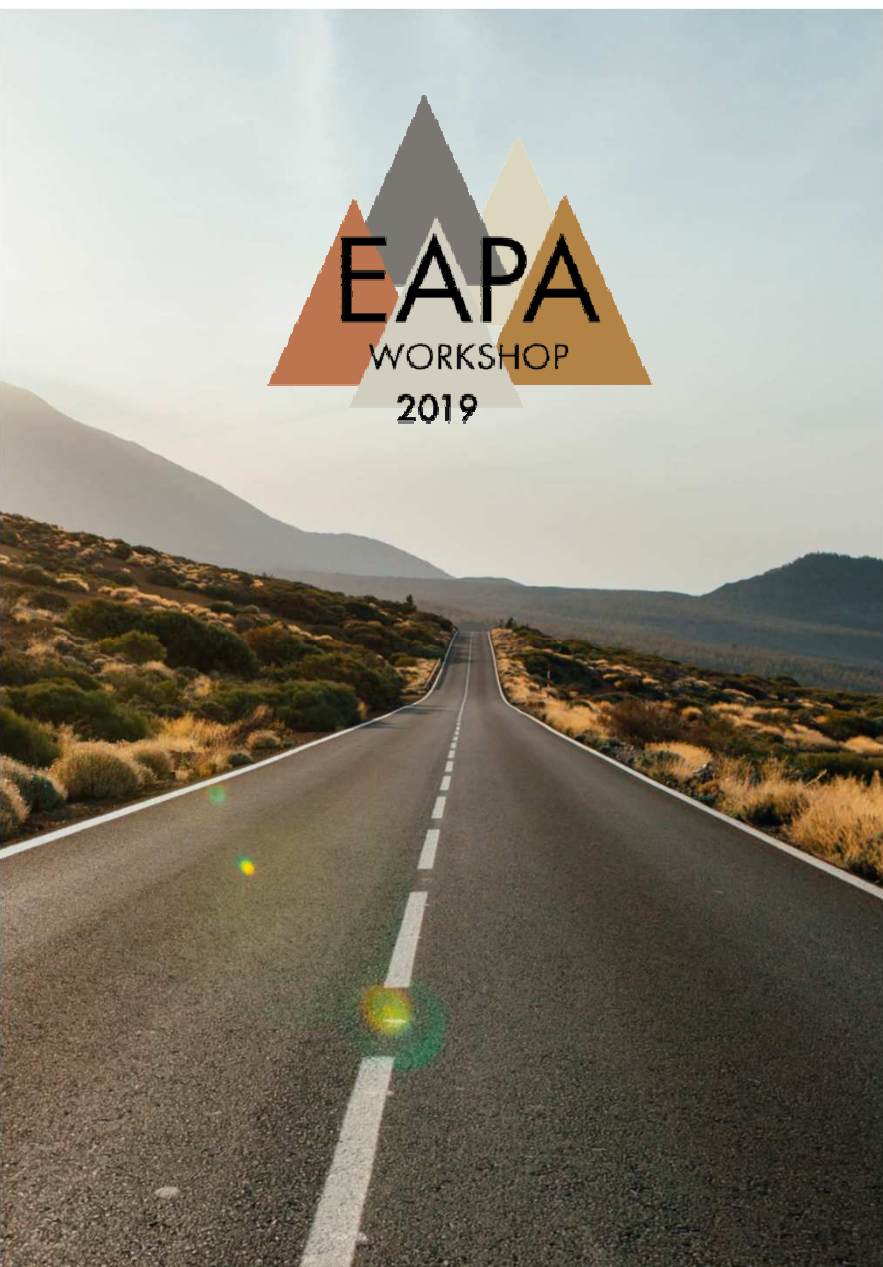
▪

Bitumen extraction and recovery in road industry: A global methodology in solvent substitution from a comprehensive review

L. Ziyani, L. Boulangé, A. Nicolai, V. Mouillet

[Journal of Cleaner Production, Volume 161, 10 September 2017, Pages 53-68](#)

And several other papers in E&E Madrid 2020



Thank you

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