



**HRVATSKO ASFALTERSKO DRUŠTVO**

**CROATIAN ASPHALT ASSOCIATION**

# **THE MURE PROJECT – MULTIPLE RECYCLING OF ASPHALT ROADS**

# **MURE PROJEKT – VIŠESTRUKO RECIKLIRANJE ASFALTNIH CESTA**

**XAVIER CARBONNEAU, COLAS**

**MEĐUNARODNI SEMINAR ASFALTNI KOLNICI 2021**

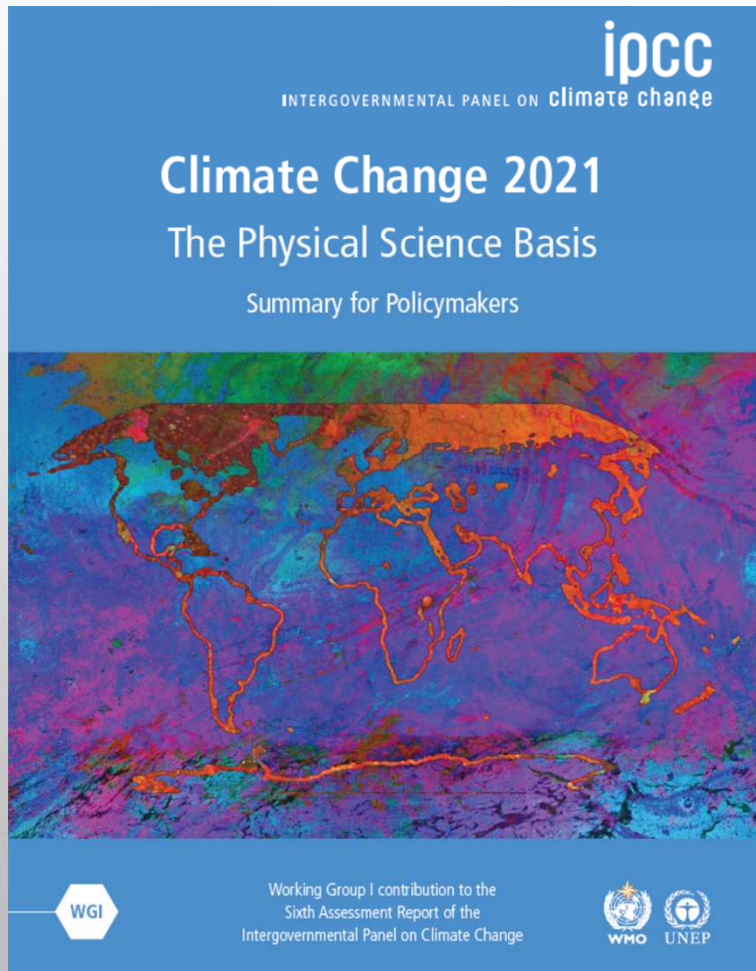
**INTERNATIONAL SEMINAR ASPHALT PAVEMENTS 2021**

**OPATIJA, 30.09. – 01.10. 2021.**

# **CONTENT**

- **Climatic change & Road industry**
- **Recycling in France**
- **Mure Project**
  - **Jobsites**
  - **Accelerated aging**
  - **Mechanical performances**
  - **Improvture**
- **Conclusion**

# CLIMATIC CHANGE AND ROAD INDUSTRY

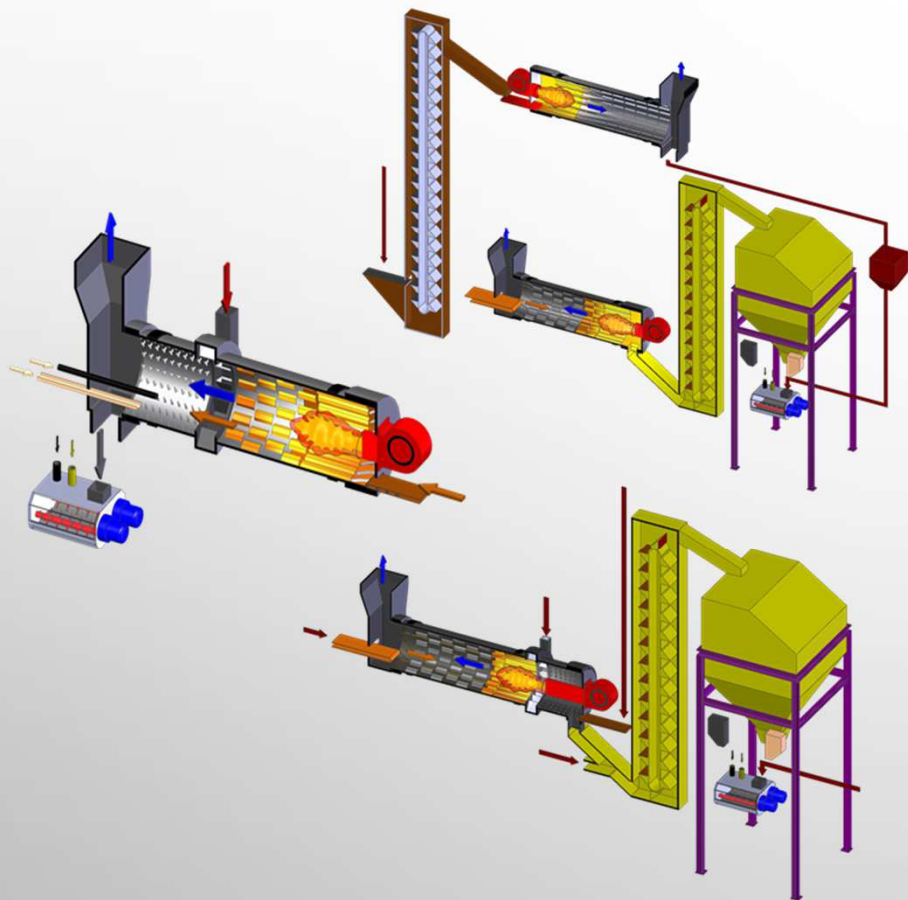


Reduce CO2 footprint

For Road industry

- Recycling
- Warm mixes
- Warm + Recycling
- Cold techniques

# RECYCLING IN FRANCE

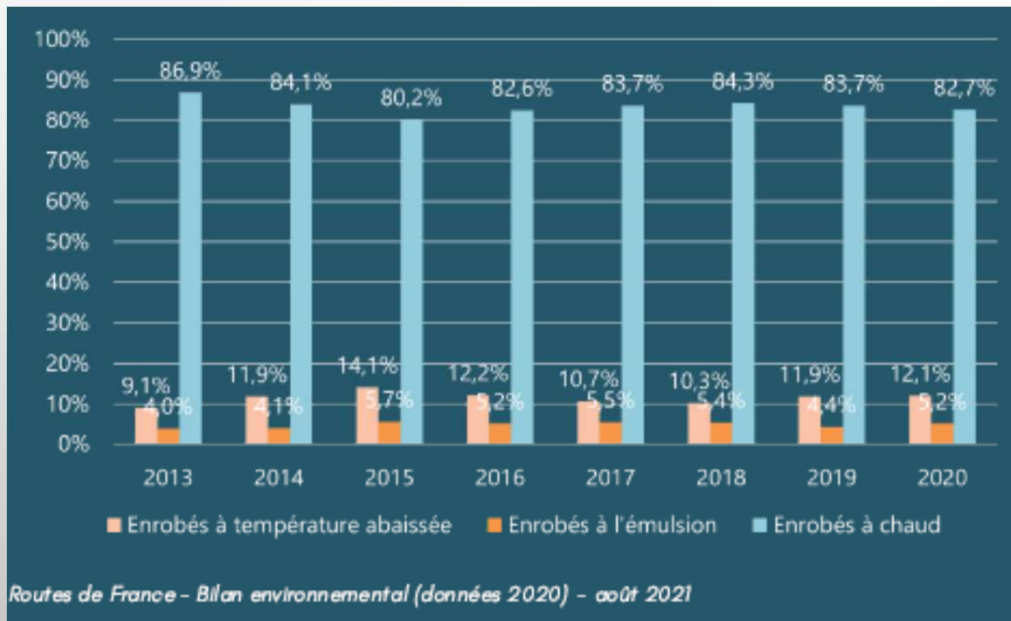


## RULES

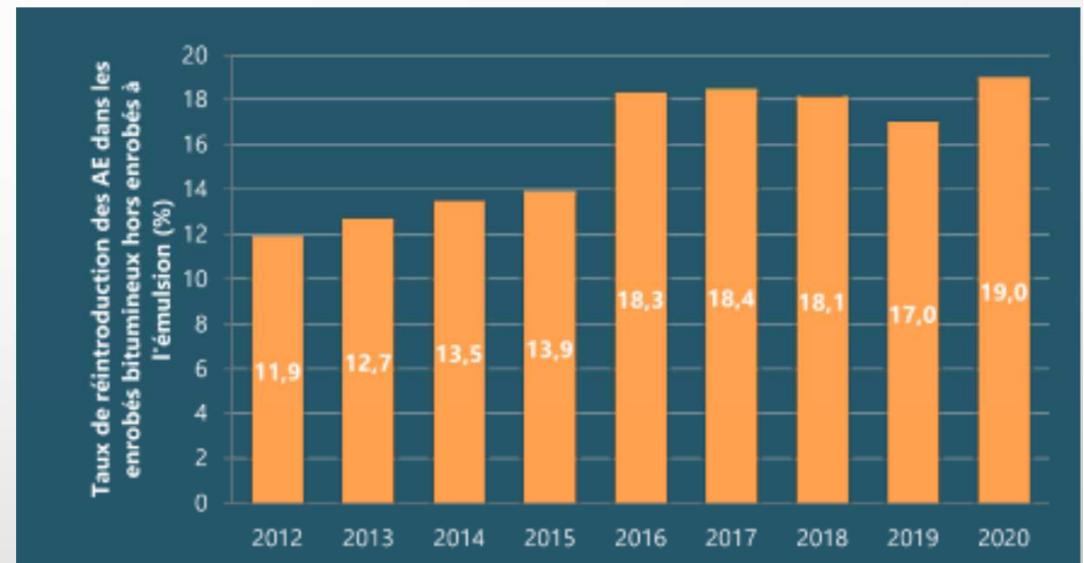
**All kind of plants**  
**Main part : RAP 20-40 %**  
**About 20-25 % can go up to 50% (or over)**

# RECYCLING IN FRANCE

## AC MIX PRODUCTION



## % RAP in AC MIXES



No more increase

Fears from clients

MURE Project

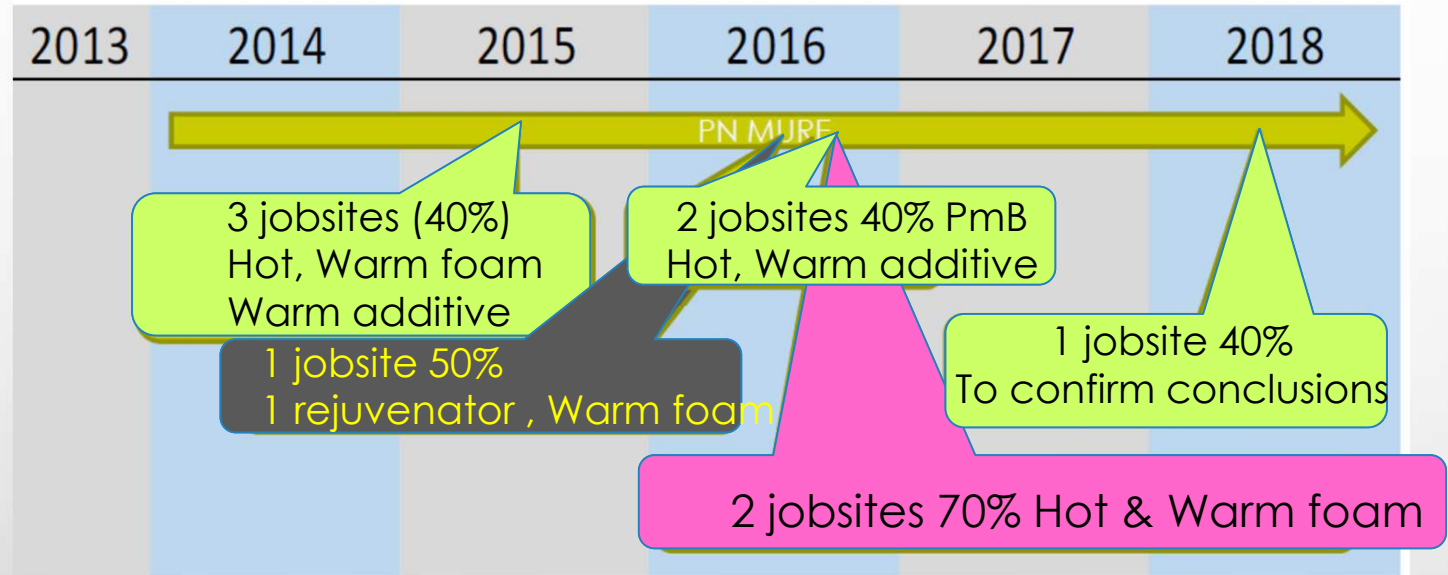
# MURE PROJECT



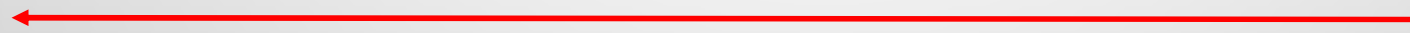
## 35 Partners

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

# MURE PROJECT - JOBSITES

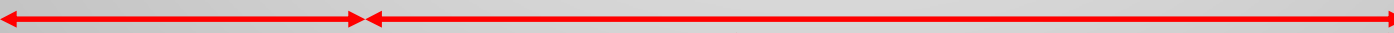
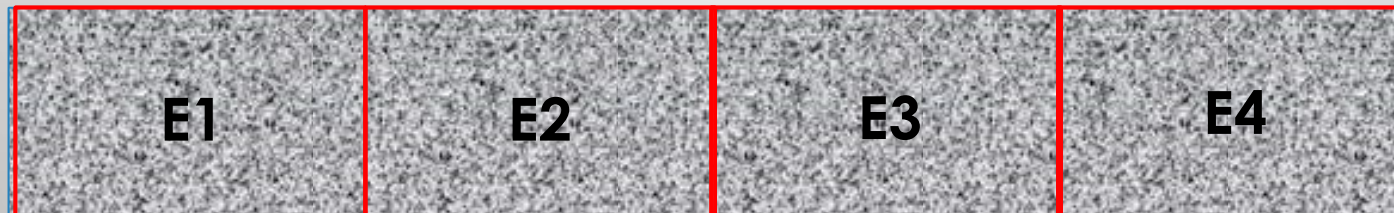


400 m



REF mix

Mix (40% RAP)



E3 MIX 40% RAP (E2 Milled & Aged)

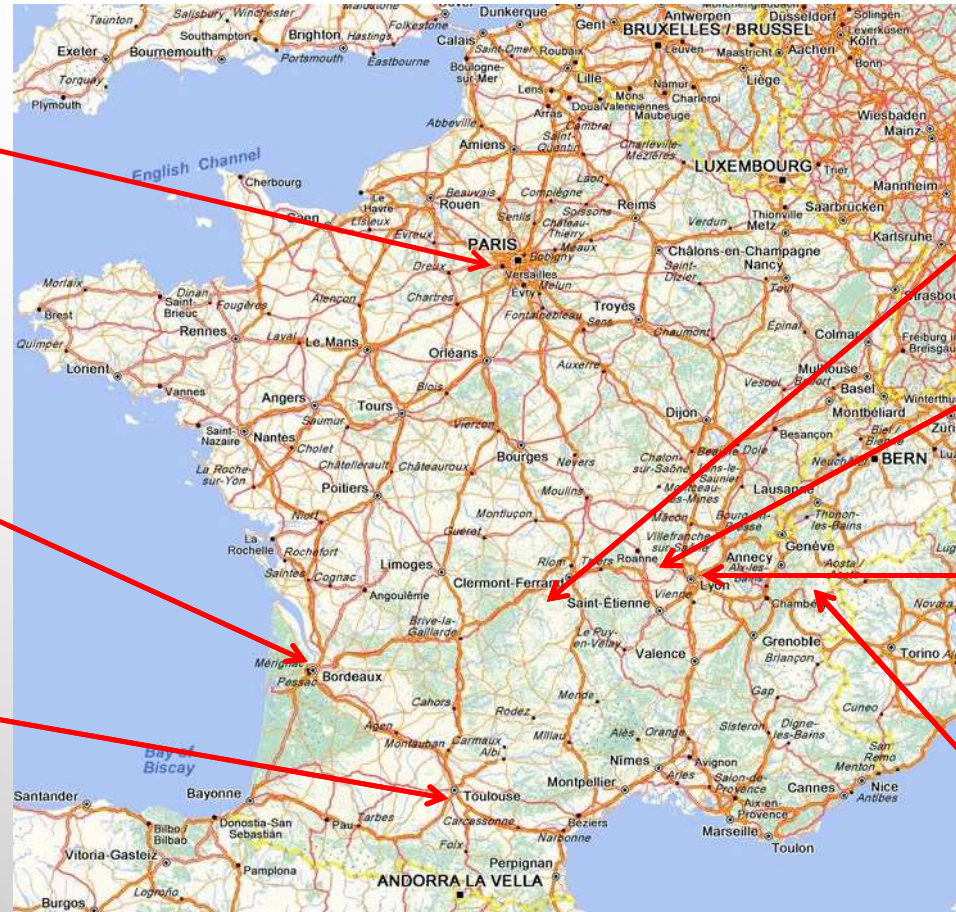
E4 Mix 40% RAP (E3 Milled and Aged)

# MURE PROJECT - JOBSITES

Département 92  
R0, R40,  
Hot & Warm foam

Arsac (33)  
R0, R30, R50,  
R50 + recycling agent  
Warm Foam

Portet sur Garonne (31)  
R0 et R40  
Hot + Warm additive  
(Pmb)



Moriat (63) R0 et R40  
Warm Foam

INITIAL

Rono (69) R0 et R40  
Hot

INITIAL

Villeurbanne (69)  
R0 et R40  
Warm additive

INITIAL

ATMB  
R0 et R70  
Hot 1 Warm foam

INITIAL

MULTI RECYCLING



# MURE PROJECT – ACCELERATED AGING



**Wirtgen HM 4500**

**Loose mix 4cm**

**Heating panels at ~20cm**

**Speed 1m/min**

**2 passes : ~ rilem lab protocol**



	Initial mix	Results (rilem)	Accelerated aging
Pen (1/10 mm)	24	16	18
R&B (°C)	63	68	66
ICO	5,2	7,5	5,8

# MURE PROJECT – ACCELERATED AGING



**300 t of RAP produced**

**Rehandling and mixing  
to prevent agglomeration**



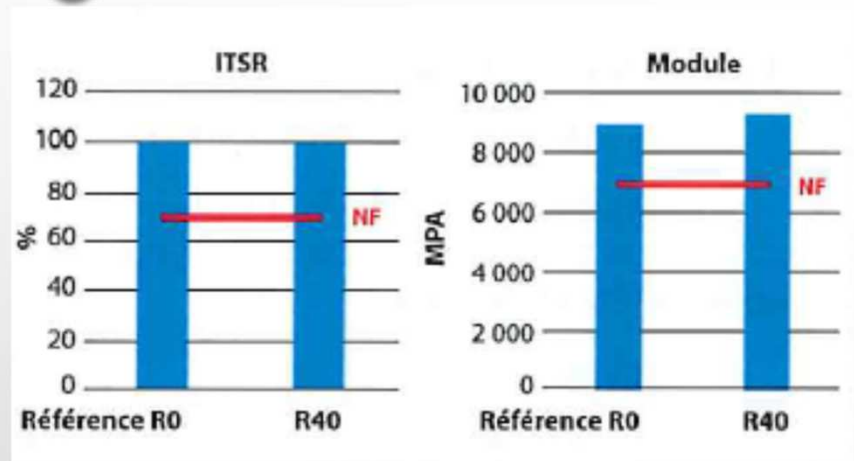
**Storage and transfert to  
asphalt plant**

# MURE PROJECT – MECHANICAL PERFORMANCES

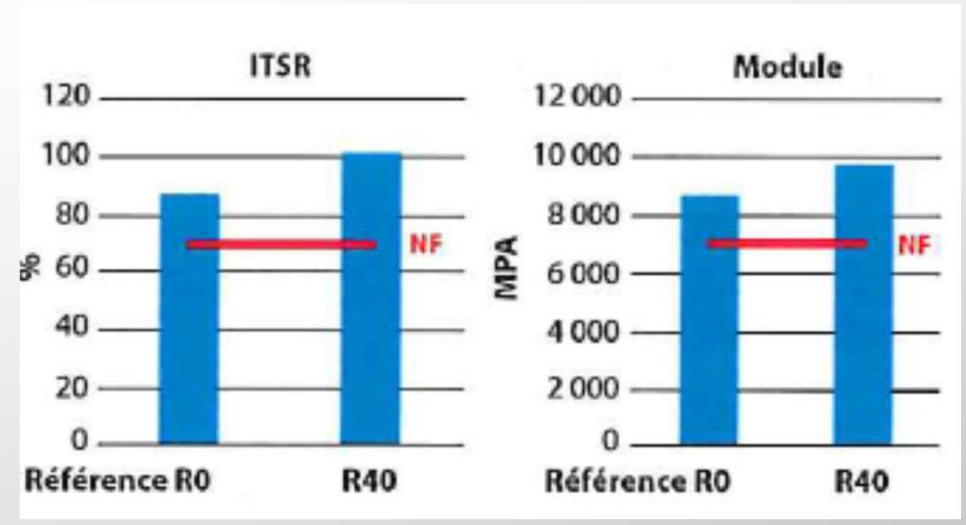
Comparison between lab mix design & measures on industrial samples

		Lab mixes	Plant samples
Water resistance	EN 12697-12	x	x
Rutting (large)	EN 12697-22	x	x
Modulus (IT-CY)	EN 12697-26	x	x
Fatigue resistance	EN 12697-24	x	x
Rap binder mobilisation			x
Workability			x

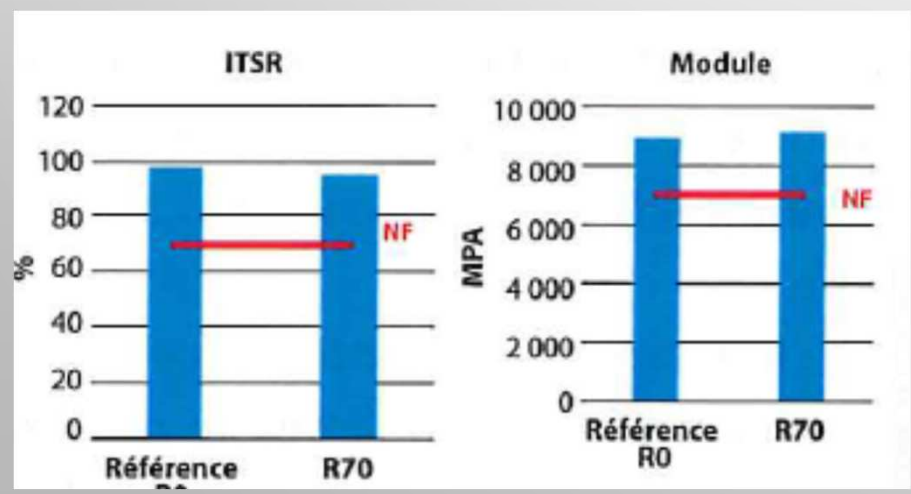
# MURE PROJECT - MECHANICAL PERFORMANCES



Warm Additive E1/E2 ( JOBSITE 1 )

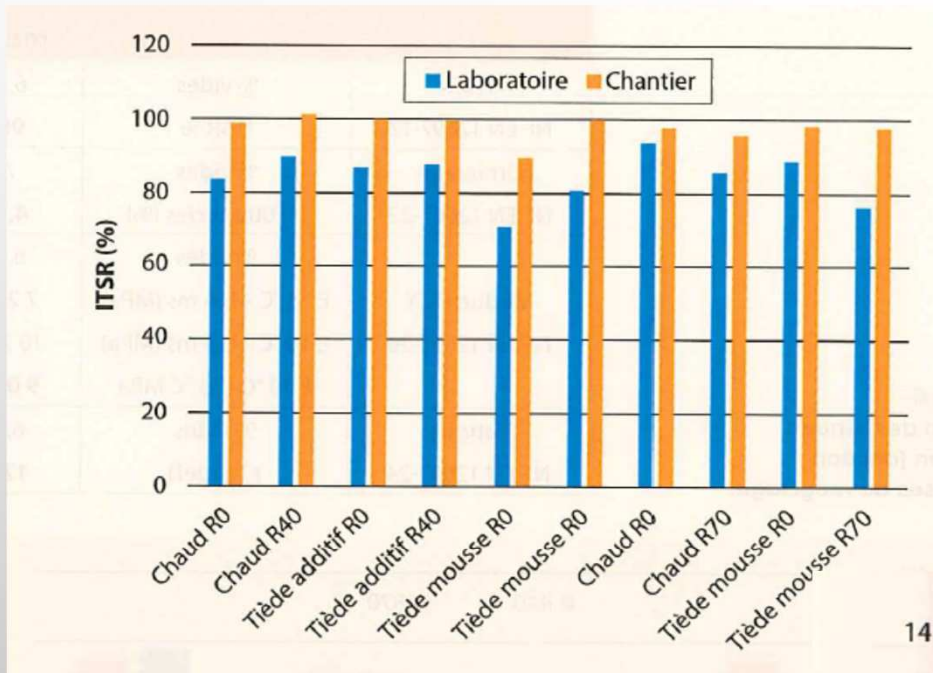


Warm Foam (E1/E2 JOBSITE 3)



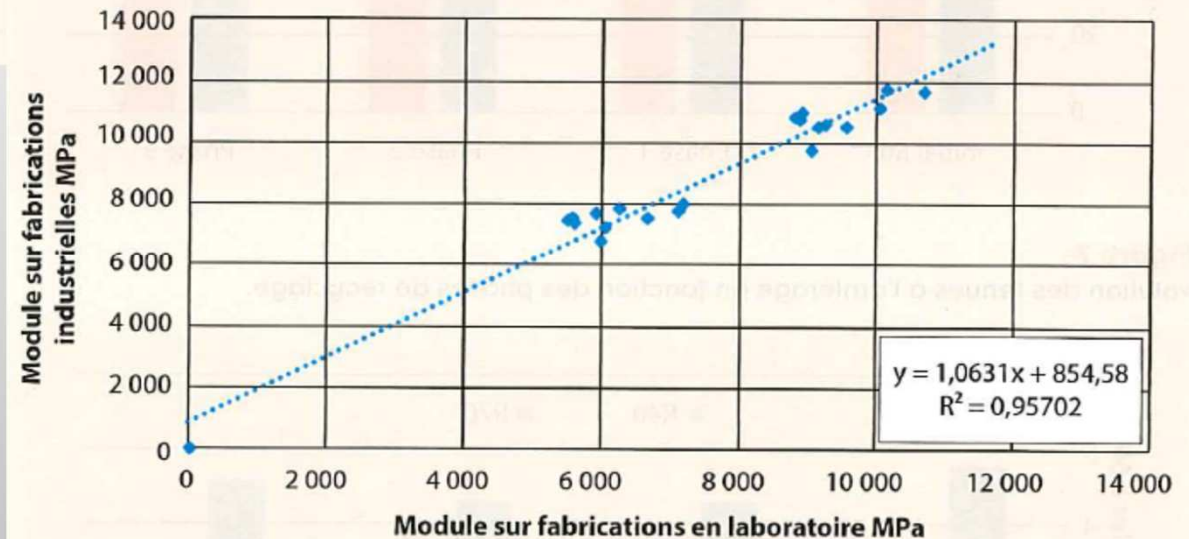
Warm Foam E1/E2 ( JOBSITE 8 )

# MURE PROJECT – MECHANICAL PERFORMANCES

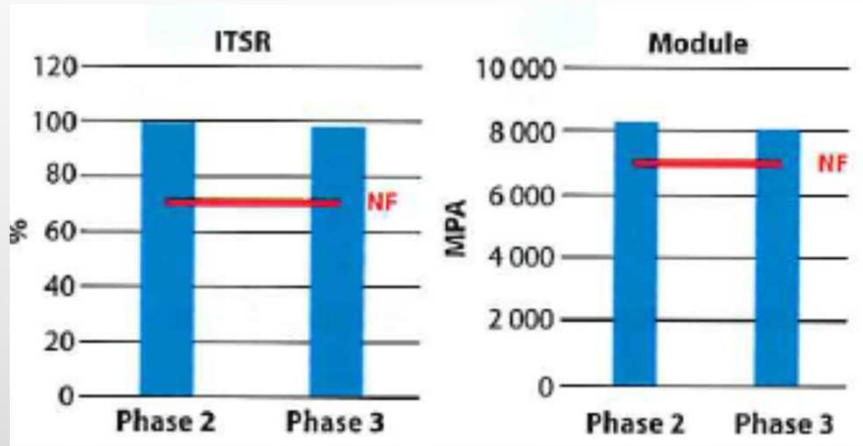


## LAB – INDUSTRIAL MIX

**Good correlation  
Lab results safe for clients.**

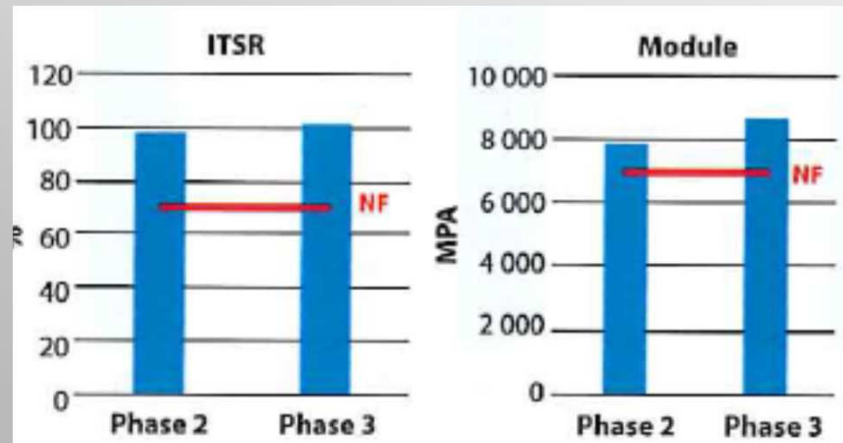


# MURE PROJECT – MECHANICAL PERFORMANCES



MULTI RECYCLING

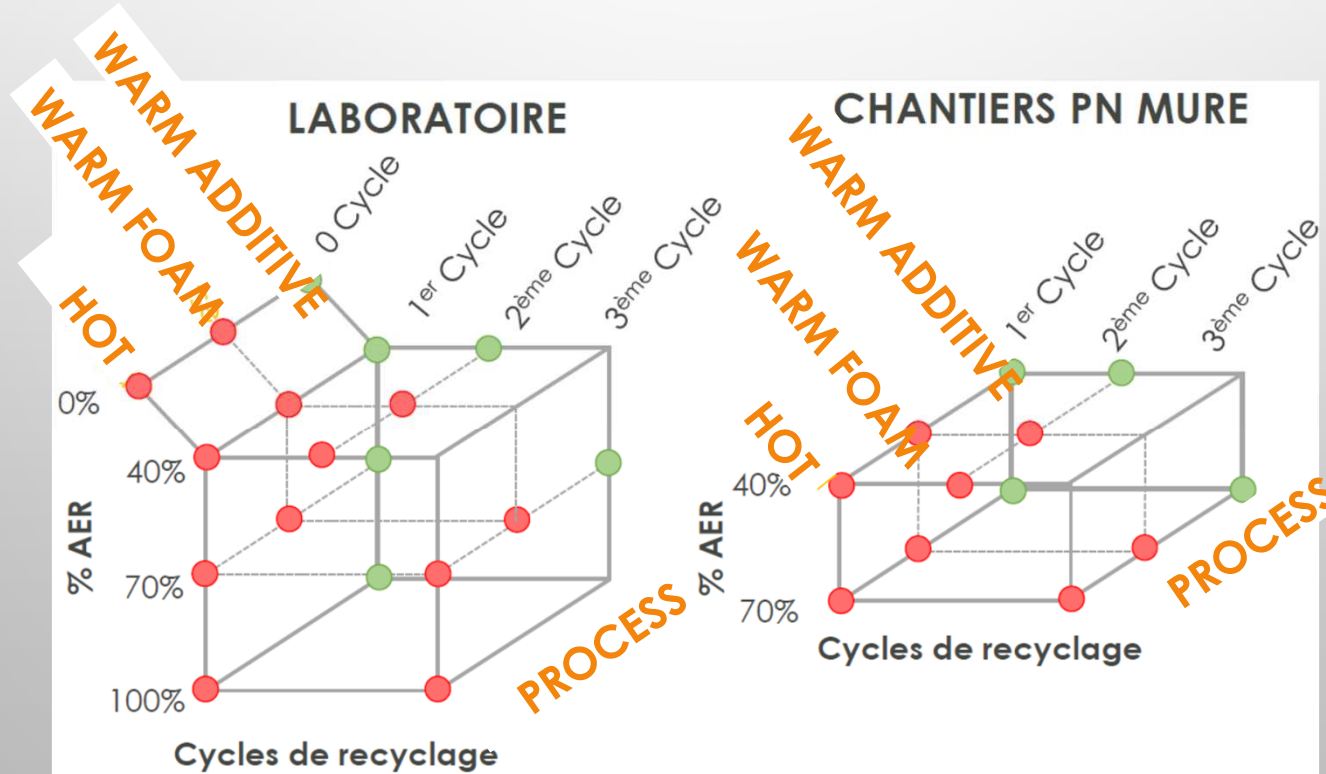
Warm additive R40 E2/E3 JOBSITE 1



HOT R70 E2/E3 JOBSITE 7

# IMPROVMURE

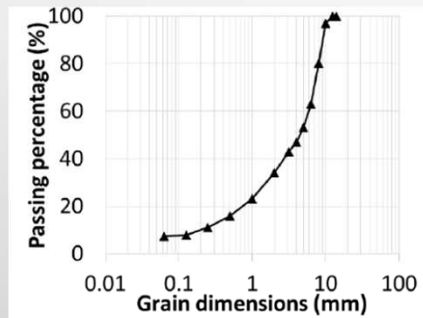
- ❖ **Scientific part IMPROVMURE**
- ❖ **Budget 2,3 M€ (Ifsttar, Eiffage, ENTPE, RdF, Cerema DterMed)**
- ❖ **RAP content 40 and 70 %**
- ❖ **Warm additive & Foam**
- ❖ **Rheology , Mechanical , Emissions, Blending, Aging...**



# IMPROVMURE

## AC 10 WEARING COURSE

**SAME GRADING CURVE  
(except 100%)**



**SAME BINDER CONTENT  
5,4% (total)**



**SAME NEW AGGREGATES**

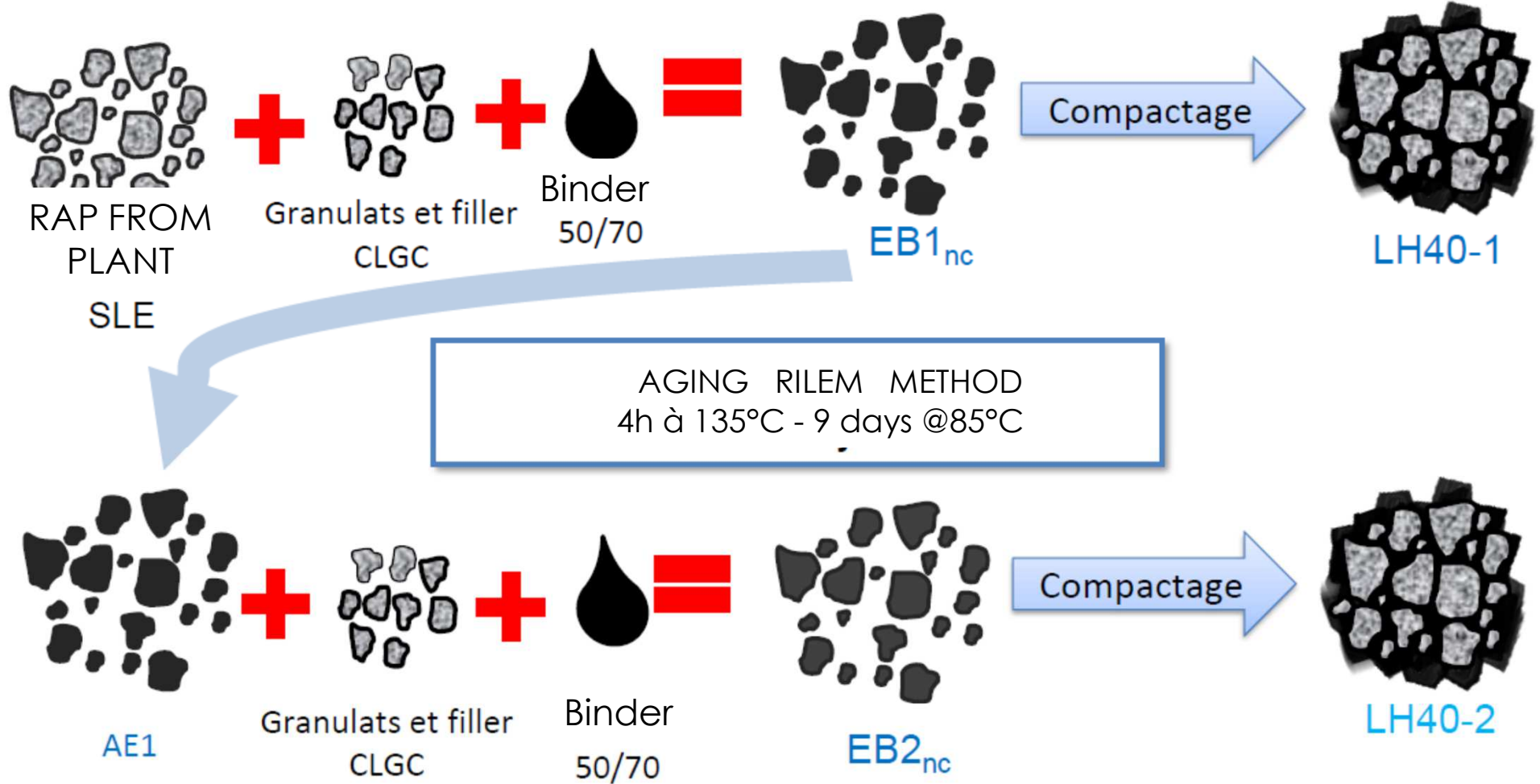


**ADDED BINDER (DEPEND RAP CONTENT)  
SIMILAR PEN ON FINAL BINDER – ASSUMPTION OF PERFECT BLENDING**

AE (%)	BINDER	PEN	R&B
0	35/50	41	52,5
40	50/70	60	48,4
70	160/220	180	39,2

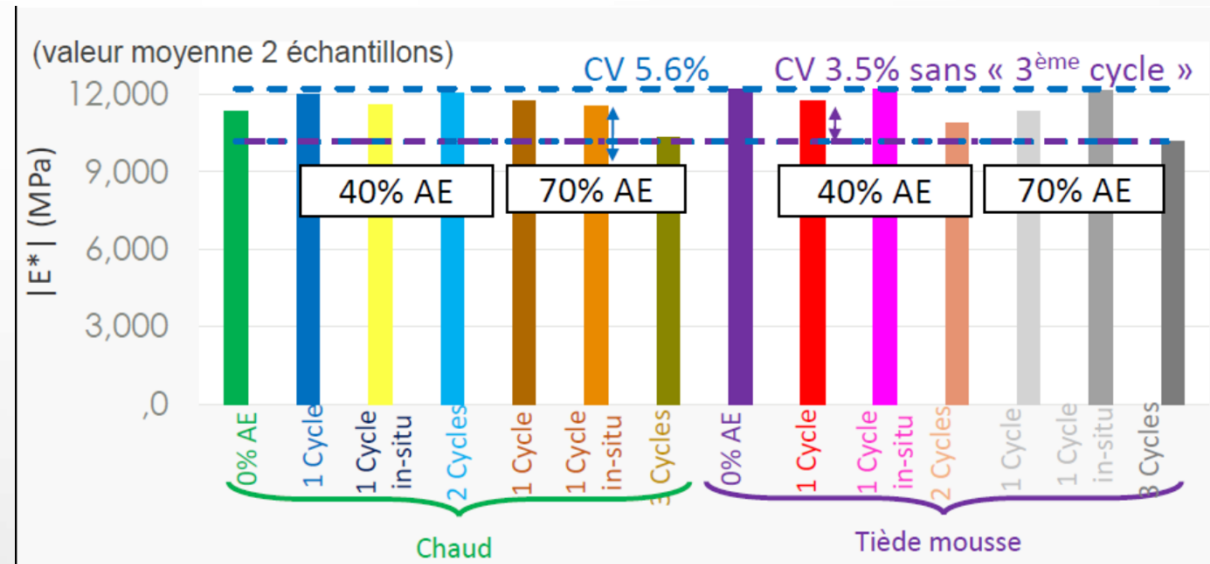
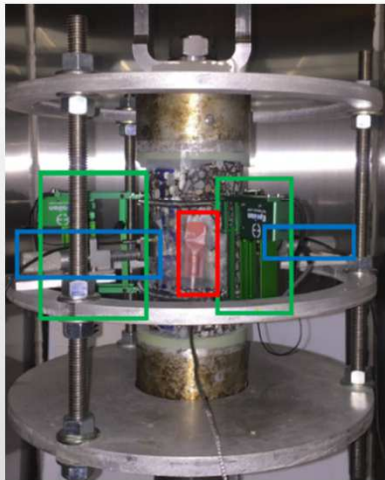


# IMPROVMURE

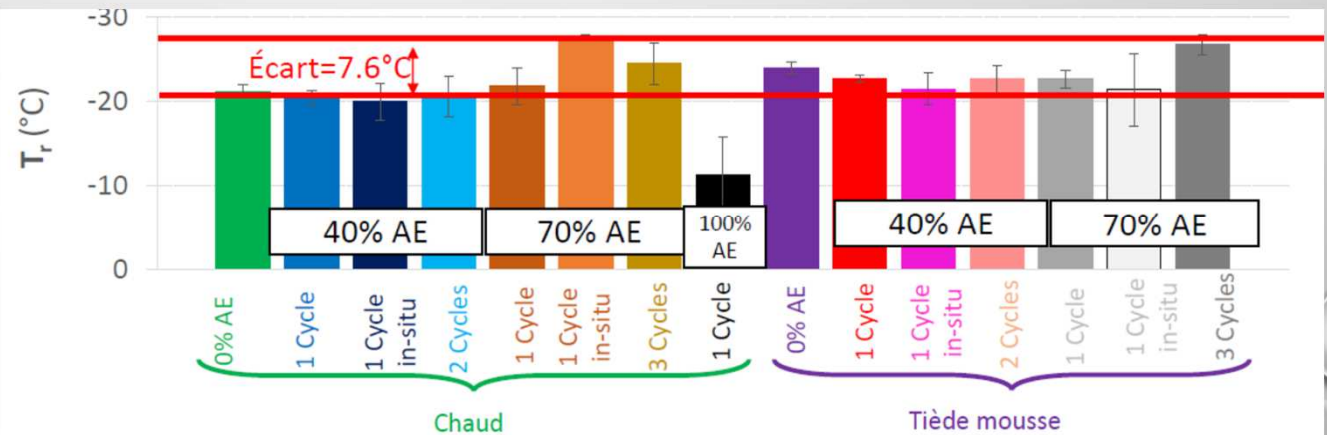
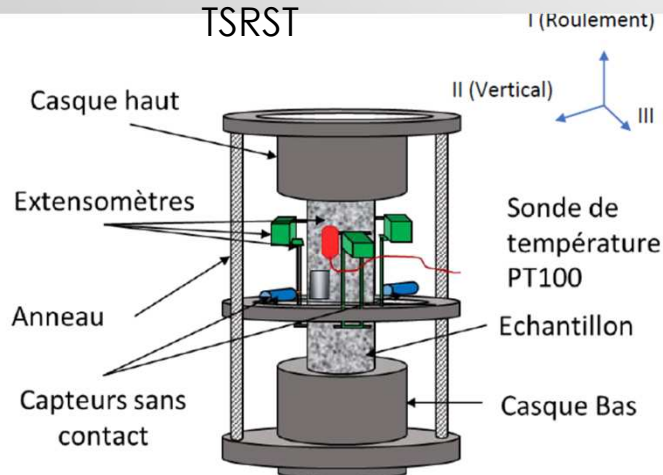


# IMPROVMURE

## COMPLEX MODULUS (T/C)



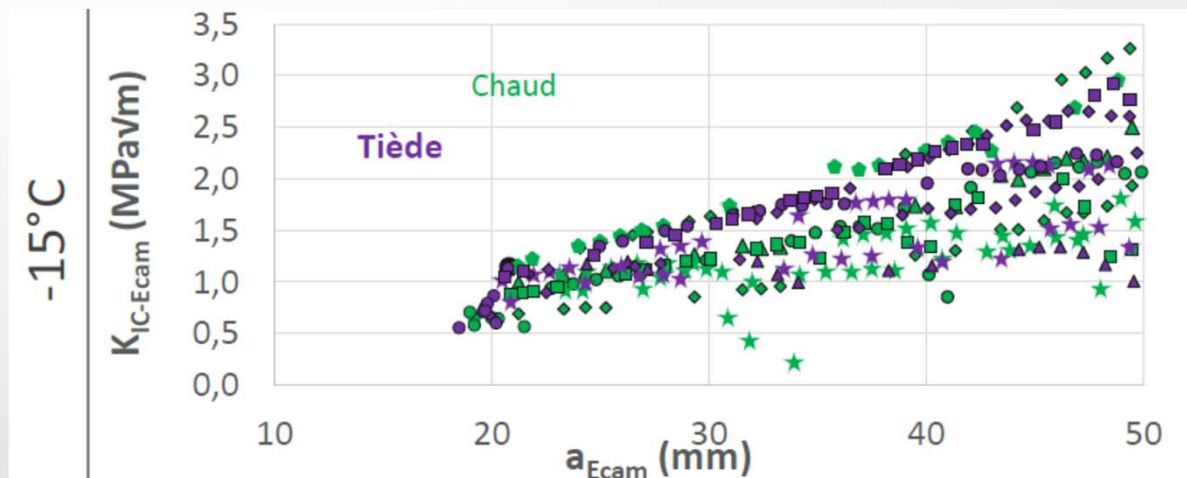
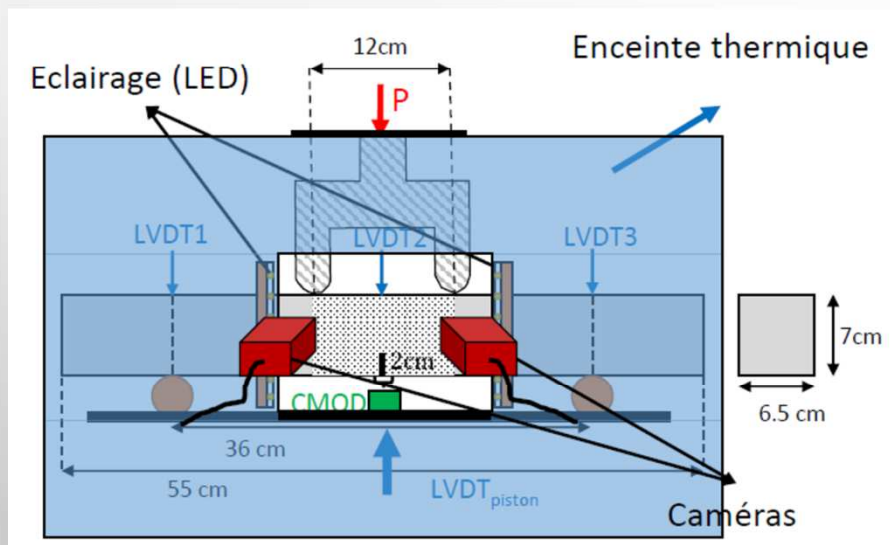
## TSRST



**No significant differences : Choice of the added new neat binder !**

# IMPROVMURE

## CRACK PROPAGATION



No difference in Energy for crack propagation  
(RAP Content, process )

# IMPROVMURE

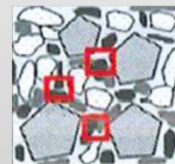
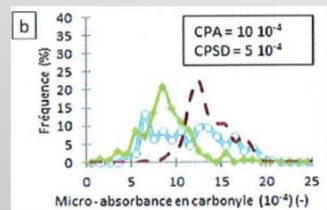
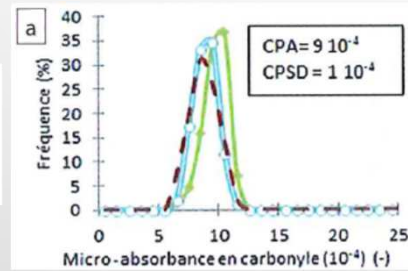
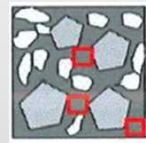
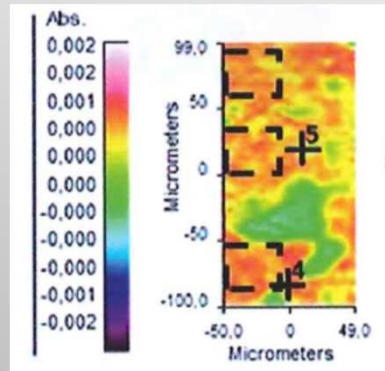
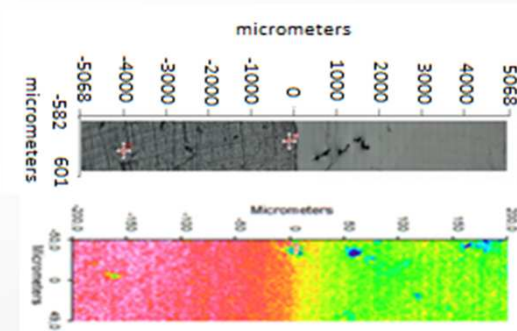
## BLENDING OF BINDERS

C=O reference for aging and blending of binders

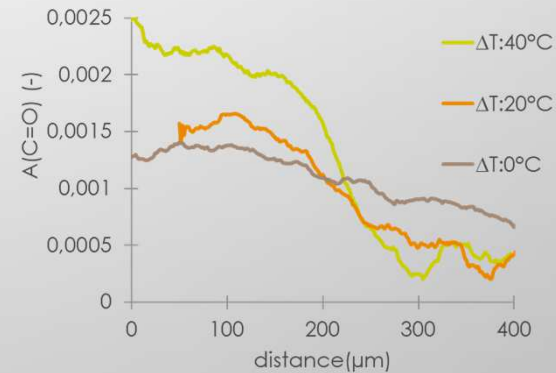


FR IT Imaging

Interface between Aged and neat binders



New binder 160  
Aged binder 120-140-160°C



APPLIED TO MIXES  
RESEARCH TOOL TO SHOW HOMOGENEITY

Blending ↑ when ΔT ↓

## **CONCLUSION 1/2**

- Slight decrease of water resistance with RAP and Warm process
- Modulus (Neat binders + binders from RAP) not affected by multi recycling
- TSRST and Crack propagation : Low effect of % RAP, 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 ?

## **CONCLUSION 2/2**

- Good behavior of mixes with 40% RAP.
- Blending of binder almost complete
- Possible effect at 70%
- No effect of multi recycling (3 steps at 40%)
- No evidence that rejuvenator is needed !
- ↓ Temperature ↓ fumes