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ASPHALT EMULSION MANUFACTURERS ASSOCIATION

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ISAET '21
7th International Symposium on Asphalt Emulsion Technology

Grave emulsion workability and performance
Mix design impact

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VALOCHEM
VALORIZATION OF CHEMICALS

Agenda

- I – What is Grave Emulsion (GE) ?
- II – Field of use & Drivers
- III – Limitations
- IV – Improvement
- V – Impact of Mix Design
- VI – Wearing Course CMA
- VII – Conclusions

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I - What is Grave Emulsion (GE) ?

- GE is a coating emulsion technique obtained through dispersion at ambient temperature of :
  - a grave (aggregate regular distribution from fine to large)
  - a slow breaking asphalt emulsion


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- Typical formulation example

Aggregates 0/14 mm	90%
Emulsion	7%
Water	3%

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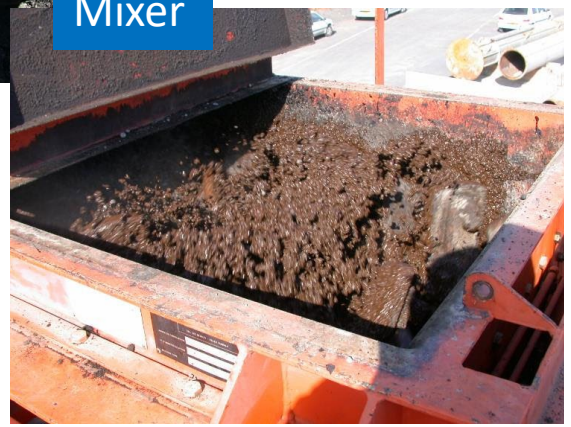
Limited Manufacturing Equipment

Plant

Mixer



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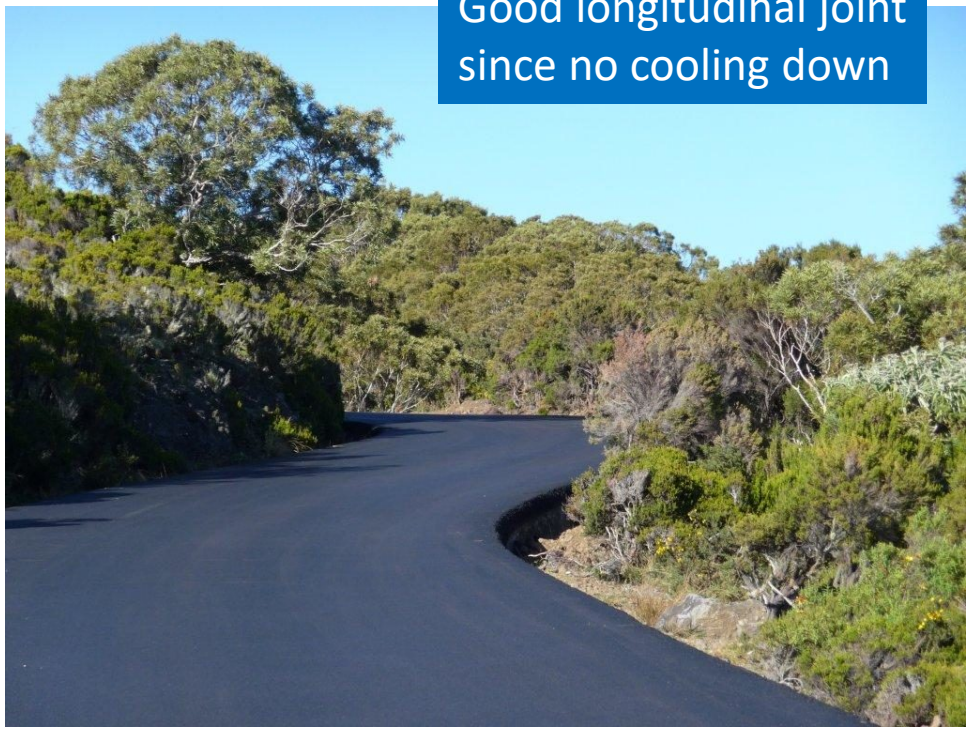
Limited Laying Equipment

Weather conditions : dry , T°C > 10

Good longitudinal joint since no cooling down



Compaction reduces the % of voids, accelerates emulsion breaking and mix setting

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Expected Performance

The addition of asphalt emulsion brings permanent cohesion without impact to the internal friction between aggregates that is taking place in a grave

Thus, GE is expected to provide :

- **Rutting resistance**
- **Bottom to top cracking prevention**

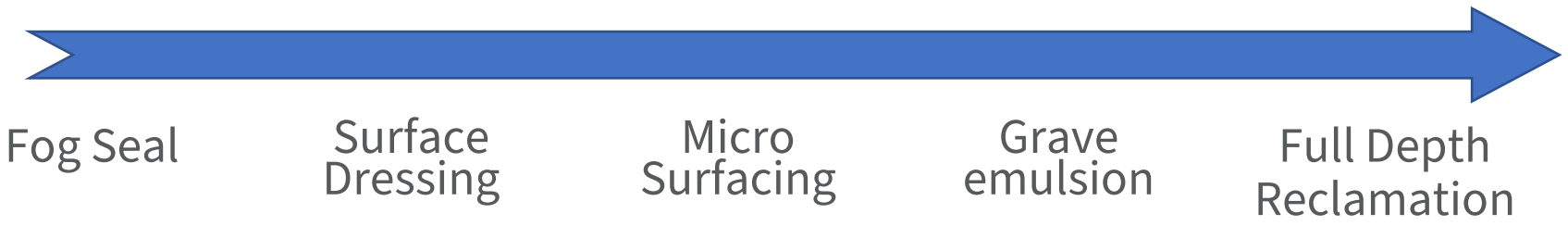
Other technical characteristics

- Workability
- Adaptability to deformations
- Good longitudinal joint
- Storability
- Immediate traffic reopening after lay-down

II - In which cases ?

Low to medium traffic roads

- New road bases
- Maintenance technique : **reinforcement or reprofiling** of aged intermediate/top layer



GE Categories

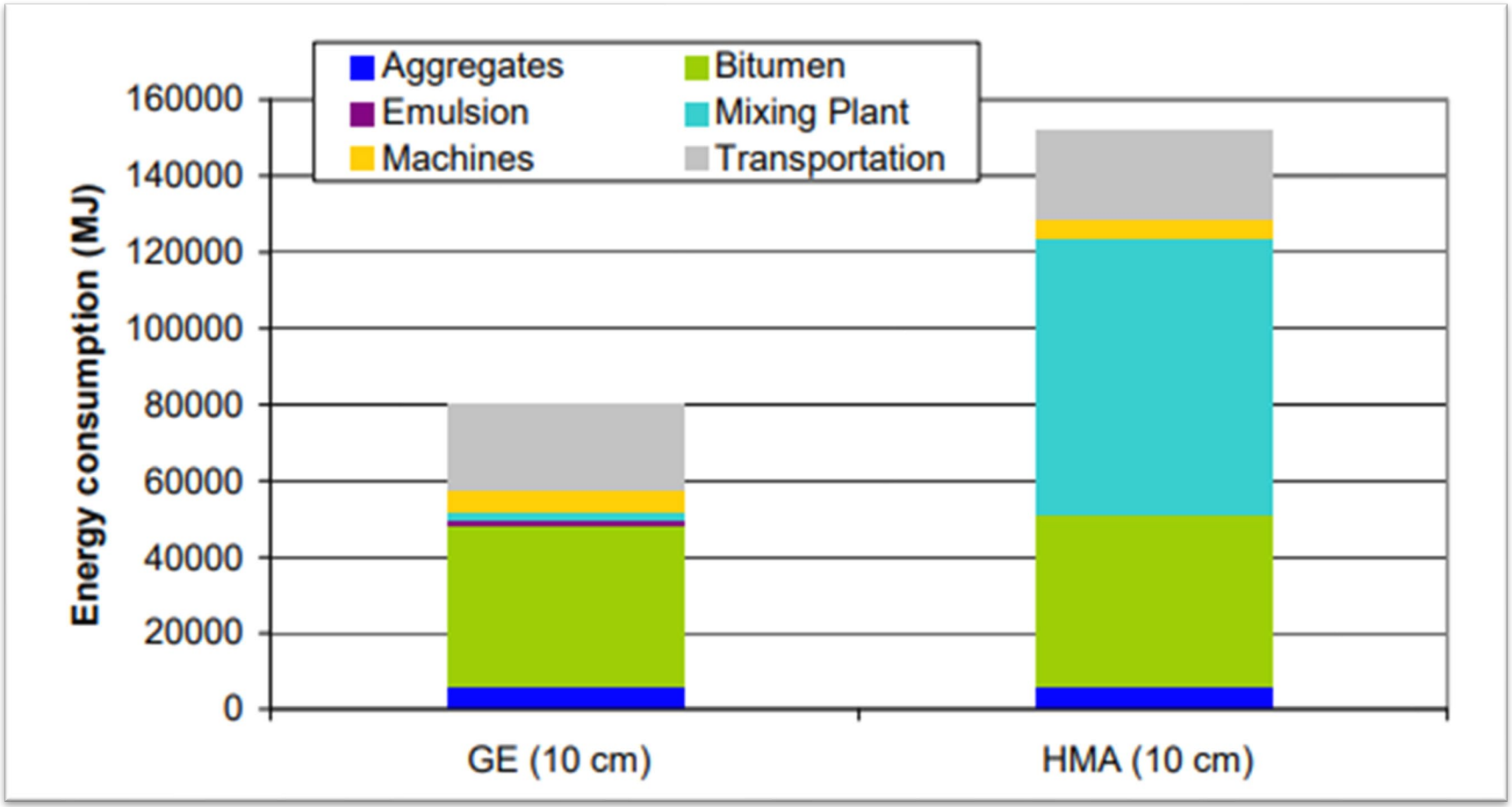
- Reprofiling
- Structuration

Grave emulsion	Grading (mm)	Normal thicknesses of application (cm)	Use
Type R	0/6	0 to 4	Reprofiling or local repair work
	0/10	0 to 6	
	10/14	3 to 8	
Type S	0/10	5 to 10	For sub-base layer as part of new or road reinforcement jobs
	0/14	6 to 12	
	0/20	8 to 15	

GE Drivers vs. HMA/WMA

- Sustainability
  - Smaller quantity of raw materials (reprofiling down to zero)
  - 100% RAP possible
- Lower environmental impact
  - Ambient temperature
  - Simple mobile manufacturing plants close to job site
- Economics
  - Limited equipment
  - Low energy
  - Potential 100% RAP use

Energy consumption



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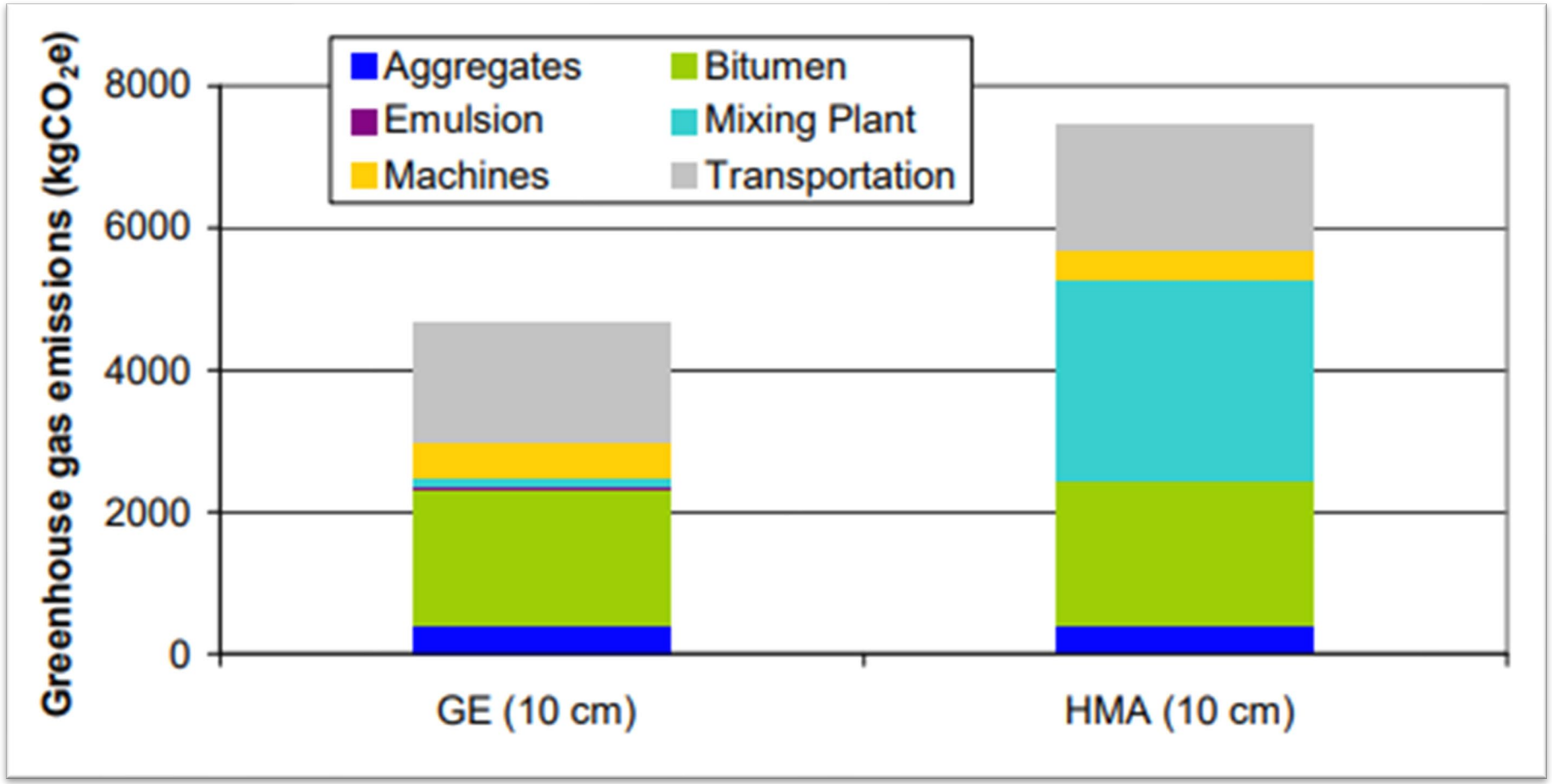
Greenhouse gas emissions



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Other GE advantages vs. HMA/WMA

- Simple manufacturing equipment : no heating, no filter
- No ageing during mixing
- 3+ hours of transport are no issue
- Storable version can be layed down right away after several weeks storage
- Finisher is not an obligation, Grader is usually enough
- Like WMA : no exposition of operators to fumes and aerosols

III - GE limitations

GE is a major success in France

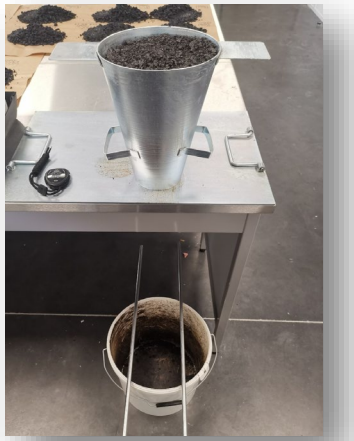
- Applied since 60+ years in France
- 1.2 M Tons of GE / year

Because limitations are taken into account

- **Curing** is required after application (water in porosity vs. air)
- **Post-treatment** after application
  - Wear course likely applied on the top to withstand tire shear forces (surface dressing or micro)
- Performance achievement requires **cautious lab formulation**

Lab formulation to reach GE Specifications

- Good **coating** : Visual  o uncoated aggregate



- Good **workability** : Cold Mix Flow Workability (CMFW) smooth application in the field

- Good **adhesion** : Duriez  ood water resistance

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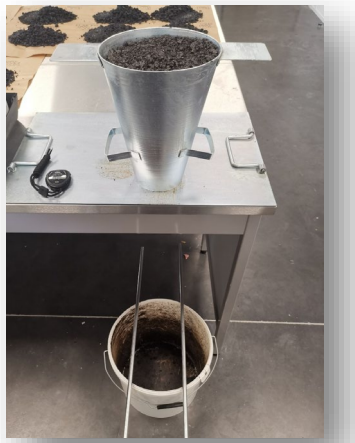
Coating & Workability

- Coating

Class	% cover of surface	Coating quality
E1	> 97%	Full
E2	90 to 96%	Very Good
E3	75 to 89 %	Medium
E4	< 75 %	Bad

- Workability
  - < 50 s for handwork
  - < 200 s for paver job



Adhesion : Duriez test

7 Days in the AIR +

7 Days in WATER

7 Days in the AIR

Compression

$$\frac{r}{R} = \frac{\text{Compressive strength in water}}{\text{Compressive strength in the air}}$$

The closer r/R to 1, the better the water resistance

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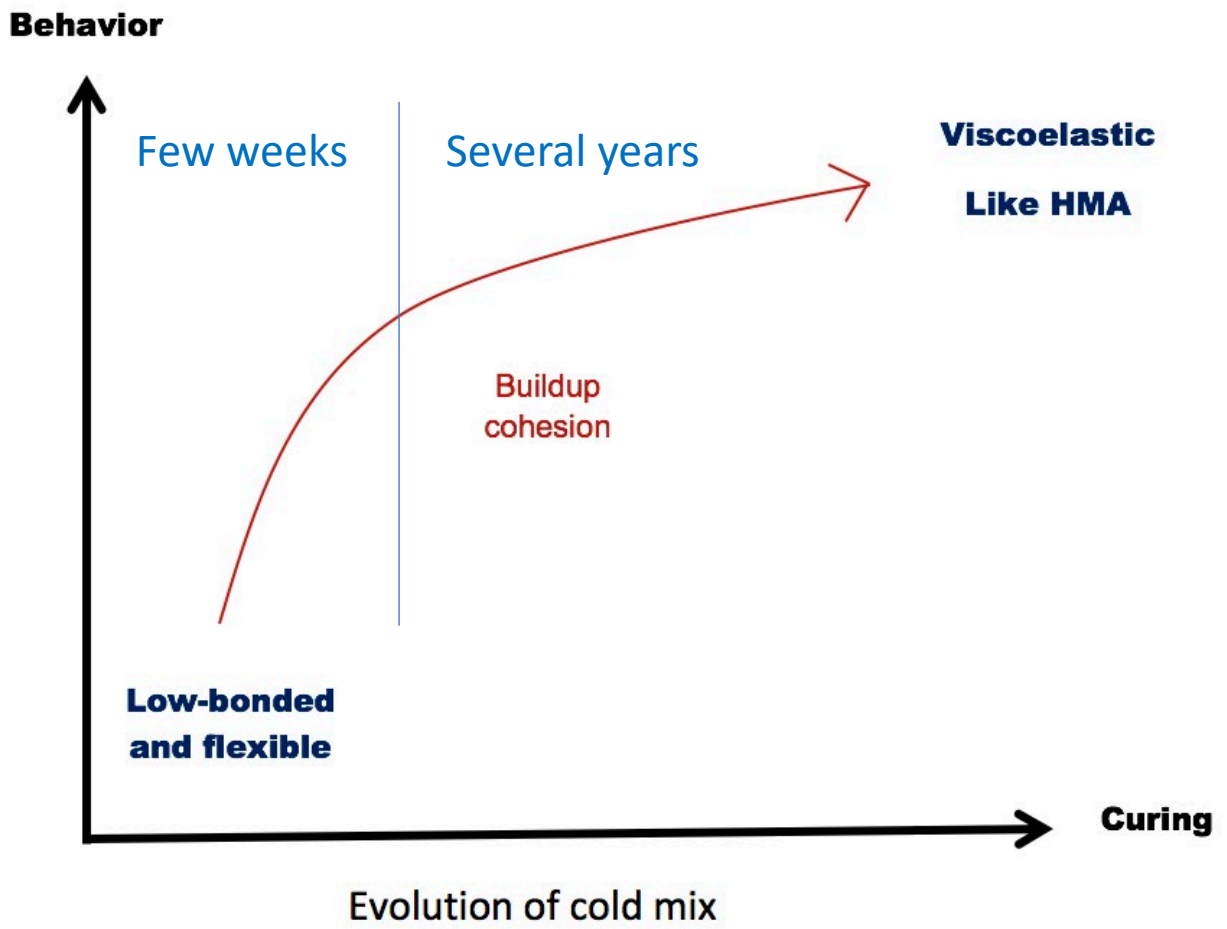
GE is an evolving material vs. HMA

- Cohesion Build-up depends upon :
  - Chemical interaction between aggregate and surfactant
  - Compaction
  - Traffic
  - Weather



State of the Art

	Lignin emulsifier	Polyamine emulsifier
Coating	+++	+
Workability	+++	++
Water resistance	+	+++

➡ Need for development of an emulsifier that matches all 3 specifications

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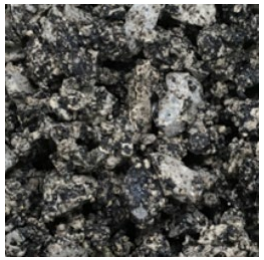
IV - New emulsifier for GE

	Valosurf GE	Valosurf GE	Lignin based emulsifier	Polyamine based emulsifier	*Specification for a reprofiling GE*
Coating	Full	Full	Full	Bad	
Dosage (kg/t)	18	14	14	/	
R (MPa)	5.0	4.5	4.4		*> 1.5*
Duriez r/R (18°C)	0.77	0.60	0.33		*> 0.55*
Binder content (%)	3.9	3.9	3.9		

Aggregate 0/10 :
100% Schist (Shale)



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V - GE Mix Design : Influence of aggregate

	Schist	Limestone
0/4 (parts)	35	50
2/6 (parts)	35	50
10/14 (parts)	30	
Water (parts)		2
Coating	E1 Full	E2 Dull Black
Dosage (kg/t)	14	14
R (MPa)	4.5	5.6
Duriez r/R (18°C)	0.60	0.30
CMFW (s)	/	40
Binder content (%)	3,9	4,6

➡ Aggregate/emulsifier interaction is key

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GE Mix Design : Impact of RAP Incorporation (1)

	A - 0%	B – 50 %	C – 80%
0/4 limestone (parts)	50	20	
2/6 limestone (parts)	50	30	20
RAP 0/10 (parts)	0	50	80
Water (parts)	2	2	2
Emulsion (parts)	**8**	**6**	**4**
Binder content (%)	4.6	5.7	6.0
Coating	**E2 Dull black**	**E2 Black**	**E1 Black and Shiny**
CMFW (s)	40	46	6
R (MPa)	5.6	6.4	6.2
Duriez r/R (18°C)	0.30	0.50	0.66

→ Coating increases with % RAP

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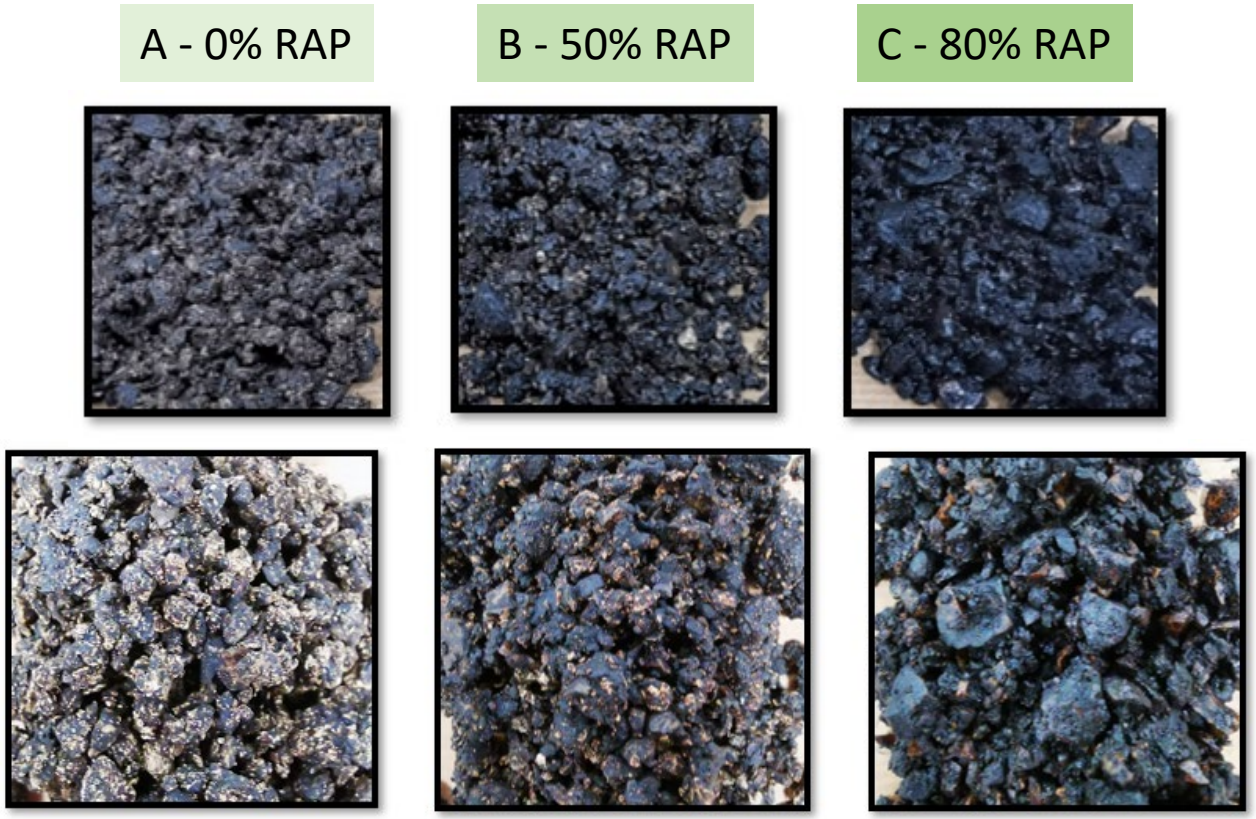
Coating improvement with RAP



GE Mix Design : Impact of RAP Incorporation (2)

	A - 0%	B – 50 %	C – 80%
0/4 limestone (parts)	50	20	
2/6 limestone (parts)	50	30	20
RAP 0/10 (parts)	0	50	80
Water (parts)	2	2	2
Emulsion (parts)	8	6	4
Binder content (%)	4.6	5.7	6.0
Coating	E2 Dull black	E2 Black	E1 Black and Shiny
CMFW (s)	**40**	**46**	**6**
R (MPa)	5.6	6.4	6.2
Duriez r/R (18°C)	0.30	0.50	0.66

➡ CMFW workability is very good

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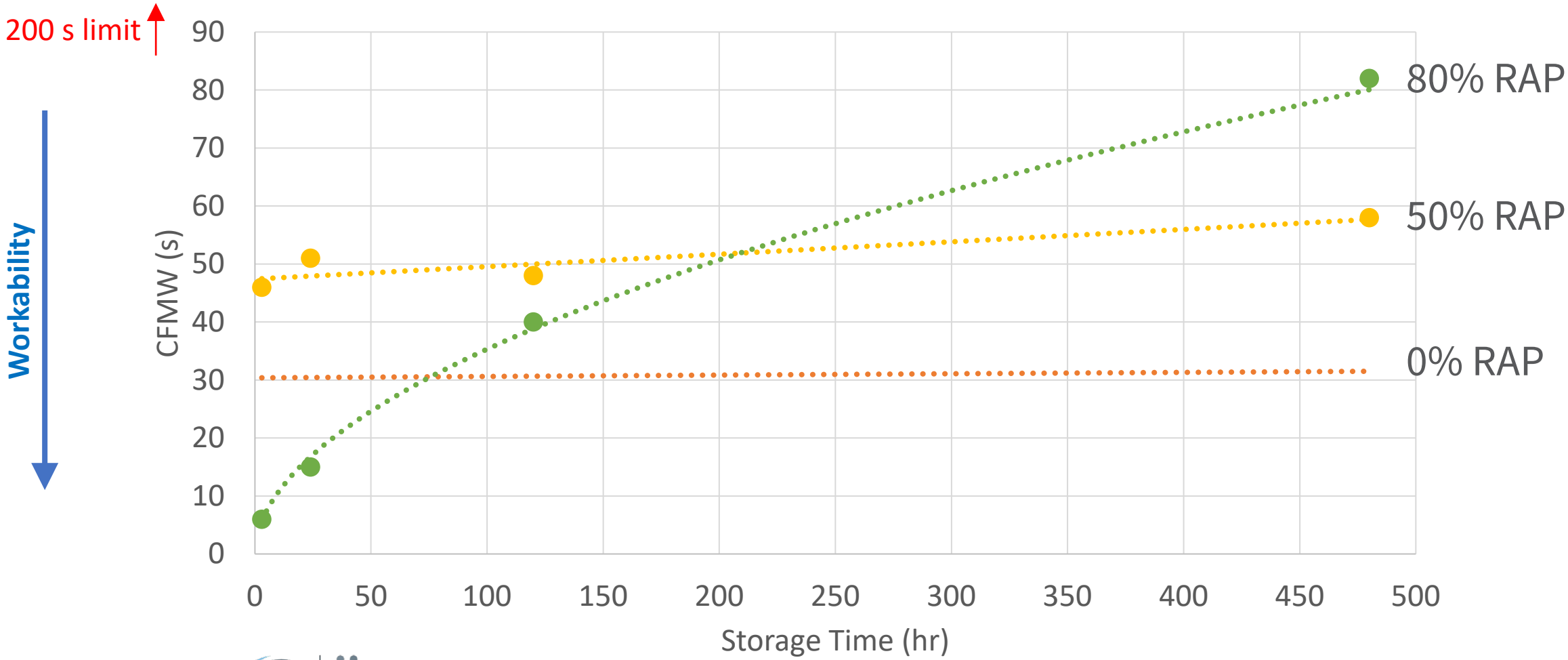
CFMW improvement with RAP



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GE Mix Design : Impact of RAP Incorporation (3)

	A - 0%	B – 50 %	C – 80%
0/4 limestone (parts)	50	20	
2/6 limestone (parts)	50	30	20
RAP 0/10 (parts)	0	50	80
Water (parts)	2	2	2
Emulsion (parts)	8	6	4
Binder content (%)	4.6	5.7	6.0
Coating	E2 Dull black	E2 Black	E1 Black and Shiny
CMFW (s)	40	46	6
R (MPa)	**5.6**	**6.4**	**6.2**
Duriez r/R (18°C)	**0.30**	**0.50**	**0.66**

→ Duriez increases with % RAP

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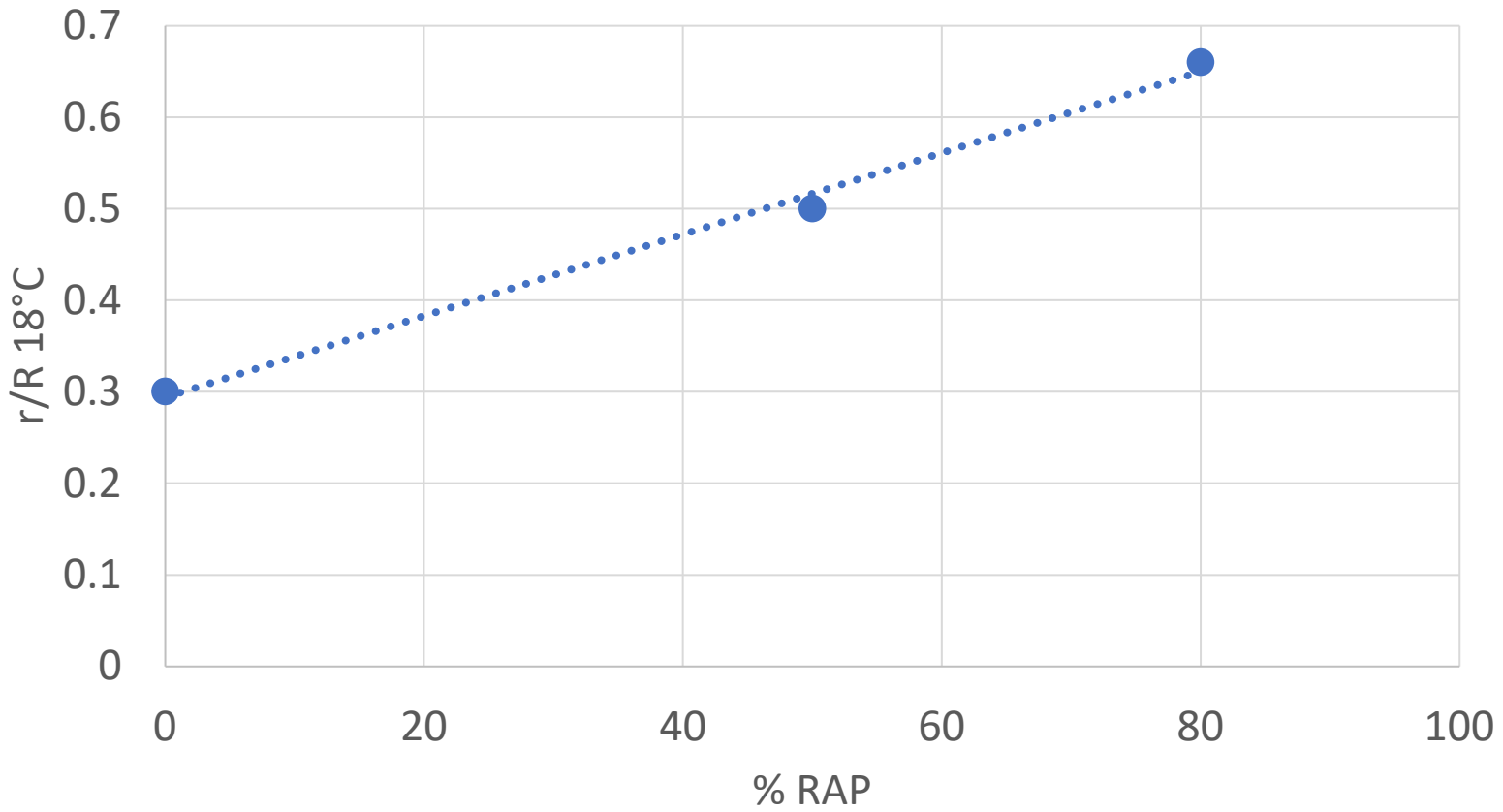
Cohesion improvement with RAP



+25% RAP ≃ 0.1 Duriez

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VI - Characteristics of Wearing Course CMA

- vs. GE
  - Higher residual binder
  - **Higher Duriez water resistance r/R = 0.55 → 0.70**

- vs HMA/WMA :
  - High deflection withstanding
  - High reprofiling capacity
  - High rutting resistance with good flexibility

CMA Mix Design : Impact of RAP Incorporation

Aggregate 0/10 :
100% Schist

Emulsifier :
ValoSurf GE

	F1	F2	F3
0/4 (parts)	27	15	12
4/6 (parts)	28	25	15
6/10 (parts)	35	30	23
RAP (parts)	**10**	**30**	**50**
Water (parts)	0	0	0
Emulsion (parts)	**8,3**	**7,3**	**6,3**
Binder content (%)	**5,5**	**5,9**	**6,3**
Coating	**E1 Black and Shiny**	**E1 Black and Shiny**	**E1 Black and Shiny**

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Duriez Testing : 35°C vs. 18°C

35°C testing may be more relevant for top layer, since under curing the mix may evolve from fresh water sensitive state to a more resistant state

	F1	F2	Specs
RAP (parts)	10	30	
Binder content (%)	5,5	5,9	
Coating (%)	E1 Black and Shiny	E1 Black and Shiny	
Workability 3h (s CA) 24h (s CA)	 31 121	 120 135	 < 200 < 200
Duriez 18°C R18 (Mpa) r18/R18	 **3.8** **0.65**	 **8.5** **0.61**	 > 2.5 > 0.7
Duriez 35°C **R35 (Mpa)** r35/R35	 **4.9** **0.81**	 /	 > 0.8

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Reuse of RAP : Addition of Rejuvenators

RAP 1

RAP 1 + 0.5% vegetal Flux

RAP 1 + 0.5% Rejuvenator

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Reuse of RAP : Addition of Rejuvenators

RAP 2

RAP 2 + 0.5% Rejuvenator

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VII Conclusions

- GE is a valuable cold maintenance technique for reprofiling and restructuring (before FDR)
- A new GE emulsifier provides a better balance between coating and adhesion
- GE performance improves with RAP incorporation and allows significant reduction of emulsion content
- Small content of RAP up to 30% can be used as well on Wearing Course CMA. Higher amounts may require rejuvenator and more emulsion compared to GE
- In CMA cases, optimized process for incorporation of rejuvenator seems critical to ensure good performance


Thank you for your attention
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