AV '21 CONFERENCE ASPHALT PAVEMENTS 2021

Grave Emulsion: a Performing Tool for Road Maintenance

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Cold Techniques are the Methods of Choice for Road Preservation and Maintenance

40 SDRUŽENÍ PRO VÝSTAVBU SILNIC

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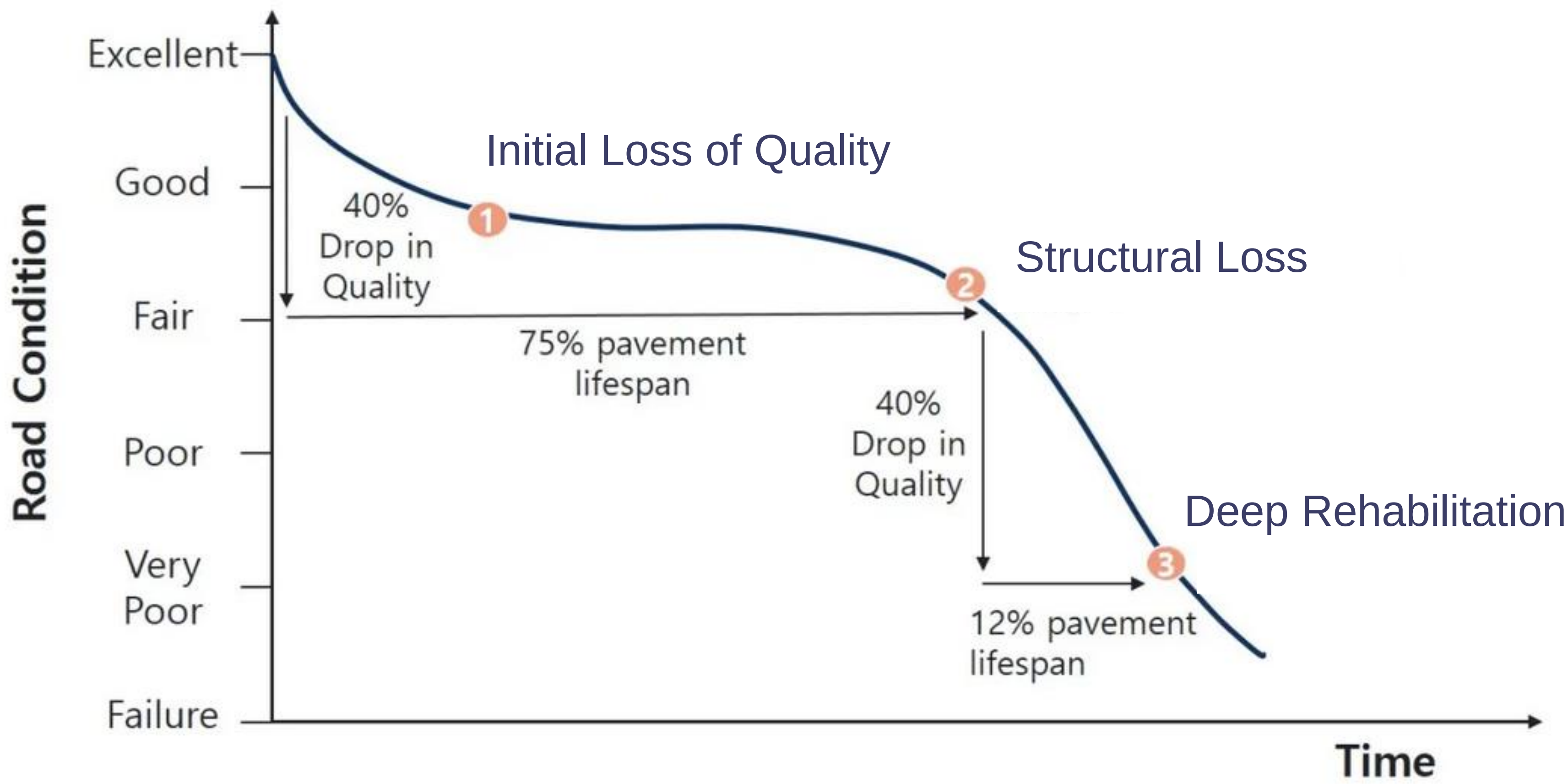
EAPA

PRAGOPROJEKT

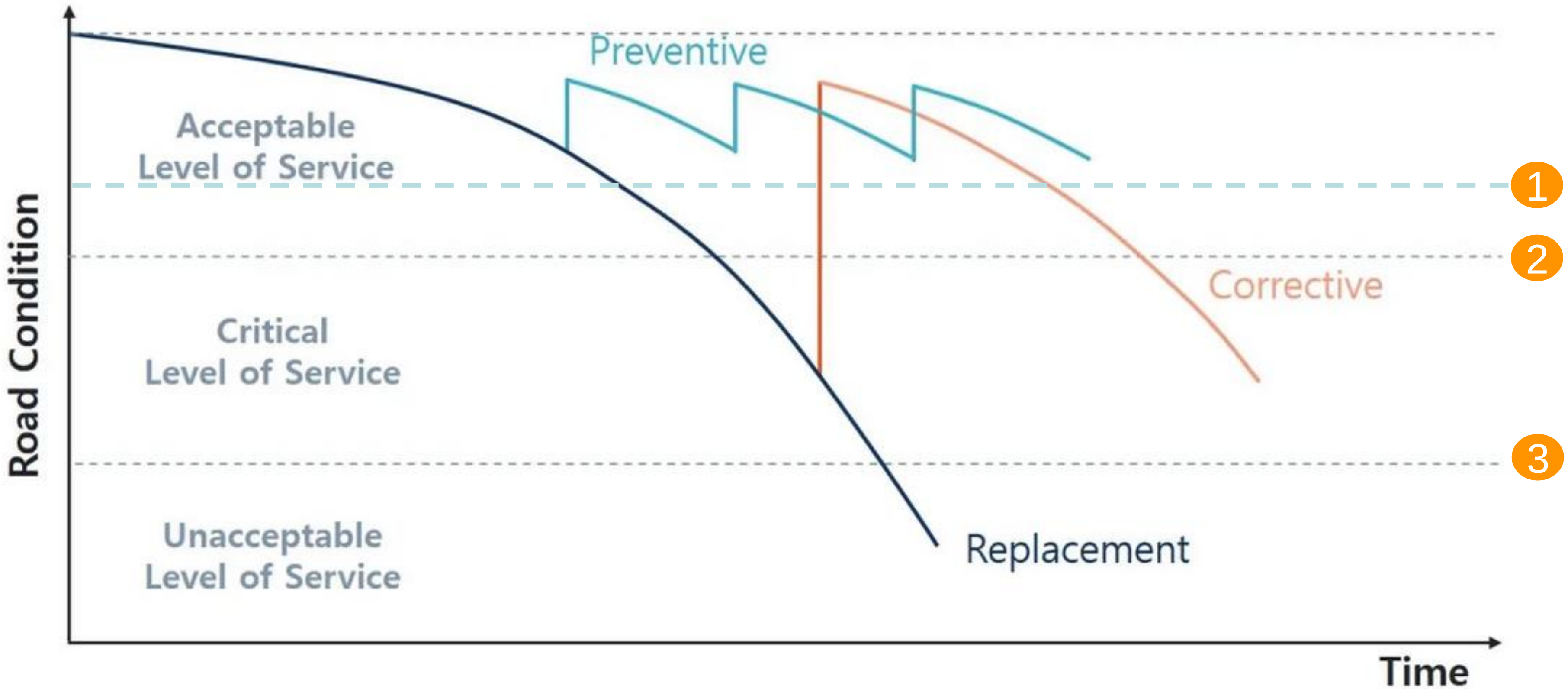
I- Road Maintenance: Cold Techniques

Road Condition Evolution



Source: ALG Transport & Infrastructure, 12 - Nov. 2020

Maintenance Strategies



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Source: ALG Transport & Infrastructure, 12 - Nov. 2020

Maintenance Optimization

1. Quality
2. Environmental footprint
   - CO_2 release
   - Raw material sustainability
   - Health and safety of workers
3. User Satisfaction
   - Road smoothness and comfort
   - Delays linked to road maintenance/rehabilitation
4. Cost

➥ **Cold laying techniques are often the optimized choice**

Maintenance Techniques

Fog Seal
Crack Seal
Scrub Seal
Chip Seal
Slurry Seal
Microsurfacing
Cape Seal
Grave Emulsion
Thin WMA/HMA

Grave Emulsion
Cold in-Place Recycling
Hot in-Place Recycling
CMA
WMA/HMA

Full Depth Reclamation

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Source: Pavement Preservation and Recycling Alliance

II – Grave Emulsion

What is Grave Emulsion (GE) ?

GE is a coating emulsion technique involving a dispersion of

- a slow breaking asphalt emulsion
- a grave (aggregate regular distribution from fine to large)
- at ambient temperature

+

+

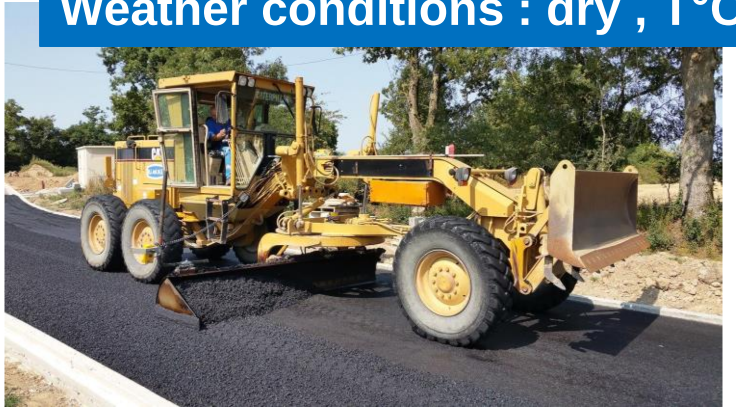
Typical formulation example

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

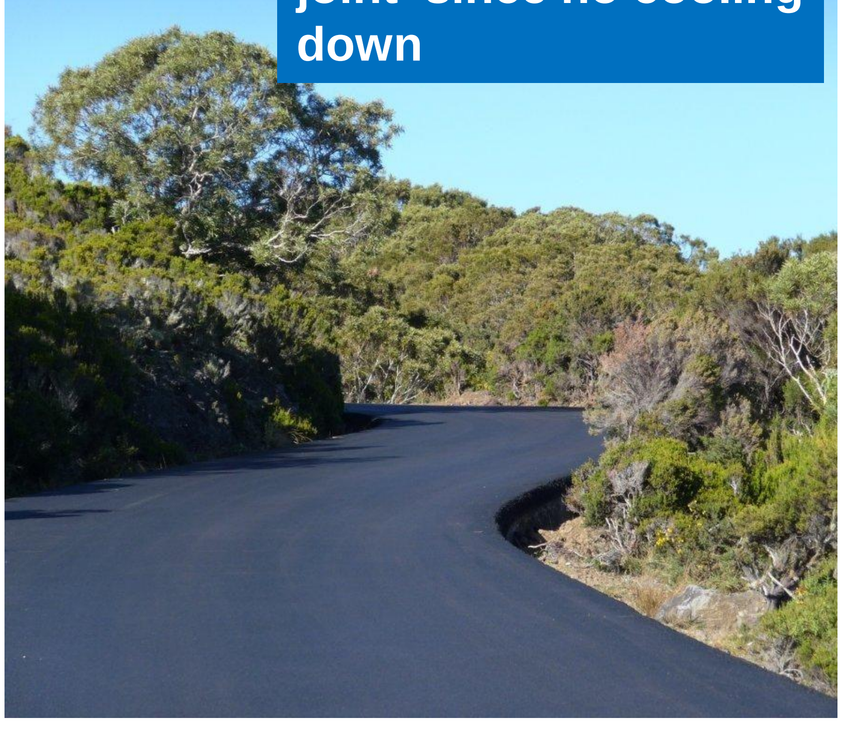
Limited Manufacturing Equipment

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

Expected Performance

The addition of asphalt emulsion brings permanent cohesion without impacting 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 joints
- Storability
- Immediate traffic reopening after lay-down

In which cases ?

Low to Medium Traffic Roads

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

Fog Seal → Surface Dressing → Micro Surfacing → Grave emulsion → Full Depth Reclamation

GE Categories

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

GE Drivers vs. HMA/WMA

Sustainability

- Smaller quantity of raw materials (reprofiling down to zero)
- 100% RAP possible

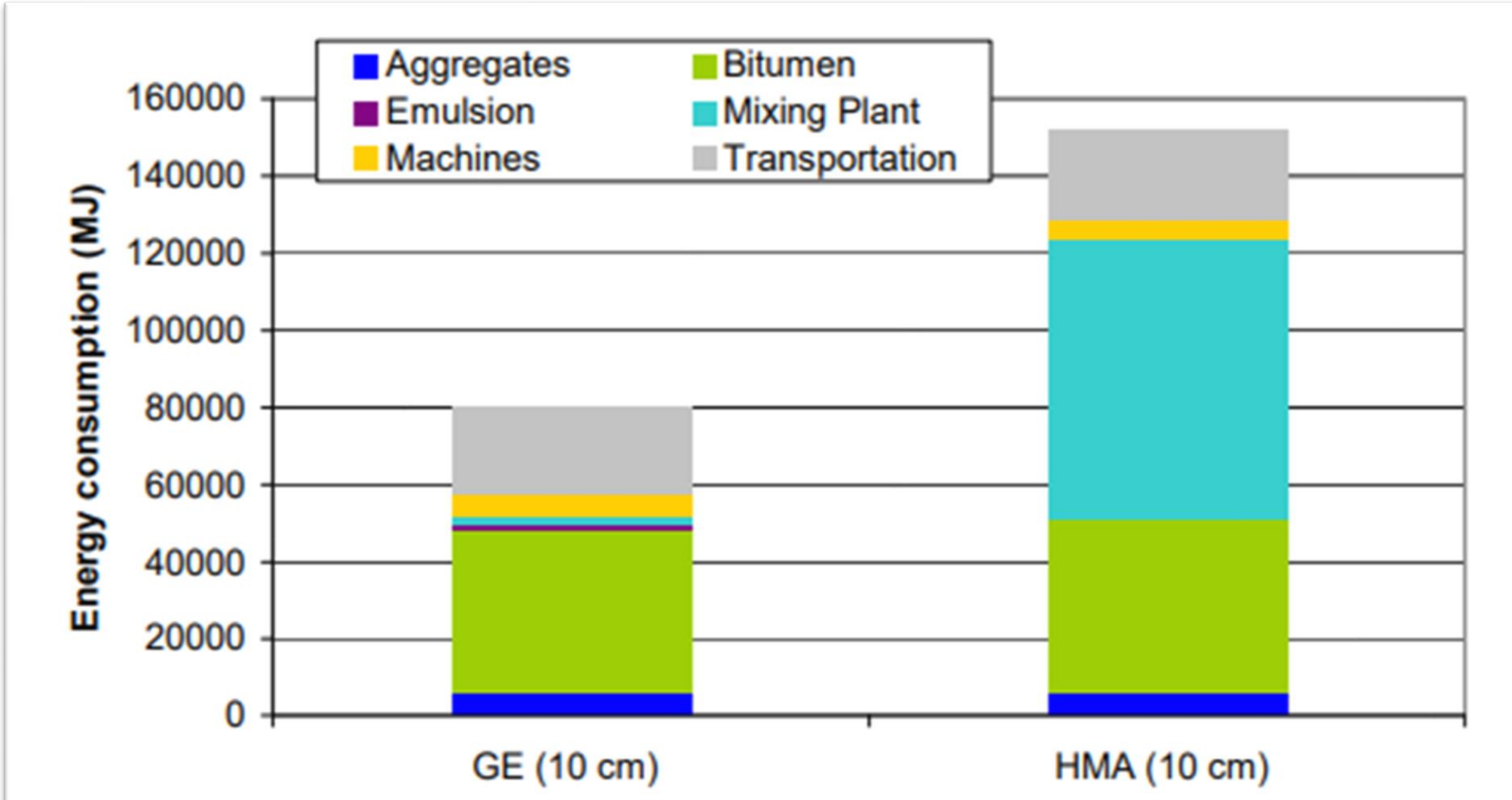
Lower Environmental Impact

- 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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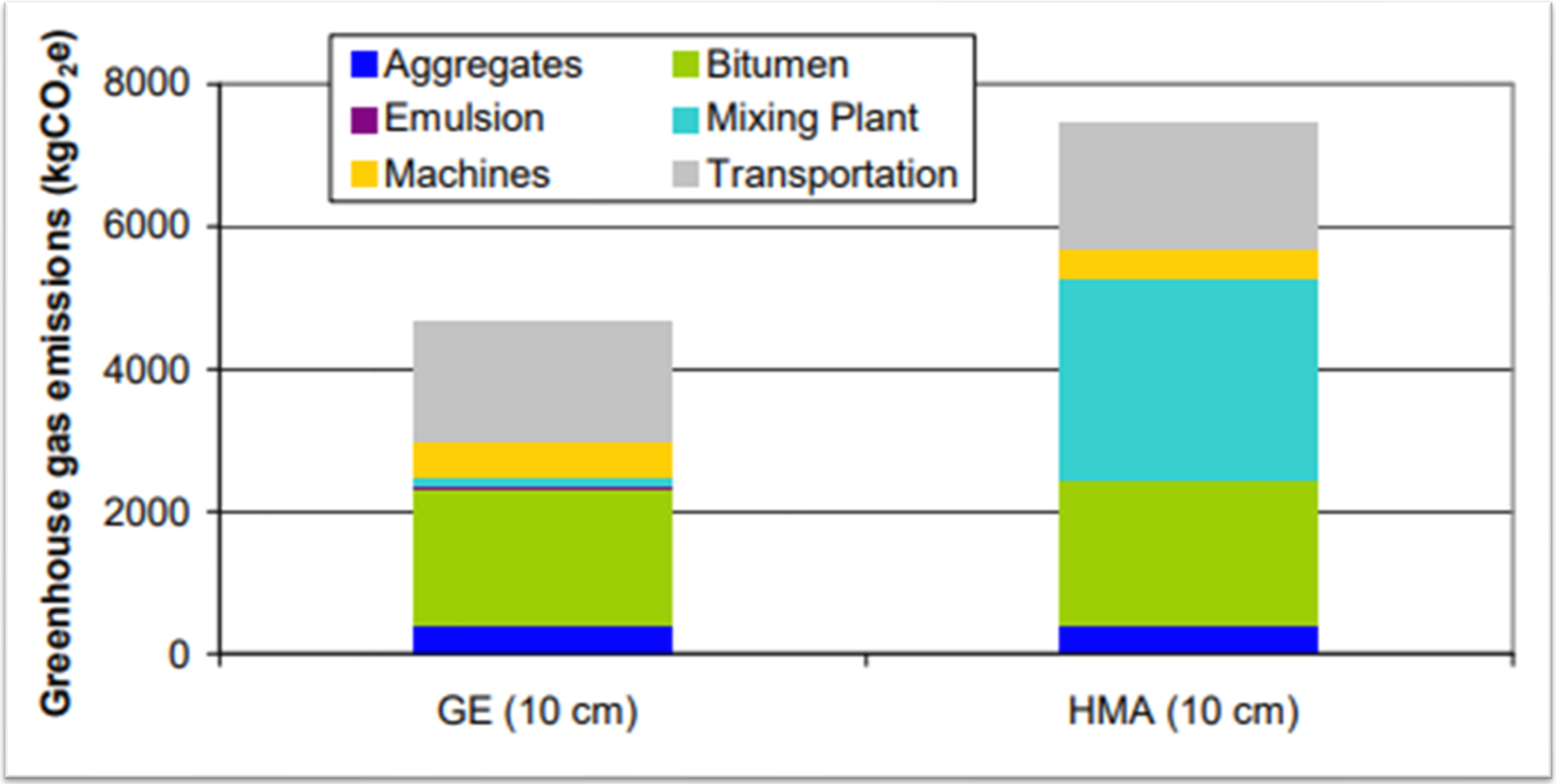
Source: ***https://hal.archives-ouvertes.fr/hal-00845930/document***

Green House Gas Emissions



Source: ***https://hal.archives-ouvertes.fr/hal-00845930/document***

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

GE Limitations

Major success in France

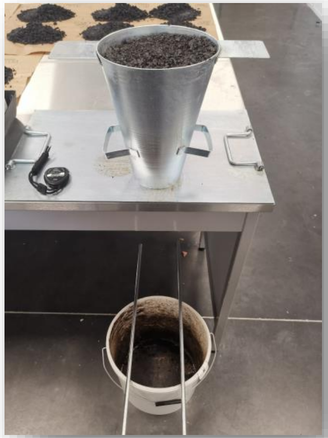
- Applied since 60+ years
- 1.2 M Tons of GE / year

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 specifications

Good coating : Visual  ➜ no uncoated aggregate



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

Good adhesion : Duriez  ➜ good water resistance

Coating and 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 (CMFW)

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

Duriez Test

7 Days in the AIR

7 Days in WATER

7 Days in the AIR

Compression

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

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

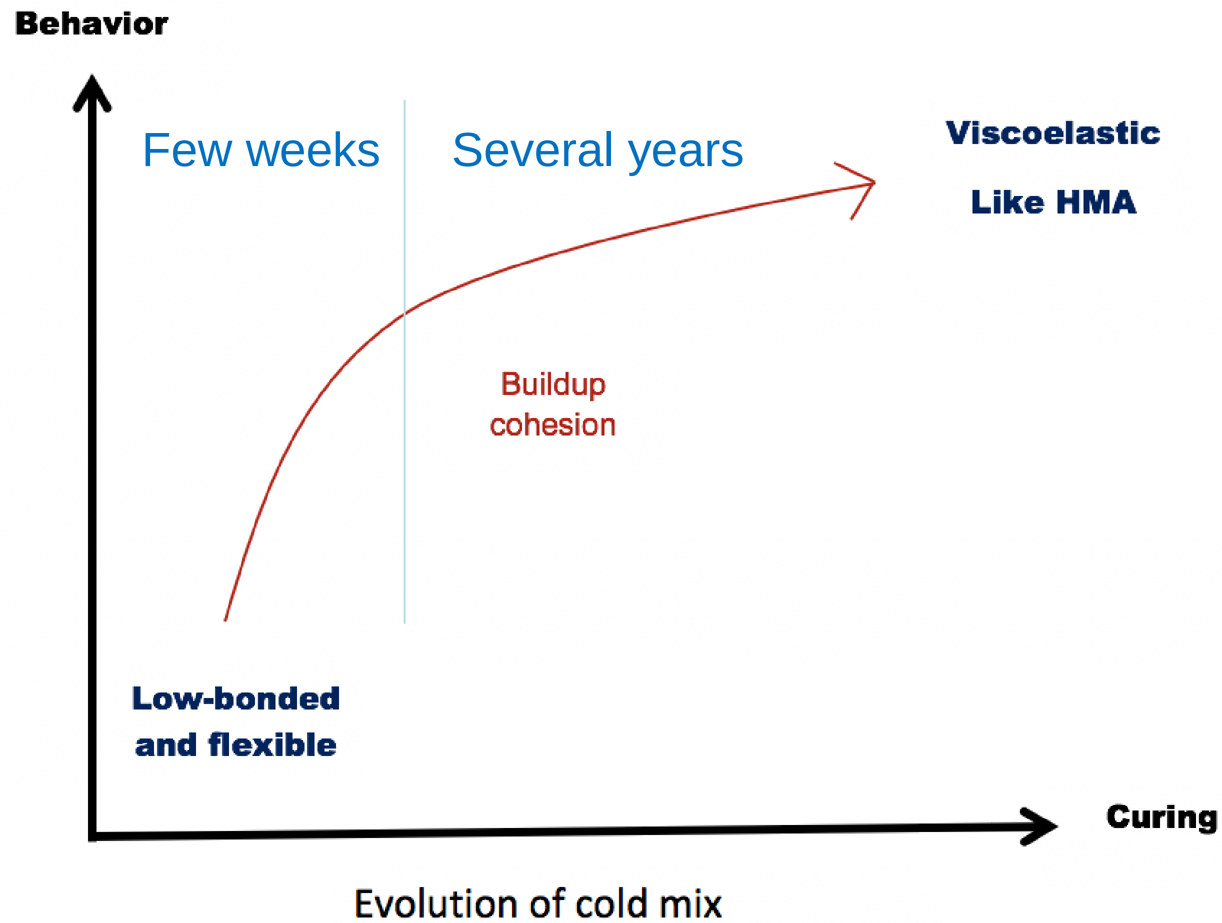
R

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

GE is an evolving material vs. HMA/WMA

Cohesion speed:

- Chemical interaction between aggregate and surfactant
- Compaction
- Traffic
- Weather



III – New Emulsifier for Grave Emulsion and Cold Mix: ValoSurf™ GCM

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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ValoSurf™ GCM

	Valosurf GCM	Valosurf GCM	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)

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

Impact of RAP Incorporation

	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) GCM	**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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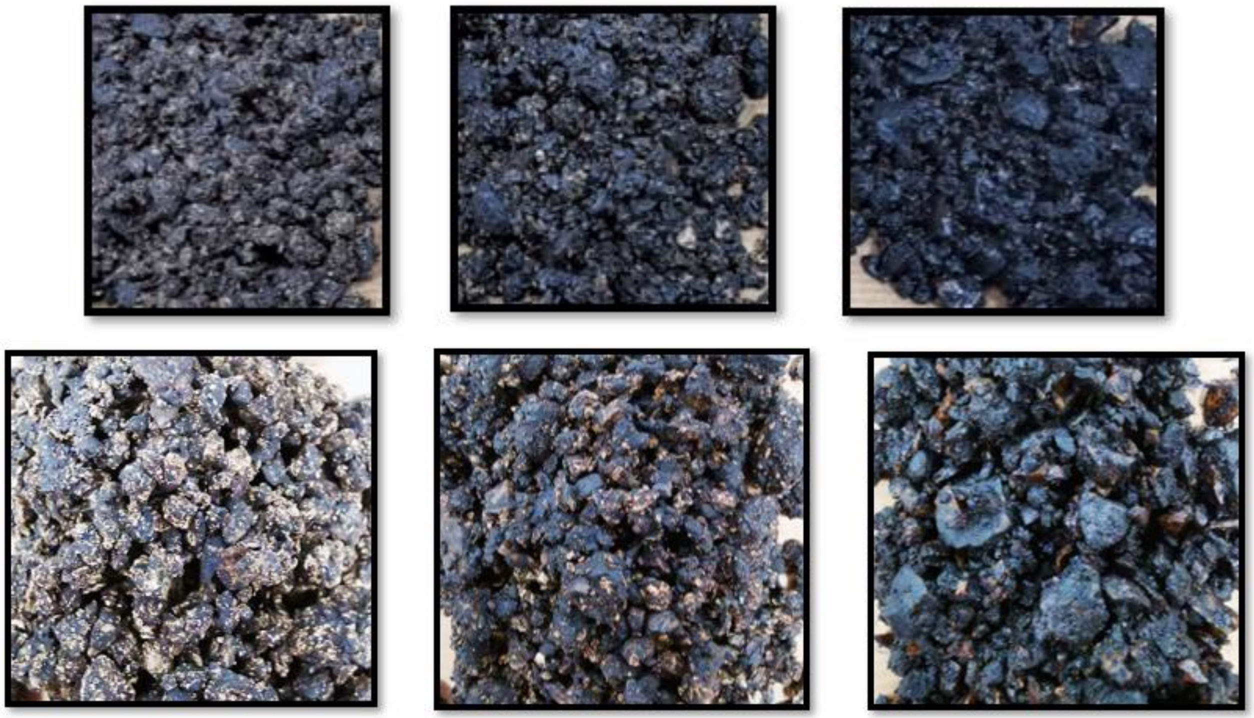
Coating Improvement with RAP

A - 0% RAP | B - 50% RAP | C - 80% RAP



Right after mix

After 48 hrs

Impact of RAP Incorporation

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0/4 limestone (parts)	50	20	
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RAP 0/10 (parts)	0	50	80
Water (parts)	2	2	2
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R (MPa)	5.6	6.4	6.2
Duriez r/R (18°C)	0.30	0.50	0.66

➥**CMFW is very good**

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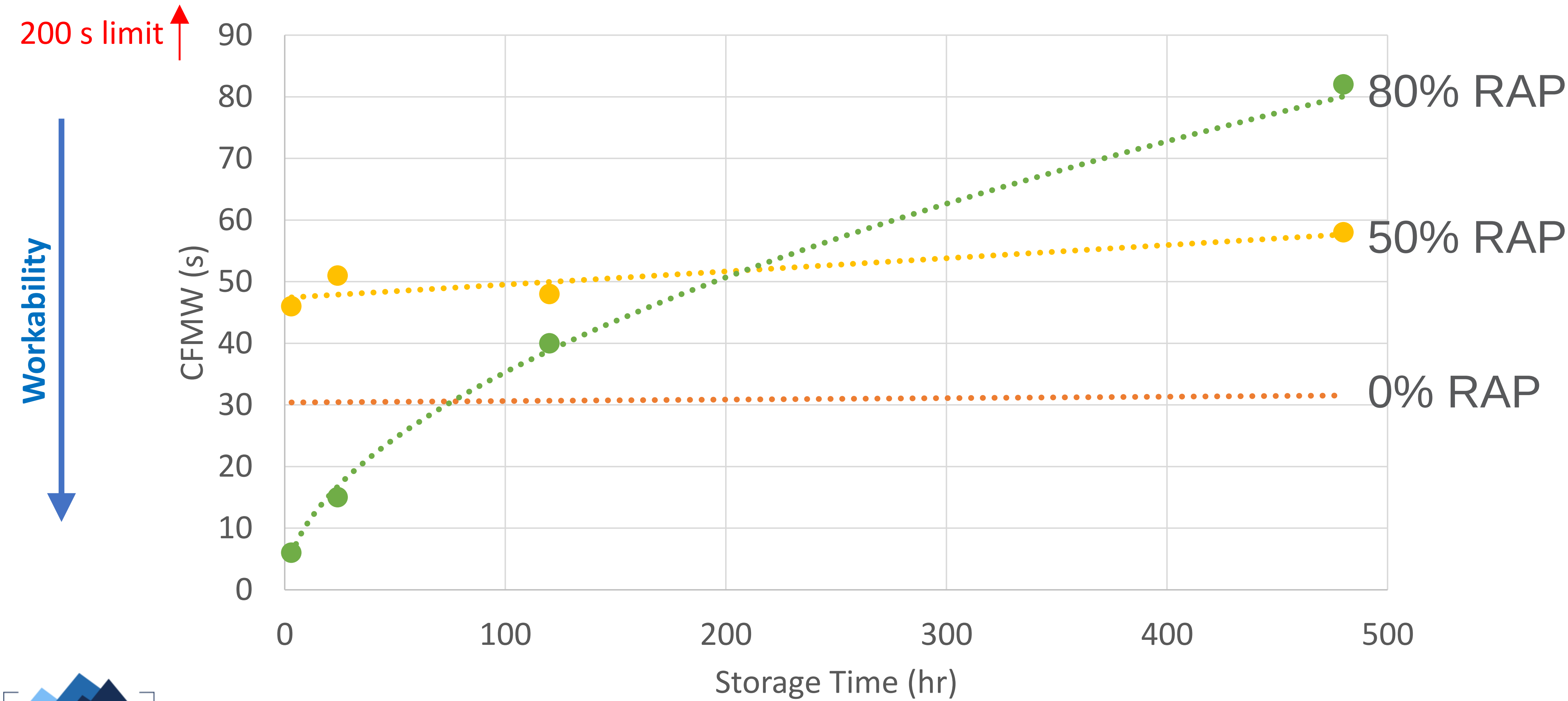
CMFW Change with RAP



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➥**Duriez increases with %RAP**

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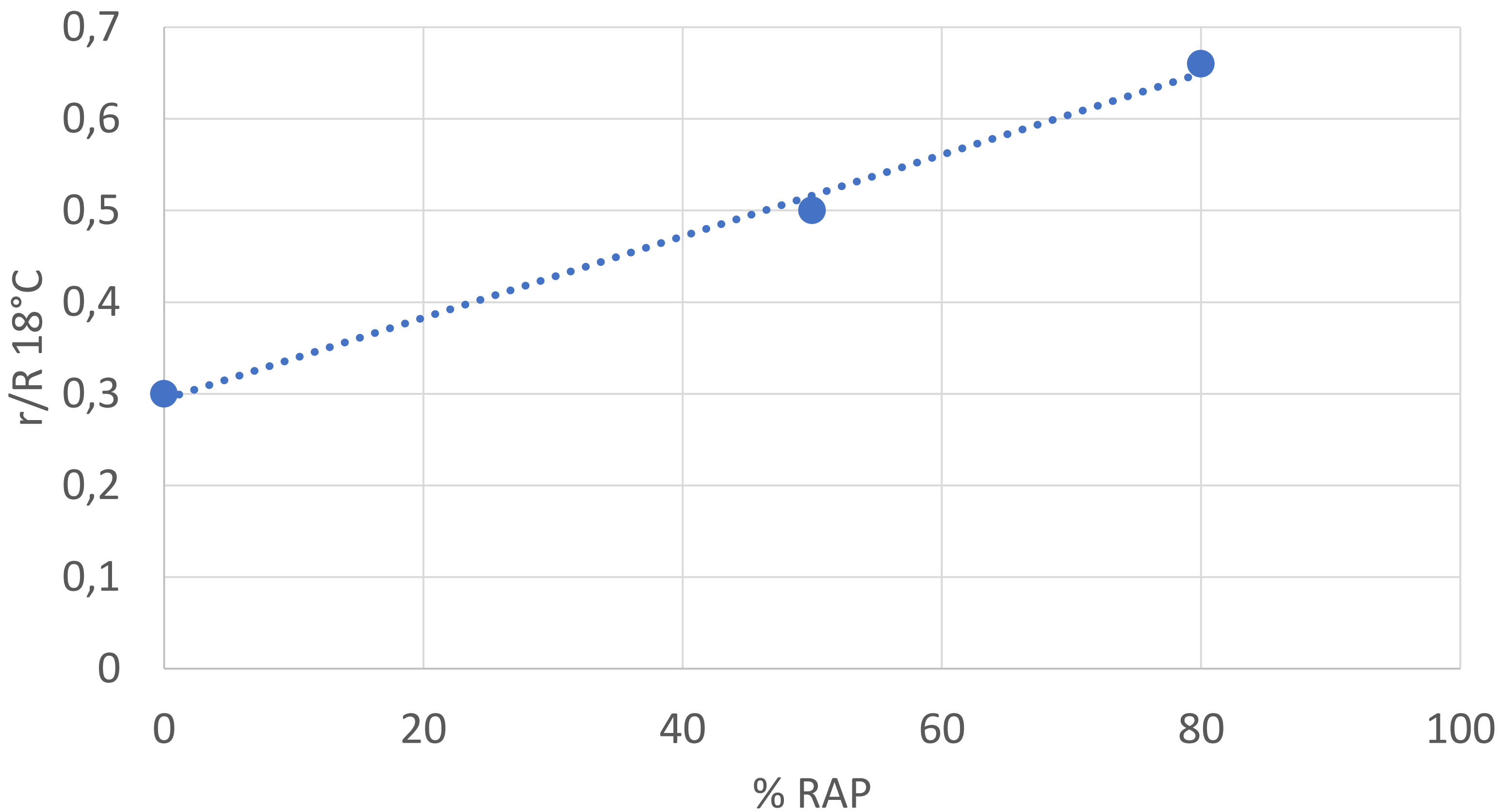
Cohesion Improvement with RAP



+25% RAP ≃ 0.1 Duriez

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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

Impact of RAP Incorporation

Aggregate 0/10 : 100% Schist

Emulsifier : ValoSurf GCM

	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: 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	
CMFW 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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IV – Conclusions

- **Optimization of the maintenance/rehabilitation strategy translates into a better balance between environmental footprint, user satisfaction and overal cost**
- **GE is a valuable cold maintenance technique for reprofiling and restructuring (before FDR)**
- **A new emulsifier for Grave Emulsion and Cold Mix provides a better balance between coating and adhesion**
- **GE performance improves with RAP incorporation and allows a 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**