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Recycling asphalt overview of more than 25 years of use in France

Yves Brosseaud

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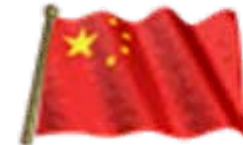
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Recycling asphalt overview of more than 25 years of use in France

Y. Brosseaud – LCPC



content

- Historic et definitions
- Situation rules and regulations
- Situation today with regard to sustainable development
- Examples of some cases
- Outcome of behaviors (evolutions and tendencies)
- Conclusion

Historic

- At the beginning of 80: apply the experiences from USA:
 - Consequence of first petroleum crisis 1976
 - Used of TSE with ring for recycling
 - Average rate with high proportion : 30 to 50%
 - Used of rejuvenators (soft oil : RJO 400)
 - Will of administration : RN, free motorways
 - Applied researches in LRPC, refineries, companies
- Abandonment of the process between middle of 1980 and 2000, except for « big construction site (motorways) »
- Re-used of technique under the influence of sustainable development : start 2000





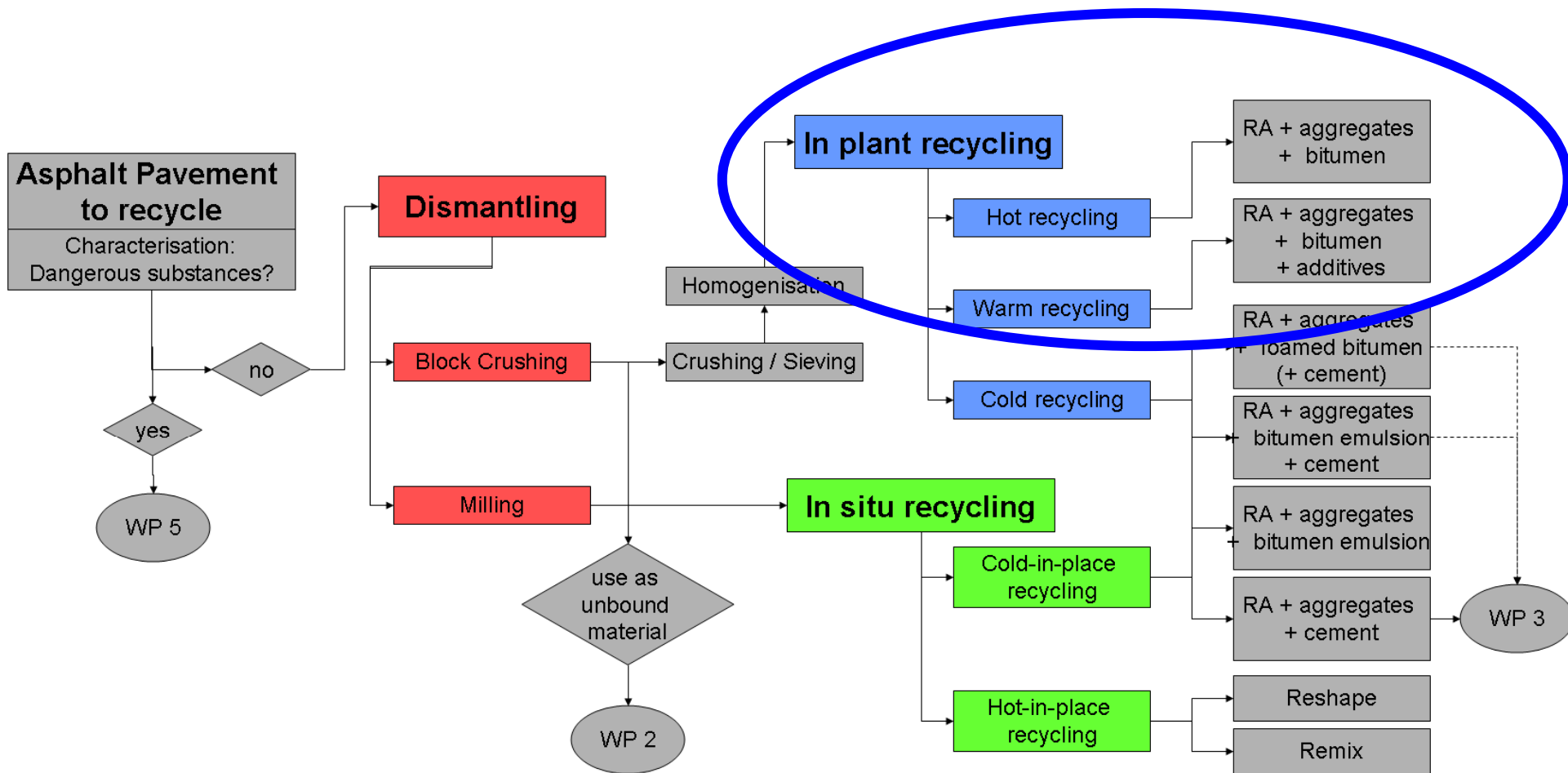
Hot recycling asphalt on mixing plant

Recycling in place in hot

or cold conditions



Techniques for recycling of reclaimed asphalt



Classification from Direct-mat: european research project on recycling material in the road

Standardization of reclaimed asphalt

- **Norme XP P 98-135 :**
 - « Enrobés hydrocarbonés : Caractérisation des agrégats d'enrobés pour recyclage à chaud en centrale »,
 - Classification des agrégats en fonction de leur teneur en liant (TL), pénétration (B) ou TBA, granulométrie (G), caractéristiques intrinsèques (R).



Rate of RA vs composition

Composants de l'agrégat d'enrobé	Liant bit.	Teneur	TL _{NS}	TL ₂		TL ₁		
		Pénétrabilité ou TBA	B _{NS}		B ₂	B ₁		
	Granulats	Granularité	G _{NS}		G ₂		G ₁	
		Caract. intrinsèques	R _{NS}			R ₁	R _{NS}	R ₁
Usage dans la chaussée	Couche de roulement		0	10	a)	30	10 ^{a)}	40
	Couche de liaison		10	20	30	40		
	Couche d'assise							

a) Si la teneur en liant moyenne de l'agrégat est supérieure à 5,5 ppc, alors on peut introduire jusqu'à 10% d'agrégat d'enrobés dans l'enrobé recyclé même si les caractéristiques intrinsèques des granulats ne sont pas connues (R_{NS})

回收沥青混合料特性和RAP 参量



Manuel LPC d'aide à la formulation
des enrobés à chaud
法国沥青混合料设计指南

在路面中应用	层位		RAP 掺配比率 (%)				
	表面层		0	0	10 根据 ⁽¹⁾	30	40
	联结层		10	20	30	40	
	基层		10	20	30	40	
回收沥青组成资料	胶结料含量		范围	无规定	≤2%	≤1%	
	沥青胶结料	残留物性质 (针入度或软化点)	针入度 0.1mm	无规定	≥5	≥5	
			针入度范围		-	≤15	
			软化点温度℃		≤77	≤77	
			软化点范围		-	≤8	
	集料	颗粒尺寸分布	D, 通过率, 范围	无规定	80-99	85-99	
			2mm, 通过率, 范围		≤15	≤10	
			0.063 mm, 通过率, 范围		≤20	≤15	
	内在特性	分类	棱角性	无规定	例如 LA ₂₀ , M _{DE} 20		
					-	C _{90/1}	

(1) 如果 RAP 平均油石比超过 5.5%，可以认为这种回收料是一种沥青混合料，只不过其集料选择的技术标准与回收混合料的集料最低标准非常接近，不管如何，石灰岩集料不能用于表面层。

regulations

- **Note du Directeur des Routes du 3 octobre 2000 sur la gestion des agrégats dans le cadre du réseau routier national :**

« Pour des bétons bitumineux destinés à être employés sous un trafic inférieur ou égal à T1 ou celle des béton bitumineux minces destinés à être employés sous un trafic inférieur ou égal à T3, il n'existe pas d'inconvénient technique à réutiliser, dans la limite de 10%, des agrégats d'enrobés hydrocarbonés sans avoir à effectuer des études préalables,... »

Voluntary commitment (private companies)

- **Concernant les granulats et agrégats:**
 - Réemployer ou valoriser 100% des matériaux géologiques naturels excavés sur les chantiers: « zéro apport extérieur » à l'horizon 2020
 - Atteindre un recyclage de 100% des routes: faire progresser le pourcentage de recyclage en centrale d'environ 20% aujourd'hui à 60% en 2012
- **Réduction des consommations d'énergie et des émissions de GES (↘ de 33% à l'horizon 2020)**
 - Optimisation de la fonction « transport »
 - Abaissement de la température des enrobés

Limits on the variations of the RAP characteristics

Country	Grading [%] by mass			Binder content [%] by mass	Penetration [1/10 mm]	Softening point $T_{R\&B}$ [°C]
	< 0,063	>0,063; < 2	> 2			
Belgium ¹⁾	±3		±10	±1	±10	±10
Denmark	Not specified					
France	Not specified					
Germany ²⁾	x	x	x	x	-	x
Hungary	Not specified					
Ireland	Not specified					
Poland ²⁾	x	x	x	x		x
Portugal	±1,5	±3	±5	±0,4	±4	-
Serbia	Not specified					
Slovenia	Not specified					
Spain	±1,5	±3	±5	±0,4	±4	-
Sweden	Not specified					

¹⁾ If tolerances are not met, the allowed RA content is reduced to half of the allowed value
²⁾ The homogeneity of the indicated characteristics defines the percentage of RA

Some figures

Production française d'enrobés « neufs » \approx **40 Millions de t/an**



\approx **6,5 Millions de t** de fraisats



23% réutilisés dans la production d'enrobés « neufs »
(\approx **1,7 Millions de t**, soit 4% de la production totale d'enrobés)

Objectif français: 23 \rightarrow 60% en 2012 \approx économie de 4 millions de tonnes d'enrobés neufs
 \approx Production annuelle de 10 carrières
 \approx d'1 raffinerie

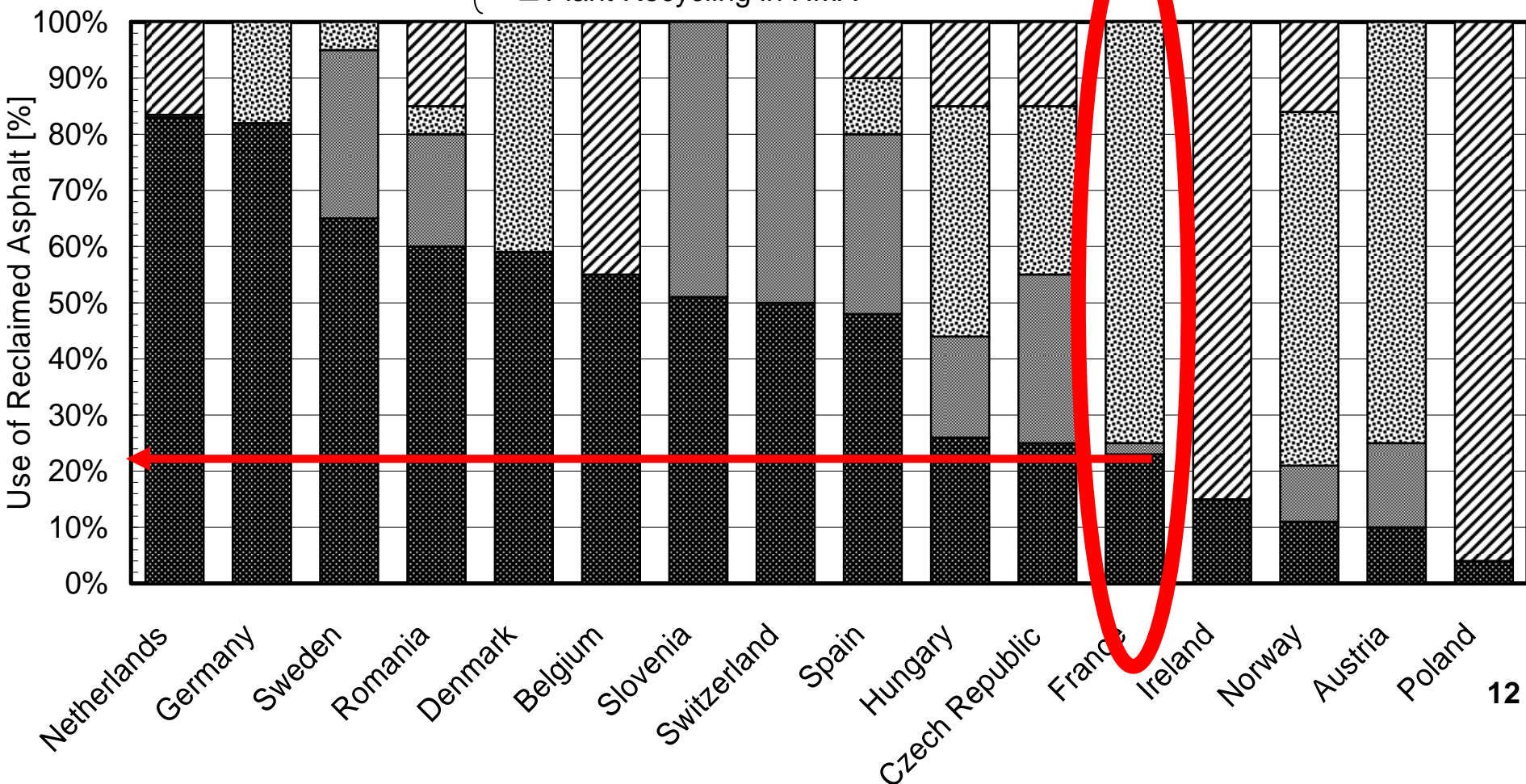
Objectif européen: >70% d'ici 2020

Use of reclaimed asphalt material in road

Percentage of different end-of-life strategies for reclaimed asphalt

- ▨ Other
- ▤ Recycling in unbound layers
- ▣ In Situ / Plant Recycling (half warm & cold)
- Plant Recycling in HMA

Source: EAPA 2008



Promotion of old asphalt

- Availability of resources : maintenances operations, treatment (crushing, sieve, storage,...)
- Multi-recycling
- Limits of technique:
 - Existing of pollutant:
 - Tar
 - Asbestos fibers
 - Technical constraints :
 - Quality of reclaimed asphalt : bitumen not too hard, heterogeneity, variability,...
 - Mix design : pertinence, representativeness with %RAP
 - Plant equipment : capacity to recycle

Perfect command of recycling



General recyclability of reclaimed road materials in new hot mix asphalt

	Recycled unbound material	Recycled hydraulically bound material	Reclaimed Asphalt
Belgium			o
Denmark	x		o
France			o
Germany	x	x	o
Hungary			o
Ireland			o
Poland	x	x	o
Portugal			o
Serbia	-	-	-
Slovenia	x	x	o
Spain			o
Sweden			o
-: not allowed in any HMA type x: as aggregate in some types of HMA - same requirements as on virgin aggregates (further environmental specification needed) o: Special specifications			

Limits of the RAP content due to mixing plant

	Continuous drum mixing plant		Batch plant			
Country	a1	a2	b1	b2	b3	b4
Belgium	-	-	10 %		-	50 %
Denmark	Not specified					
France	25 %	60 %	20 %			75 %
Germany	40 %	-	30 %		40 %	100 %
Hungary	Not specified					
Ireland	Not specified					
Poland	> 30 %					
Portugal	Not specified					
Serbia	Not specified					
Slovenia	-	-	30 %		40 %	80 %
Spain	25 %	50 %	10 %	10 %	25 %	50 %
Sweden	Not specified					

-: plant type not available

Continuous drum mixing plants (a)

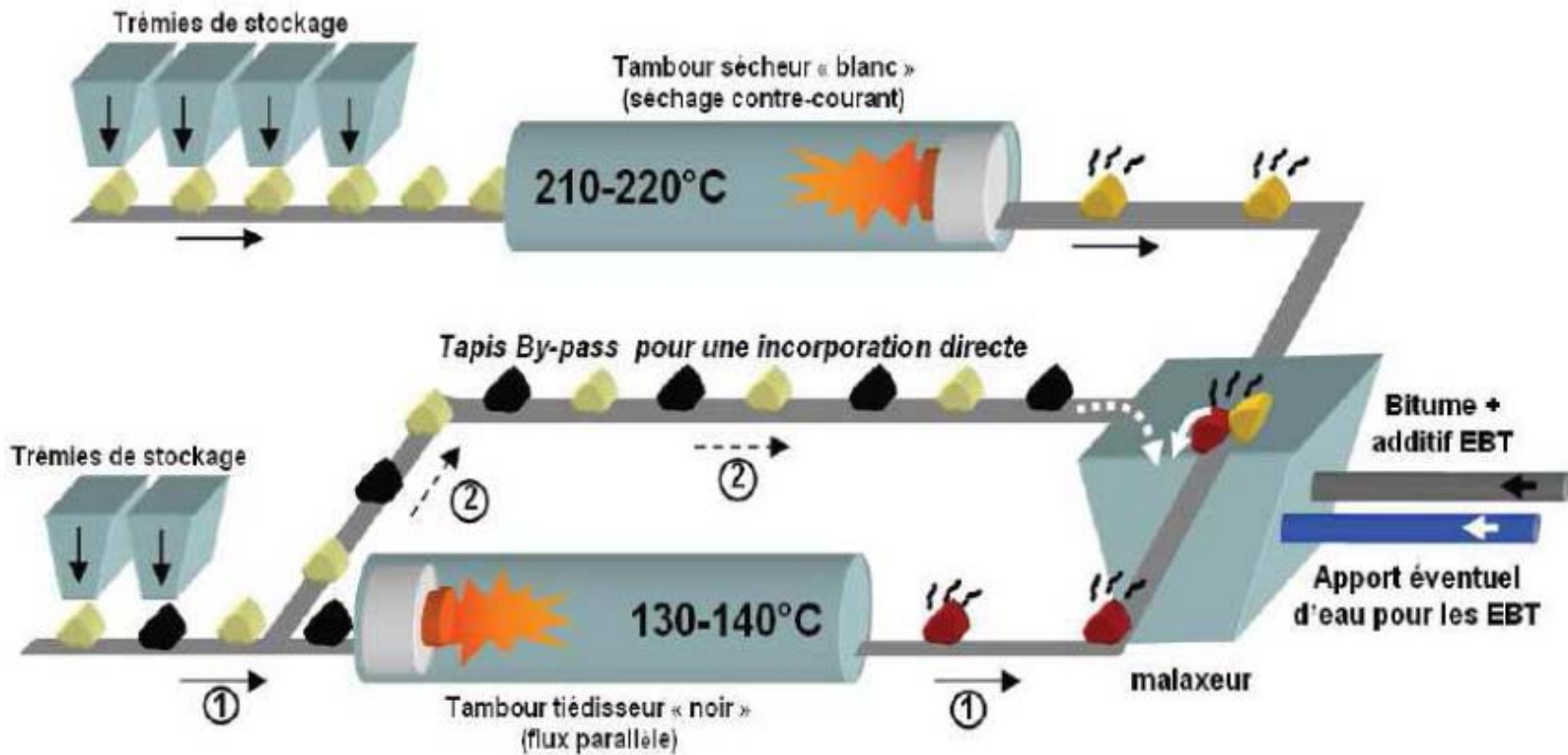
a1) Heating reclaimed asphalt together with hot mix of stone fractions (a1)

Continuous mixing plant with double drums



Photographie d'une centrale HPR (Haut Pouvoir de Recyclage)

Continuous mixing plant with double drums



Scheme for high rate recycling in warm conditions

Example 1

- Recycling of old thick AC (BBSG pure bitumen) of wearing course, on heavy lane in motorway (milling) in new high modulus (EME or HMA) mix in base course, on another motorway, cross section.
- Rate : 50 to 65% RA
- Tonnage : 10 000 tonnes
- Year : 2008

Motorway job site (north of France) Continuous mixing plant

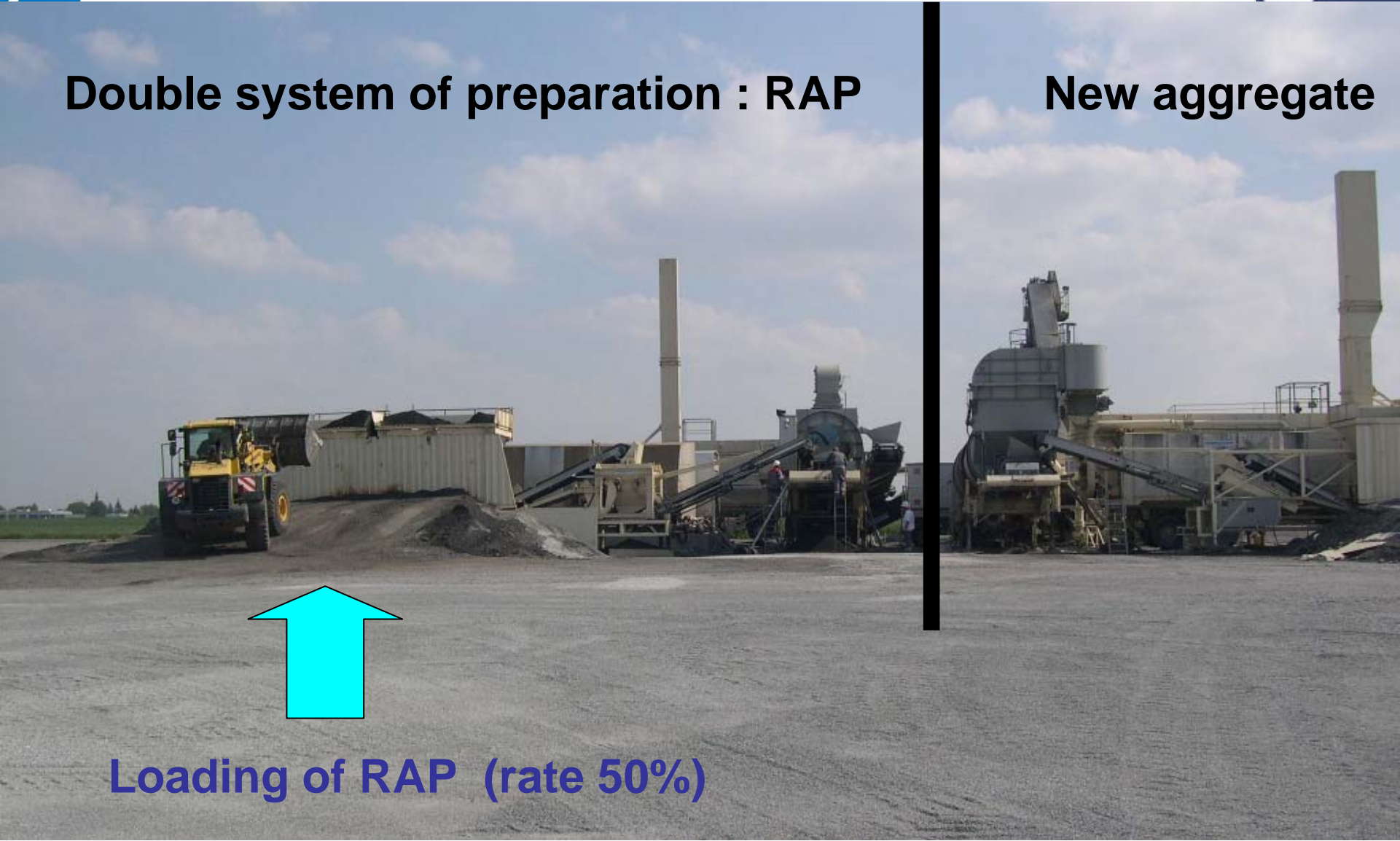


**High rate of recycling in HMA
50 and 65 % of old surface asphalt mixes
21 may 2008**



Double system of preparation : RAP

New aggregate



Loading of RAP (rate 50%)

Example of HMA recycling at 50 and 65%

Formulation

New limestone aggregates :

- 0/4	7%	0 %
- 6/10	12 %	6 %
- 10/20	28,4 %	27,3 %

RAP (old BBSG 0/10 *) :

50 % **65 %**

Binder added (grade 15/25) :

2,6 % **1,7 %**

Total bitumen content :

5,35 %

Theoretical grading :

0,063	2	6	10	14	20 mm
7,5	30	50	70	85	98 %

* *TL theoretical value = 5,5%*

Fabrication Temperature : 170 and 180°C

Example of results on HMA with 50% RAP



Tests		Results
GSC	120 girations	3,8 %
Duriez r / R		0,87%
Rut after 30 000 cycles	5,2% void content	3.8 %
Modulus at 15°C – 10 Hz	2,8 % void content	14 100 MPa

Example 2

- Reconstruction of heavy lane on motorway,
by re-use, in binder course in thick asphalt (6 cm), a high
modulus asphalt mix for surface layer (BBME)
- Rate : 50 % reclaimed asphalt
- Tonnage : 16 000 tones
- Year : 2007

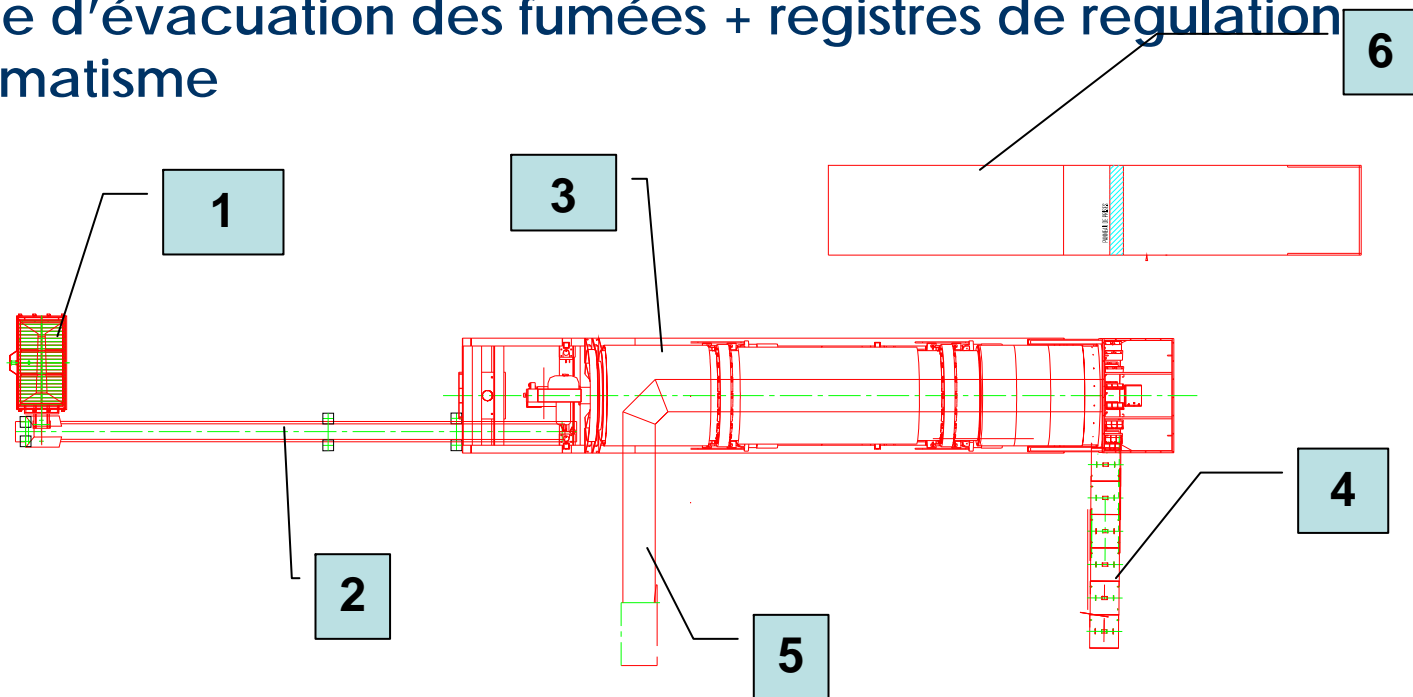
Continuous mixing plant RMS 300 Recyclé



KIT of recycling

COMPOSITION of recycling KIT

1. Doseur à agrégats
2. Transporteur
3. Tambour TSR 25
4. Convoyeur à raclettes de transfert vers le malaxeur
5. Gaine d'évacuation des fumées + registres de regulation
6. Automatisme



COMPOSITION of RECYCLING KIT

Doseur à
agrégats
d'enrobés



COMPOSITION DU KIT RECYCLAGE



Tambour TSR 25

COMPOSITION DU KIT RECYCLAGE

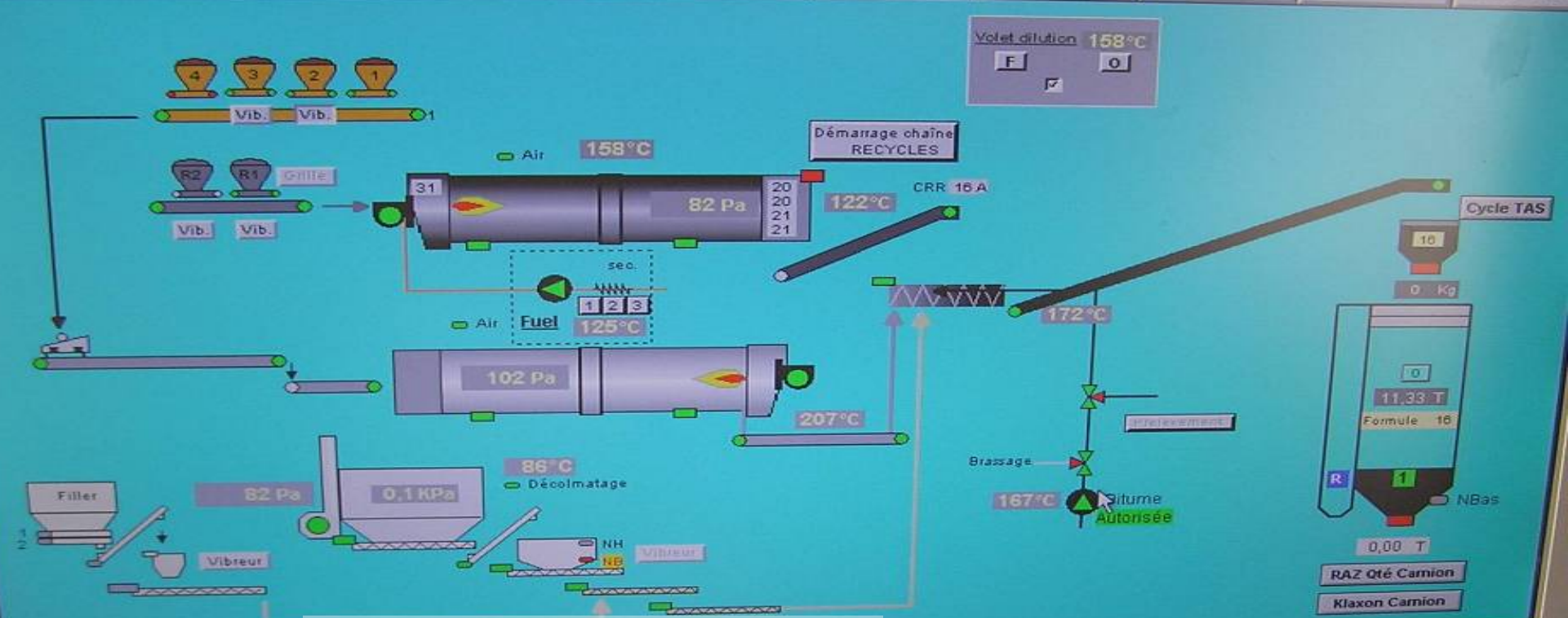


Convoyeur à raclettes de transfert vers le malaxeur

COMPOSITION DU KIT RECYCLAGE



PORTIE BRULEUR REGUL. CONFIG. DIAGNOS. DEFAUTS OUTILS VERSION



Automatisme

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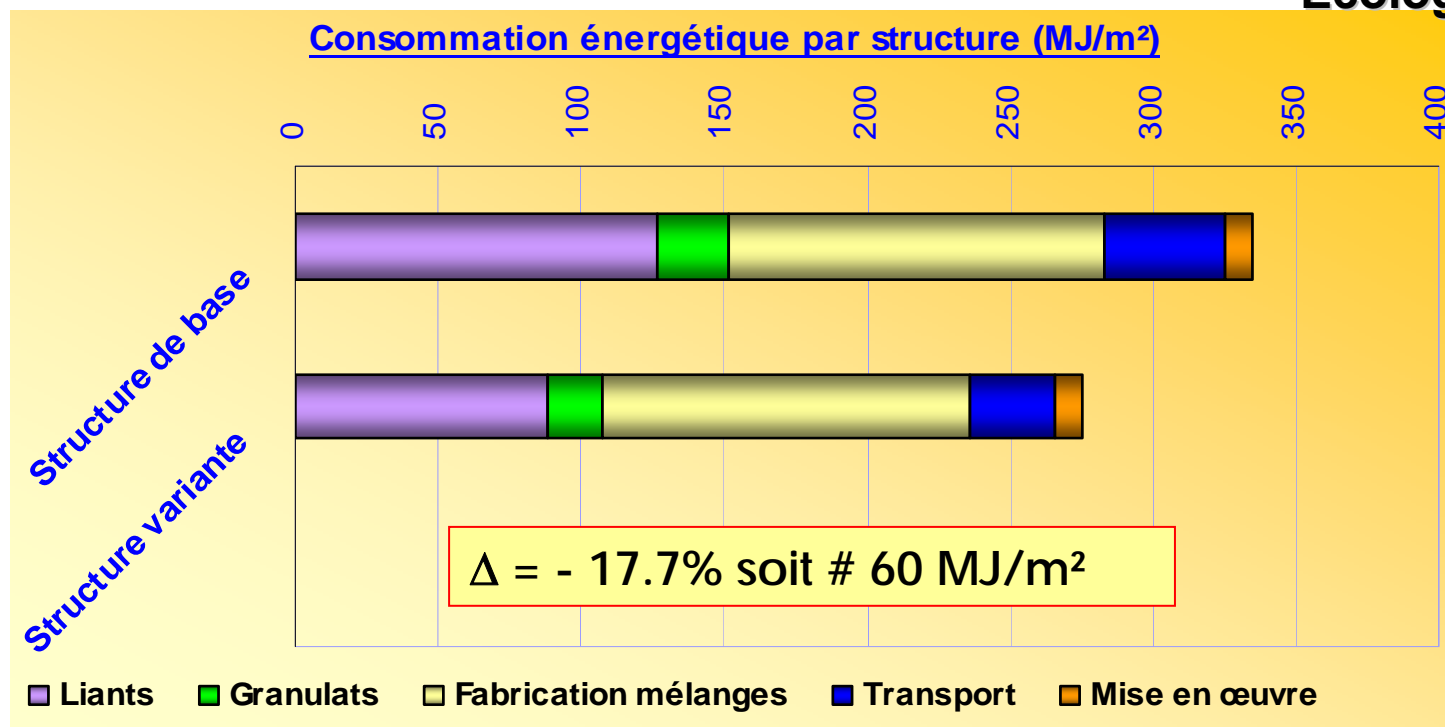
<p>COMPRESSEUR TSA</p> <p>COMPRESSEUR TSR</p> <p>VENT D.H.</p> <p>OUV. T.A.S.</p>	<p>TSA</p> <p>Brûleur Autorisé</p> <p>M.A. BRULEUR</p> <p>Réarmement</p>	<p>TSR</p> <p>Brûleur Autorisé</p> <p>M.A. BRULEUR</p> <p>Réarmement</p>	<p>BRULEUR TSR</p> <p>158°C</p> <p>REGULATION 39%</p> <p>Consigne: 100°C</p>	<p>BRULEUR TSA</p> <p>207°C</p> <p>REGULATION 43%</p> <p>Consigne: 168°C</p>	<p>82 Pa REGISTRE TSR</p> <p>REGULATION 57%</p> <p>Consigne: 25Pa</p>	<p>102 Pa REGISTRE TSA</p> <p>REGULATION 55%</p> <p>Consigne: 90Pa</p>	<p>82 Pa REGISTRE FILTRE</p> <p>REGULATION 66%</p> <p>Consigne: 65Pa</p>	<p>Acquitter</p> <p>48 V Cab</p> <p>48 V Arm</p> <p>Attente</p> <p>Autorisé</p>
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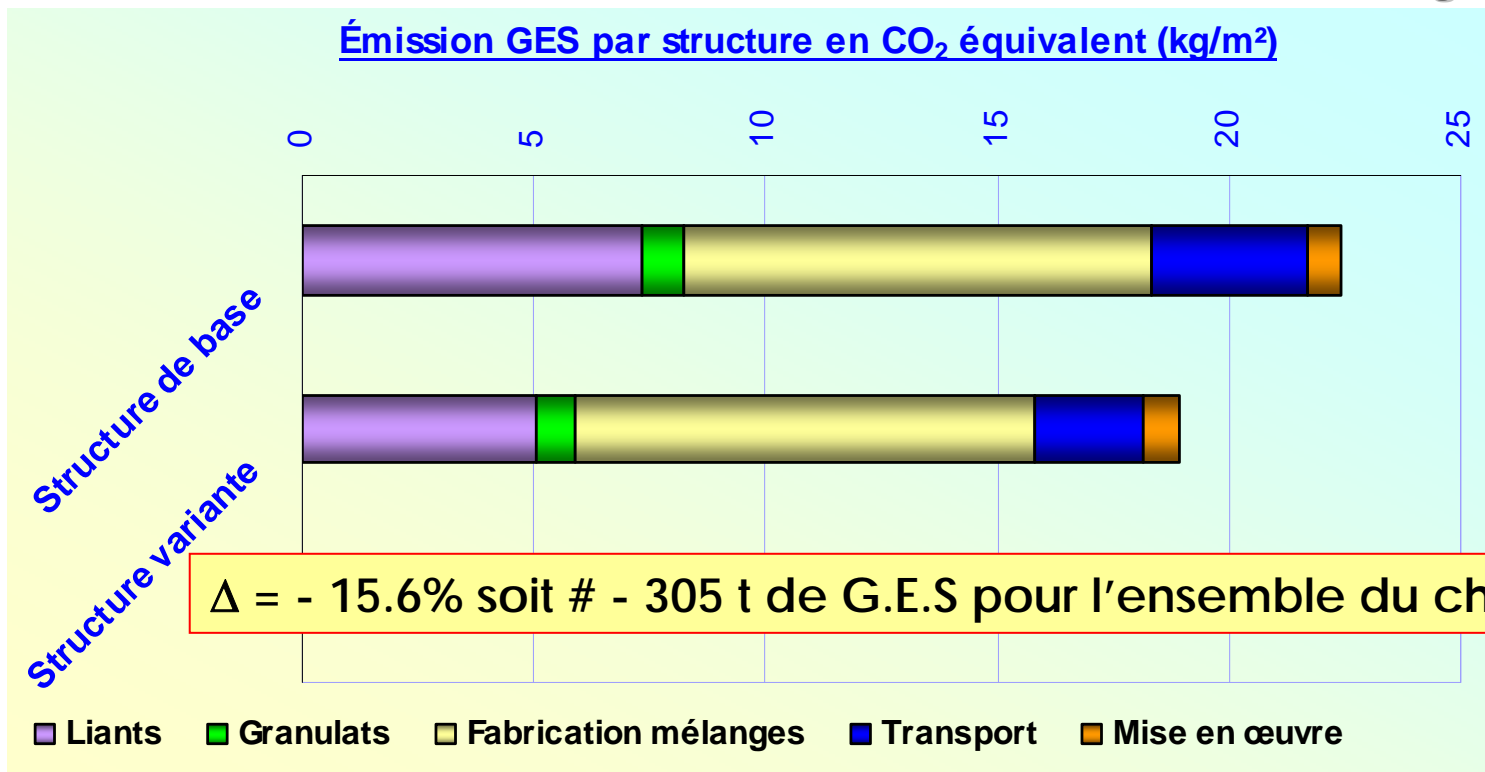
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Energy assessment of recycling

Ecologiciel®



Structure	Liants	Granulats	Fabrication mélanges	Transport	Mise en œuvre	Total
Structure de base	126,3	25,6	130,8	42,1	10,0	334,8
Structure variante	87,8	19,2	129,1	29,3	10,0	275,4



Structure	Liants	Granulats	Fabrication mélanges	Transport	Mise en œuvre	Total
Structure de base	7,32	0,93	10,06	3,37	0,75	22,43
Structure variante	5,05	0,83	9,93	2,35	0,75	18,92

Preliminary study in lab is essential



- Assess the sources : homogeneity RA
- Identification of components (on different sections and layers): binder content and residual properties, granularity of milling
- Formula of new mix with RA (rate of recycling, nature of bitumen or rejuvenator added, and aggregates)
- Performances must equal to those of new AC
- No new study if the rate of recycling is less than:
 - < 10% in wearing course
 - < 15 % in binder, base, sub base courses (researches, publications LCPC/USIRF)
- Traditional pavement design study

Maximum allowed percentage of RAP in HMA mix design requirements specific to mixtures containing RAP

Country	Maximum allowed percentage of RA in HMA for			Use of equation 1 and/or 2	$D_{RA} \leq D$	Other mix design requirement
	Surface course	Binder course	Base course			
Belgium	25 %		50 %	x	x	x ¹⁾
Denmark	30 %	30 %	100 %			
France	40 %			x		
Germany	50 %		100 %	x	x	x ^{2),3)}
Hungary	10 %	20 %		x	x	
Ireland	10 %	50 %	50 %			
Poland	20 %	30 %		x	x	x ^{2),3)}
Portugal	10 %	50 %		x	x	
Serbia	Not specified					
Slovenia	not defined			-	x	x ³⁾
Spain	-	10 % – 50 %				x ¹⁾
Sweden	20 %	30 %		Performance specifications		

¹⁾ in Flanders, the proportion of bitumen originating from RA in the binder of RHM for base courses of roads is limited

²⁾ The virgin binder used in asphalt mixes with RA may be one grade to the lower viscosity than the usual suitable binder

³⁾ virgin binder should not be softer than 70/100

Processes of recycling

- In practice:
 - What limits? What rate of recycling?
 - Binder : Penetrabilities, RBT, % asphaltènes?
 - Technology and environmental limits :
 - No sufficient homogeneity of mix,
 - Consumption energy
 - Fumes and streams emitted (toxicity)
 - Equipments of mixing plant
 - ...
- Rejuvenator binder:
 - large scale available, but low market and low development today, in the future?

Tendencias et evolutions

- “Recycling easy” with the use of WAM technique (already observe in the past, high workability due to residual water bring by RA)
- Recycling essential to respect the topics of sustainable development
- Steps today:
 - Harmonization of practices in Europe (Direct Mat project)
 - Writing a guide to recommend this technique by road administrators : state of the art, practical advises, specifications, prescriptions,..
- Researches:
 - Ageing accelerated, to predict and et anticipate the behaviors on field
 - Recycling with high rate, reach near 100%
 - Performances of binder after recycling : compatibility, homogeneity of mix (old and new binder), characterization,...
 - Definition of de damage criteria on old AC, to fix the “level of recyclable”

Conclusion

- The recycling in plant of hot AC is a competitive solution in term of :
 - Environment
 - Technique
 - Economy
 - Energy
 - Sustainable development
- But researches stay necessary to improve the whole performances of material, essentially on the prediction of ageing and performances, in medium and long time.

Don't throw away four old roads Reuse and recycle them !

merci de votre attention

