

ASFALJNI KOLNICE 2018
ASPHALT PAVEMENTS 2018



Hot recycling: state of the art and new challenges

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STATE OF THE ART

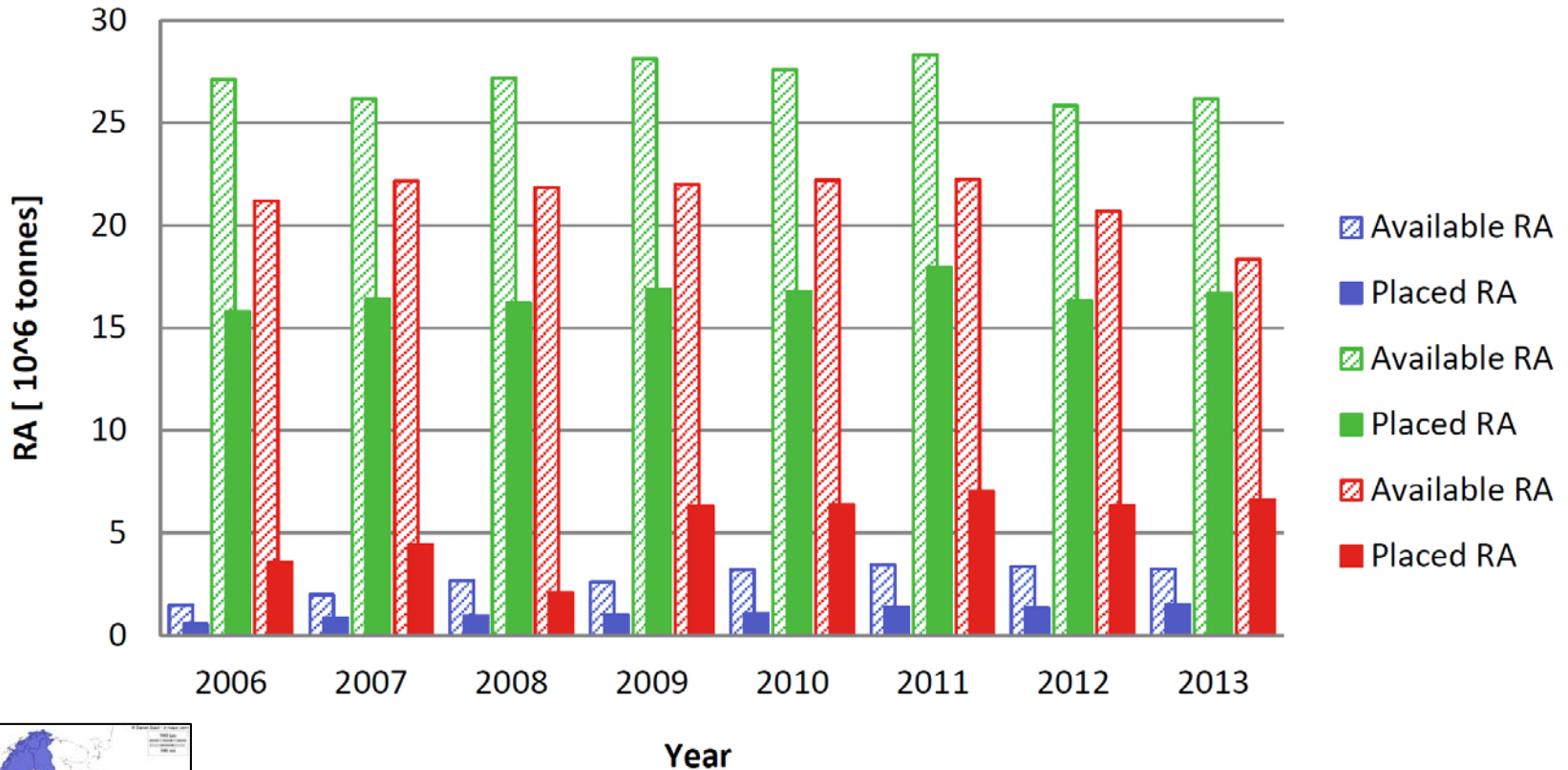


University of Parma

2014	Production of HMA [x10⁶ ton]	Amount of RAP [x10⁶ ton]	Amount of RAP recycled in HMA [%]
France	38,8	7,0	40
Germany	45,0	14,0	82
Spain	34,4	1,6	56
Netherlands	9,5	4,0	80
UK	21,5	4,0	80
USA	327,0	66,6	84
Italy	23,0	10,0	20
Turkey	46,2	1,2	3

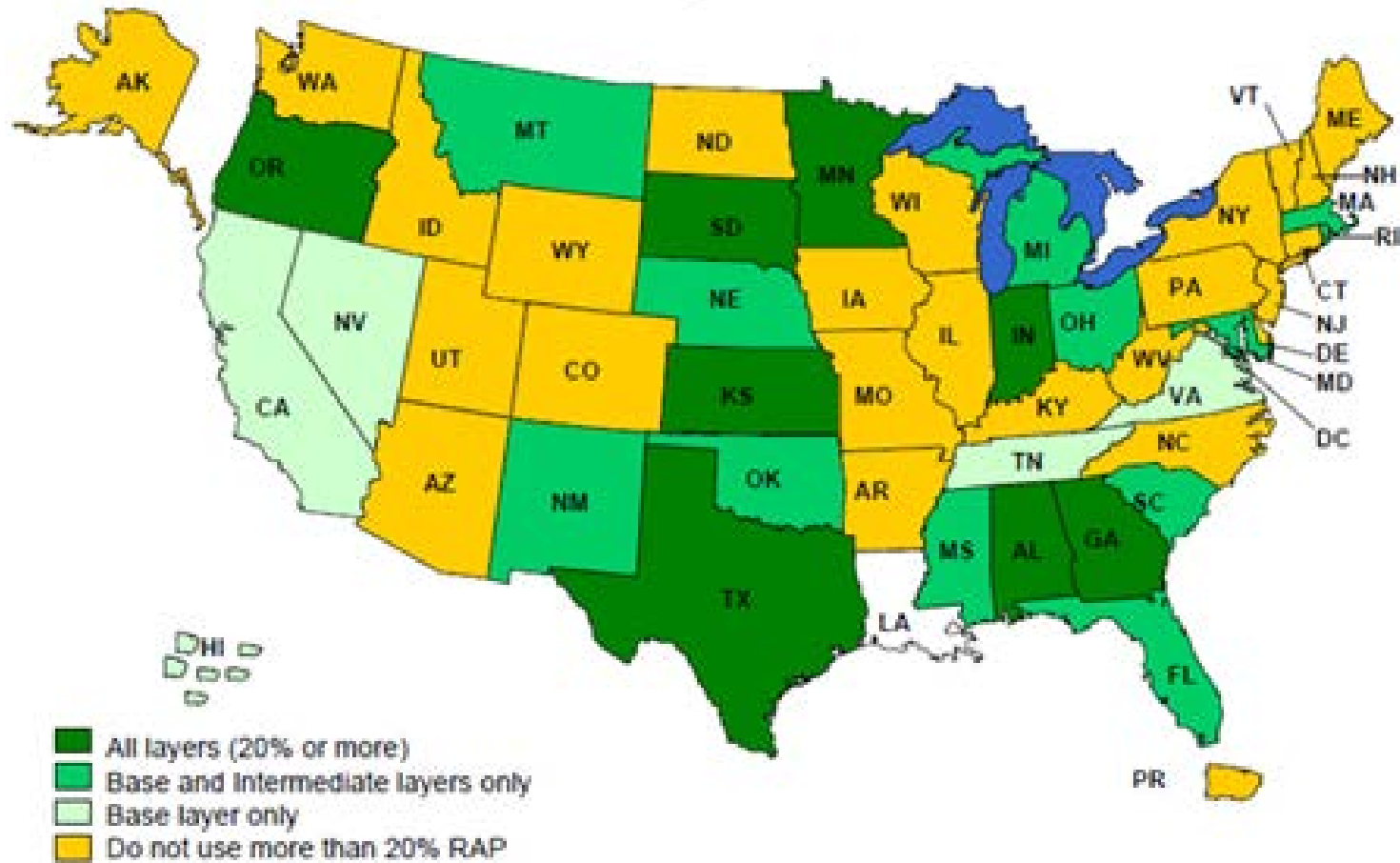
Data source: OCSE, EAPA, SITEB

STATE OF THE ART



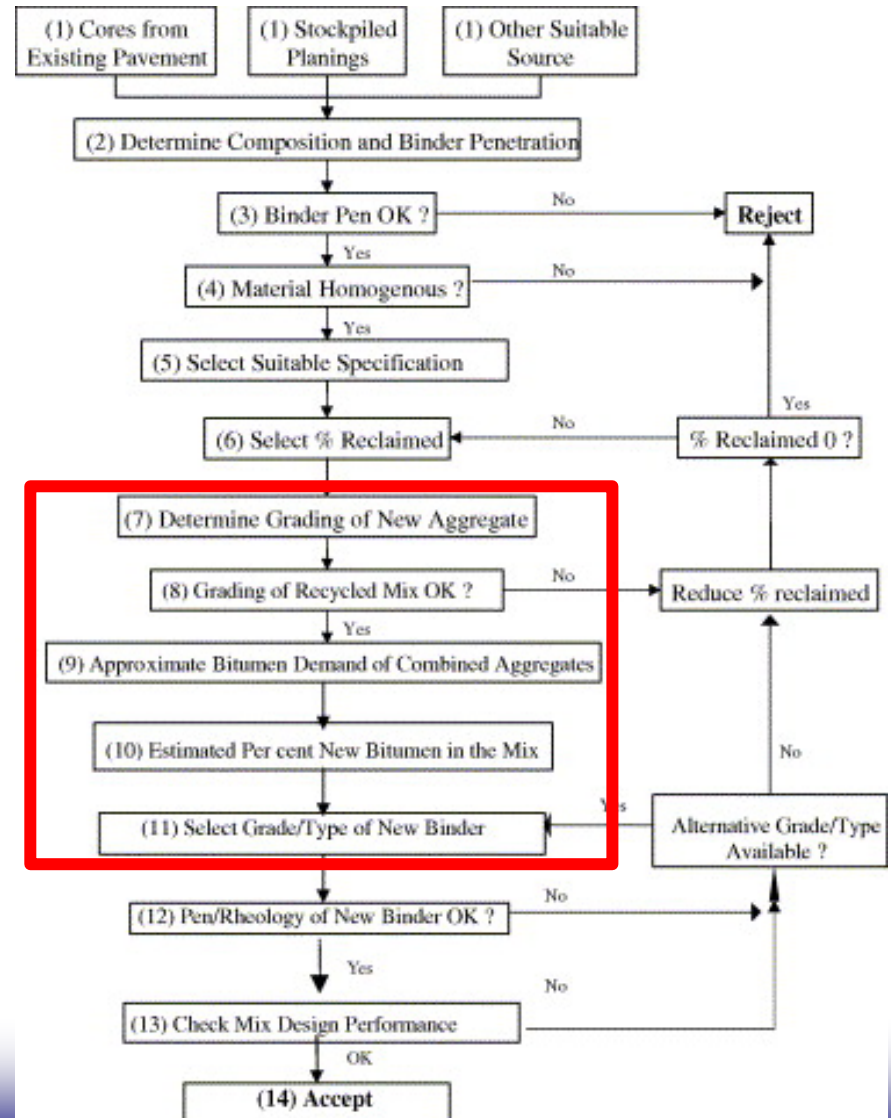
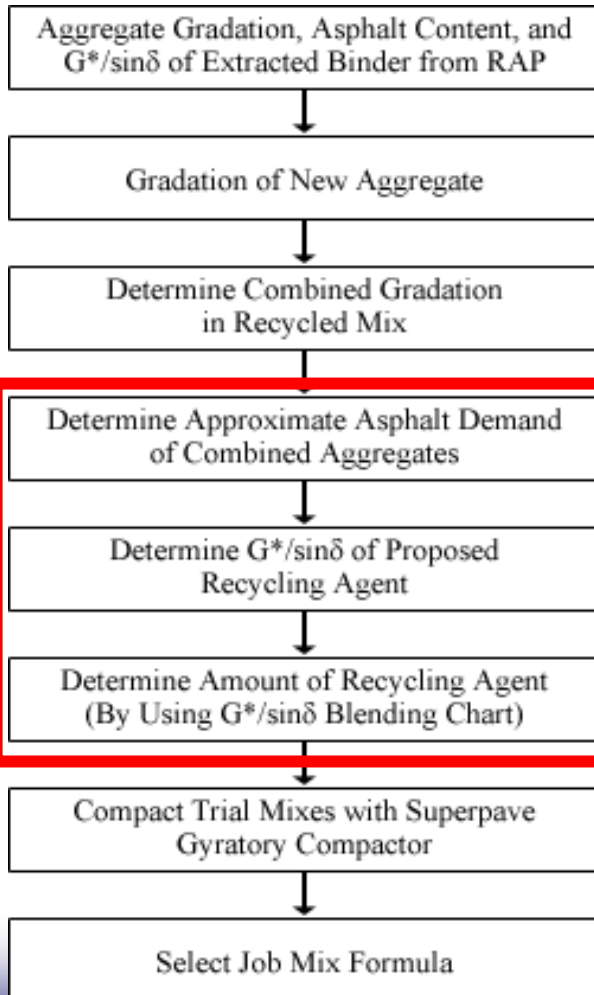
Available and Placed RA for: south Europe (red country); middle Europe (green country); north Europe (blue country)

STATE OF THE ART



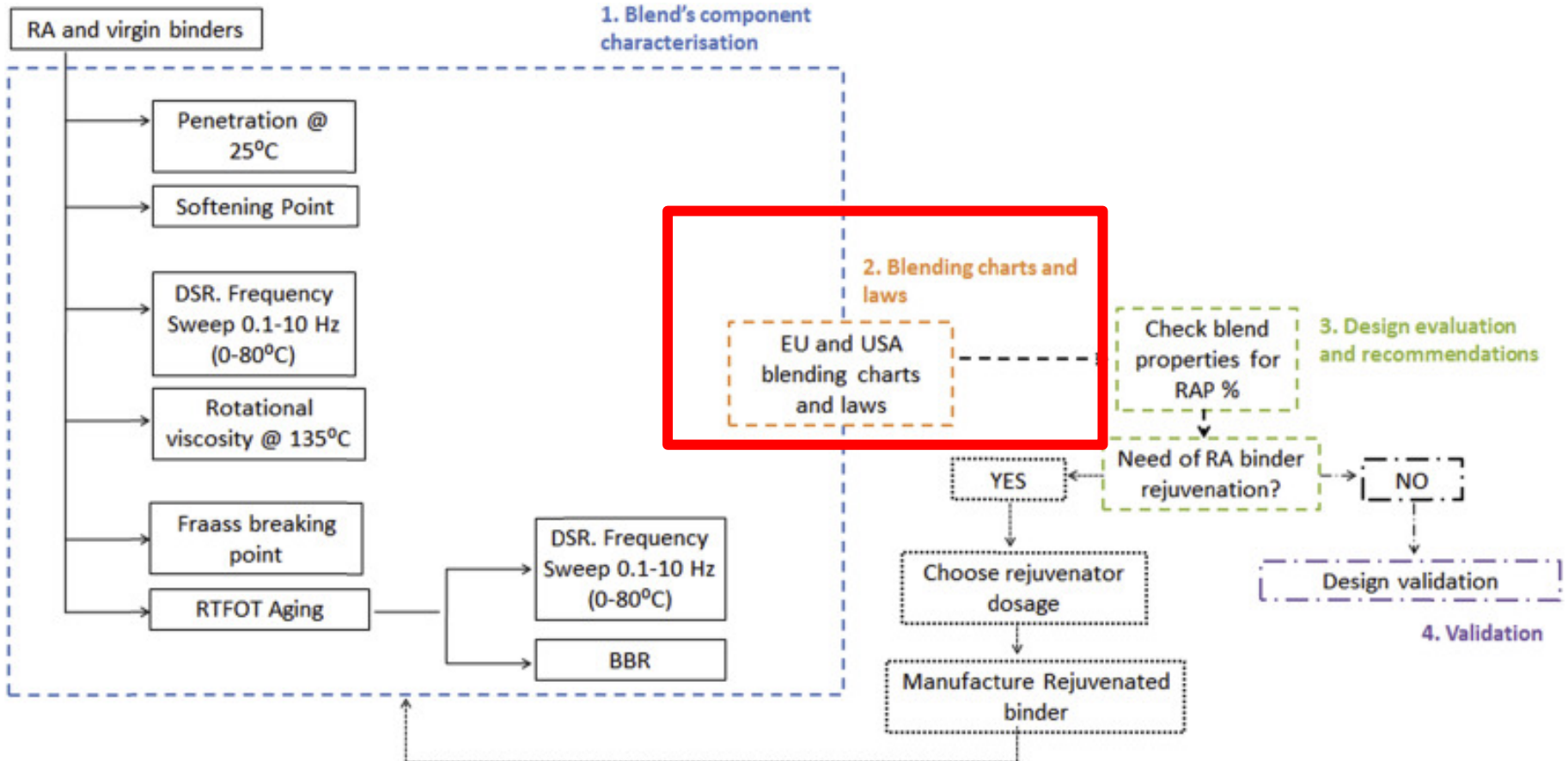
STATE OF THE ART

Mix Design process



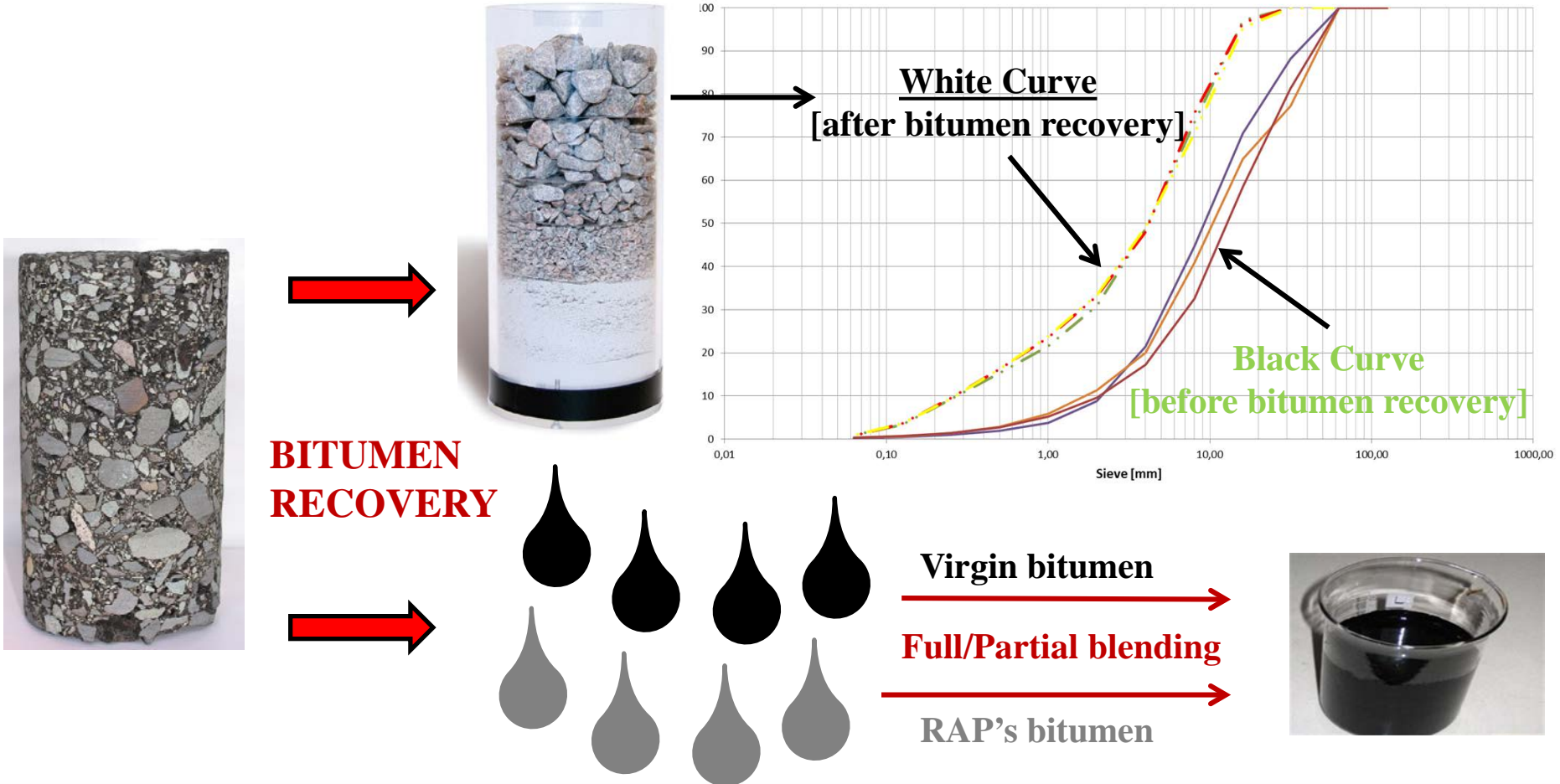
STATE OF THE ART

Mix Design process



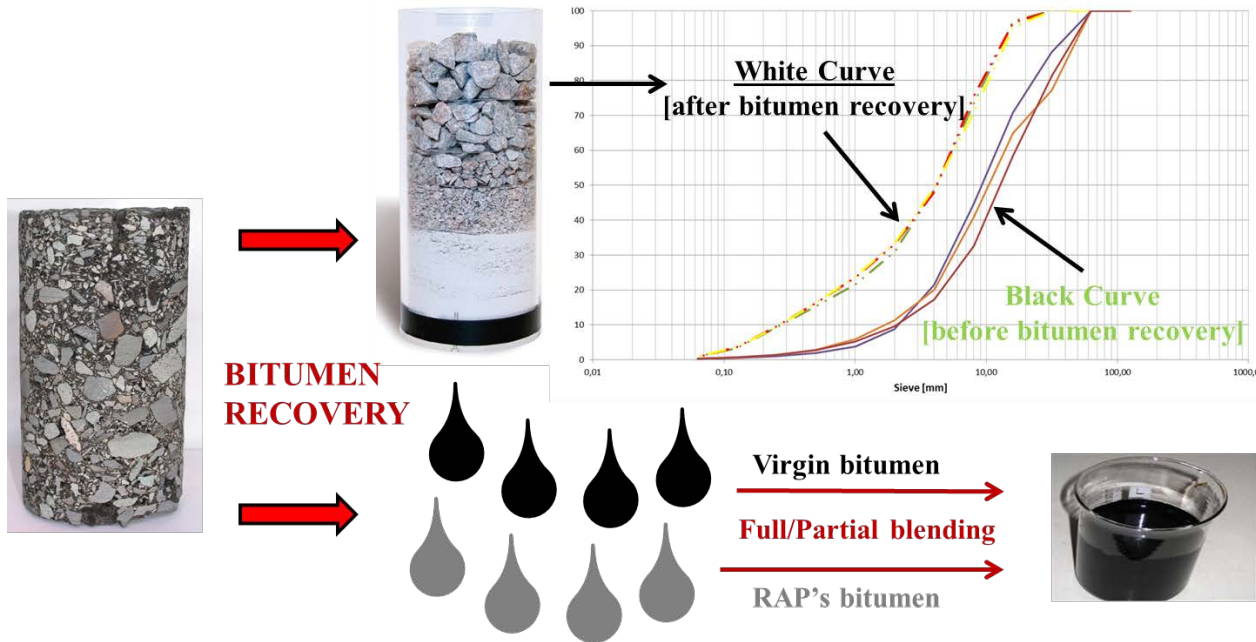
STATE OF THE ART

Base of Mix Design



STATE OF THE ART

Base of Mix Design



Size distribution after bitumen recovery



Total amount of bitumen after recovering



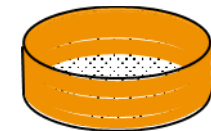
The basic concept is to satisfy the requirements of quality control

BLENDING AND COATING A SIMPLE TEST

Size classes	8/11	2/4
100% passing	11 mm	4 mm
100% retained	8 mm	2 mm



Mixing $T = 150^{\circ}\text{C}$



*2,5 kg aggregates
8/11*

*2,5 kg RAP
2/4*

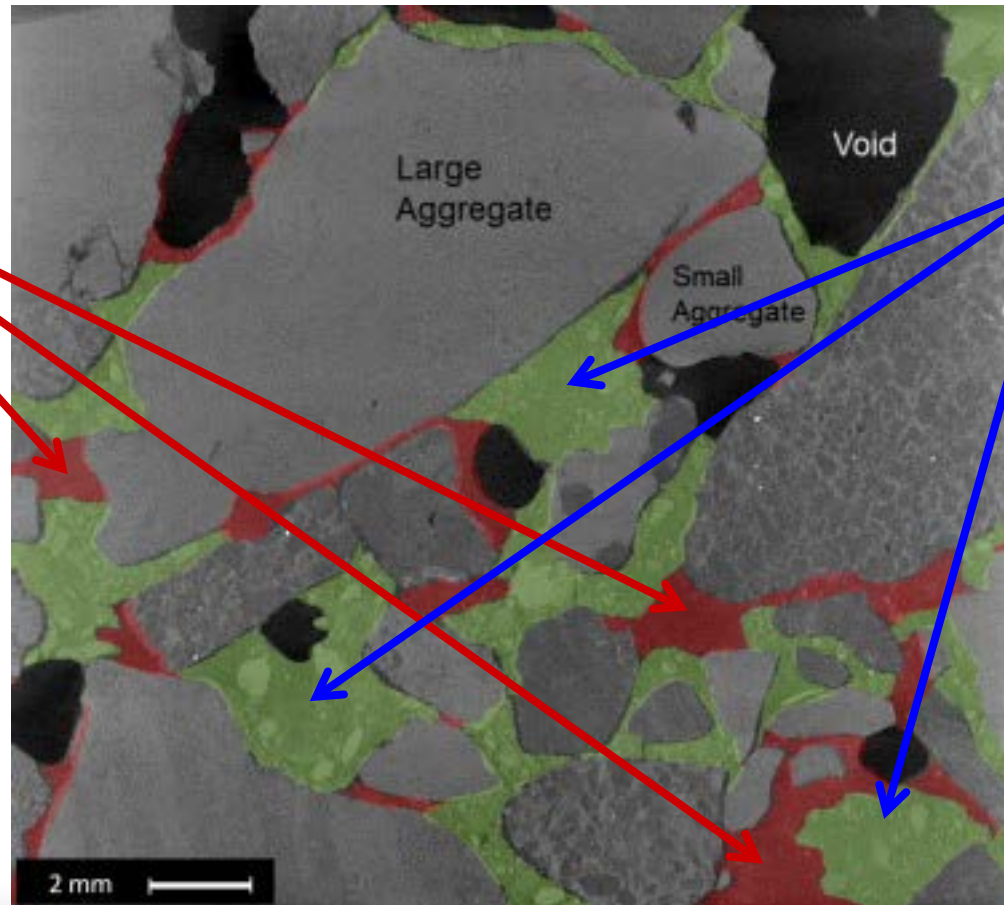
After mixing

bitumen recovered from aggregates: 0,4% on weight of aggregates

bitumen recovered from RAP: 8% on weight of RAP

BLENDING & DIFFUSION

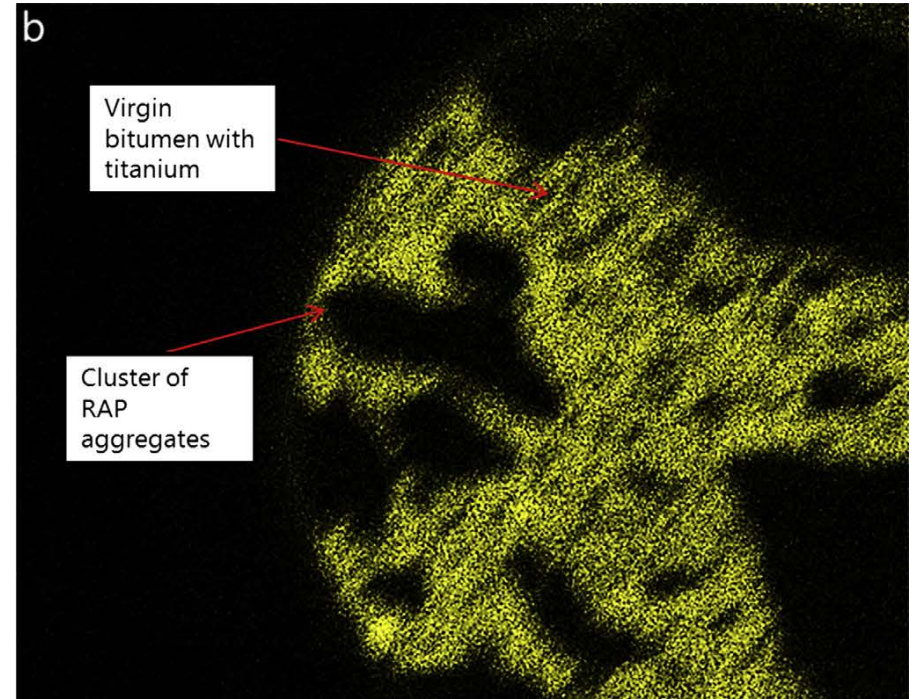
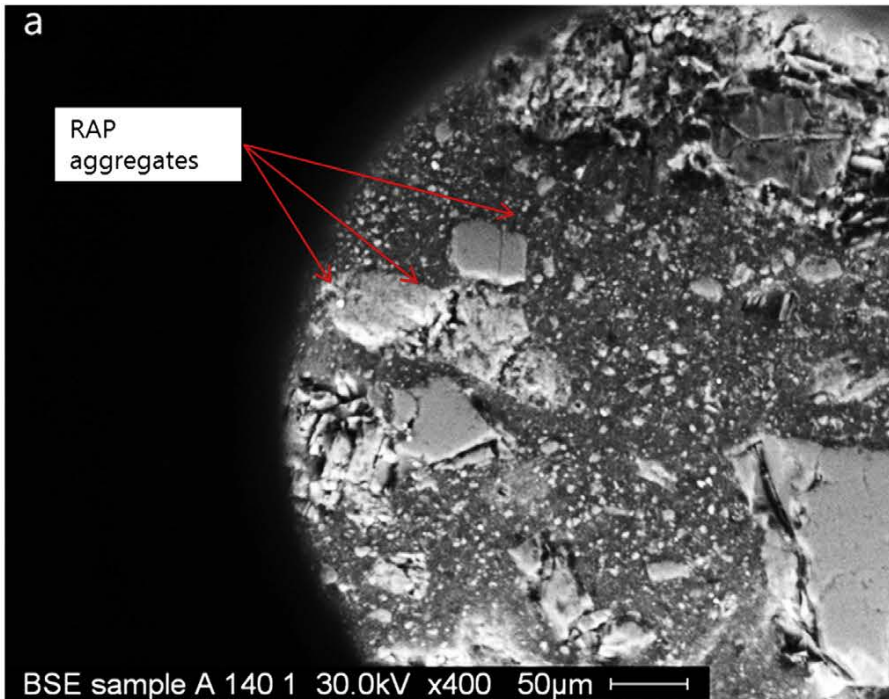
Two different chemical additives: one in RAP's bitumen and one in new binder



virgin binder

RAP's binder

CLUSTERING



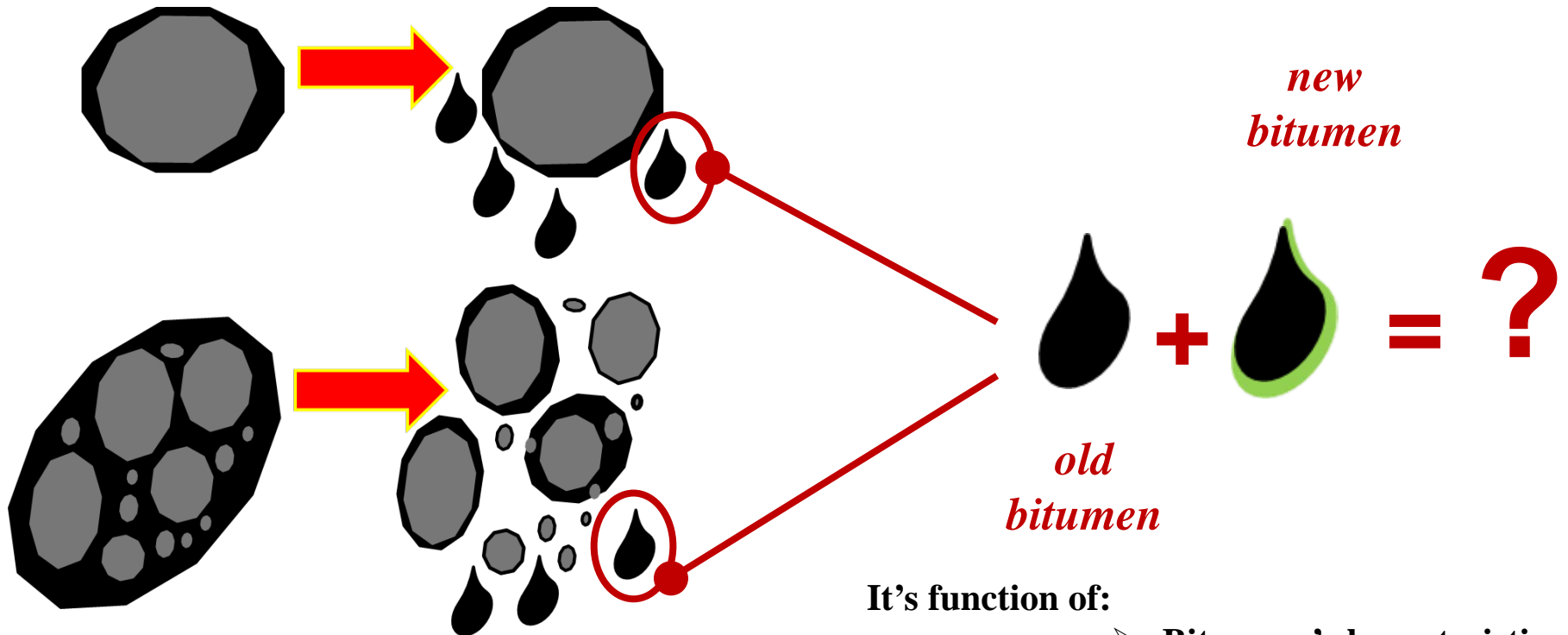
OPEN PROBLEMS

Mechanical effects related with mixing and heating induce an evolution of RAP



OPEN PROBLEMS

There is not always full blending between RAP's bitumen and new bitumen

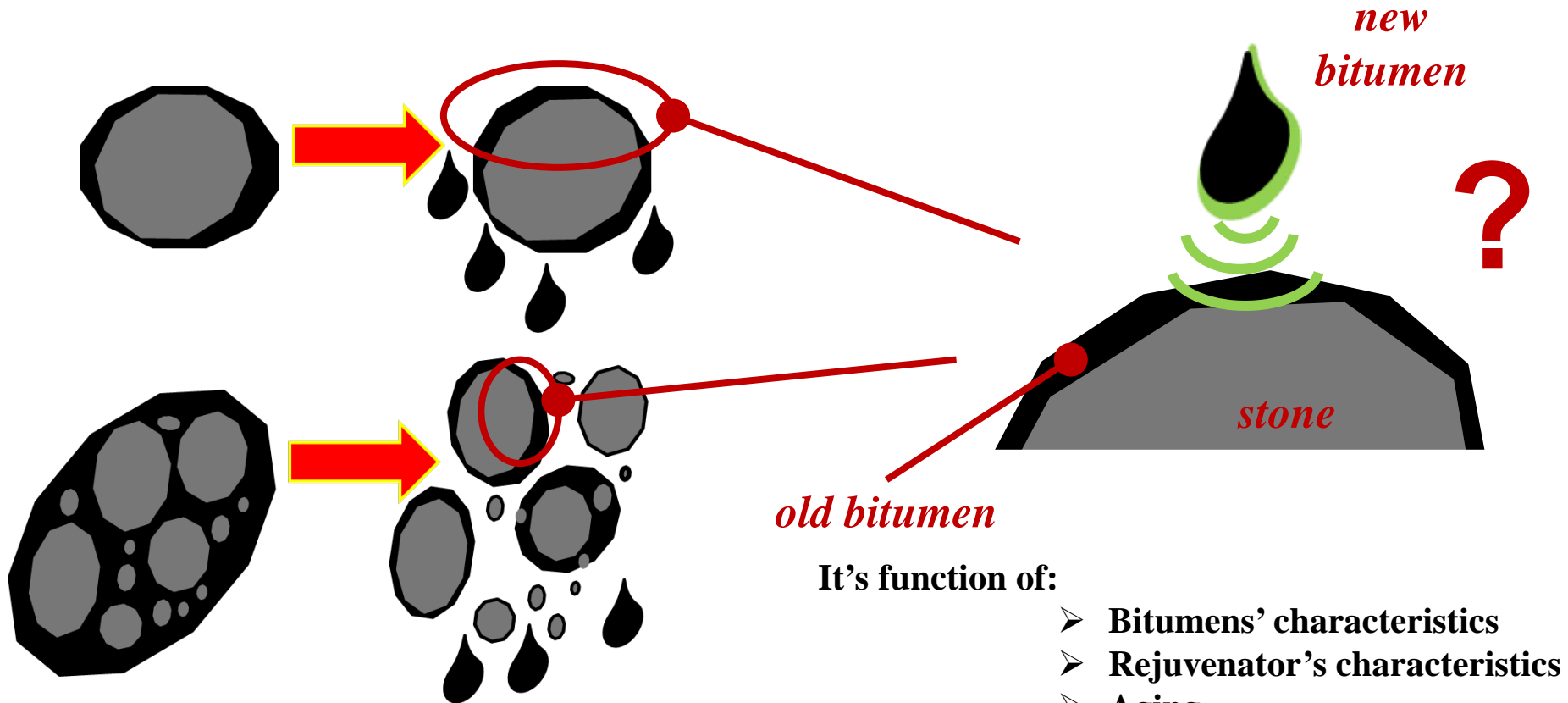


It's function of:

- Bitumens' characteristics
- Aging
- Mixing temperature
-

OPEN PROBLEMS

**Not all the old bitumen leaves RAP:
there is diffusion of new bitumen in old bitumen**



It's function of:

- Bitumens' characteristics
- Rejuvenator's characteristics
- Aging
- Mixing temperature
-

UNCORRECT DOSAGE OF BITUMEN

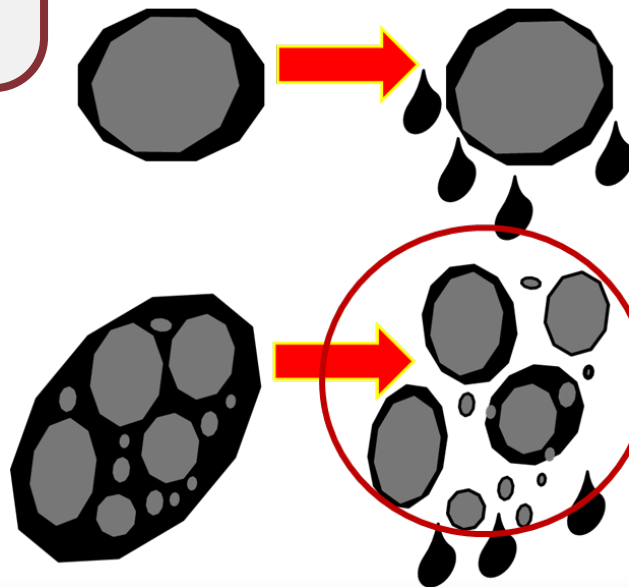
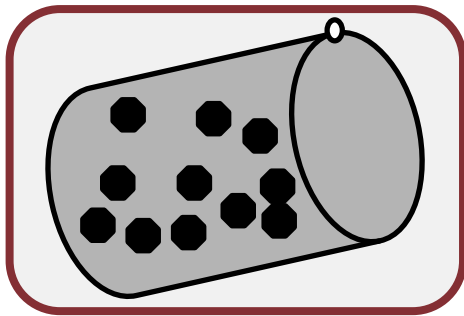


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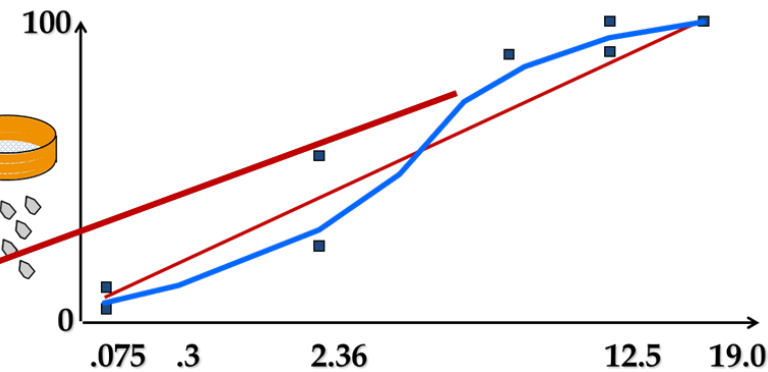


OPEN PROBLEMS

Combined effect of temperature, impact and abrasion change the size of the RAP's particles during mixing....

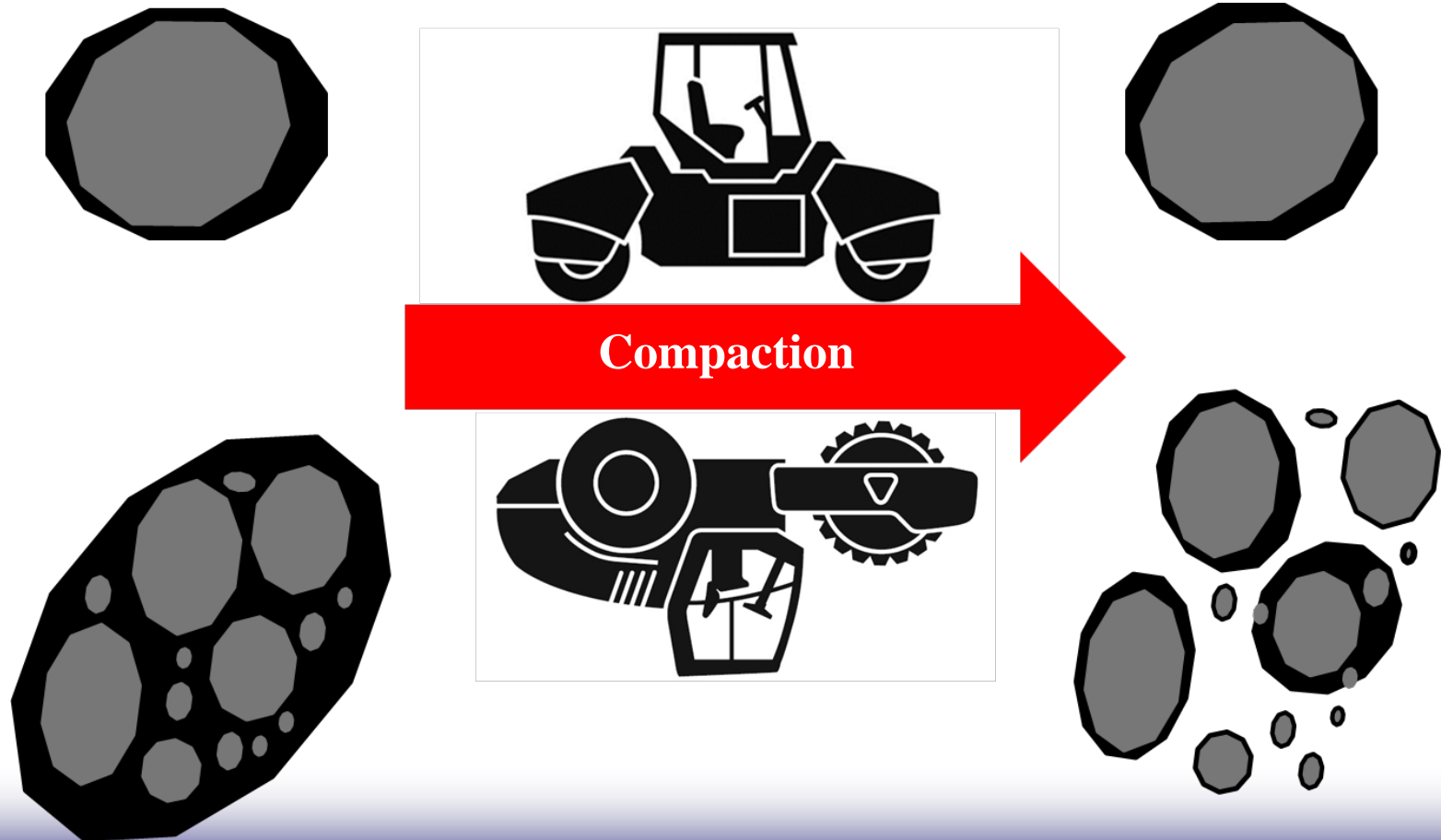


final grading curve?



OPEN PROBLEMS

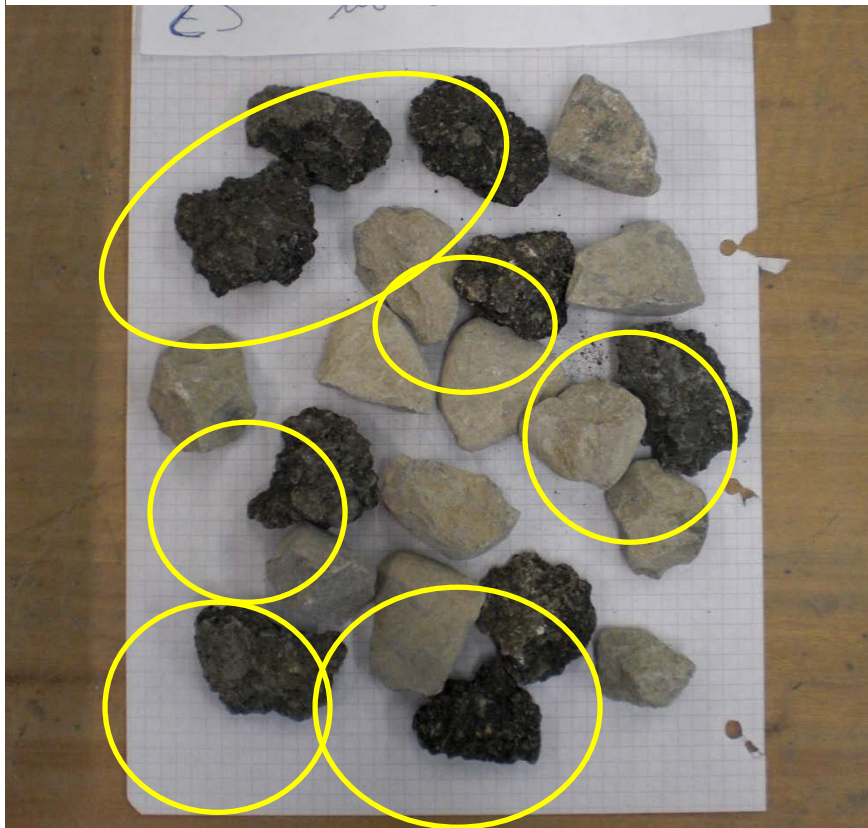
.... and compaction effect also



OPEN PROBLEMS

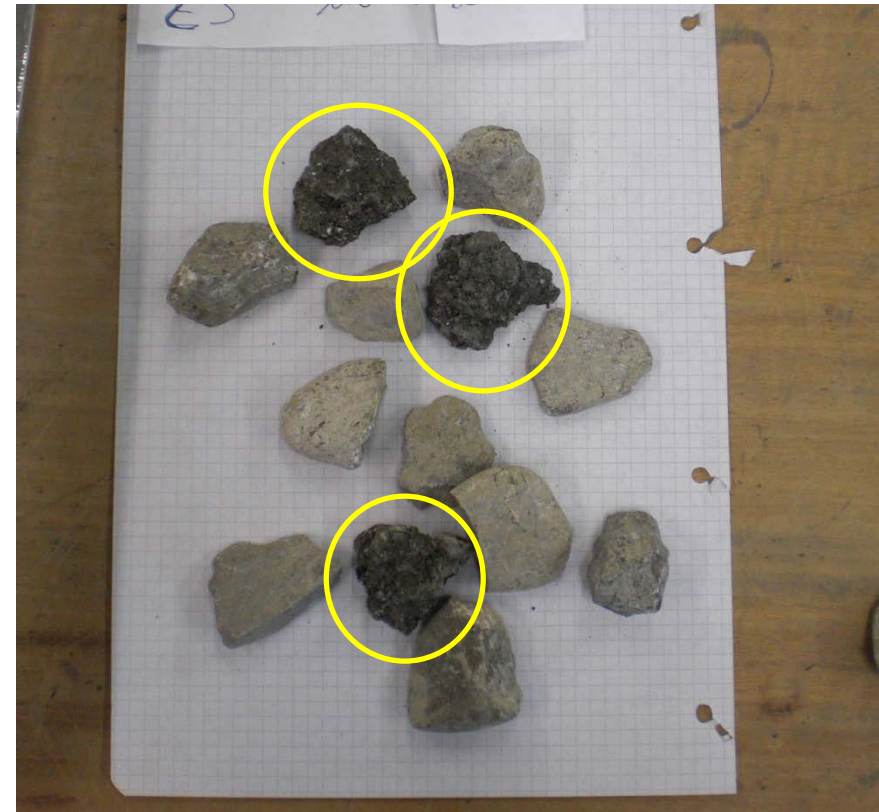
Before compaction

Retained at sieve 25mm



After compaction

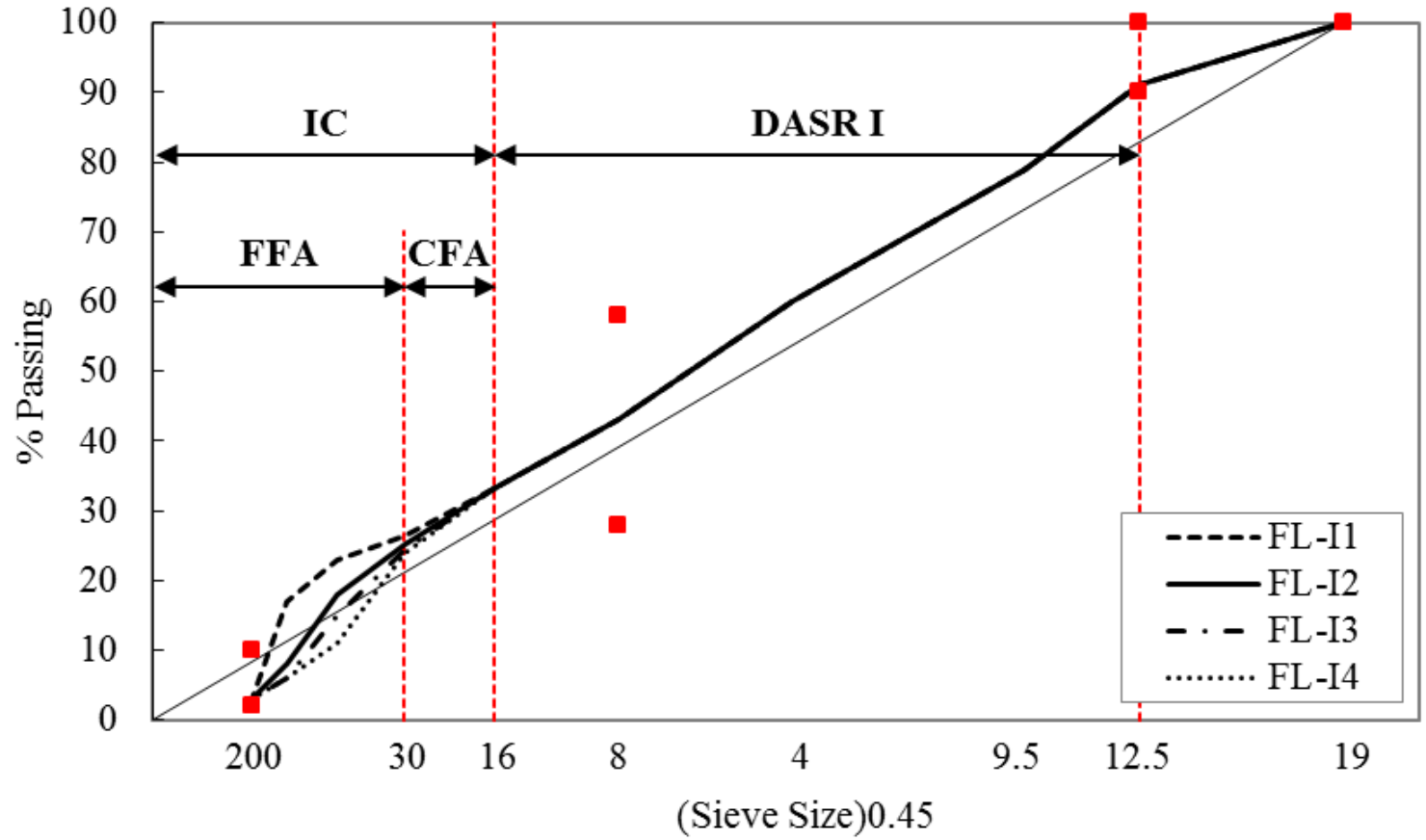
Retained at sieve 25mm



EFFECT OF AGGREGATES SIZES DISTRIBUTION ON MIX PERFORMANCE

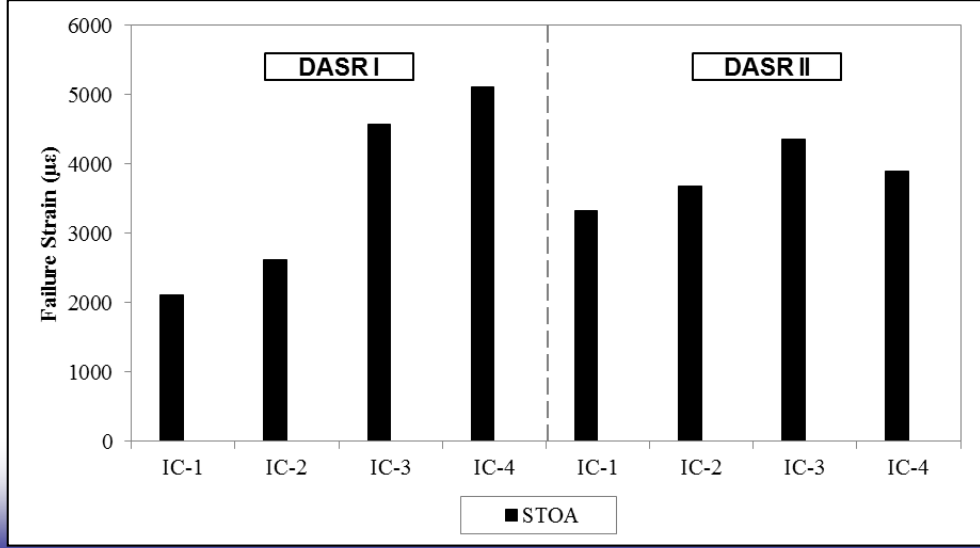
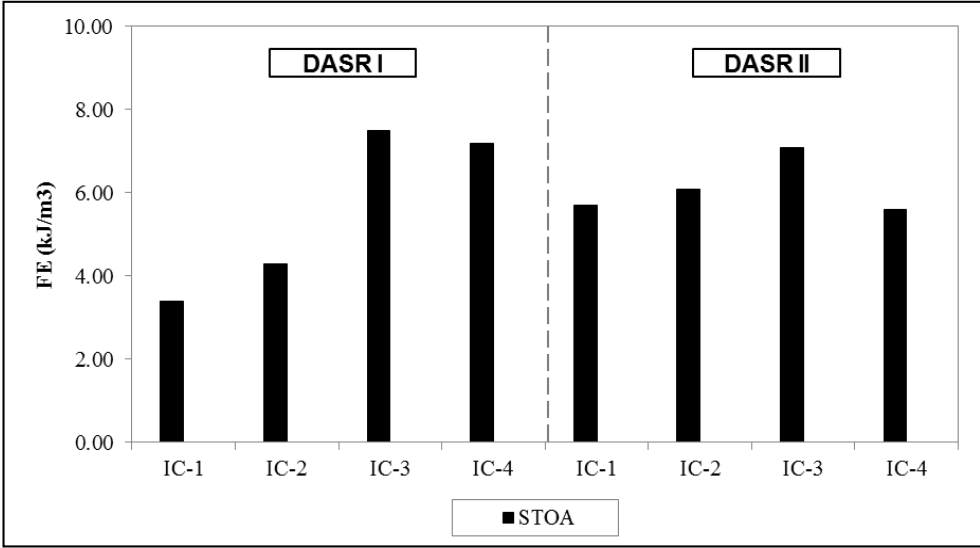


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Data source: University of Florida & University of Parma

EFFECT OF AGGREGATES SIZES DISTRIBUTION ON MIX PERFORMANCE



Data source: University of Florida & University of Parma

Etherogeneity of RAP

Different damages



Etherogeneity of RAP



OGFC



Rubber asphalt



SMA



Coarse HMA

..... and more

OPEN PROBLEMS



University of Parma

- How to guarantee that the mix design's requirements are satisfied during production and lay down of hot recycled mixtures?
- How to guarantee that the RAP used in the production match the characteristics of RAP used in the mix design?



The related control has to be made in time frame in agreement with operation's program

WARNING TESTS



OK



WARNING



STOP

- **COHESION TEST**
- **FRAGMENTATION TEST**



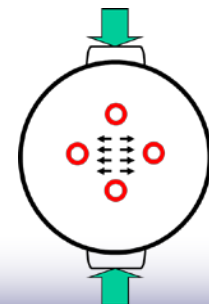
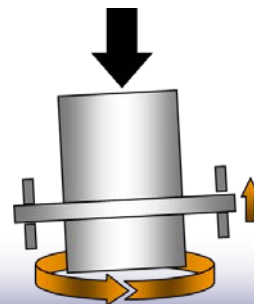
RILEM RECOMMENDATION
[publication in progress]

COHESION TEST

Full grading of dry (dried at 30°C until weight loss within 24 hours is less than 1%) RAP is tested with max 20mm aggregates.

Compaction done with gyratory compactor with 150 mm mold and 30 gyrations in agreement with ASTM D6925 or EN12697/31 at 3 different temperatures of material (conditioning time: 4 hours): 20°C, 70°C and 140°. Air voids level should be reported.

After compaction condition samples at 25°C for 24 hours and perform ITS tests.

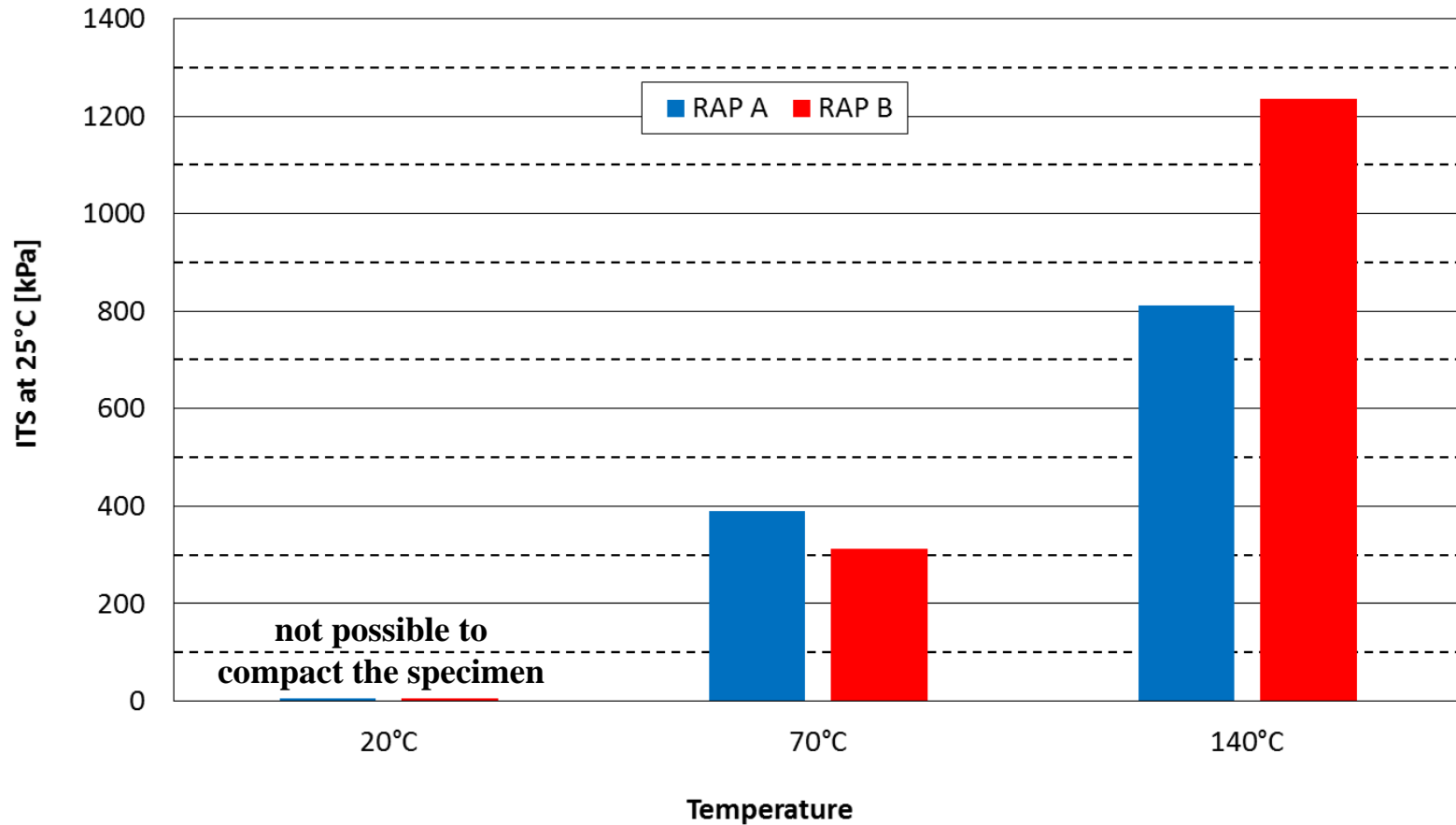


COHESION TEST



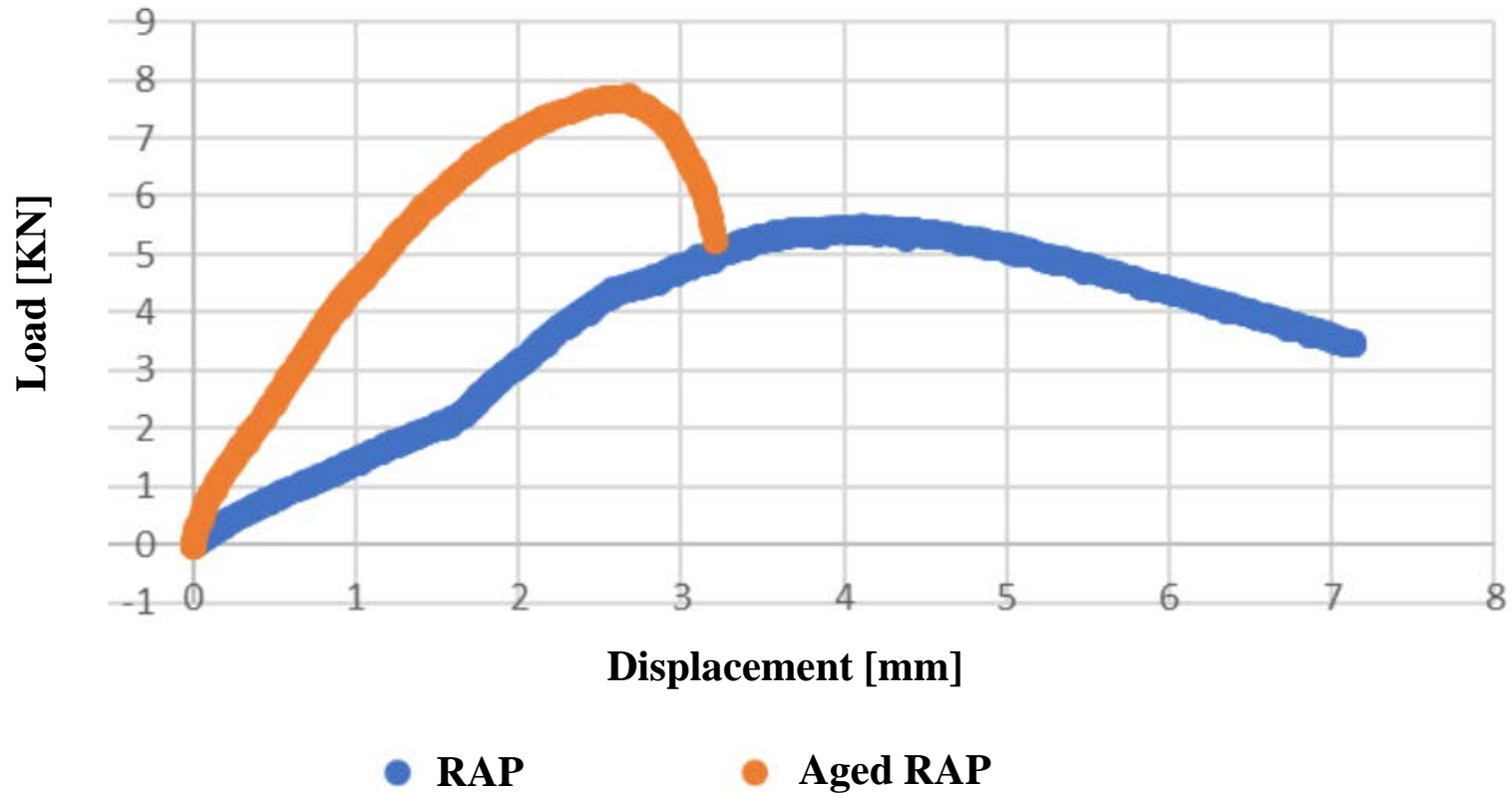
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Two different RAPs



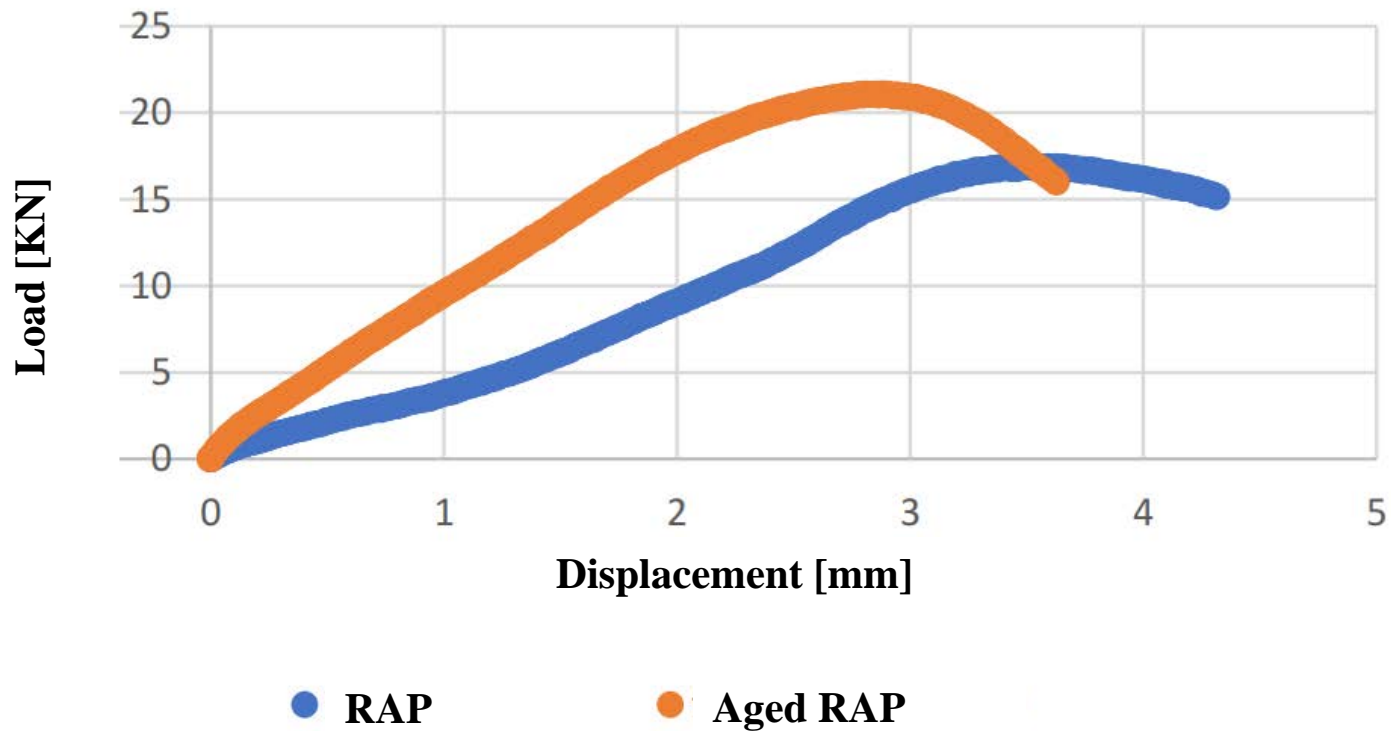
COHESION TEST

Same RAP before and after artificial aging
[specimens compacted at 70°C]



COHESION TEST

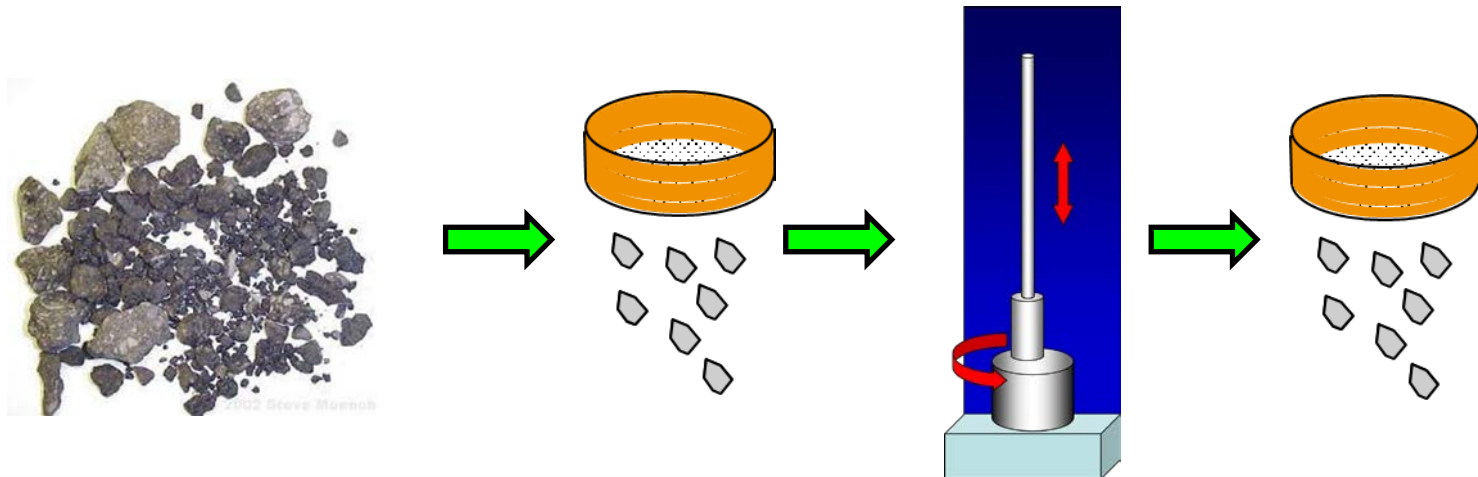
Same RAP before and after artificial aging
[specimens compacted at 140°C]



FRAGMENTATION TEST

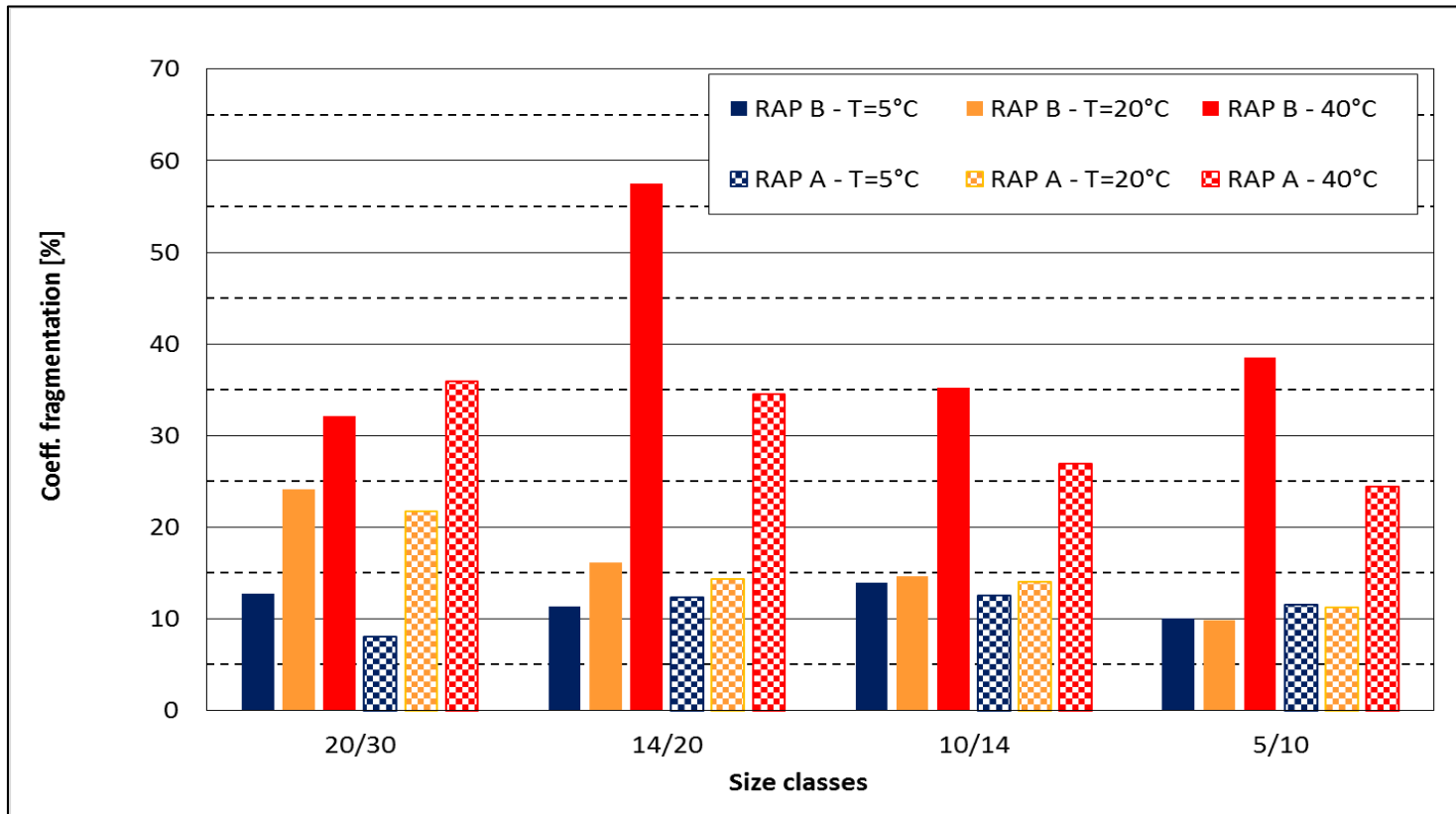
The coefficient of fragmentation is the ratio between the weight of the material passing at 1.6mm sieve after hammering and the weight of the material before hammering.

The fragmentation test has to be performed at 3 different temperature of material: 5°C, 20°C and 40°C



FRAGMENTATION TEST

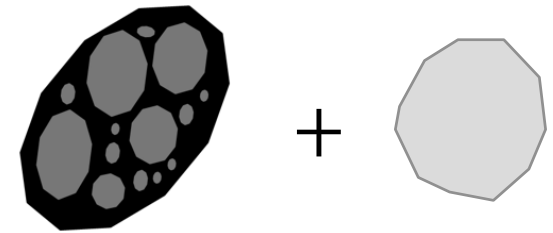
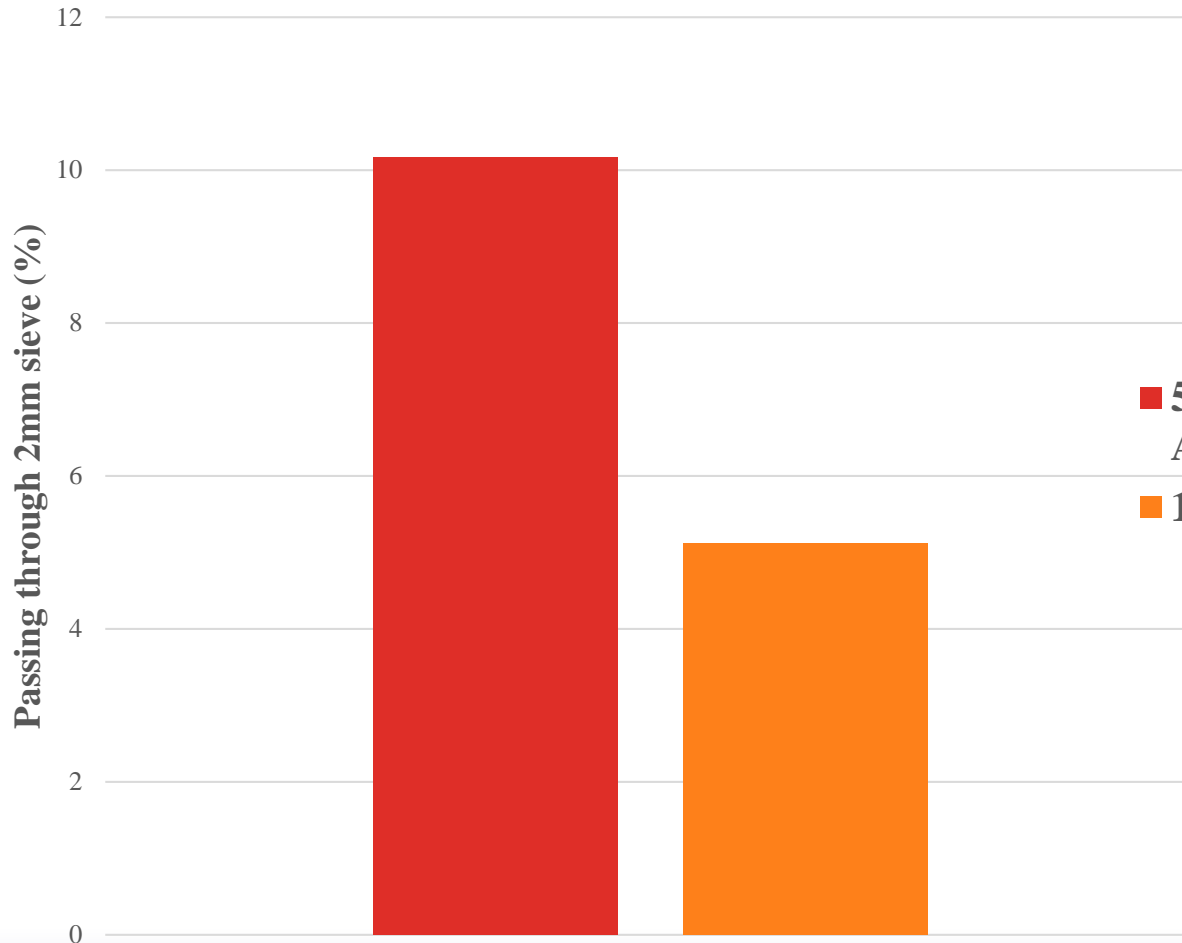
Two different RAPs



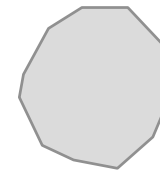
Size classes	20/30	14/20	10/14	5/10
100% passing	30 mm	20 mm	14 mm	10 mm
100% retained	20 mm	14 mm	10 mm	5 mm

FRAGMENTATION TEST

15-20 mm class compacted at 20°C



- 50% RAP + 50% VIRGIN AGGREGATES
- 100% VIRGIN AGGREGATES



Rilem Technical Committee 264 - RAP

Recycling of Asphalt Pavement



University of Parma

Chairman: G. Tebaldi (University of Parma)

Secretary: E. V. Dave (University of New Hampshire)

- TG 1: Cold Recycling -with foam bitumen and with bituminous emulsion
D. Perraton & A. Carter, ÉTS Montréal
- TG 2: Hot and Warm Recycling
P. Marsac, IFSTTAR & M. Rubio Gámez, University of Granada
- TG 3: Asphalt Binders and Additives for RA
M. Hugener, EMPA & A. Cannone Falchetto Technical University of Braunschweig
- TG 4: Life Cycle Assessment
T. Parry, University of Nottingham & Y. Qiao, University of New Hampshire
- TG5: Degree of Binder Activation
D. Presti, University of Nottingham & K. Vasconcelos, University of São Paulo

I HAVE A QUESTION

?

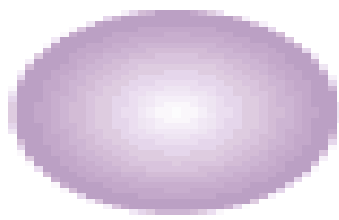
WHY?

HOW?

WHEN?

WHAT?

WHY?



?



Virgin large aggregate
8/11 mm



RAP small aggregate
2/4 mm

+ heat
+ mixing 2 min



Virgin large aggregate
+ RAP binder



RAP small aggregate
+ RAP binder

+ virgin bitumen



Virgin large aggregate
+ RAP binder
+ virgin binder



RAP small aggregate
+ RAP binder
+ virgin binder

EU methodology

$$a \log \text{pen}_1 + b \log \text{pen}_2 = (a + b) \log \text{pen}_{\text{mix}}$$

pen_1 is the penetration of the binder recovered from the RAP

pen_2 the penetration of the added virgin binder,

pen_{mix} the calculated penetration value of the binder in the mixture containing RAP

a and b the ratios by mass of the binder from the RAP and of the virgin binder, ($a + b = 1.0$)

$$T_{\text{R\&B mix}} = aT_{\text{R\&B1}} + bT_{\text{R\&B2}}$$

$T_{\text{R\&B1}}$ is the softening point of the binder recovered from the RAP,

$T_{\text{R\&B2}}$ is the softening point of the added virgin binder

$T_{\text{R\&B mix}}$ the softening point of the binder in the mixture containing RAP,

a and b the ratios by mass of the binder from the RAP and of the virgin binder, ($a + b = 1.0$).

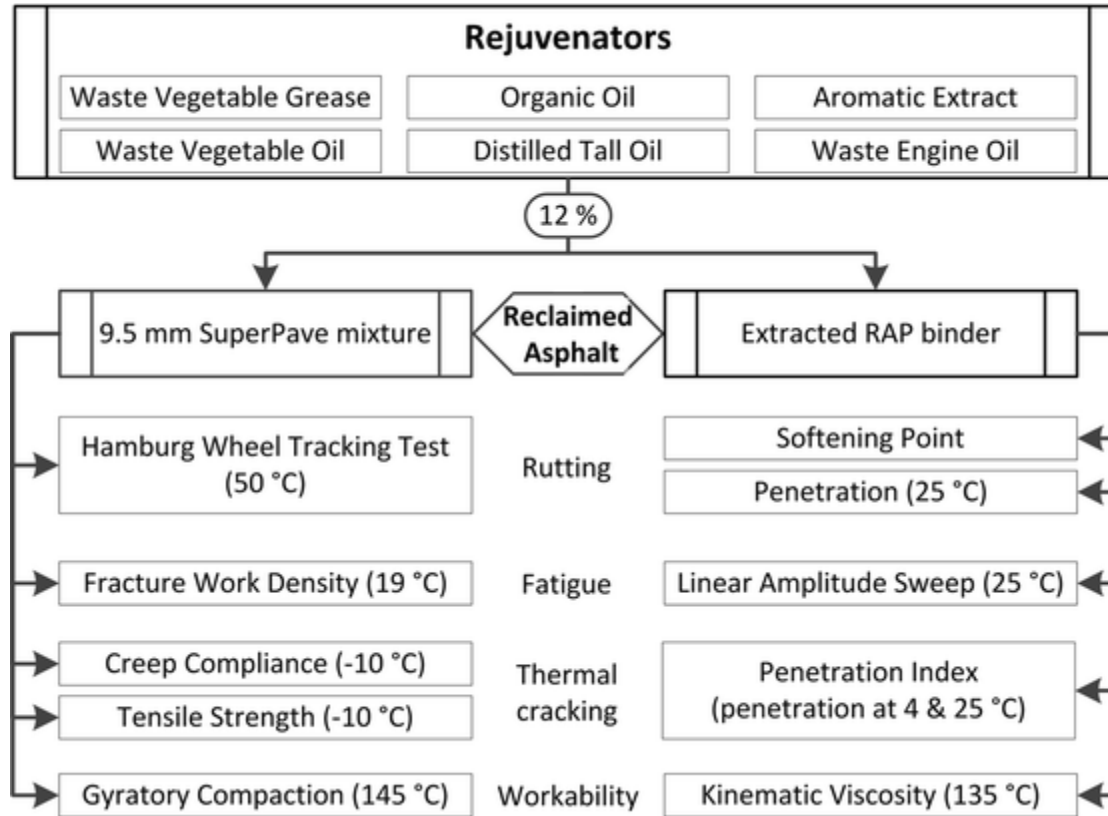
EU methodology

$$T_{\text{blend}} = T_{\text{RAP}} * \% \text{RAP} + T_{\text{VB}} * \% \text{VB}$$

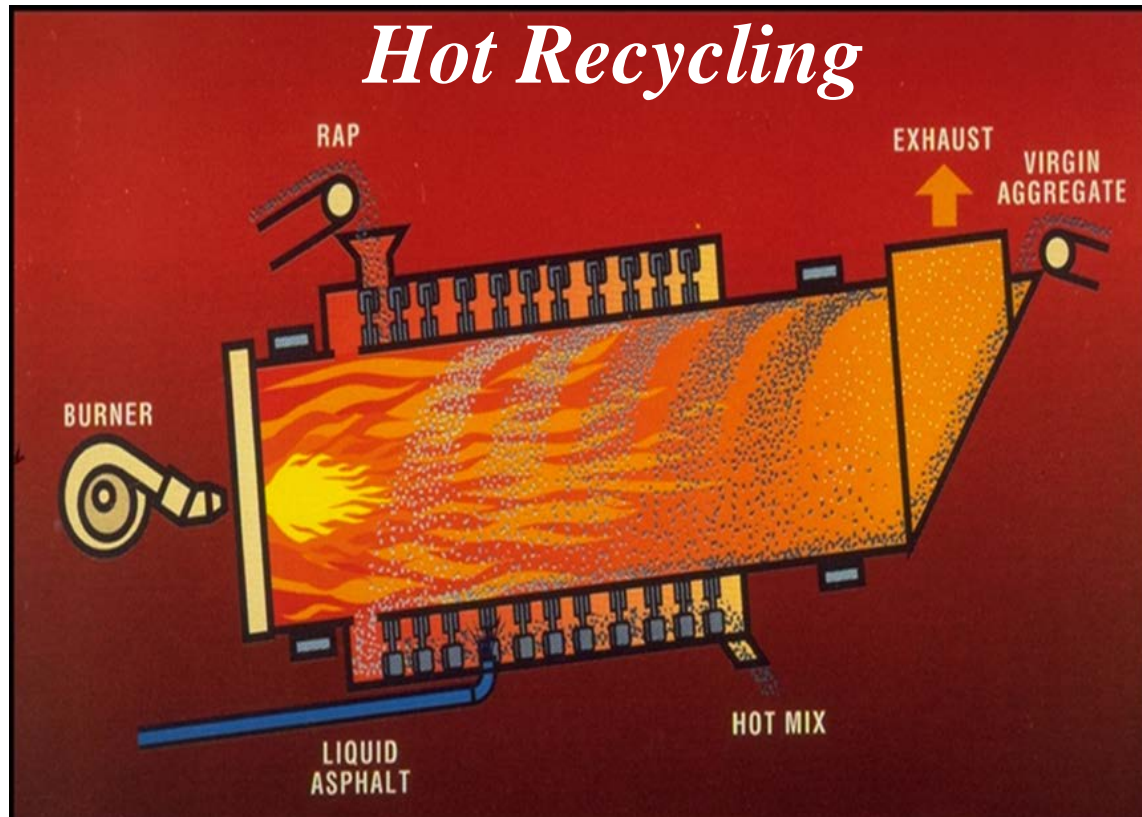
T_{blend} is the critical temperature of the final blend of binders, T_{RAP} the critical temperature of the RAPb, T_{VB} the critical temperature of the virgin binder used as rejuvenator, %RAP the percentage of RAP and %VB the percentage of virgin binder in the blend.

Paesi	Conglomerato bituminoso prodotto anno 2013 (t)	Fresato d'asfalto ottenuto dalla rimozione delle pavimentazioni stradali (t)	% di fresato recuperato
Francia	35.400.000	6.900.000	64%
Germania	41.000.000	11.500.000	90%
Spagna	13.300.000	205.000	85%
Olanda	9.700.000	4.500.000	76%
Regno Unito	19.200.000	5.000.000	80%*
Turchia	46.200.000	1.200.000	3%
USA	318.100.000	323.000.000	95%
<u>Italia</u>	<u>22.300.000</u>	<u>10.000.000</u>	<u>20%</u>

(*) dato stimato

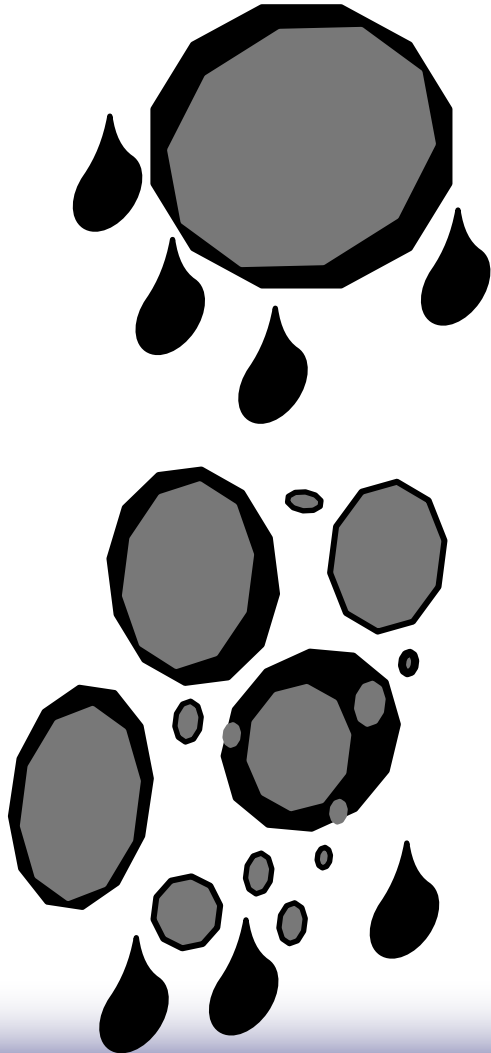
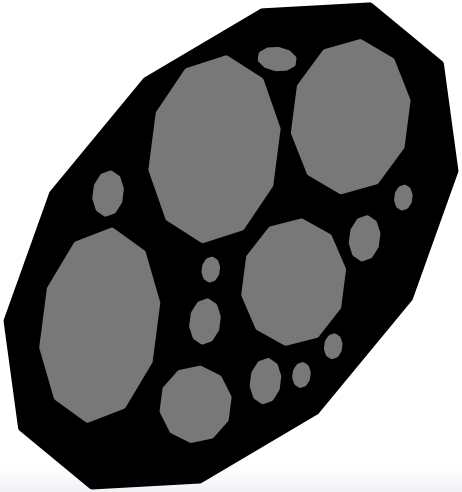
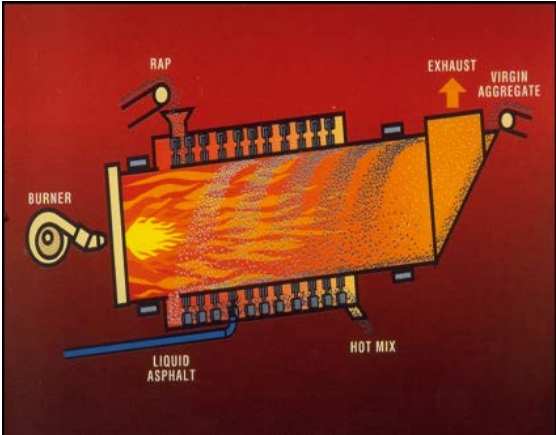
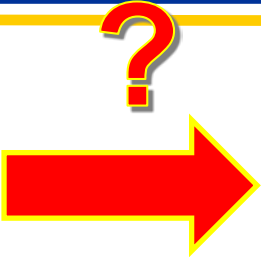
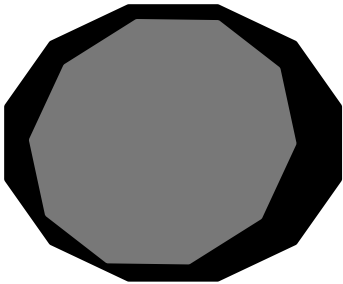


Use of RAP or RAP recycling



Basic concept: to replace a part of natural aggregates and a part of “added bitumen” with aggregates and bitumen of RAP

OPEN PROBLEMS





STATE OF THE ART

Mix Design process

STUDY METODOLOGY

Preliminary Laboratory test on Materials

