

Asphalt concrete mixtures with high RA content Design and performance

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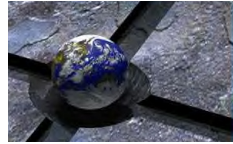




Background:

Hot mix asphalt recycling in Portugal

- > 1999 - First known applications of RA in the production of hot mix asphalt concrete in Portugal
- > Growing interest in asphalt recycling since then
- > 2006 - LNEC published E 472 (*Guide for the production of recycled hot mix asphalt*); reviewed 2009
- > 2009 – Review of E 472



Background:

Hot mix asphalt recycling in Portugal

- > 2009 – New specifications for highway works (Estradas de Portugal) include provisions for use of RA in Hot Mix Asphalt Concrete (HMAC)
- > Many CE marked HMAC in Portugal include up to 20% of RA
- > Higher percentages of RA are used in specific cases



Objectives

- > To discuss the main issues associated with the used of high RA contents in HMAC

- > To present research results concerning mix design and performance of HMAC with high RA
 - Project REPARE (LNEC + FCT UC + UM)



Main issues associated with high RA content in HMAC

> Technology

No longer an issue

> Mix design

> Grading of aggregate mixture

Too many fines

> Binder properties

Properties of final blend?

> Variability



Control of variability in HMAC with RA At the asphalt plant

> Separation of RA into 2 or more stockpiles

- According to RA particle size



- More flexibility to adjust aggregate gradation
- Better consistency of binder content (finer particles will have higher content)

> Blending the materials to get a uniform stockpile



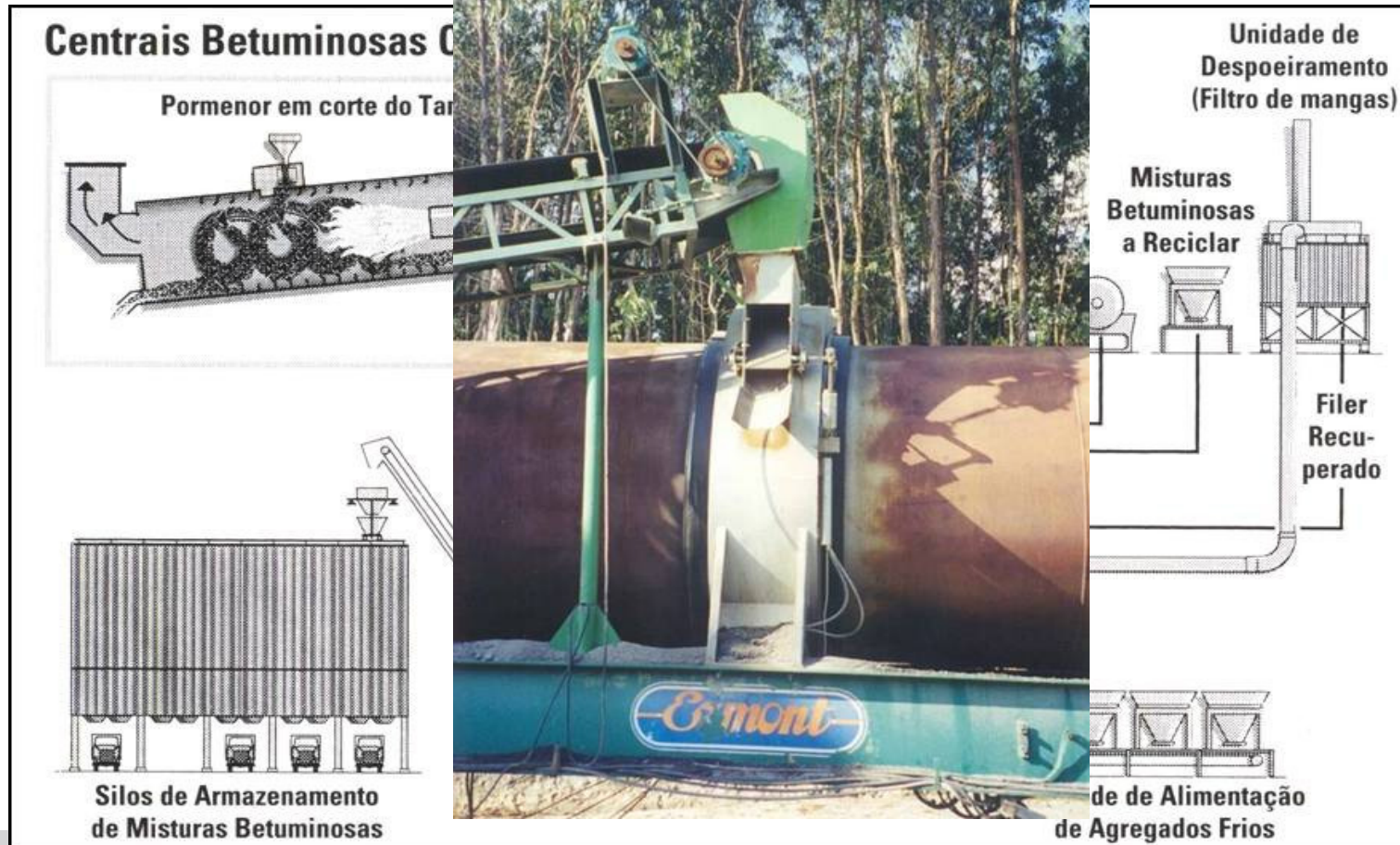
Control of variability in HMAC with RA At the lab

- > Test several samples for aggregate gradation and binder content and properties
 - Reblend the materials if variability is too high

- > Use representative samples of RA for mix design
 - Blend different samples to get a representative sample



Early applications of HMAC using RA Rehabilitation of EN 105 road pavement (1999)





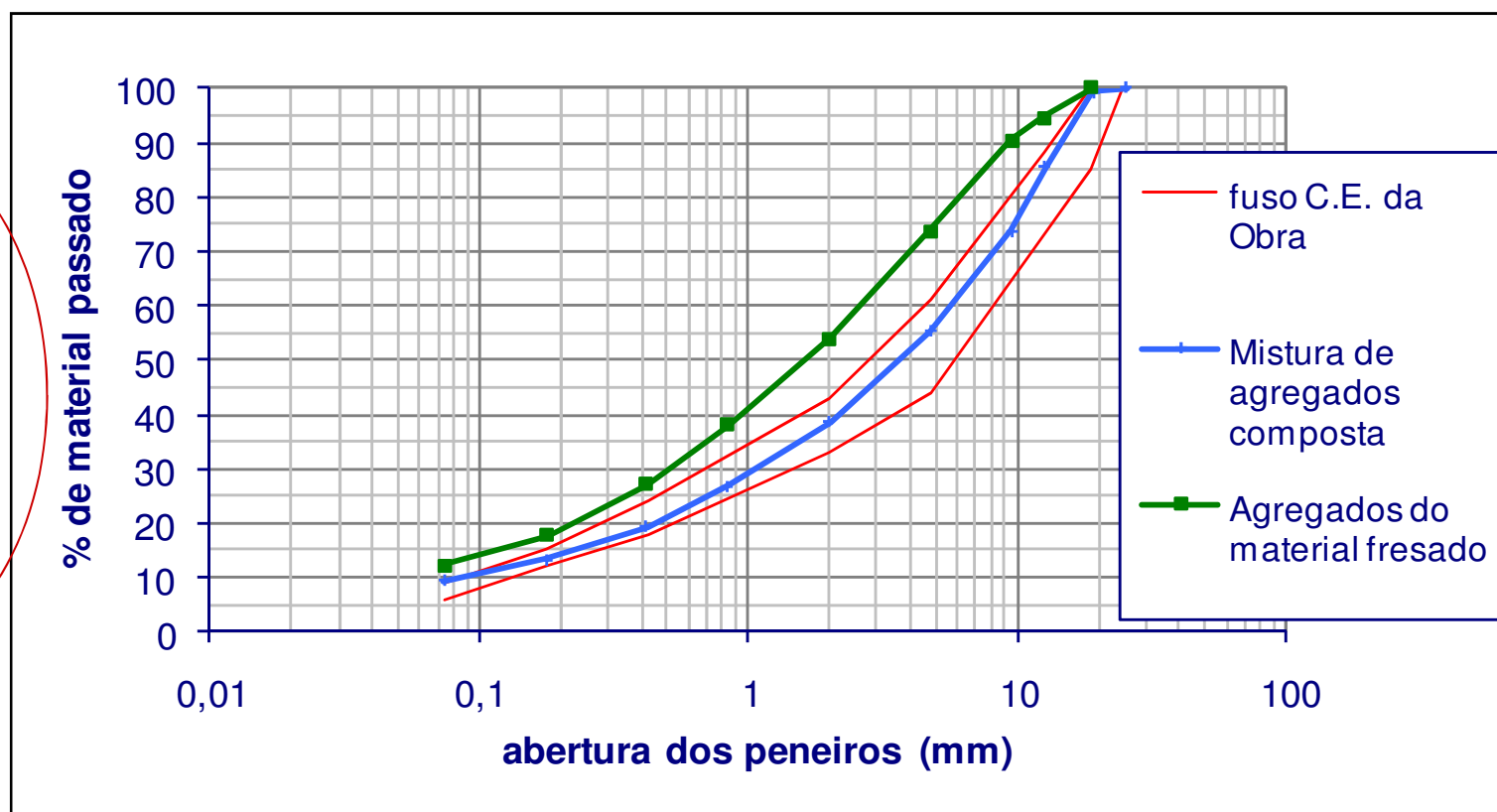
Rehabilitation of EN 105 Mix composition (binder course)

- **40 % Reclaimed Asphalt**
- **15 % Aggregate 14/20**
- **10 % Aggregate 10/14**
- **10 % Aggregate 6/10**
- **23 % Fine aggregate 0/6**
- **2 % Aded filler**

Virgin bitumen: pen 35/50
Final binder content: 5,4 %

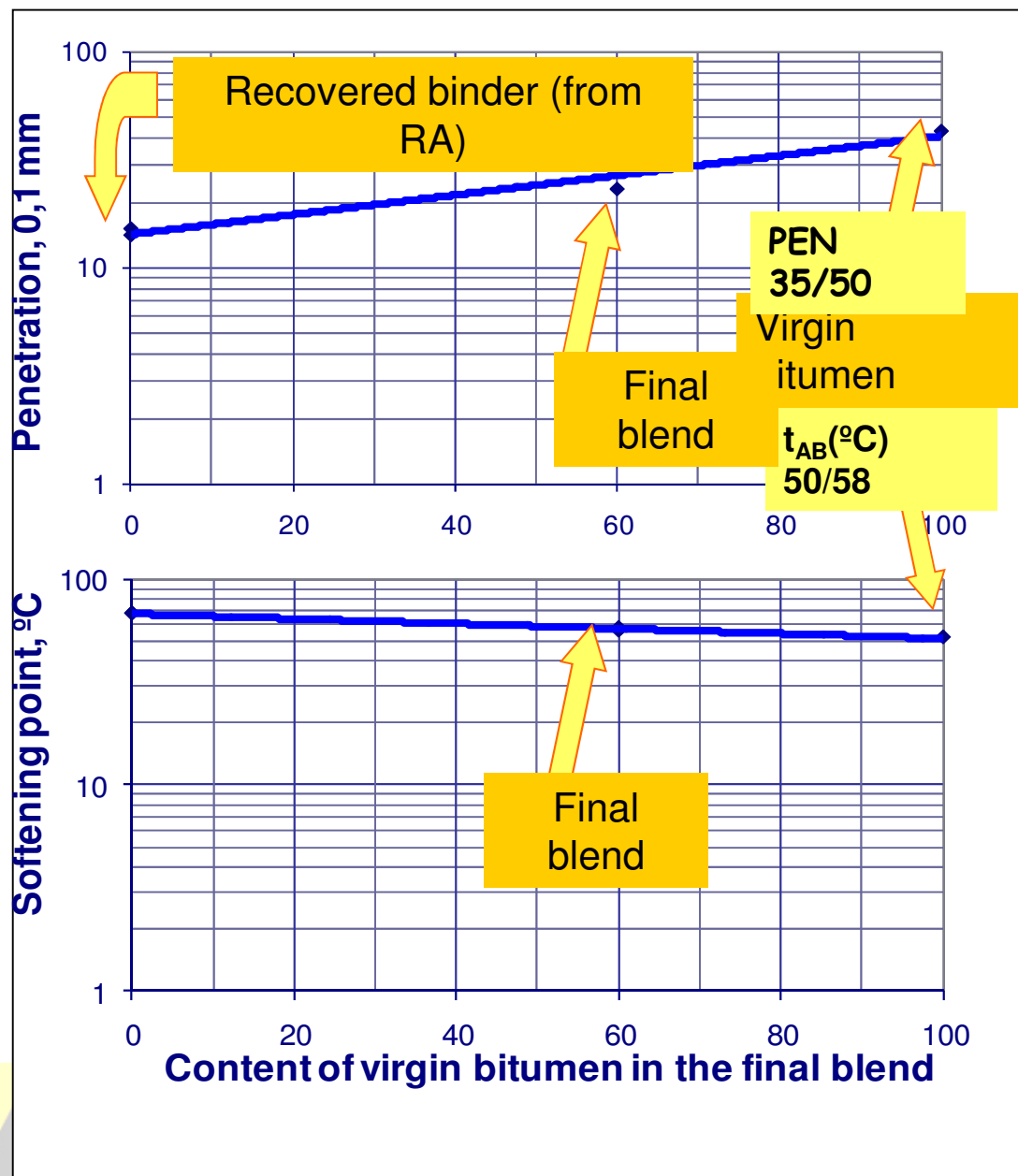
Rehabilitation of EN 105 Grading of aggregate mixture

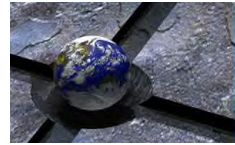
**EN 105
Hot mix
asphalt
concrete
with 40%
RA**





Rehabilitation of EN 105 Binder properties



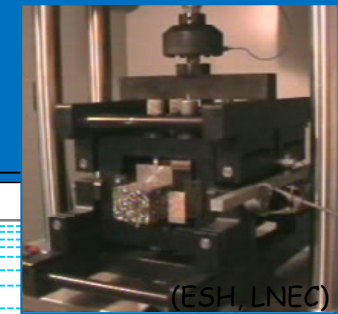


Rehabilitation of EN 105

Stiffness and fatigue

4 PB (f=10Hz; t = 22°C)

Stiffness: $E \approx 4000 \text{ MPa}$

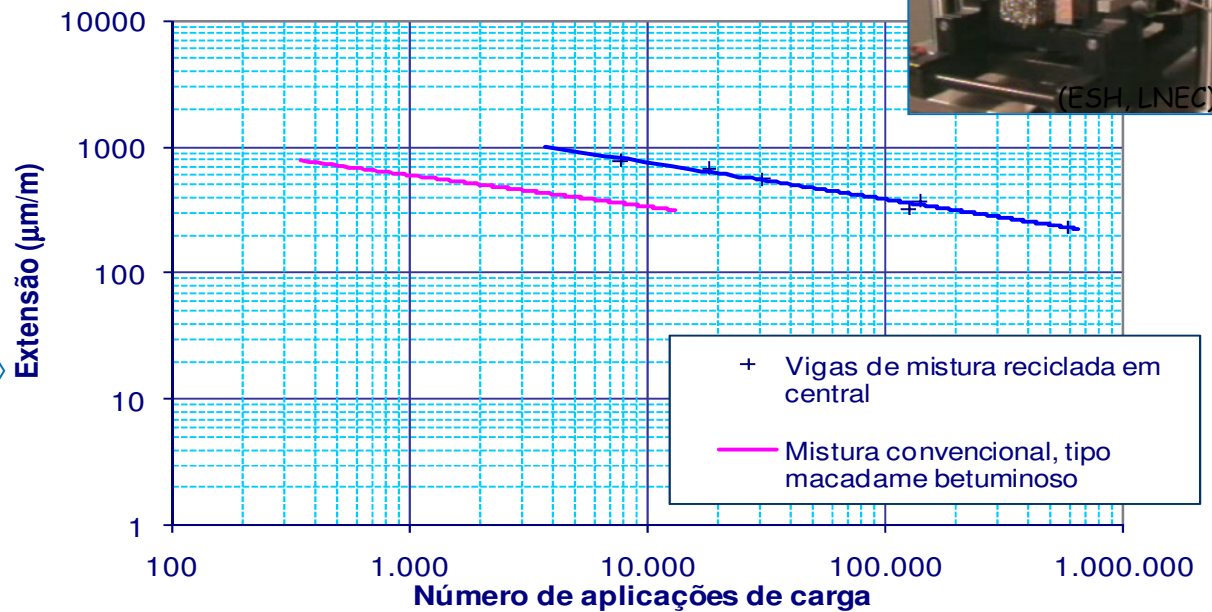


FWD tests

$E > 5000 \text{ Mpa}$ (@ ~20°C)

Field testing

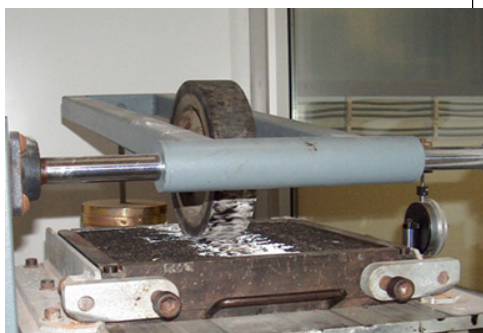
Lab testing



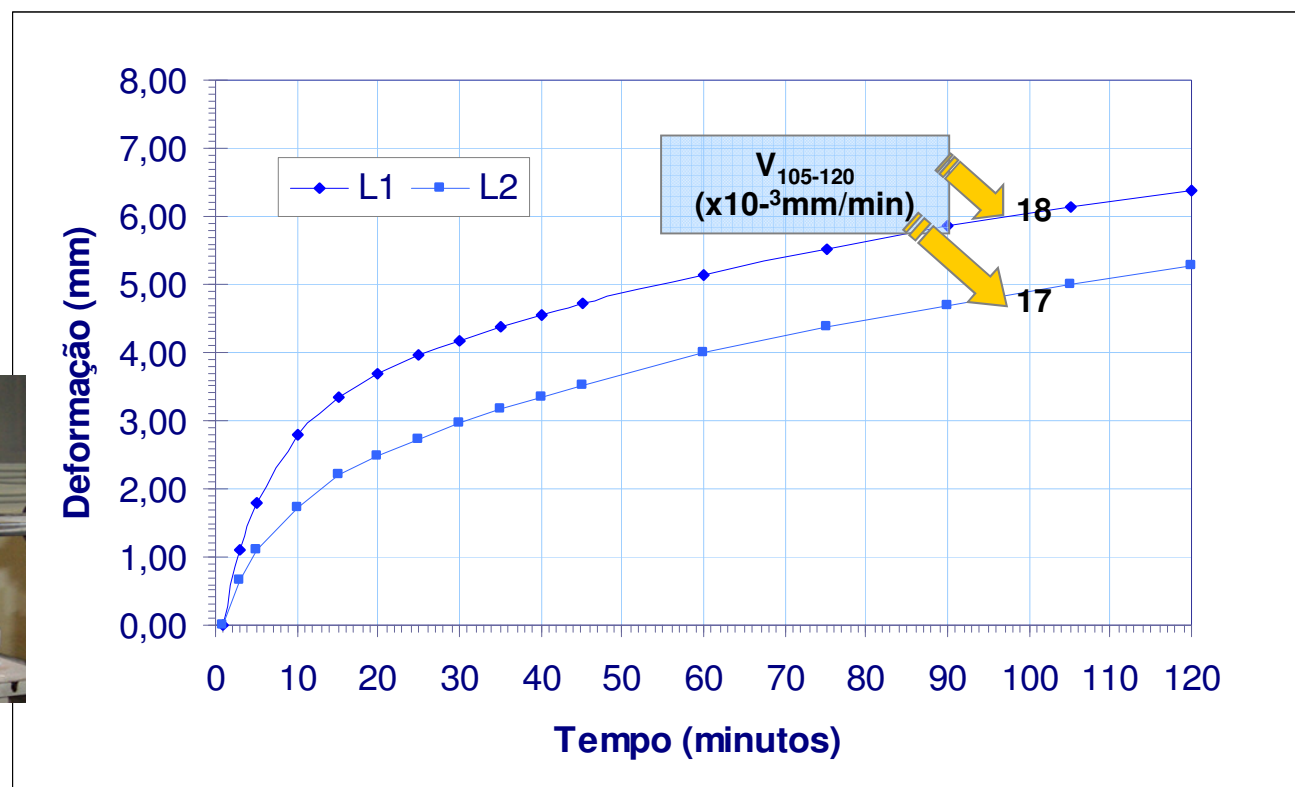
Rehabilitation of EN 105

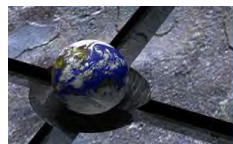
Resistance to permanent deformation

Wheel tracking tests ($t = 60^{\circ}\text{C}$)



(WT, LNEC)

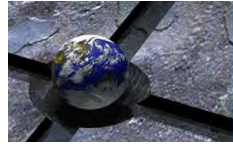




Rehabilitation of EN 105



Still in good shape after 10 years!



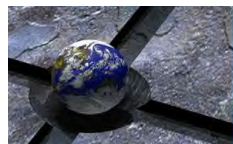
HMAC with high RA content

Laboratory investigation

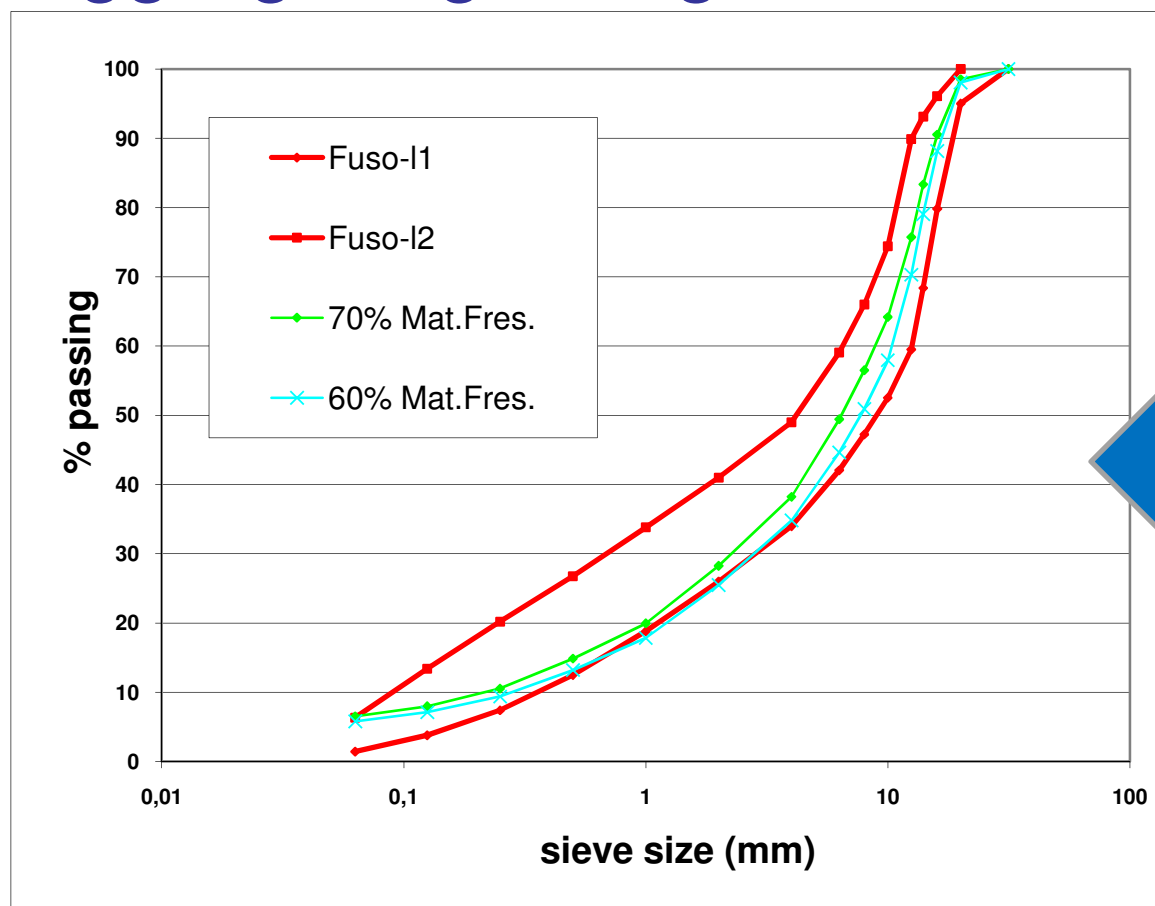
> Laboratory mixtures produced with the following materials:

- RA milled from motorway A1 (Pombal / Condeixa); 5,1% binder content (pen 14 x 0,1mm).
- Virgin binder:
 - Pen 35/50
 - Pen 50/70
 - Pen 70/100
- Virgin aggregates: limestone

> Follow-up of previous studies concerning mixtures with up to 40% RA (António Baptista, 2006)



HMAC with 60 - 70% RA Aggregate grading

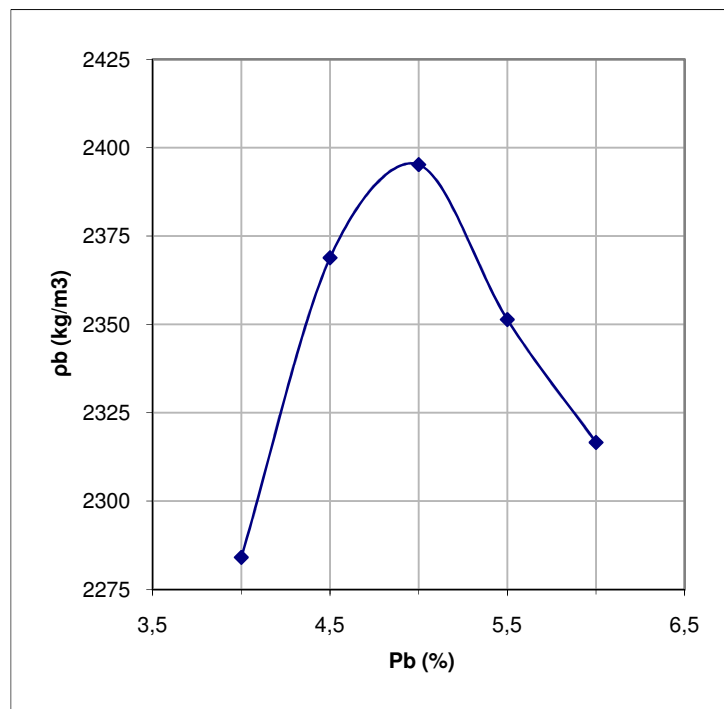


- No added filler
- Only 15/25 mm virgin aggregates

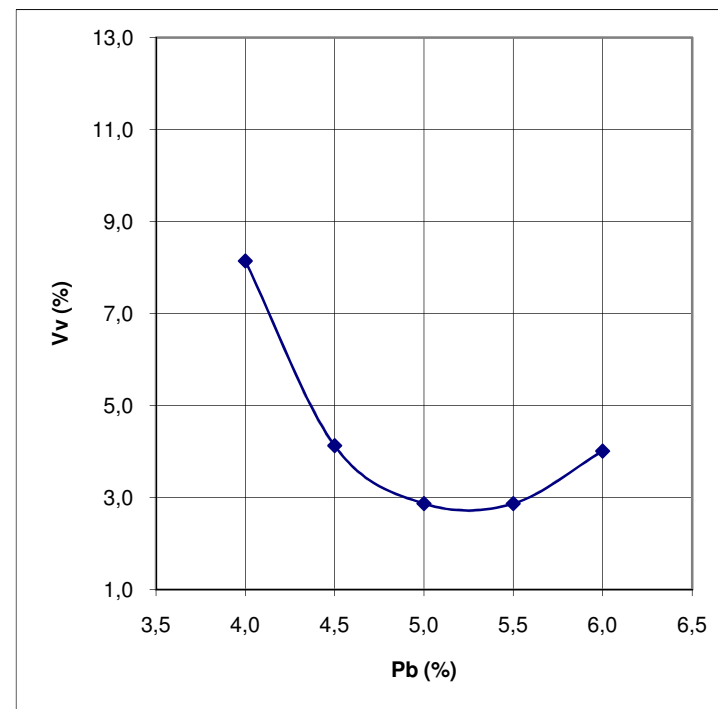


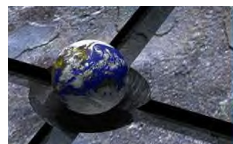
Marshall mix design for HMAC (1/3) 70% RA; pen 50/70 virgin binder

Density



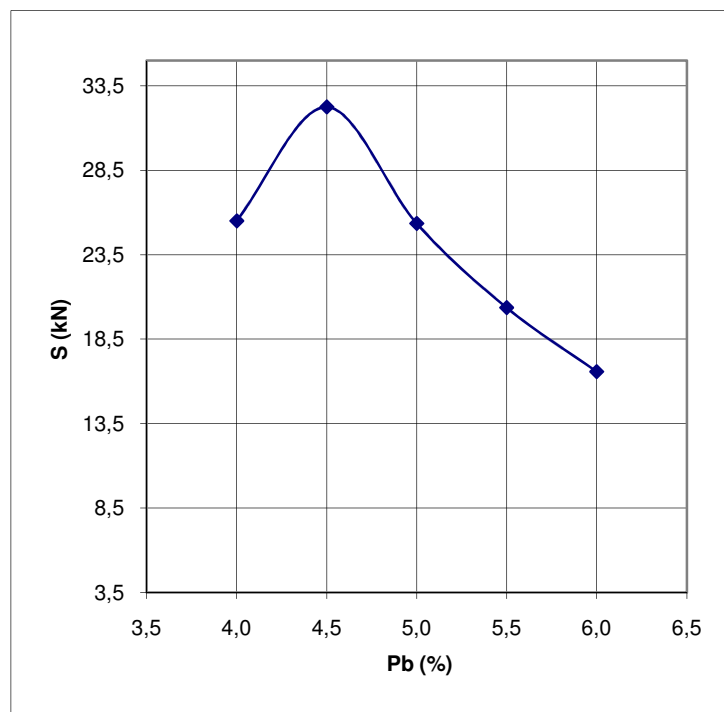
Void content



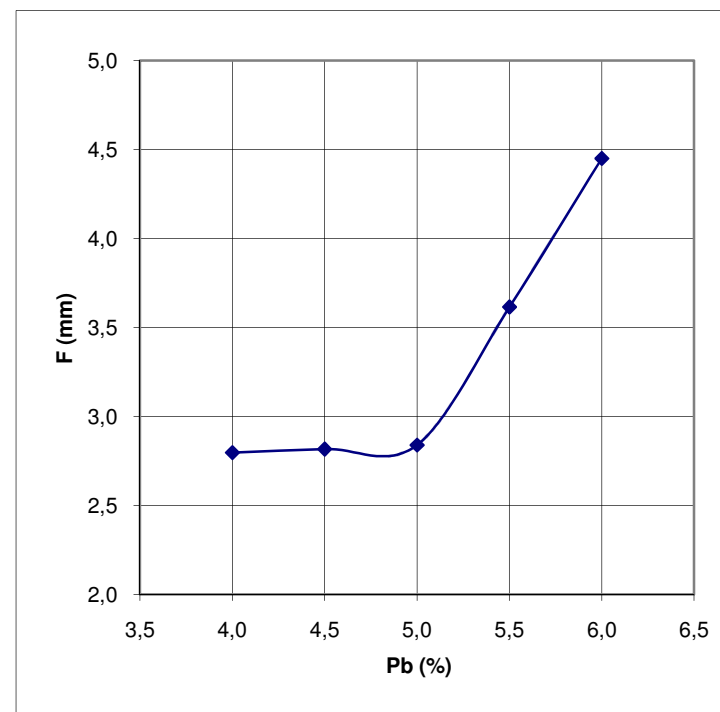


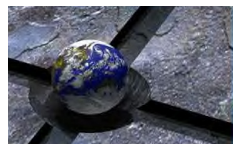
Marshall mix design for HMAC (2/3) 70% RA; pen 50/70 virgin binder

Marshall stability



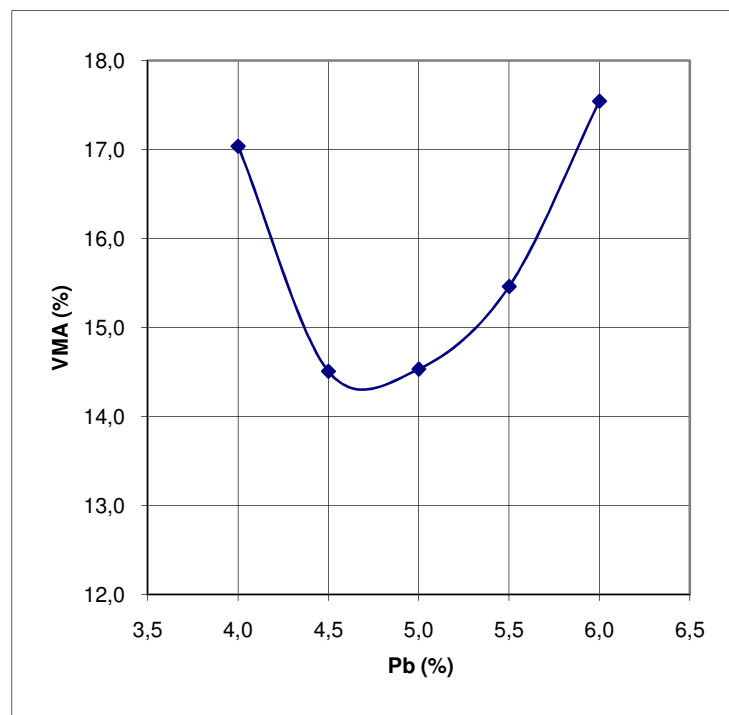
Flow



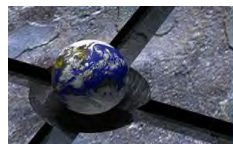


Marshall mix design for HMAC (3/3) 70% RA; pen 50/70 virgin binder

Voids in Mineral Aggregate



Selected binder
content:
5,0 % (total)



HMAC with 70% RA; 50/70 pen virgin binder

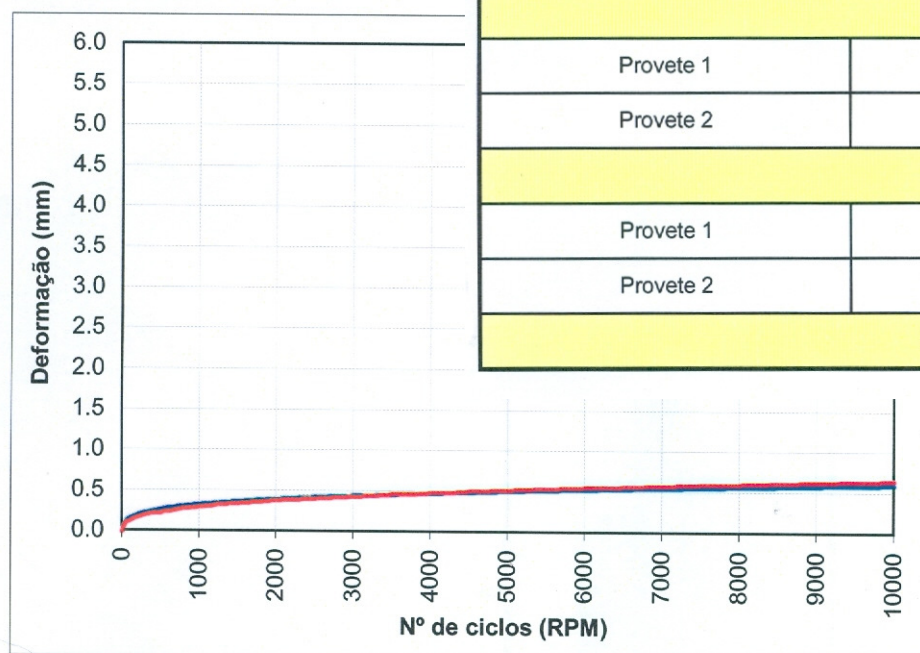
Marshall characteristics and water sensitivity

	Bulk Density (Mg/m ³)	Void content (%)	Marshall Stability (kN)	Marshall Flow (mm)	VMA (%)	ITSR (%)
Results	2,395	2,9	25,4	2,8	13,4	100
EP specification	-	3 - 6	7,5 - 15	2 - 4	≥ 14	-



HMAC with 70% RA; 50/70 pen virgin binder

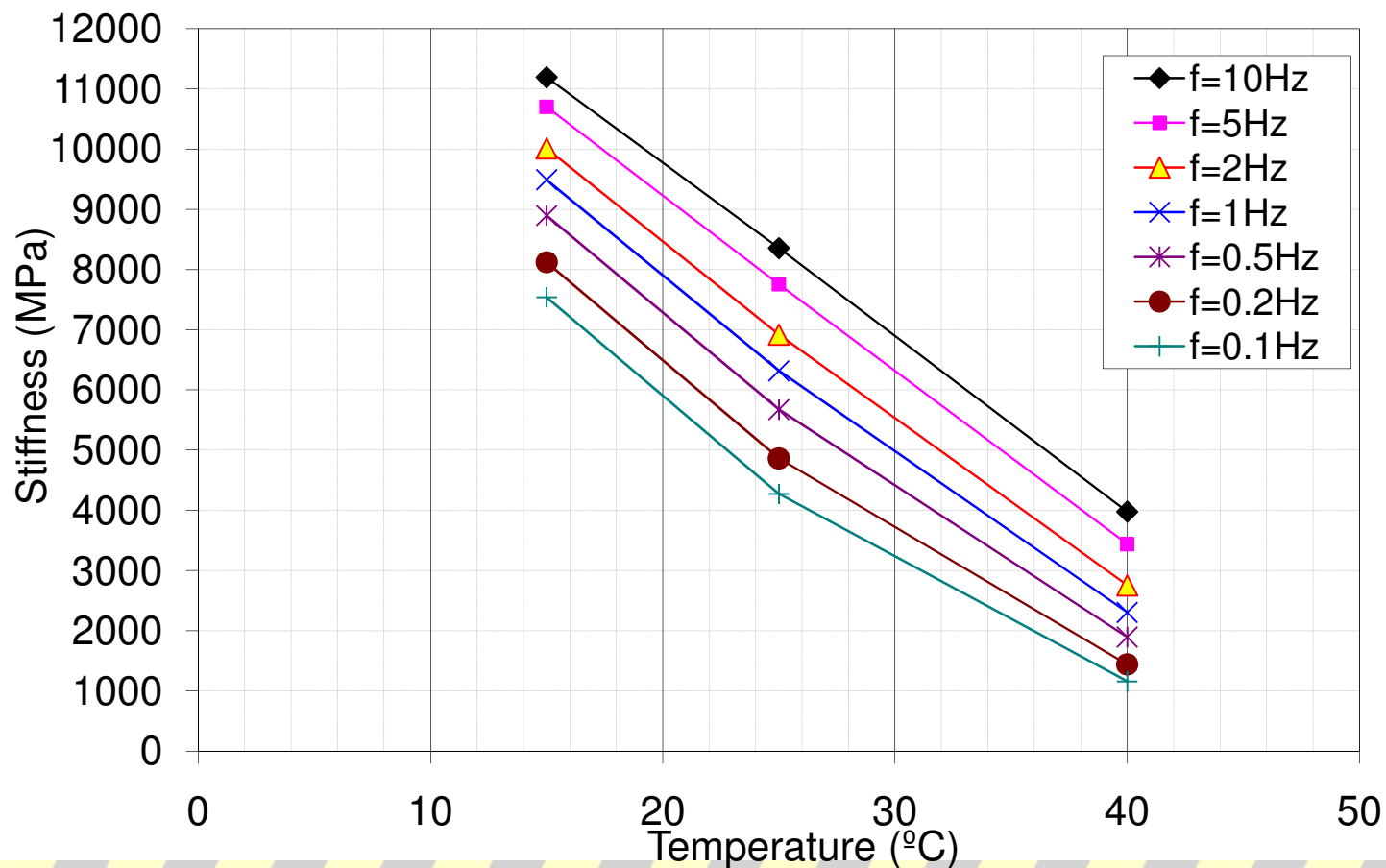
Wheel tracking test



IDENTIFICAÇÃO	PARÂMETRO	
Provete 1	Deformação máxima (profundidade de rodeira a 10000 ciclos), mm	0.60
Provete 2	Deformação máxima (profundidade de rodeira a 10000 ciclos), mm	0.65
Média da profundidade de rodeira a 10000 ciclos, mm		0.6
Provete 1	Taxa de deformação (entre o ciclo 5000 e 10000), mm/10 ³ ciclos	0.02
Provete 2	Taxa de deformação (entre o ciclo 5000 e 10000), mm/10 ³ ciclos	0.03
Taxa de deformação média (WTS_{AIR}), mm/10³ ciclos		0.02
Provete 1	Percentagem de profundidade de rodeira a 10000 ciclos	1.2
Provete 2	Percentagem de profundidade de rodeira a 10000 ciclos	1.3
Média da percentagem da profundidade de rodeira (PRD_{AIR}), %		1.3

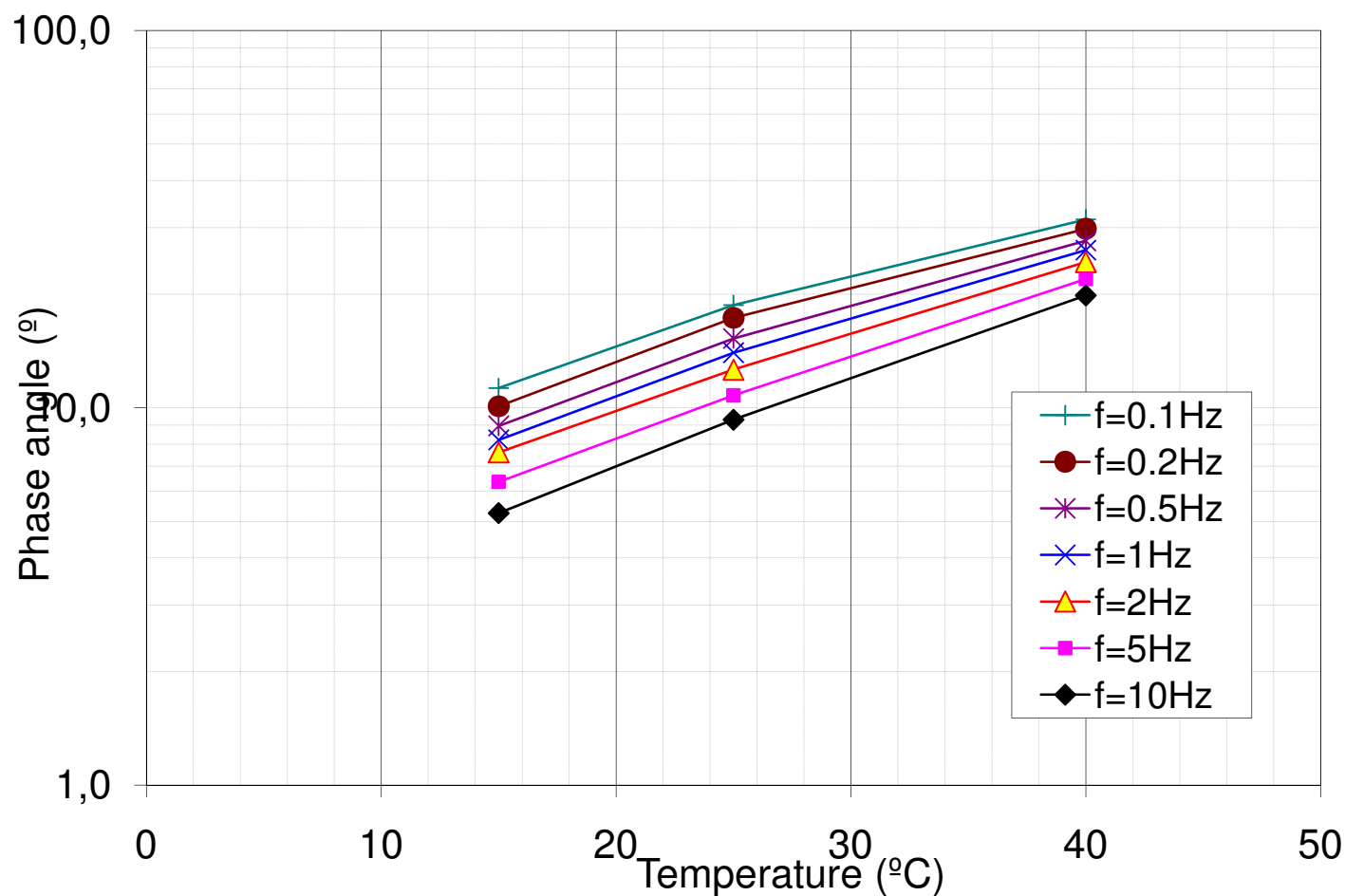
HMAC with 70% RA; 50/70 pen virgin binder

Stiffness



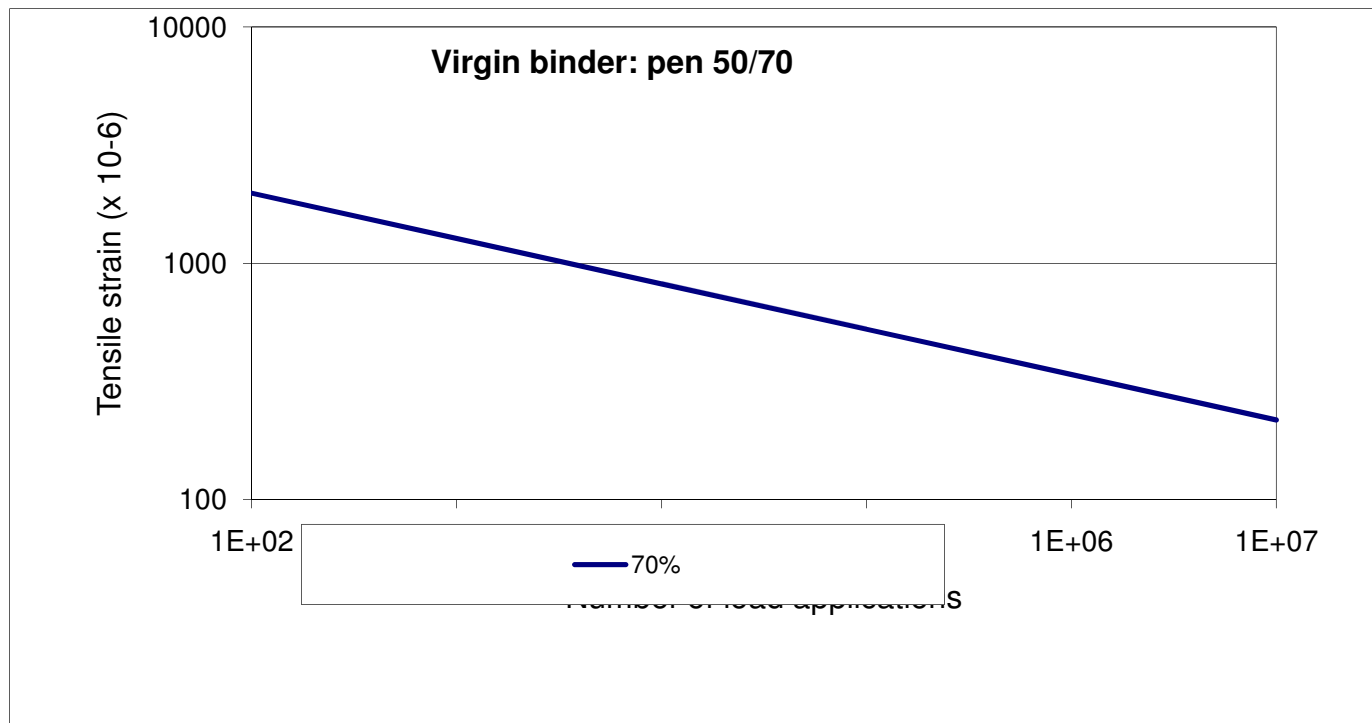
HMAC with 70% RA; 50/70 pen virgin binder

Stiffness





HMAC with 70% RA; 50/70 pen virgin binder Fatigue (25°C; 10 Hz)

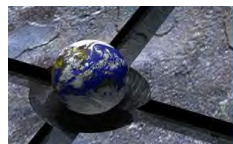




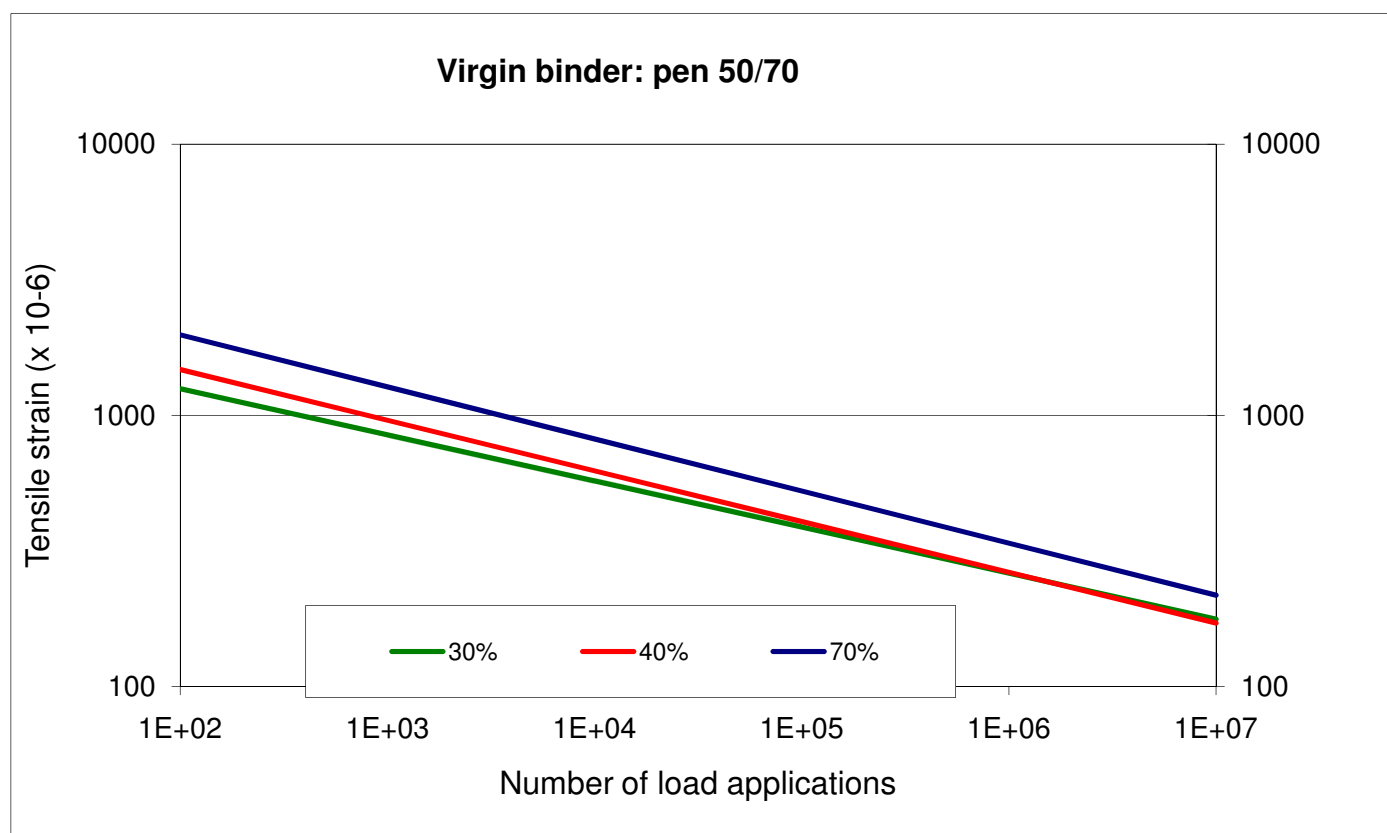
HMAC with high RA content

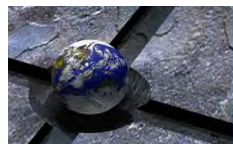
Laboratory mixtures

RA	Virgin binder (pen grade)			Final binder content
0	35/50	-	-	4,2%
20 %	35/50	50/70	-	4,3%
30 %	35/50	50/70	70/100	4,4%
40 %	35/50	50/70	70/100	4,7%
70 %	-	50/70	70/100	5,0%

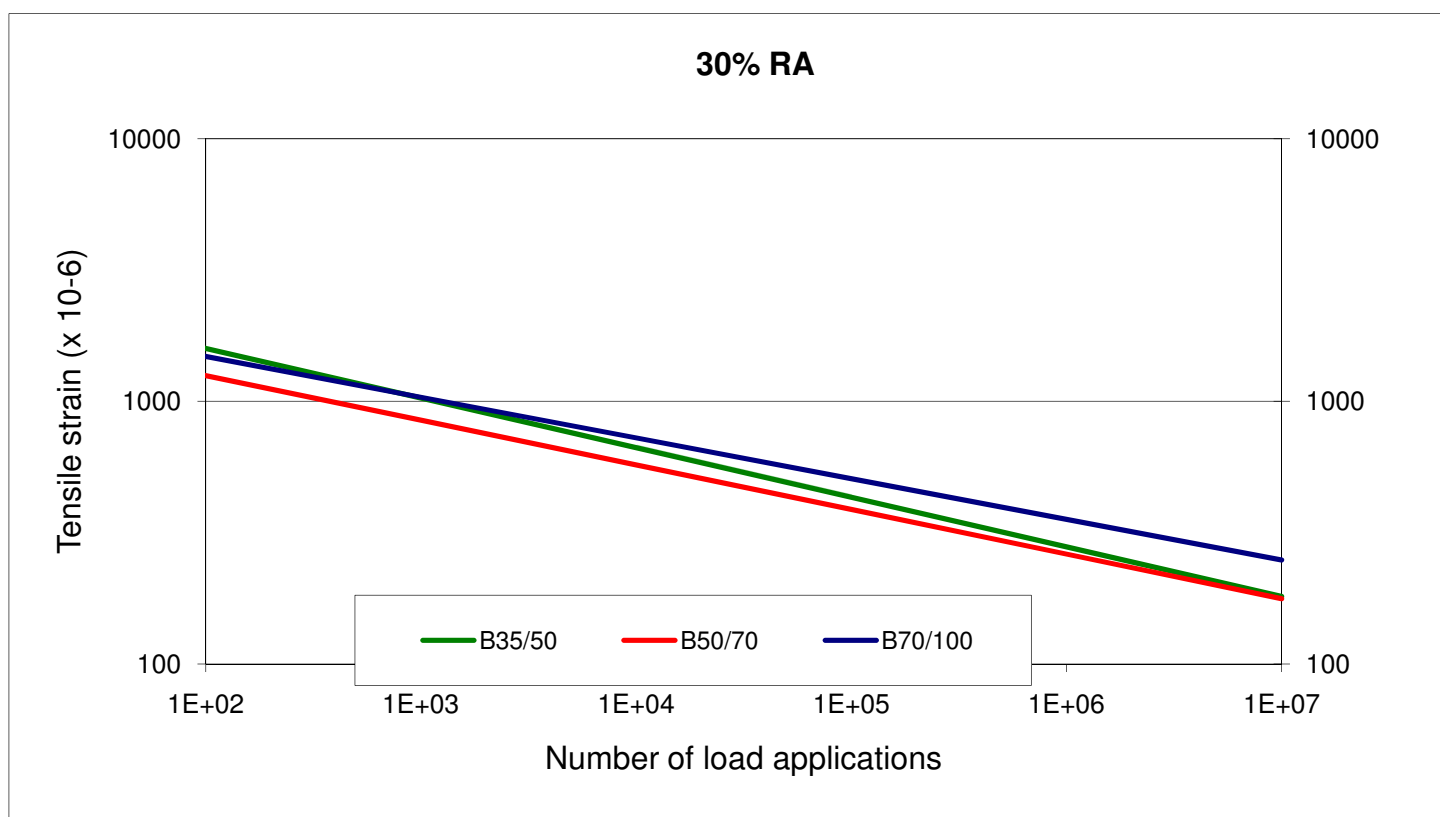


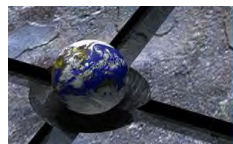
Fatigue of laboratory mixtures with RA (4PB @ 25°C; 10 Hz)



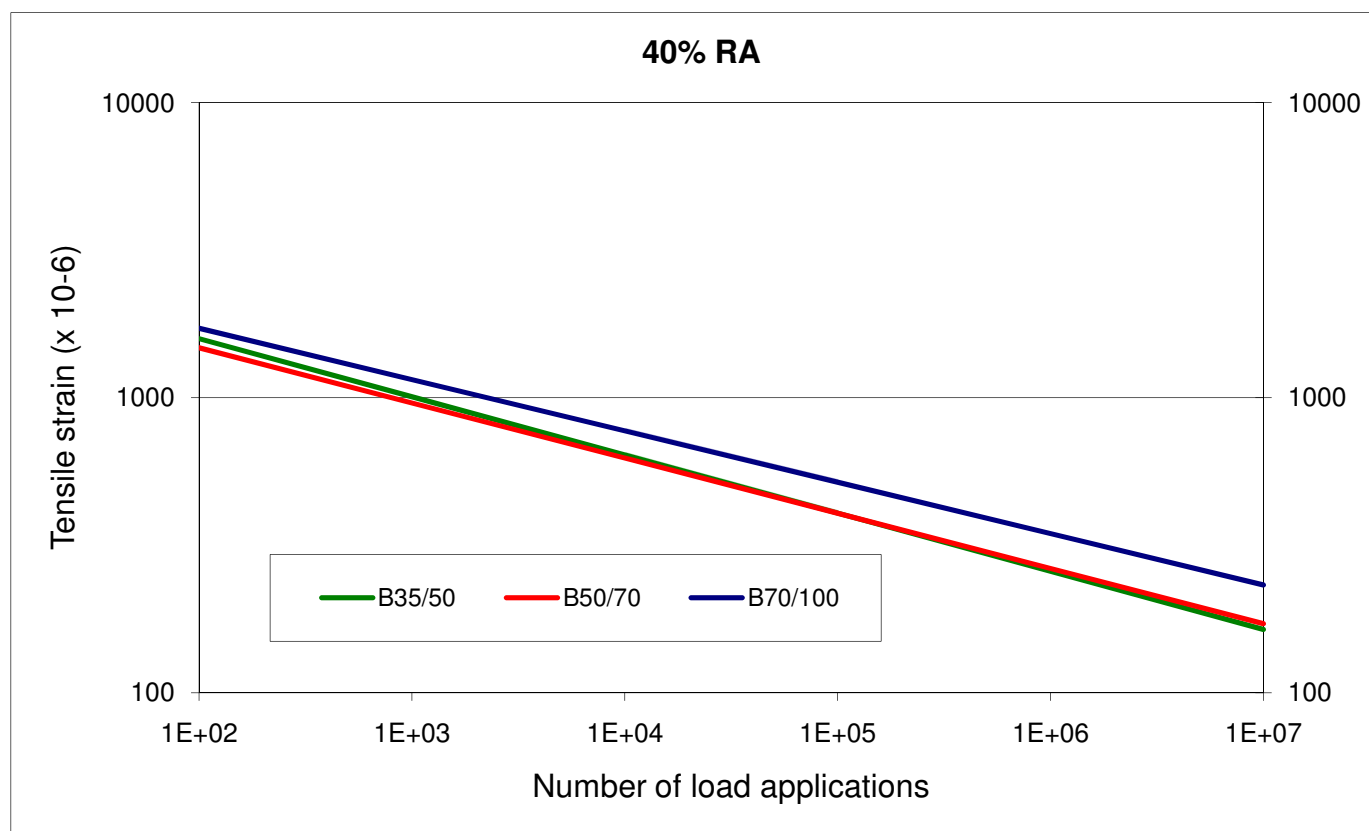


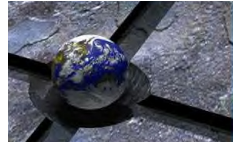
Fatigue of laboratory mixtures with RA (4PB @ 25°C; 10 Hz)





Fatigue of laboratory mixtures with RA (4PB @ 25°C; 10 Hz)





Final remarks

> Using high RA content in HMAC

- Need extra care to control variability
- Dificult to comply with standard (empirical) specifications
- You can still achieve good performance!

> Future work

- Assess ageing of mixtures with high RA
- Move to performance specifications