RUBBER MODIFIED ASPHALT MIXES:

AVAILABLE TECHNOLOGIES

SPANISH EXPERIENCE AND SPECIFICATIONS

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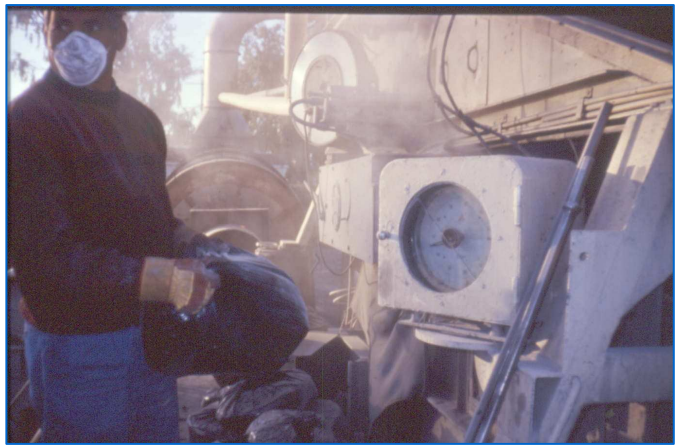
RUBBER MODIFIED ASPHALT MATERIALS



- DRY PROCESS:

addition of rubber powder during the manufacturing of the asphalt mixture

- WET PROCESS:

Previous manufacture of a rubber modified binder to be used in asphalt mixture production

TIRE RUBBER IN ASPHALT MIXTURES?

- INTERACTION BITUMEN-RUBBER?
- DOES IT ACHIEVE ENHANCED PROPERTIES?
- AVAILABLE TECHNOLOGIES?
- ACCUMULATED EXPERIENCE IN SPAIN?
- …

BITUMEN – RUBBER INTERACTION

- BITUMEN AND RUBBER DO INTERACT
- THE INTERACTION PROGRESSES AS:
  - THE TEMPERATURE INCREASES
  - THE INTERACTION TIME INCREASES
  - THE PARTICLE SIZE DECREASES
  - THE MIXING ENERGY INCREASES
  - THE CONTENT OF LIGHT FRACTIONS IN THE BITUMEN INCREASES

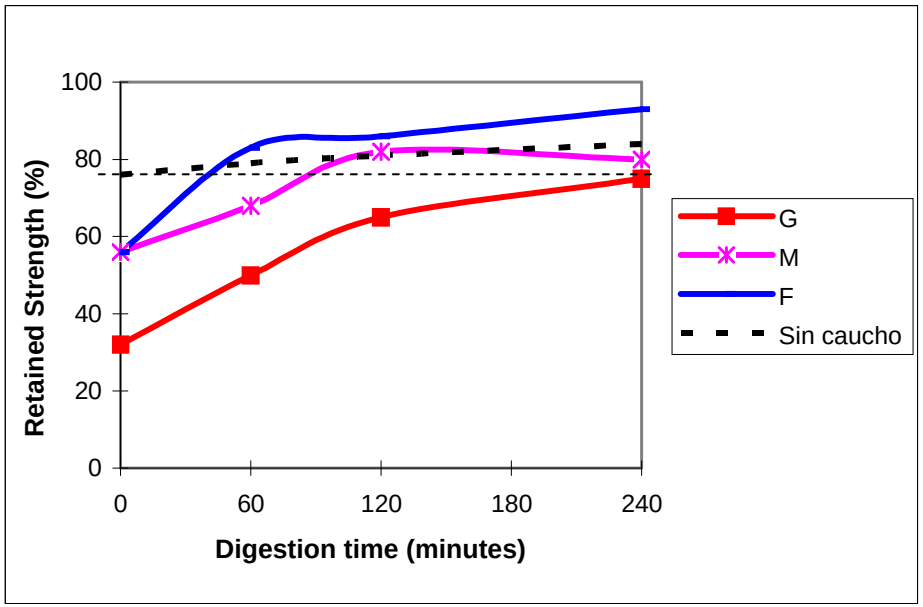
THIS PHENOMENA IS CALLED "**DIGESTION**"

BITUMEN – RUBBER INTERACTION (I)

YEAR 1999. DOCTORAL THESIS (J.Gallego):

DRY PROCESS

Water sensitivity test

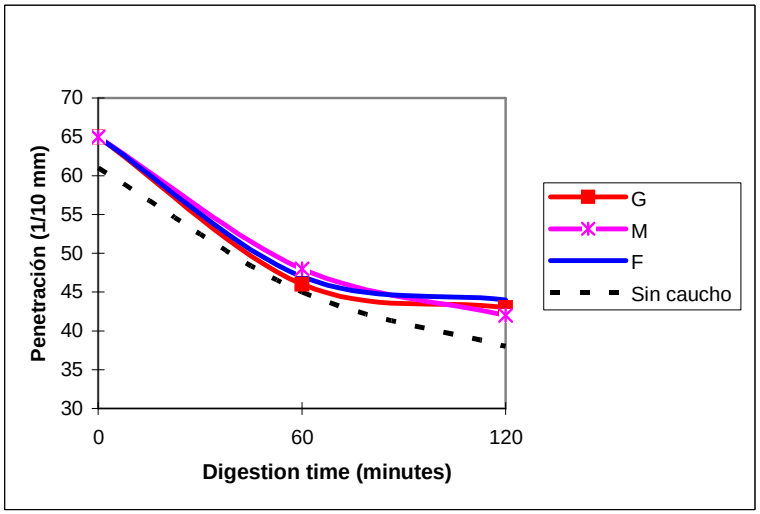


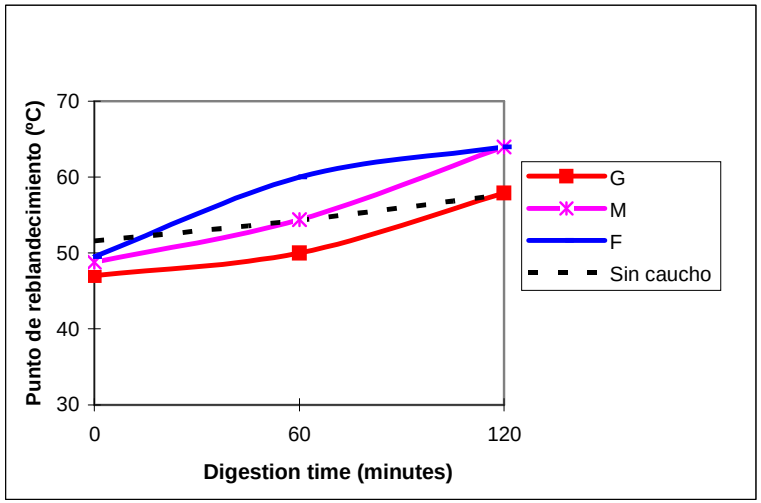
Particle size: **G** >1,32mm ; 1,32 > **M** > 0,63 mm ; 0,32 mm > **F**

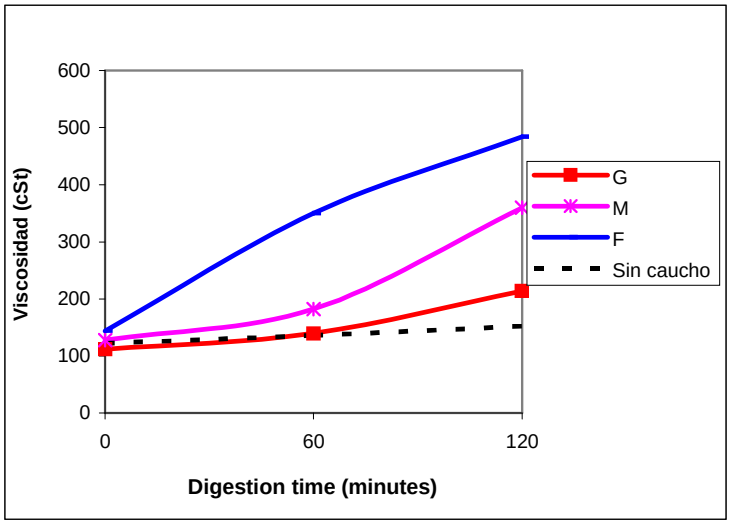
In all cases 1,5% of rubber over weight of mixture

BITUMEN– RUBBER INTERACTION (II)

DRY PROCESS







EFFECTS OF INSUFFICIENT DIGESTION TIME !!!

TWO YEARS AFTER CONSTRUCTION

M-300 ROAD (LOECHES – ALCALÁ DE HENARES (MADRID) 1996

SOLUTIONS TO GUARANTEE DIGESTION TIME

1) DRY PROCESS WITH SUFFICIENT DIGESTION TIME

2) WET PROCESS: PREVIOUS MANUFACTURE OF A RUBBER MODIFIED BINDER

- **"CONVENTIONAL"** RUBBER MODIFIED BITUMEN

  - EQUIVALENT TO EVA-MODIFIED BITUMEN

- **"HIGH RUBBER-CONTENT BITUMEN"**

  - STRONGLY MODIFIED BITUMEN

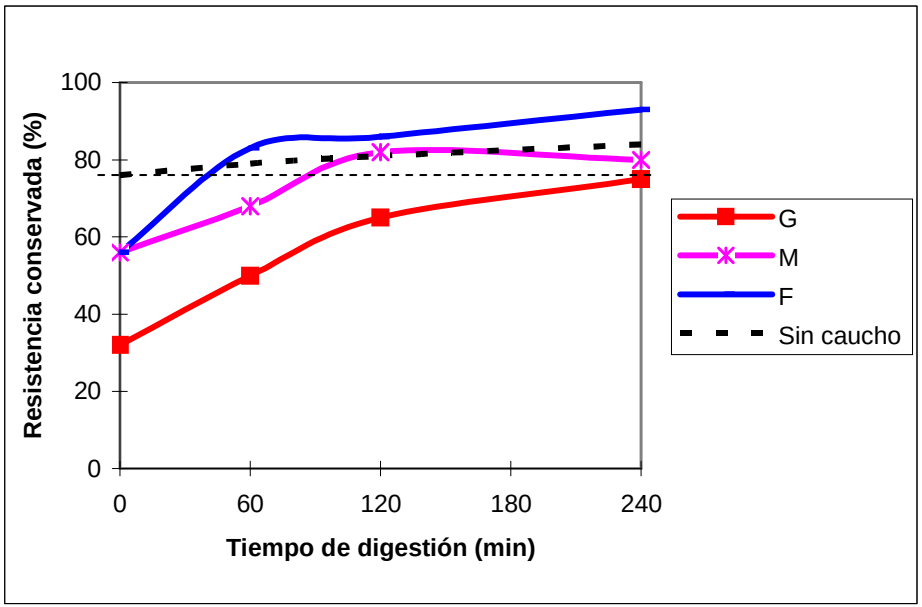
SOLUTIONS TO GUARANTEE DIGESTION TIME

1) DRY PROCESS WITH SUFFICIENT DIGESTION TIME

1) DRY PROCESS WITH SUFFICIENT DIGESTION TIME

DRY PROCESS

Water sensitivity test



Particle size: **G** >1,32mm ; 1,32 > **M** > 0,63 mm ; 0,32 mm > **F**

In all cases 1,5% of rubber over weight of mixture

SOLUTIONS TO GUARANTEE DIGESTION TIME

1) DRY PROCESS WITH SUFFICIENT DIGESTION TIME

PROJECT DATA:

- ASPHALT MIXTURE TYPE
- AVAILABLE RUBBER SIZE
- AVAILABLE DIGESTION TIME
  - + Mixture hoppers of the plant
  - + Shipping to work site
  - + Trucks delay
  - + Hopper of the paver
  - + Compacting operation

Retained strength after immersion

DEFINITION OF:

- **Rubber size**
- **% of rubber**
- **Minimum digestion time allowed**

SOLUTIONS TO GUARANTEE DIGESTION TIME

2) WET PROCESS

CONVENTIONAL RUBBER MODIFIED BINDERS

(TERMINAL BLENDING)

2) WET PROCESS TERMINAL BLENDING

- RUBBER MODIFIED BINDERS AT 5-15% RUBBER O/ WEIGHT OF MODIFIED BINDER
- CONVENTIONAL TERMINAL BLENDING
- OTHERS POLYMER THAN TIRE RUBBER ARE USUALLY ADDED
- SULFUR COMPOUNDS MAY BE ADDED
- EXTENDER OILS MAY BE ADDED

Every manufacturer has it own formula to meet specifications

SOLUTIONS TO GUARANTEE DIGESTION TIME

3) WET PROCESS

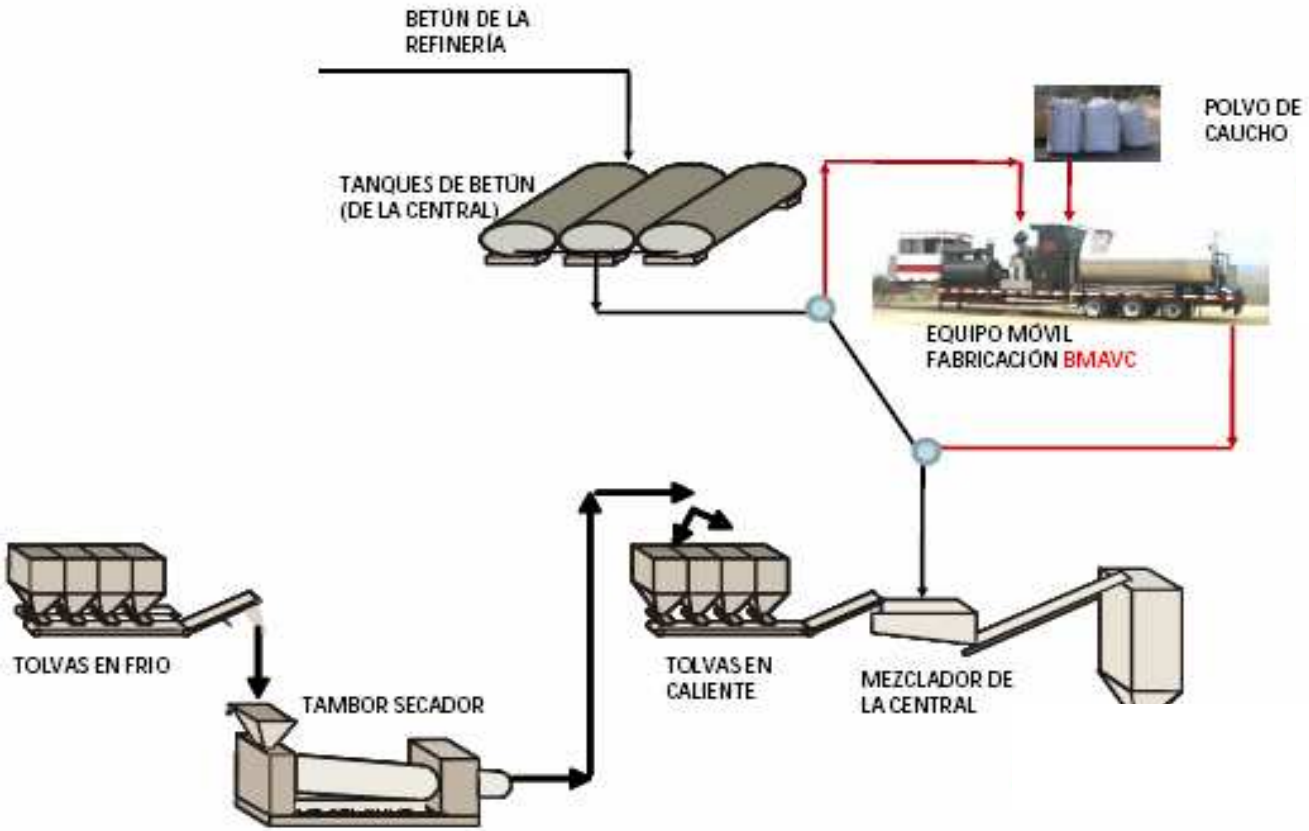
RUBBER MODIFIED BITUMEN

AT HIGH RUBBER CONTENT

3) WET PROCESS AT HIGH RUBBER CONTENT

- RUBBER MODIFIED BINDERS AT 15-22% OF RUBBER O/ WEIGHT OF MODIFIED BINDER
- ESPECIAL PLANTS (BLENDING UNIT) FOR HIGH RUBBER CONTENT (POWERFUL TO WORK WITH A VERY HIGH VISCOSITY PRODUCT).
- THE BLENDING UNIT IS USUALLY MOBILE. THE CONNECTION TO THE APHALT PLANT GETS 1 DAY PERIOD OF INACTIVITY IN THE PLANT
- NO ADDITIVES: JUST BITUMEN AND RUBBER

3) WET PROCESS AT HIGH RUBBER CONTENT



SPANISH EXPERIENCE

1) DRY PROCESS

SPANISH EXPERIENCE – DRY PROCESS

Spain has more than 300 km of pavement by the dry process

Most of them:

- Rubber size < 0,5 mm
- % of rubber: 0,5-1% (up to 2%)
- % bitumen + rubber: 5-6% o/ mixture
- Digestion time: 1-2 hours
- Wearing, binder and base courses
- Mainly*** **low volume of traffic**

MANUAL OPERATION

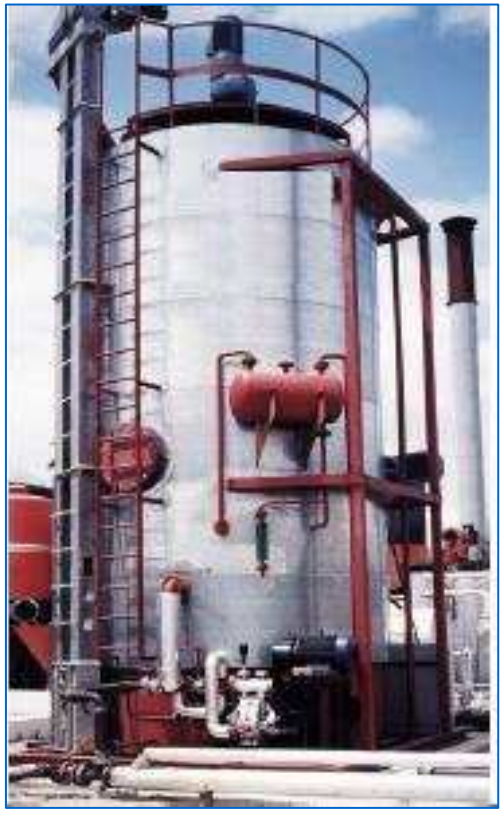
AUTOMATIC OPERATION

SPANISH EXPERIENCE

2) RUBBER MODIFIED BITUMEN

(TERMINAL BLENDING)

SPANISH EXPERIENCE (TERMINAL BLENDING)



- 400 km of roads and streets
- Rubber size < 0,5 mm
- % de rubber: 8-12% o/ weight of modified binder
- % Bitumen+ rubber: 5,5-6% o/ mixture
- NO additional digestion needed
- Wearing and binder course
- Some problems of sediments in the tanks

SPANISH EXPERIENCE

3) RUBBER MODIFIED BINDER

“AT HIGH RUBBER CONTENT”

SPAIN - RMB AT HIGHT RUBBER CONTENT

- 400 km of roads (Technical adviser: Universidad Politécnica Madrid)
- Rubber size < 1 mm
- % of rubber: 18-22% o/ weight of modified binder
- % bitumen + rubber: 8-9% o/ weight of the mixture
- NO additional digestion needed
- Wearing and binder courses (even airport runway)

SPAIN – RMB AT HIGH RUBBER CONTENT

MOBILE BLENDING UNIT

SPAIN – RMB AT HIGH RUBBER CONTENT

SPAIN – RMB AT HIGH RUBBER CONTENT

SPAIN – RMB AT HIGH RUBBER CONTENT

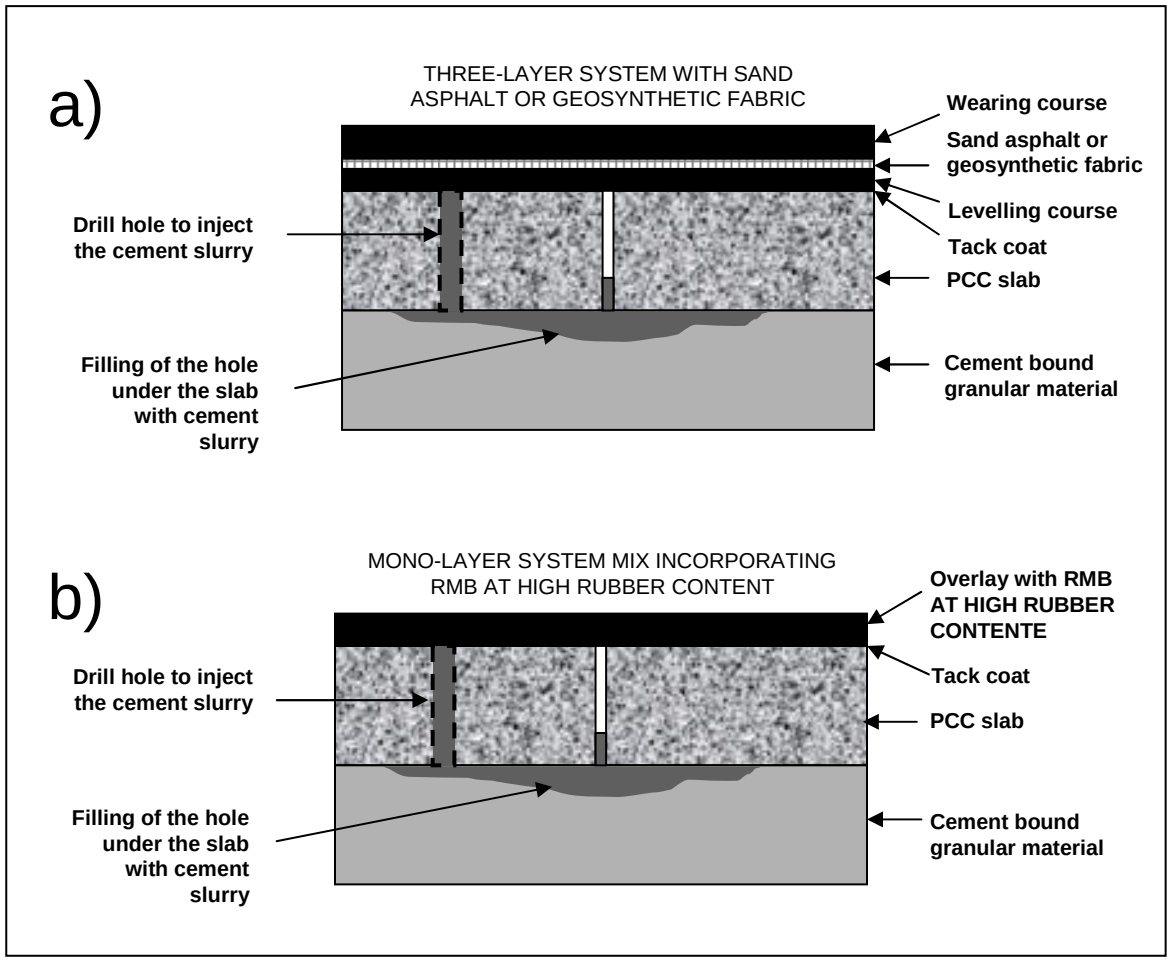
AP-7

Autopista del Mediterráneo

OVERLY:

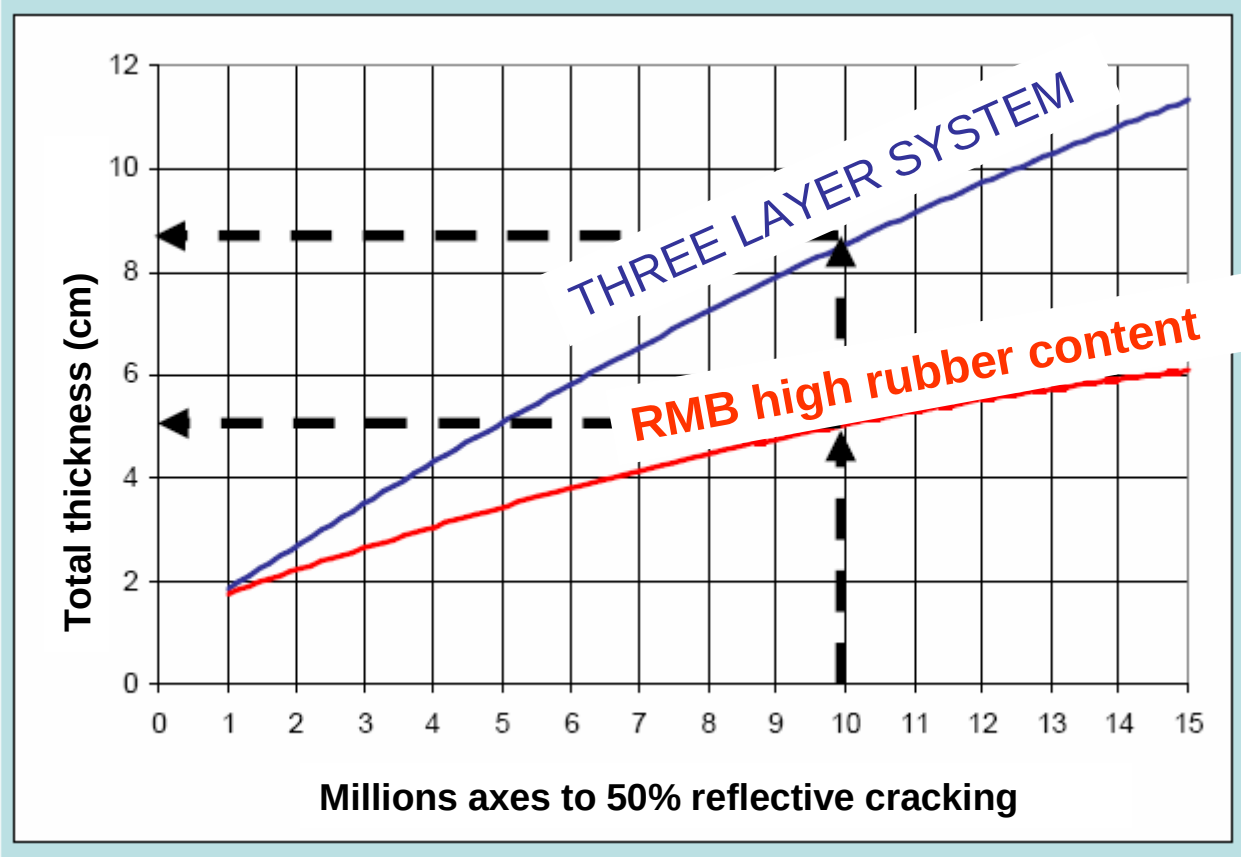
5 cm of asphalt mixture with
9% of RMB at high rubber content

SPAIN – RMB AT HIGH RUBBER CONTENT



SPAIN – RMB AT HIGH RUBBER CONTENT

SPAIN – RMB AT HIGH RUBBER CONTENT



IN SHORT …

TECNOLOGY		RUBBER OVER (BITUMEN + + RUBBER)	(BITUMEN + RUBBER) OVER MIXTURE	RUBBER OVER MIXTURE	NOVELTY IN PERFORMANCE VERSUS PMB
DRY PROCESS		10-20 %	5,2-5,7 %	0,5-1,0 %	NO
WET PROCESS	TERMINAL BLENDING	5-12 %	5,5-6,0 %	0,3-0,7 %	NO LIKE THE PREVIOUS PMB
	AT HIGH RUBBER CONTENT (MOBILE BLENDING UNIT)	18-22 %	8,0-9,0 %	1,4-2,0%	YES HIGH STRENGTH IN PREVENTING REFLECTIVE CRACKING

The percentages on the ABOVE table must be checked in the laboratory in every study case

RUBBER MODIFIED BINDERS:

SPANISH SPECIFICATIONS

CIRCULAR ORDER 5bis / 2002

YEAR 2002:

CIRCULAR ORDER 5bis/2002 by Dirección General de Carreteras del Ministerio de Fomento:

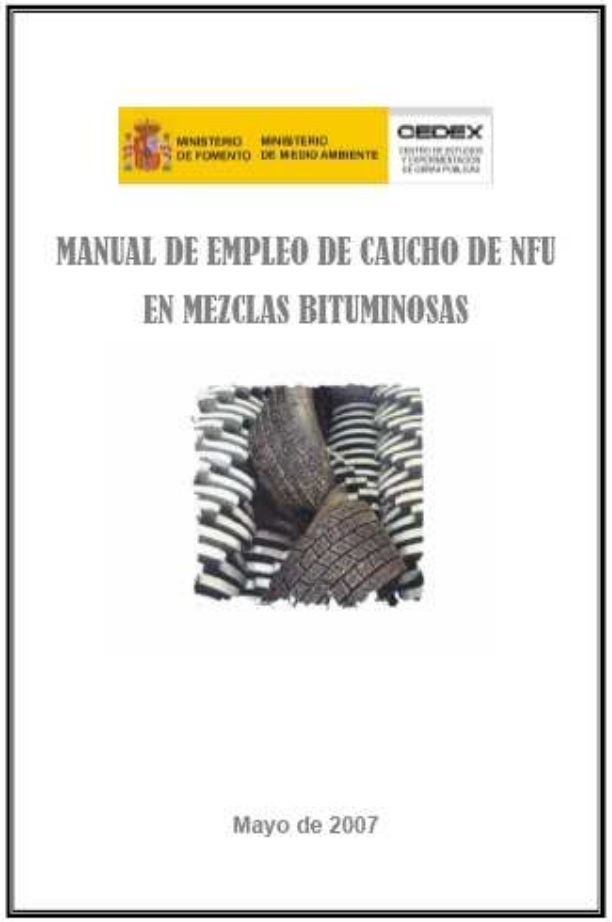
Mandatory order to change some articles of the Spanish Specifications PG-3 regarding binders for asphalt mixes.

Literal translation:

Material incorporating ground rubber from waste tires will be applied “as long as the application is technical and economically viable”.

MANUAL DE MEZCLAS CON CAUCHO

YEAR 2007:



HANDBOOK:

RUBBER FROM WASTE TIRE TO MODIFY ASPHALT MIXTURES

(CEDEX) –MMA-MFOM

By a group of experts from the industry, the University and the Public Road Administration (Ministerio de Fomento)

It is not a mandatory document but a guide to select the proper technology. It provides the pavement engineer with good practice information to achieve success in the application of several technologies with rubber.

CIRCULAR ORDER 21 /2007

YEAR 2007:

ORDEN CIRCULAR 21/2007 by Dirección General de Carreteras del Ministerio de Fomento:

It is a mandatory document that establish the requirements of asphalt material incorporating rubber from waste tires.

DRY PROCESS = Rubber added to the hot asphalt mixture

WET PROCESS
- Betunes mejorados con caucho “BC” (Enhanced bitumen)
- Betunes modificados con caucho “BMC” (Rubber modified binders)
- Betunes modificados de alta viscosidad con caucho “BMAVC” (Rubber modified bitumens at high rubber content)

CIRCULAR ORDER 21 /2007

Enhanced bitumen (BC)

- Just a bit of rubber
- Terminal blending manufacture
- Properties do not reach PMB in art. 215 PG-3 (Spanish specifications for PMB)
- New specification for this category

Rubber modified binder (BMC)

- An intermediate content of rubber
- Terminal blending
- They must meet article 215 ofl PG-3

Rubber modified binders at high rubber content (BMAVC)

- High rubber content
- High viscosity at working temperatures
- Manufactured in Mobile blending units
- New specifications for this category

CIRCULAR ORDER 21 /2007

Tabla 1.- Especificaciones de betunes mejorados con caucho (BC)

Característica		Norma de referencia	Unidad	BC35/50	BC50/70
Betún original					
Penetración, 25ºC		UNE EN 1426	0,1mm	35-50	50-70
Punto de reblandecimiento anillo y bola		UNE EN 1427	ºC	≥ 58	≥ 53
Punto de fragilidad Fraass		UNE EN 12593	ºC	≤ -5	≤ -8
Fuerza ductilidad (5cm/min)	5ºC	UNE EN 13589 UNE EN 13703	J/cm²	≥ 0,5	
Recuperación elástica a 25 ºC		UNE EN 13398	%	≥ 10	
Estabilidad al almacenamiento(*)	Diferencia anillo y bola	UNE EN 13399	ºC	≤ 10	
	Diferencia de penetración		0,1mm	≤ 8	≤ 10
Solubilidad		UNE EN 12592	%	≥ 92	
Punto de Inflamación v/a		UNE EN ISO 2592	ºC	≥ 235	
Residuo del ensayo de película fina y rotatoria		UNE EN 12607-1			
Variación de masa		UNE EN 12607-1	%	≤ 1,0	
Penetración retenida		UNE EN 1426	%p.o.	≥ 65	≥ 60
Variación del Punto de Reblandecimiento		UNE EN 1427	ºC	mín -4 máx +8	mín -5 máx +10

(*) Únicamente exigible a ligantes que no se fabriquen "in situ"

CIRCULAR ORDER 21 /2007- Ref. art 215 del PG-3

Característica		Unidad	Norma NLT	BM-1		BM-2		BM-3a		BM-3b		BM-3c		BM-4		BM-5	
				Mín.	Máx.	Mín.	Máx.	Mín.	Máx.	Mín.	Máx.	Mín.	Máx.	Mín.	Máx.	Mín.	Máx.
Betún original																	
Penetración (25 °C; 100 g; 5 s)		0,1 mm	124	15	30	35	50	55	70	55	70	55	70	80	130	150	200
Punto de reblandecimiento anillo y bola		°C	125	70	—	65	—	58	—	60	—	65	—	60	—	55	—
Punto de fragilidad fraass		°C	182	—	-4	—	-8	—	-10	—	-12	—	-15	—	-15	—	-20
Ductilidad (5 cm/min):	A 5 °C	cm	126	—	—	2	—	4	—	25	—	30	—	40	—	50	—
	A 25 °C	cm	126	10	—	—	—	—	—	—	—	—	—	—	—	—	—
Consistencia (flotador a 60 °C)		s	183	3.000	—	2.000	—	700	—	1.200	—	2.000	—	1.200	—	1.200	—
*Estabilidad al almacenamiento**																	
Diferencia punto reblandecimiento		°C	328	—	5	—	5	—	5	—	5	—	5	—	5	—	5
Diferencia penetración (25 °C)		0,1 mm		—	5	—	8	—	10	—	10	—	10				
Recuperación elástica	25 °C	%	329	—	—	10	—	15	—	40	—	70	—				
	40 °C	%	329	15	—	—	—	—	—	—	—	—	—				
Contenido en agua (en volumen)		%	123	—	0,2	—	0,2	—	0,2	—	0,2	—	0,2				
Punto de inflamación		°C	127	235	—	235	—	235	—	235	—	235	—				
con cemento			122	1,0	—	1,0	—	1,0	—	1,0	—	1,0	—	1,0	—	1,0	—
Residuo después de película fina																	
Variación de masa		%	185	—	0,8	—	0,8	—	1,0	—	1,0	—	1,0	—	1,4	—	1,5
Penetración (25 °C; 100 g; 5 s)		% p.o.	124	70	—	70	—	65	—	65	—	65	—	60	—	55	—
Variación punto de reblandecimiento anillo y bola		°C	125	-4	8	-4	8	-5	10	-5	10	-5	10	-6	10	-6	10
Ductilidad (5 cm/min):	A 5 °C	cm	126	—	—	1	—	2	—	12	—	15	—	20	—	25	—
	A 25 °C	cm	126	5	—	—	—	—	—	—	—	—	—	—	—	—	—

BM-3b with rubber (Caucho) will be called BMC-3b

CIRCULAR ORDER 21 /2007

Tabla 2.- Especificaciones de betunes modificados de alta viscosidad con caucho (BMAVC)

Característica		Norma de referencia	Unidad	BMAVC-1	BMAVC-2	BMAVC-3
Betún original						
Penetración, 25ºC		UNE EN 1426	0,1mm	15-30	35-50	55-70
Punto de Reblandecimiento		UNE EN 1427	ºC	≥ 75	≥ 70	≥ 70
Punto de Fragilidad Fraass		UNE EN 12593	ºC	≤ -4	≤ -8	≤ -15
Fuerza Ductilidad (5cm/min)	5ºC	UNE EN 13589 UNE EN 13703	J/cm²	--	≥ 2	≥ 3
	10 ºC			≥ 2	--	--
Consistencia (Flotador a 60ºC)		NLT 183	s	≥ 3000		
Viscosidad dinámica	135 ºC	UNE EN 13302	mPa.s		≤ 7500	≤ 5000
	170ºC			≥ 2000	≥ 1200	≥ 800
Recuperación elástica	25ºC	UNE EN 13398	%	≥ 10	≥ 20	≥ 30
Estabilidad al almacenamiento (*)	Diferencia de anillo y bola	UNE EN 13399	ºC	≤ 5		
	Diferencia de penetración		0,1mm	≤ 20		
Punto de Inflamación v/a		UNE EN ISO 2592	ºC	≥ 235		
Residuo del ensayo de película fina y rotatoria		UNE EN 12607-1				
Variación de masa		UNE EN 12607-1	%	≤ 0,8	≤ 0,8	≤ 1,0
Penetración retenida		UNE EN 1426	%p.o.	≥ 60		
Variación del Punto de Reblandecimiento		UNE EN 1427	ºC	mín -4 máx +10		mín -5 máx +12

(*) Únicamente exigible a ligantes que no se fabriquen "in situ"

Más de 400 km en España

CIRCULAR ORDER 21 /2007

PROPER APPLICATION OF THESE TECHNOLOGIES

- **ENHANCED BITUMEN (BC) =>** Application in projects that used to apply net bitumen
- **RUBBER MODIFIED BINDERS (BMC) =** Application in projects that used to apply PMB
- **RUBBER MODIFIED BINDERS AT HIGH RUBBER CONTENT (BMAVC) =** Application in projects which demand materials to prevent reflective cracking

Amendments in PG-3 (art. 542 y 543)

The new rubber-binders appear in the tables of binders to be selected

TABLA 542.1 - TIPO DE LIGANTE HIDROCARBONADO A EMPLEAR
(Artículos 211 y 215 de este Pliego y OC 21/2007)
A) EN CAPA DE RODADURA Y SIGUIENTE

ZONA TÉRMICA ESTIVAL	CATEGORÍA DE TRÁFICO PESADO					
	T00	T0	T1	T2 y T31	T32 y arcenes	T4
CÁLIDA	B40/50 BC35/50 BM-2 BM-3c		B40/50 B60/70 BC35/50 BC50/70 BM-2 BM-3b BM-3c	B40/50 B60/70 BC35/50 BC50/70 BM-3b	B60/70 BC50/70	
MEDIA	B40/50 B60/70 BC35/50 BC50/70 BM-3b BM-3c		B60/70 BC50/70 BM-3b			B60/70 B80/100 BC50/70
TEMPLADA	B40/50 B60/70 BC35/50 BC50/70 BM-3b BM-3c		B60/70 B80/100 BC50/70 BM-3b		B60/70 B80/100 BC50/70	

- Se podrán emplear también betunes modificados con caucho que sean equivalentes a los betunes modificados de esta tabla, siempre que cumplan las especificaciones del artículo 215 de este Pliego. En ese caso, a la denominación del betún se añadirá una letra C mayúscula, para indicar que el agente modificador es caucho procedente de neumáticos fuera de uso.

CAMBIOS EN EL PG-3 (art. 542 y 543)

TABLA 543.1 - TIPO DE LIGANTE HIDROCARBONADO A EMPLEAR

(Artículos 211 y 215 de este Pliego y OC 21/2007)

TIPO DE MEZCLA	CATEGORÍA DE TRÁFICO PESADO				
	T00 y T0	T1	T2(*) y T31	T32 y arcenes	T4
DISCONTINUA	BM-3c	BM-3c BM-3b	BM-3b B60/70 BC50/70	B60/70 B80/100 BC50/70	
DRENANTE	BM-3c	BM-3c BM-3a BM-3b	BM-3a BM-3b B60/70 BC50/70	B60/70 B80/100 BC50/70	

(*) Para tráfico T2 se emplearán betunes modificados en autovías o cuando la IMD sea superior a 5.000 vehículos por día y carril

- Se podrán emplear también betunes modificados con caucho que sean equivalentes a los betunes modificados de esta tabla, siempre que cumplan las especificaciones del artículo 215 de este Pliego. En ese caso, a la denominación del betún se le añadirá una letra C mayúscula, para indicar que el agente modificador es caucho procedente de neumáticos fuera de uso.

CHANGES IN PG-3 (art. 542 y 543)

•BMAVC binders had not been incorporated in the PG-3 because the need an aggregate grading different from those of conventional asphalt mixes. So, they need an new article for their use, no just particular changes in the existing specifications of asphalt mixtures.

CIRCULAR ORDER 21bis /2009

After two years of experience it was necessary to improve the C.O. 21/2007 because of problems with the stockability of rubber binders in the tanks of the asphalt plants.

C.O. 21bis/2009 establish the use of vertical tanks provided with a vertical stirrer to prevent sedimentation of the rubber during its storage period at the asphalt plant

THANK YOU