Binder interaction in asphalt pavement recycling. Some experiences in Spain

José Luis Peña
TIMELINE OF RECYCLING TECHNOLOGY IN SPAIN

BINDER SELECTION

BLENDING PROCESS
Timeline of recycling technology in Spain

1983
First experiences for hot recycling with low RAP rates < 20% (A-2 motorway)

1986
Research project ACESA-REPSOL using rejuvenators for hot recycling (1,5 km test track).

1991
In situ cold-recycling: test track (Huesca)
Timeline of recycling technology in Spain

90’s
several works with in situ cold recycling and rejuvenators included into the emulsion

1996
in situ hot recycling

2002
Publication of normative rules for hot and cold recycling (PG-4).
Timeline of recycling technology in Spain

- **2000's**: First experiences with half-warm recycling
- **2012**: Hot recycling with high RAP rates (50-60%). Batch and continuous asphalt plants
- **2017**: Revision of normative rules for hot and cold recycling (PG-4).

**Revision of normative rules for hot and cold recycling (PG-4).**

**Hot recycling with high RAP rates (50-60%). Batch and continuous asphalt plants.**
Use of rejuvenators in Spain

- In plant hot recycling
- In situ hot recycling
- In situ cold recycling

Rejuvenators included in the bitumen. No standarizacion for this chemicals.
Aged bitumen

<table>
<thead>
<tr>
<th>Proyecto</th>
<th>Carretera</th>
<th>Kilometrajes</th>
<th>Ligante de aportación</th>
<th>Tipo de mezcla</th>
<th>Mezcla reciclada (Ton)</th>
<th>RAP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N-230</td>
<td>163.2 al 187.1</td>
<td>B 100</td>
<td>S20 R50</td>
<td>30.000</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>A-7</td>
<td>566.0 al 572.0</td>
<td>B 110</td>
<td>G/S20 R50</td>
<td>20.000</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>A-140</td>
<td>16.3 al 22.2</td>
<td>REJUV-250</td>
<td>S20 R60</td>
<td>16.128</td>
<td>60</td>
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<td>REJUV-200</td>
<td>S12 R40</td>
<td>12.960</td>
<td>40</td>
</tr>
</tbody>
</table>
Aged bitumen

Original bitumen

- 35-50 pen
- 50-70 pen

RAP

- Aged bitumen
- 6-15 pen
Selection of binder

Penetration (defines type and amount of the new binder)

Ring&ball

IP

Fraass breaking point

Ductility

2002 standards

GOAL
Replicate a new paving bitumen

For mixes with RAP >25%
Selection of binder

**GOAL**

"The new binder will be selected on the basis of the proportion and the characteristics of the aged binder of the RAP, so that when combined with the mixed binder that is obtained, fulfills characteristics similar to those indicated in the specs for paving bitumens.”

- Penetration
- Ring&ball
- Fraass breaking point
- Force-ductility
- Viscosity (rotating spindle)
- Complex modulus
- Phase angle

**2017 standards**

Warm mixes allowed
Former criteria assumed total blending of aged and new bitumen

Binder blending-diffusion

Source SNF2018

BLENDING-DIFUSSION
Leading properties

- Chemical affinity.
- Viscosity.
- Temperature.
- Time.
- Mixing energy.
Binder blending-diffusion

Performance of cold-recycled mixes after 10 years of service

RESULTS
Similar performance than base hot mixes

Source Proyecto Fénix
Even in cold recycling blending-diffusion occurs

DSR configuration to monitor the diffusion between two bitumens of different viscosity

Source Project SCORE
Binder blending-difussion

Mixing procedures

Source: “Motores y Carreteras”
Hot recycling can lead to an increase in the carbon footprint of the manufacturing process.

Some types of rejuvenators based on aromatic compounds can increase emissions from asphalt mixtures.

Getting the right blending between the new binder, rejuvenators and aged binder when cold RAP is added to the mixer, usually requires a decrease in the production rate of asphalt plants.
Blending verification

Fourier IR spectroscopy test to verify blending of new and aged binders
Current practice in Spain

- Regular use of cold recycling.

- Low rates of RAP in hot recycling (15-30%). Typically, added to the mixer as cold RAP (without rejuvenators).

- Rheological evaluation scarcely used: only in some R&D projects.
Main failure mode in Spanish roads is cracking.

Increasing RAP rates without a suitable “rejuvenating” treatment could increase severity of cracking failure.

Most of the works are focused on the surface course, where RAP is not allowed for intermediate and high road traffic intensity.

It is difficult to implement rheological tests of the binder during mix design.

A practical approach could be addressed to use mechanical tests of the mixes to verify a suitable blending and rejuvenating effect.
Thank you

José Luis Peña
@joluperd