Update of Emulsion based mixes (cold & warm)

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**EMULSIONS MARKET IN SPAIN**

- **Stable market** (2004 to 2007) and now in decrease
- **50 Production Plants**
- **Results**
  - 310,000 t in 2005
  - 251,000 t in 2009

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PRODUCTION 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL ANIONICS</td>
<td>4,188</td>
</tr>
<tr>
<td>TOTAL CATIONICS</td>
<td>246,941</td>
</tr>
<tr>
<td>Quick</td>
<td>199,385</td>
</tr>
<tr>
<td>Medium</td>
<td>10,776</td>
</tr>
<tr>
<td>Slow</td>
<td>36,780</td>
</tr>
<tr>
<td>THERMO-ADHERENT</td>
<td>31,060</td>
</tr>
<tr>
<td>MODIFIED EMULSIONS</td>
<td>13,047</td>
</tr>
<tr>
<td>TOTAL EMULSIONS</td>
<td>251,129</td>
</tr>
</tbody>
</table>

**CIFRES IN TONNES**

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### Types of Emulsions

<table>
<thead>
<tr>
<th>Types of Emulsions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Emulsions</td>
<td>94%</td>
</tr>
<tr>
<td>Polymer Modified Emulsions</td>
<td>6%</td>
</tr>
</tbody>
</table>

### Particle Polarity

<table>
<thead>
<tr>
<th>Particle Polarity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cationic Emulsions</td>
<td>97%</td>
</tr>
<tr>
<td>Anionic Emulsions</td>
<td>3%</td>
</tr>
</tbody>
</table>

### Applications

<table>
<thead>
<tr>
<th>Applications</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>78% Quick setting emulsions</td>
<td>22%</td>
</tr>
<tr>
<td>51% Tack coat</td>
<td></td>
</tr>
<tr>
<td>7% Medium setting emulsions</td>
<td></td>
</tr>
<tr>
<td>51% Surface dressing</td>
<td>78%</td>
</tr>
<tr>
<td>15% Slow setting emulsions</td>
<td></td>
</tr>
<tr>
<td>Porous cold mixes</td>
<td>2%</td>
</tr>
<tr>
<td>2% Grave-emulsion</td>
<td></td>
</tr>
<tr>
<td>5% Slurry-seal</td>
<td></td>
</tr>
<tr>
<td>2% Recycling</td>
<td></td>
</tr>
<tr>
<td>6% Priming emulsions</td>
<td></td>
</tr>
</tbody>
</table>
HOW INCREASE THE EMULSION MARKET?

We are working to:

• Represent Emulsions producers and to support them.

• Improve our emulsions for the new requirements.

• Acceptance of European Specifications (EN 13808)

• Focus on Government to enclose cold and warm techniques in the work projects.

• Education and training of new professionals
Main Problems found in conservation of roads

- Lack of financial resources
- Lack of natural resources
- High energy costs
- Few human resources with proper qualification
- For environmental issues in road construction. They allow minimizing the use of non-renewable resources (fuel, bitumen, aggregates).

- There are techniques that let us reach similar performance levels than the conventional ones (warm mixes).

- The use of bituminous emulsions allows the manufacturing and working temperature close to ambient. Avoid generation of greenhouse gases.
COLD MIXES

- COATS
  - Priming & Tack Coat
  - Surface Dressing

- MIXES
  - Slurry Surfacing
  - Open Cold Mixes
  - Emulsion-Bound Granular Material
  - Cold Recycling

WARM MIXES

- Warm Mixes
- Warm Recycling
OBJECTIVES:

During the past years, we have been present in the improvement of cold techniques related to the development of new and more efficient bituminous emulsions on road works.

This is the position for prime emulsions, where some research has been done to develop this type of emulsions with ecological fluxes, to be able to pour them onto hydraulic layers before laying asphalt mixes for wearing courses.
NEW EMULSIONS FOR IMPREGNATING

- Flux free (VOC´s free)
- Low viscosity and small size particles
- Efficiency (Penetration power according to EN 12849)
Correct tack coating is extremely important, not only in order to seal the existing surface against the entry of water and, but also to bond the wearing course to the base course.

Inadequate bonding between layers can result in detachment, followed by longitudinal wheel path cracking, potholes and other distresses, such as rutting that greatly reduce the life of the pavement.
The use of conventional emulsions for tack coats can cause problems as they frequently stick to the tires of construction vehicles. Consequently, the bond between the asphalt layers is inadequate. The importance of tack coats in the performance of the pavement means that bituminous emulsions are constantly being improved.

New types of emulsions have been developed from hard bitumen. They are called "thermo-adherent " emulsions and they are resistant to construction vehicles.
Main goals:
• High adhesion to pavement surface and no adherence to tyres.
• Cleanliness on work site.
• Others:
  – More efficiency and lower dosage (save 30% dosage)
  – To improve storage stability (>7 days)
  – To improve workability
  – Reduced setting time (20-60 minutes, depending on the climatic conditions)
WE HAVE SEVERAL TESTS TO MEASURE THE EFFECTIVENESS OF NEW TACK COAT EMULSION AND TO VERIFY ITS PERFORMANCE IN SERVICE, COMPARED TO A CONVENTIONAL EMULSION:

LCB SHEAR TEST, developed in the Road Research Laboratory of the Technical University of Cataluña (Spain)
Spreading. Recommendations

• Tack coat emulsion must be applied by an emulsion spray bar over the entire width of the application area.
• The recommended rates may be between 300-400 g/m² of emulsion.
• Heating is not recommend above 60°C for its final application.
• Spreading of the upper layer of HMA will be carried out after the tack coat emulsion has broken.
RESISTANCE TO WORK TRAFFIC
WHY SURFACE DRESSINGS?

- SAFETY THANKS TO MACROTTEXTURE
- GOOD FOR DURABILITY OF THE PAVEMENTS
- ECONOMIC WEARING COURSE
- HIGH VERSATILITY OF THE MAINTENANCE TECHNIQUES
- NOYSY WEARING COURSE
OTHER APPLICATIONS:

1. Slurry seals (maintenance technique)

2. Cold mixes (decreasing technique) and warm mixes (increasing technique)

3. Cold and warm recycling
• **SLURRY SEAL (MAINTENANCE/SAFETY ROAD)**

- **SURFACE WATERPROOFING**
  - Ageing prevention
  - Increase Durability
  - Avoid water action in Base layer

- **NON-SLIPPING SURFACE LAYERS**
  - Avoid roughness loss
  - Improve slipping resistance

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USEFUL FOR:

- NEW WEARING COURSE
- NEW BINDER COURSE
- BITUMINOUS MACADAM
- FLEXIBLE PAVEMENT
- POTHOLES REPAIR
- CRACKING RESISTANT PAVEMENT
Lab tests on cold mix formulations

Open graded cold mix - Grading envelope

<table>
<thead>
<tr>
<th>TAMIZ UNE</th>
<th>CURVA</th>
<th>AF10</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,5</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>2,5</td>
<td>4,7</td>
<td>0</td>
</tr>
<tr>
<td>0,32</td>
<td>1,3</td>
<td>0</td>
</tr>
<tr>
<td>0,08</td>
<td>1,0</td>
<td>2</td>
</tr>
</tbody>
</table>

![Graph showing grading envelope for cold mix formulations](image-url)
## Tests on Open Cold Mix Formulations

<table>
<thead>
<tr>
<th></th>
<th>Emulsion C67BF4</th>
<th>Emulsion C67BF4 Bio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Emulsión</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Breaking Time, s</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Initial Covered Surface Area, %</td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td>24 H Covered Surface Area, %</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Coating Qualification</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>Cohesión / Workability</td>
<td>GOOD</td>
<td>GOOD</td>
</tr>
<tr>
<td>Behaviour in the Presence of Water</td>
<td>VERY GOOD</td>
<td>VERY GOOD</td>
</tr>
</tbody>
</table>

Cold mix after coating (before compaction)

Cold mix after compaction
These types of cold mixes...

1. are suitable for minor repairs on all classes of roads, paths and footways.
2. harden over time to match the performance of traditional hot-mixed asphalt.
3. may be overlaid with any road surfacing material, or sealed with surface treatments, such as surface dressing or microsurfacing.
4. suffer no immediate damage from rain or frost, when properly laid.
Porous hot mix asphalt repairing

- High flexibility
- Excellent mechanical performance
- Stockage capability
- Workability at ambient temperature
- High drainability
- Good initial cohesion after compaction
- Used of modified medium setting emulsion
Warm techniques: Porous mixes
To recover the original properties of the pavement and, if possible, improve them.

Properties:

- Structural capacities or mechanical resistance
- Resistance to water action
- Resistance to fatigue
It is an homogeneous mixture, properly laid and compacted, of milled material from one or more pavement layers (6 - 12 cm), with bituminous emulsion, water and additives (if required).

The recommended emulsion is a slow setting emulsion, type C60 B5 according to EN 13808.

Classes:
1. type III (only RAP)
2. type I or type II (RAP + granular material)

More information on ATEB web.
Milled material (RAP) 100
Emulsión C60B5 (ref % dry RAP) 3
Prewetting water (ref % dry RAP) 2,5

Inmersion - Compression test results:

<table>
<thead>
<tr>
<th></th>
<th>ECL-2</th>
<th>BIOECL-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry resistance (MPa)</td>
<td>4,1</td>
<td>4,5</td>
</tr>
<tr>
<td>Soaked resistance (MPa)</td>
<td>3,2</td>
<td>3,3</td>
</tr>
<tr>
<td>Retained resistance (%)</td>
<td>77</td>
<td>75</td>
</tr>
<tr>
<td>Specific gravity s.s.s (g/cm³)</td>
<td>2,272</td>
<td>2,274</td>
</tr>
</tbody>
</table>
Items to have in consideration

Need of paving rehabilitation

- Characterization of the existing pavement and quantification of required solicitations
- Diagnosis of possible problems and forecast of their evolution
- Choice of the most adequate solution and its project

Method

Solution
Advantages

It takes advantage of cold recycling:

- Recycling up to 100%
- Using bituminous emulsions

It takes advantage of hot recycling:

- It can be produced in continuous or discontinuous plants
- The opening to traffic is immediate – no need of curing period
Cold recycling “in situ” with BITUMINOUS EMULSION
- 100% of milled material + water + emulsion (medium temp.)
- Curing time between 20 to 30 days

Hot recycling in plant with BITUMEN
- Milled material + aggregates + bitumen (160ºC)
- 20 to 30% milled material

Warm recycling with bituminous emulsion
- 100% of milled material + emulsion (medium temp.)
- Produced in plant
- Without later curing period
Update of Emulsion based mixes (cold & warm)

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RAP

GRANUALATES if it is required

Bituminous emulsion

Mixture

WARM MIXTURES PRODUCTION
Materials

Aggregates
Milled material

Binder
Special emulsion (C60B7) that provides:

- Coating 100%, with no binder run-off
- Resistance to thermal shock
- High initial cohesion
- High active and passive adhesivity
- High workability
Milled material characterization:

- Grading envelope
- Binder content and characteristics

Immersion-compression test:

- Compression of samples at different loads
  - 17 at 6 ton (6 ton to obtain similar densities as the ones found in the field)
- Temperatures
  - Mixing = 90°C
  - Compacting = 60°C

Dynamic modulus test
**Recovered binder**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration</td>
<td>13</td>
</tr>
<tr>
<td>Softening point (°C)</td>
<td>66</td>
</tr>
<tr>
<td>Solubility (%)</td>
<td>98,8</td>
</tr>
<tr>
<td>Asphaltenes (%)</td>
<td>18,5</td>
</tr>
</tbody>
</table>
### Immersion-compression

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry resistance</td>
<td>5.0 MPa</td>
</tr>
<tr>
<td>Wet resistance</td>
<td>3.7 MPa</td>
</tr>
<tr>
<td>Retained resistance</td>
<td>75%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.249 g/cm³</td>
</tr>
<tr>
<td>Air voids</td>
<td>7.1%</td>
</tr>
</tbody>
</table>

### Dynamic modulus 20°C – 10Hz

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic modulus</td>
<td>6.736 MPa</td>
</tr>
<tr>
<td>Phase angle</td>
<td>17°</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.193 g/cm³</td>
</tr>
<tr>
<td>Air voids</td>
<td>7.5%</td>
</tr>
</tbody>
</table>
- Conventional hot mix Plant:
  - Continuous
  - Discontinuous

- Implementation of a feed system, if necessary
- No need of technical adaptations (adaptations cost is null)
- Similar to the manufacture and put in place of a hot bituminous mix
- Milled material is warmed at 90 – 95°C
- Mix with emulsion
- Storage capability
- Transport to the local laying
Update of Emulsion based mixes (cold & warm)

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ATEB (Spain)

- Conventional laying
- The spreading equipment is the same as the one used for Hot bituminous mixes
- Previous compaction
- Special attention to the minimum temperature of compaction
- Compaction is made by using a metallic cylinder and a pneumatic one
- Opening to traffic is immediate
Work experience (Warm recycling in EN 244)
Work experience (Warm recycling in EN 244)
## Emissions Measurements

<table>
<thead>
<tr>
<th></th>
<th>Hot mix</th>
<th>Warm mix</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>155ºC-165ºC</td>
<td>80ºC-90ºC</td>
<td>70 ºC</td>
</tr>
<tr>
<td>Fumes temperature</td>
<td>65,6ºC</td>
<td>45ºC</td>
<td>- 30ºC</td>
</tr>
<tr>
<td>CO₂ (%)</td>
<td>2,12</td>
<td>1,39</td>
<td>- 35 %</td>
</tr>
<tr>
<td>CO (ppm)</td>
<td>217</td>
<td>131,6</td>
<td>- 40 %</td>
</tr>
<tr>
<td>NOx (mg/m³ eg. NO₂)</td>
<td>26,8</td>
<td>11,5</td>
<td>- 65 %</td>
</tr>
<tr>
<td>Air Dust (mg/m³)</td>
<td>168</td>
<td>21</td>
<td>- 88 %</td>
</tr>
</tbody>
</table>
- It is a environmentally friendly solution
- Use of milled material up to 100% (possible no need of new aggregates)
- Storage capability
- No curing period needed
- Manufacture at 80-100°C
- Laying and compaction > 60°C
THANK YOU FOR YOUR ATENTION!

MERCI POUR VOTRE ATTENTION

GRACIAS POR SU ATENCIÓN