EMULSION BASED MIXES

Cold and half-warm mixes

Marimar Colás, ATEB President & IBEF Vice-President
0. CONTENT

1. Emulsion market in Spain
2. Why emulsion based mixes
3. Slurry seal
4. Open cold mixes
5. Warm mixes
6. Recycling
   1. Cold in place recycling
   2. Warm recycling
7. Conclusion
1. EMULSION MARKET IN SPAIN

- Stable market (2004-2007)
- Then in decrease cause economical crisis (min. 130.000t in 2013)
- Increase of 14% last year...
- Results
  - 315.000 t in 2004
  - 251.000 t in 2009
  - 148.000 t in 2014

<table>
<thead>
<tr>
<th>PRODUCTION 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL ANIONICS</td>
</tr>
<tr>
<td>TOTAL CATIONICS</td>
</tr>
<tr>
<td>Quick</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>Slow</td>
</tr>
<tr>
<td>THERMO-ADHERENT</td>
</tr>
<tr>
<td>MODIFIED EMULSIONS</td>
</tr>
<tr>
<td>TOTAL EMULSIONS</td>
</tr>
</tbody>
</table>

CIFRES IN TONNES

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# 1. EMULSION MARKET IN SPAIN

<table>
<thead>
<tr>
<th>Types of emulsions</th>
<th>89 % Conventional emulsions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11 % Polymer modified emulsions</td>
</tr>
<tr>
<td>Particle polarity</td>
<td>97 % Cationic Emulsions</td>
</tr>
<tr>
<td></td>
<td>3 % Anionic emulsions</td>
</tr>
<tr>
<td>Aplications</td>
<td></td>
</tr>
<tr>
<td>· 70 % Quick setting emulsions</td>
<td>40 % Tack coat</td>
</tr>
<tr>
<td></td>
<td>30 % Surface dressing</td>
</tr>
<tr>
<td>· 5 % Medium setting emulsions</td>
<td>Porous cold mixes</td>
</tr>
<tr>
<td>· 25 % Slow setting emulsions</td>
<td>3 % Grave-emulsion</td>
</tr>
<tr>
<td></td>
<td>5 % Slurry-seal</td>
</tr>
<tr>
<td></td>
<td>15 % Recycling</td>
</tr>
<tr>
<td></td>
<td>5 % Priming emulsions</td>
</tr>
</tbody>
</table>
How to 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
2. WHY EMULSION BASED MIXES?

- 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.
TYPES OF EMULSION BASED MIXES

COLD MIXES
- SLURRY SURFACING
- OPEN COLD MIXES
- EMULSION-BOUND GRANULAR MATERIAL
- COLD RECYCLING

WARM MIXES
- WARM MIXES
- WARM RECYCLING
3. SLURRY SEAL (MAINTENANCE & SAFETY ROADS)

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

- **NON-SLIPPING SURFACE LAYERS**
  - Avoid roughness loss
  - Improve slipping resistance
4. OPEN COLD MIXES

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

Open graded cold mix - Grading envelope

<table>
<thead>
<tr>
<th>TAMZUNE</th>
<th>CURVA</th>
<th>AF10</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</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>25</td>
<td>47</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>

% paa

Tamiz une

CURVA

AF10
# Lab tests on open cold mix formulations

**Cold mix after coating (before compaction)**

<table>
<thead>
<tr>
<th></th>
<th>EMULSION C67BF3</th>
<th>EMULSION C67BF3 BIO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ÁGREGATE</strong></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>EMULSOIÓN</strong></td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>BREAKING TIME, s</strong></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>INITIAL COVERED SURFACE AREA, %</strong></td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td><strong>24 H COVERED SURFACE AREA, %</strong></td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td><strong>COATING QUALIFICATION</strong></td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td><strong>COHESIÓN / WORKABILITY</strong></td>
<td>GOOD</td>
<td>GOOD</td>
</tr>
<tr>
<td><strong>BEHAVIOUR IN THE PRESENCE OF WATER</strong></td>
<td>VERY GOOD</td>
<td>VERY GOOD</td>
</tr>
</tbody>
</table>

**Cold mix after compaction**
**Application in patching**

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.
5. WARM TECHNIQUES

- 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 Porous mixes
6. RECYCLING?

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
Reasons for recycling a pavement

• Recover the original proprieties of the pavement and, if possible, improve them.
• Which ones?
  • - Structural capacities or mechanical resistance
  • - Resistance to water action
  • - Resistance to fatigue
Cold (in place) recycling with BITUMINOUS EMULSION
- 100% of milled material + water + emulsion (ambient temp.)
- Curing time between 20 to 30 days

Hot recycling (in plant) with BITUMEN
- Milled material + aggregates + bitumen (>160ºC)
- 20 to 50% milled material

Warm recycling with bituminous emulsion
- Up to 100% of milled material + emulsion (medium temp.)
- Produced in plant at 90-110ºC
- Without later curing period
6.1. COLD RECYCLING

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.
WORK MIX FORMULATIONS FOR RECYCLING

Milled material (RAP) 100
Emulsión C60B5 (ref % dry RAP) 3
Prewetting water (ref % dry RAP) 2,5

<table>
<thead>
<tr>
<th>ECL-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry resistance (MPa)</td>
</tr>
<tr>
<td>Soaked resistance (MPa)</td>
</tr>
<tr>
<td>Retained resistance (%)</td>
</tr>
<tr>
<td>Specific gravity s.s.s (g/cm³)</td>
</tr>
</tbody>
</table>

- Dry resistance (MPa): 4,1
- Soaked resistance (MPa): 3,2
- Retained resistance (%): 77
- Specific gravity s.s.s (g/cm³): 2,272
WARM MIXTURES PRODUCTION

RAP
GRANUALATES if it is required

Bituminous emulsion

Mixture

WARM MIXTURES PRODUCTION
6.2. Advantages for warm recycling

Takes advantage of cold recycling:
- Recycles up to 100%
- Uses bituminous emulsions

Takes advantage of hot recycling:
- Could be produced in continuous or discontinuous plants
- The opening to traffic is immediate – no need of curing period
Materials

Aggregates

Milled material

Binder

Special emulsion (C60B5) that provides:

• Coating 100%, with no binder run-off
• Resistance to thermal shock
• High initial cohesion
• High active and passive adhesivity
• High workability
Laboratory study

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>Property</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>

**Laboratory study**

**RAP**

- Penetration: 13
- Softening point (°C): 66
- Solubility (%): 98.8
- Asphaltenes (%): 18.5
## Laboratory study

### Mechanic results (comp. 6t)

#### 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>17º</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>
Manufacture and put in place

- Conventional hot mix Plant:
  - Continuous
  - Discontinuous
- Implementation of a feed system, if necessary
- No need of special technical adaptations
- Similar to manufacturing and putting in place of a hot bituminous mix
- Milled material is warmed at 90 – 95ºC
- Mix with emulsion
- Storage capability and transport to the local laying

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Put in place of warm recycling

- 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
Work experience
## Emissions Measurements

<table>
<thead>
<tr>
<th></th>
<th>Hot mix</th>
<th>Warm mix</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
<td>155°C-165°C</td>
<td>80°C-90°C</td>
<td>70 °C</td>
</tr>
<tr>
<td><strong>Fumes temperature</strong></td>
<td>65.6°C</td>
<td>45°C</td>
<td>- 30°C</td>
</tr>
<tr>
<td><strong>CO₂ (%)</strong></td>
<td>2.12%</td>
<td>1.39%</td>
<td>- 35 %</td>
</tr>
<tr>
<td><strong>CO (ppm)</strong></td>
<td>217</td>
<td>131.6</td>
<td>- 40 %</td>
</tr>
<tr>
<td><strong>NOx (mg/m³, eg NO₂)</strong></td>
<td>26.8</td>
<td>11.5</td>
<td>- 65 %</td>
</tr>
<tr>
<td><strong>Air Dust (mg/m³)</strong></td>
<td>168</td>
<td>21</td>
<td>- 88 %</td>
</tr>
</tbody>
</table>
7. CONCLUSIONS

- It is a solutions that is compatible with the environment
- It can be used up to 100% of the milled material
- Storage possibility
- Without curing period
- Manufacturing temperature (90-110ºC)
- Laying and compacting > 60ºC
- Possibility of not having new aggregates
THANK YOU / ACKNOWLEDGEMENTS

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