Evolution of Asphalt Mixes – Innovations in France
High modulus mixes – New wearing courses
Recycling – Warm Asphalt

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Framework
- Evolutions bituminous mixes on wearing courses
- Evolutions of structural bituminous mixes
- Mains innovations
  - Very thin asphalt mixes BBTM or VTAC
  - Noise reduction wearing course, specific BBTM
  - Porous asphalt
  - Warm asphalt mixes
  - Colours in asphalt, high resistance to rut, to skid, …
- Conclusion

Evolution of the need for wearing courses
- 1960: Structural strengthening – Thick AC (6 to 10cm) [BBSG]
- 1975: Surface maintenance – Thin AC (4 to 5cm) [BBM]
on good quality of underneath layers (structural and evenness)
- 1985 – 2000: Specific surface maintenance:
  - Skid resistance: Very thin AC (2 to 3cm) [BBTM], Ultrathin AC (1cm) [BBUM]
  - Comfort, Visibility: Porous AC (4cm) [BBDr]
  - Aesthetic with fine maximum size: Very thin AC (0/6 gap) [BBTM 0/6]
  - Decreasing of the noise: BBTM 0/6, or BBDr in very thin layer
  - Heavy rutting resistance: Special AC
  - Decreasing of fatigue damage: High modulus AC [BBME]

Trends in bituminous mixtures evolutions
Dissociation of layer functions:
- wearing course = surface characteristic
- base = structure

Wearing courses: main evolutions
- Thinner and thinner thickness -> 1 to 2cm
- Reduction of maximum size: 14 / 10 / 8 / 6 / 4 mm
- Mix design -> Gap graded formula
- Mix with more and more gravels
- Higher and higher porosity -> Tack coat with seal properties
- More frequent use of polymer modified binder or special binder
- Hot mixes; except for microsurfacing (ECF)
- Standardized products -> Performance requirements

Definitions of asphalt wearing courses

<table>
<thead>
<tr>
<th>Surface layer</th>
<th>International name</th>
<th>Thickness (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBSG (Béton Bitumineux Semi Grenus)</td>
<td>DAC (Dense Asphalt)</td>
<td>5-8</td>
</tr>
<tr>
<td>BBME (Béton Bitumineux à module élevé)</td>
<td>DAC with high performance</td>
<td>5-8</td>
</tr>
<tr>
<td>BBM (Béton Bitumineux Minces)</td>
<td>TAC (Thick Layer Surfacing)</td>
<td>3-4</td>
</tr>
<tr>
<td>BBDF (Béton Bitumineux drainant)</td>
<td>PA (Porous Asphalt)</td>
<td>4</td>
</tr>
<tr>
<td>BBTM (Béton Bitumineux Très Mince)</td>
<td>VTAC (Very Thin Layer)</td>
<td>2-3</td>
</tr>
<tr>
<td>BBUM (Béton Bitumineux Ultra Mince)</td>
<td>UTAC (Ultra Thin Layer)</td>
<td>1</td>
</tr>
</tbody>
</table>

Good compromise between high skidding resistance and low noise pavements
### Ranking of wearing courses

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Maximum size D, Grading Function, Surface Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick</td>
<td>0/10 or 0/6 well gap graded</td>
</tr>
<tr>
<td>Thin</td>
<td>TS, PA</td>
</tr>
<tr>
<td>Very Thin</td>
<td>Ultra Thin</td>
</tr>
</tbody>
</table>

### Main characteristics of AC

<table>
<thead>
<tr>
<th>Type</th>
<th>BBSG</th>
<th>BBM</th>
<th>BBT</th>
<th>BRUM</th>
<th>BBDr</th>
<th>ECF</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>10 - 14</td>
<td>10</td>
<td>6 - 10</td>
<td>6 - 10</td>
<td>(6) - 10</td>
<td>6 - 8 - 10</td>
</tr>
<tr>
<td>Binder</td>
<td>BmP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thick size</td>
<td>6 to 8</td>
<td>3 to 5</td>
<td>2 to 2.5</td>
<td>1 to 1.5</td>
<td>3 to 4</td>
<td>1</td>
</tr>
<tr>
<td>Spread (mm)</td>
<td>250 to 300</td>
<td>300 to 350</td>
<td>250 to 350</td>
<td>100</td>
<td>15 to 20</td>
<td></td>
</tr>
<tr>
<td>Total spread (mm)</td>
<td>250</td>
<td>300</td>
<td>300</td>
<td>+ 400</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Surface/year</td>
<td>5</td>
<td>6</td>
<td>27</td>
<td>1.5</td>
<td>1.5</td>
<td>30</td>
</tr>
<tr>
<td>Years of use</td>
<td>25</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Network</td>
<td>All</td>
<td>RN-RD</td>
<td>All (A)</td>
<td>RD</td>
<td>A</td>
<td>RD-town</td>
</tr>
</tbody>
</table>

March 2005 - assessment: only the order of magnitude

### Cut of Asphalt Concrete

- **Reference**: Thick AC
- **Gap graded**: VTAC
- **Porous AC**

### Base materials evolution

- Higher and higher binder contents
- Smaller aggregate maximum size:
  - 31, 20, 14, 10 mm
- Increase of bitumen hardness:
  - 50, 35, 20, 10 pen
- Additives to increase hardness
- Performances improvement:
  - GB 3 then GB 4
  - EME 2
- Reduction of thicknesses

### Base and foundation materials evolution

- Asphalt mixes European standards
  - General asphalt mixes NF EN 13108-1
  - Very thin asphalt mixes NF EN 13108-2
  - Porous asphalt NF EN 13108-7
  - Type testing NF EN 13108-20
  - Factory Production control NF EN 13108-21
- French guide for the application of European standards
- French asphalt mix design guide
Dissociation of road functions (since more than 15 years)

- **Base course**: structural effect
  - sufficient modulus to reduce the force on soil,
  - good fatigue resistance,
  - excellent stability in term of rutting resistance

- **Wearing course**: all surface characteristics
  - skidding resistance,
  - water proofing,
  - roughness,
  - visibility,
  - noise
  - recycling possibility

Long term skid resistance

Cumulative traffic between 1 to 5 millions of trucks

Maximum size of mixes $D = 10 \text{ mm}$

Wearing courses: noise levels

- LOW noise NOISY
  - 75dBA
  - Thickness: thin or very thin
  - Porous
  - High texture ($SPT > 1 \text{ mm}$)
  - Good homogeneity
  - Excellent unevenness

Low noise pavement

- «Phonic» asphalt mixes
  - Low max size: 6 – 8 mm
  - Gap graded: 2/4
  - Polymer binder
  - Additives (sometimes)
  - Thickness: thin or very thin
  - Porous
  - High texture ($SPT > 1 \text{ mm}$)
  - Good homogeneity
  - Excellent unevenness

Porous asphalt

- Operational since 1985: motorway, ring roads, specific areas
- > 20% voids content (communicated)
- Less used today: winter maintenance, durability of efficiency voids (clogging)
- Porous structure
Use of Polymers modified bitumen PmB

Test on binders
- Ageing
- Complex Modulus
- Resistance to tensile (SHRP)
- Elastic recovery (elastometric)
- Relaxation capacity with BBR (SHRP)
- Cohesion with pendulum (binder for surface dressing)
- Spectrometry, Chromatography, Distillation simulated (Expertise)

- Test on asphalt concrete
  - Shear resistance (constrain under traffic)
  - Mix design program

- Microstructure of PmB SBS vs % polymer

Assessment to use PmB

How can it possible to improve the shear resistance with the binder of AC?

Device to assess the resistance to shear stresses

Patent Number FR 06 50 054 January 06, 2006

Article BLPC, N° 267, avril 2007 - http://www.lcpc.fr/fr/sources/blpc

Resistance to shear stresses

Terminology

WAM

Cold asphalt

Hot mix asphalt

Warm asphalt

Semi-warm asphalt

Latent heat vaporization of water: 537 kcal/kg
**What’s look for WAM?**

**Advantages:**
- Reduction of energy consumption
- Less pollution, concerning:
  - People (workers, users, bordering the road)
  - Environment conditions
- Decreasing of bitumen ageing during production
- Less wear on mixing plant

*WITH the same performances as hot mixes*
- Continue coating, final properties just after placement

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**Main conclusion of WMA**

- Warm modulus asphalt mix
  - Reduction of temperature: -30 to 70°C
  - Main types of WAM processes used in France:
    - Additives
    - Special binder
    - Special heating
  - Even with very high viscosity:
  - Performances (laboratory):
    - Same order of magnitude:
      - Workability
      - Rutting resistance
      - Modulus and fatigue resistance
      - Density

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**Techniques for recycling of reclaimed asphalt**

- Classification from Direct-mat:
  - European research project on recycling material in the road

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**Some figures: RAP in USA – Japan - Europe**

- Hot recycling asphalt on mixing plant
- Recycling in place in hot or cold conditions

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- RAP in Mt
- Annual production Mt
- % Recycling RAP in HMA
- % reused in road
Some figures: various situations in recycling

Use of reclaimed asphalt material in road pavement

Some modifications due to sustainable development

Limits due to plant equipments

Processes of recycling

**Some figures: various situations in recycling**

- **RAP in HMA - 2009**
  - **% RAP available 1000000**
  - **% hot recycling**
  - **% RAP HMA/total HMA**

**Use of reclaimed asphalt material in road pavement**

- **Percentage of different end-of-life strategies for reclaimed asphalt**
  - **% RAP available 100000t**
  - **% hot recycling**
  - **% RAP HMA/total HMA**

**Some modifications due to sustainable development**

- **Evolution of recycling RAP in HMA in FRANCE**

**Limits due to plant equipments**

- **Example: batch plant**
  - **Without specific device**
    - Rate of reclaim ≤ 15%
  - **With mixing for recycling**
    - Rate of reclaim ≤ 35%
  - **Double drums**
    - Rate of reclaim ≥ 50%

**Processes of recycling**

- **In practice**
  - What limits? What rate of recycling?
  - Binder: Penetrabilities, RBT, % asphalténés?
  - Technology and environmental limits:
    - No sufficient homogeneity of mix,
    - Consumption energy,
    - Fumes and streams emitted (toxicity)
    - Equipments of mixing plant

- **Rejuvenator binder**
  - Large scale available, but low market and low development today, in the future?
Assessment after 30 years of experience in RAP

- Rate RAP in new HMA various: 10 to 70%
  - Current average near 20 to 25%
- Global behavior: without major problem, even with PmB(*) excepted on specific sites:
  - Degradations with cracks, fatigue, but also rutting sometimes observed
  - Due to hazardous parameters from RAP (hardening binder, heterogeneity, etc.) or higher rate recycling
- Maintenance study + Mix design very important (questions of pertinence?)
- Difficulties to take into account the wear of old aggregates on the surface friction characteristics

(*) How is the real modification of the new mixing PmB binder: old and new one?

Tendencies et evolutions

- "Recycling easy" with the use of WMA technique (already observed in the past, high workability due to residual water bring by RA)
- Recycling essential to respect the topics of sustainable development
- Steps today:
  - Harmonization of practices in Europe (Direct Mat project)
  - Writing a guide to recommend this technique by road administrators: state of the art, practical advises, specifications, prescriptions...
- Researches:
  - Ageing accelerated, to predict and anticipate the behaviors on field
  - Recycle with high rate, reach near 100% Performances of binder after recycling: compatibility, homogeneity of mix (old and new binder), characterization...
  - Definition of damage criteria on old AC, to fix the "level of recyclable"

Conclusions

- High diversity of AC for pavement, to answer a specific target needs.
- Complementary Researches: administration – companies
- Mix design in lab, according to the standard performance specifications, allows a good ad equation between composition of AC and its uses:
  - Structure: mechanical, rut resistances,
  - Surface: workability, resistance to water, to rut
- Surface characteristics must be record during time (difficult to assess in lab) to validate the choice of AC pavement and the durability.

Durability of the wearing courses

- When the techniques are correctly used (quality of underneath, of manufacture and layout of AC) the durability of the wearing courses is not influenced by the layer thickness.
- The VTAC, UTAC, PA have a duration time at least as long as thick or thin AC, with a higher roughness and better skid resistance.
- The VTAC, UTAC, PA layout on non rutting underneath layer (example: sub base asphalt mix, High Modulus AC) show an excellent rutting resistance even under heavy load traffic.

Conclusions

- BBTM, BBUM, ECF (urban uses) on roads in good structure and geometry, present
  - High skidding resistance, Non rutting, Economic, Sustainable.
- Formula 0/6 gap graded:
  - excellent compromise Adherence – Noise – Esthetic
- BBM and especially BBSG (thick) BBME (high modulus)
  - structural effect, reduction of fatigue damages.
- BBTM 0/6: noise diminution.
- Different AC: operational, well under control and complementary.

Thanks a lot for your attention