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 10 cm) [BBSG]
- **1975**: Surface maintenance: Thin AC (4 to 5 cm) [BBM]
  - on good quality of underneath layers (structural and evenness)
- **1985 – 2000**: Specific surface maintenance:
  - Skid resistance: Very thin AC (2 to 3 cm) [BBTM], Ultrathin AC (1 cm) [BBUM]
  - Comfort, Visibility: Porous AC (4 cm) [BBDr]
  - Aesthetic with fine maximum size: Very thin AC (0/6 gap) [BBTM 0/6]
  - Decreasing of tire 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 characteristics.

base = structure
Wearing courses: main evolutions

- Thinner and thinner thickness $\rightarrow$ 1 to 2cm
- Reduction of maximum size: $14/10/8/6/4$ mm
- Mix design $\rightarrow$ Gap graded formula
- Mix with more and more gravels
- Higher and higher porosity $\rightarrow$ Tack coat with seal properties
- More frequent use of polymer modified binder or special binder
- Hot mixes; except for microsurfacing [ECF]
- Standardized products $\rightarrow$ 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></td>
</tr>
<tr>
<td>BBM (Béton Bitumineux Minces)</td>
<td>TAC (Thin Layer Surfacing)</td>
<td>3-4</td>
</tr>
<tr>
<td>BBDr (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

Thickness
Maximum size D, Grading Function, Surface Characteristics

0/10 sometime 0/14

0/10 or 0/6 well gap graded

Binder BmP

Thick
BBSG
BBME

Thin
TS
PA

Very --- Ultra Thin

Thick

Thin

Very

Ultra Thin
## Main characteristics of AC

<table>
<thead>
<tr>
<th>Type BB</th>
<th>BBSG</th>
<th>BBM</th>
<th>BBTM</th>
<th>BBUM</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>% GSC</td>
<td>4-9</td>
<td>6-12</td>
<td>6-25</td>
<td>-</td>
<td>20-28</td>
<td>-</td>
</tr>
<tr>
<td>Thick (cm)</td>
<td>6-8</td>
<td>3-5</td>
<td>2-2.5</td>
<td>1-1.5</td>
<td>3-4</td>
<td>1</td>
</tr>
<tr>
<td>Spread (kg/m²)</td>
<td>150-200</td>
<td>100</td>
<td>40-60</td>
<td>25-35</td>
<td>80</td>
<td>15 à 20</td>
</tr>
<tr>
<td>Tack coat (kg/m²)</td>
<td>250</td>
<td>300</td>
<td>300</td>
<td>+400</td>
<td>300</td>
<td>without</td>
</tr>
<tr>
<td>Surface/year (million m²)</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

![Graph showing the evolution of base and foundation materials with years and percentage bitume, grade, and module.](image)
Asphalt mixes European standards
- General asphalt mixes \textit{NF EN 13108-1}
- Very thin asphalt mixes \textit{NF EN 13108-2}
- Porous asphalt \textit{NF EN 13108-7}
- Type testing \textit{NF EN 13108-20}
- Factory Production control \textit{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 $D = 10$ mm

Traffic: 1 to 5 Millions trucks
Wearing courses: noise levels

Noise data: +300 files

- **LOW noise**
  - 75dBA

- **Intermediates**
  - 78dBA

- **NOISY**
  - 79dBA to 80.1dBA

Revêtement à tester

Extract from data base of LRPC Strasbourg 2003
Use 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 mm)
  - Good homogeneity
  - Excellent unevenness

Before arriving here ...
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 (elastomeric)
- 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)

![Microstructure of PmB SBS vs % polymer]

- <3%
- 3 to 5%
- >5%
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

liant modifié
Evolution of surface under test

Way of load application

L'esprit de recherche au cœur des réseaux
Resistance to shear stresses

Pull-out test performed on a BBTM 0/10 at room temperature

Binder A
Binder B
Binder C
Binder D
Binder E

Mass loss per unit of loaded surface area (kg/m²)

Number of loading cycles

[Hamlat, 2007]
Terminology

WAM

Latent heat vaporization of water: 537 kcal/kg

Cold asphalt

Semi-warm asphalt

Warm asphalt

Hot mix asphalt

Énergie de chauffage (Kg/T)

HEATING

VAPORIZATION

DRYING
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
No visible fumes
NO visible steams

Good homogeneity
Clean

NO urgency, have time

Warm Temperature

Good workability

Uniformity
Well aspect of joint

Exemple
Quelques Photos
agent plastifiant
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 binder
- Performances (laboratory - in field)
  - Same order of magnitude regarding:
    - Workability*
    - Rutting resistance
    - Modulus and fatigue resistance
    - Density

![estimation des tonnages BB Tièdes en France](image)
Techniques for recycling of reclaimed asphalt

Classification from Direct-mat: European research project on recycling material in the road
Hot recycling asphalt on mixing plant

Recycling in place in hot or cold conditions
Some figures: RAP in USA – Japan – Europe

HMA - RAP in World: USA - Japan - Europe in 2009

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

RAP in HMA - 2009

- RAP available 100000t
- % hot recycling
- % RAP HMA/total HMA

Countries: Netherlands, Germany, Sweden, Spain, Denmark, Belgium, Switzerland, France, Italy
Use of reclaimed asphalt material in road (2008)

Percentage of different end-of-life strategies for reclaimed asphalt:
- Other
- Recycling in unbound layers
- In Situ / Plant Recycling (half warm & cold)
- Plant Recycling in HMA

Generally all RAP is used in or near road.

Source: EAPA 2008
Some modifications due to sustainable development

Voluntary agreement for SD signed in 2009 by private road companies and French administration: **Objective 2012**: RAP used in HMA 60% 2020

2020 reused 100% soil @ road materials (back road)
Limits due to plant equipments

Example: batch plant

- Without specific device
  Rate of reclaim $\leq 15\%$

- With ring for recycling
  Rate of reclaim $\leq 35\%$

- Double drums
  Rate of reclaim $\geq 50\%$

- Double barrel
Preliminary study in lab is essential

- Assess the sources: homogeneity RA
- Identification of components (on different sections and layers): binder content and residual properties, granularity of milling, EN 13108-8 Standards (others)
- Formula of new mix with RA (rate of recycling, nature of bitumen or rejuvenator added, and aggregates)
- Performances must be equal to those of new AC
- Promote used of RAP: example in France no new study if the rate of recycling is less than:
  - < 10% in wearing course
  - < 15 % in binder, base, sub base courses (researches, publications LCPC/USIRF)
- Traditional pavement design study
In practice:
- What limits? What rate of recycling?
- Binder: Penetrabilities, RBT, % asphaltènes?
- 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,…) 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?
“Recycling easy” with the use of WMA technique (already observe 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
- Recycling 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 recorded during time (difficult to assess in lab) to validate the choice of AC pavement and the durability.
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.
Withdraw of young child 11 years old
Universal exhibition Shanghai 2010

Thanks a lot for your attention