Laboratory assessment of mechanical performance and fume emissions of LEA® HWMA (90°C) vs. traditional HMA (160°C)

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• Research of lower mixing temperature to target comparable HMA mechanical properties (at least « sufficient » for requested properties)
  
  – Ladis Csanyi, Iowa introduced steam in hot bitumen in order to mix cold aggregates
  – August Jacobi, 1928 in Germany patent foamed bitumen
  – real industrial tests happened in the 70’s in Australia
  – in France Jean Lefebvre (nowadays EUROVIA) in the 70’s tried to realize surface dressings with foamed bitumen
Processes used: HMA and HWMA

Manufacturing temperature of asphalt mix (°C)

- HMA
- LEA® mixtures
- HWMA
- Cold Mix Asphalts
- Half-Warm Mix Asphalts
- Warm Mix Asphalts
- Hot Mix Asphalts

Processes: HEATING, VAPORIZATION, DRYING
Objectives of the study

– Study the effect of **manufacturing temperature** (HWMA LEA® and HMA) on mechanical and environmental properties

– Identify the effect of process on **emissions** (Total Organic Compounds quantity and Emission Potential)
Laboratory HWMA LEA® processes

**PHASE 1**: Dry hot 1st fraction of aggregates

**PHASE 2**: Hot bitumen incorporation

**PHASE 3**: Cold and moist 2nd fraction of aggregates
   - Possible extra water added

**PHASE 4**: Thermal equilibrium reached between aggregate, residual water and bitumen

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**LEA® 1**

- **PHASE 1**: 160°C
- **PHASE 2**: 160°C
- **PHASE 3**: 95°C
- **PHASE 4**: 95°C

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**LEA® 2**

- **PHASE 1**: 160°C
- **PHASE 2**: 160°C
- **PHASE 3**: 95°C
- **PHASE 4**: 95°C

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**LEA® 3**

- **PHASE 1**: 150°C
- **PHASE 2**: 15°C
- **PHASE 3**: 95°C
- **PHASE 4**: 95°C
Materials used

- **Formula**
  - Classical French dense asphalt mixture for base course
    ‘Grave Bitume’ GB 0/14 with a binder content of **4.2%**

- **Aggregates** diorite

- **Bitumen (35/50 pen-grade)**
  - Paraffinic : Pen-grade 42, R&B 52.6°C

- **Manufacturing temperature**
  - HMA: 160°C
  - HWMA (LEA 1, 2 and 3): 95°C with 1.5% humidity by weight of dry aggregate

- **Additives**
  - 2 additives (vegetal origin) used (0.5% by weight of binder)
Tests on two samples (with the same volume) cured 2 hours at 110°C for HMA and at 75°C for H-WMA

The lower the force necessary to remove the mix from the mould, then the greater the onsite workability
LEA® mixes (90°C) appear to be slightly less workable than HMA (160°C)
The additive G makes LEA® a bit more resistant to water
• 2-point bending test at 15°C - 10Hz

Differences observed may be explained by the test repeatability as well as less binder ageing due to a lower manufacturing temperature for HWMAs
Airborne emissions methodology

Field studies

Organic emissions during construction
generated by asphalt mix
[Brandt et al., 2000]

Laboratory studies
Fumes generated by bitumen
[Brandt et al., 2000]

Laboratory studies
Fumes generated by asphalt mix at LCPC
Composition of bituminous fumes

Bituminous mixture manufacturing (and implementation)

Fumes

Particles
- Inorganic particles
- Organic aérosols

Gas
- Volatile and semi-volatile organic compounds: VOC and SVOC

Compounds emitted in our laboratory conditions

TOC(e)
**Objective**

Environmental assessment of bituminous mixes and binders in lab

**Functions**
- Generate fumes
- Collect / Sample
- Analyse

**Parameters**
- Formula
- Binder
- Process
- Additive
- Evaluation and separation of TOC by a Flame Ionization Detector (FID)
- Evolution of Total Organic Compounds (TOC) emissions according to time (up to 2 min at a stirring velocity of 20 rpm and then 28 min without stirring in loose mix configuration)
Effect of production process on Emission Potential

Influence of processes on Emission Potential results (mixes)

Lower Emissions in the case of LEAs

Graph showing emission potentials (EP) for different mixes: HMA, LEA1+A1, LEA2, LEA2+A1, LEA3+A1, LEA3+A2.

EP (10^3 mg/sm^3/kg of bitumen)

350
300
250
200
150
100
50
0

HMA
LEA1+A1
LEA2
LEA2+A1
LEA3+A1
LEA3+A2
Influence of manufacturing and parameters process upon TOC(e)
Bitumen aging and fumes emissions

**Correlation between Emission Potentiel and bitumen aging**
Main findings

- The values of stiffness modulus and fatigue resistance for the LEA mixes are very close to those obtained for HMA
- Use of experimental devices by IFSTTAR to assess environmental properties of asphalt mixes (Hot, Warm and Half-Warm mixes asphalt) and bitumen
- A lower manufacturing temperature leads to a global emission reduction in laboratory
- Mix composition and manufacturing conditions influence emissions