Introduction to Bitumen Stabilised Materials BSMs

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SARF Course on BSMs
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In Place ↔ Hot ↔ In Plant
In Cold

In Place ↔ Hot ↔ In Plant
In Cold

Diagram showing different methods of road construction, comparing in-place and plant production processes.
What defines a BSM?

- Bitumen
- Cement
- Rut resistant
- Unbound: Crushed stone / gravel / soil
- Fatigue resistant
- Stress dependent
- Strongly cemented
- Lightly cemented
- Less economical

- FBS (Aus): Quick Lime
- FBS (NZ)
- BSM (RSA)
- HMA

- 0% Stress dependent
- 1% 2% 3% 4% 5% Fatigue resistant
- 1% 2% 3% 4% 5% Bitumen
- 1% 2% 3% Rut resistant
- 1% 2% 3% 4% 5% Cement
1. BSM Binder Type

**BITUMEN EMULSION**

Colloidal Mill

- Acid or Caustic Soda
- Surfactants
- Water
- Bitumen
- Mill
- 5 microns

**FOAMED BITUMEN**

Expansion chamber

- Hot bitumen
- Water
- Air
2. Bitumen Dispersion

Microscopic Analysis

BSM-emulsion  BSM-foam
Type of Dispersion

BSM-emulsion

BSM-foam

Painting

Spot-welding
Nature of BSMs (cold)

Bitumen dispersion: Non-continuously bound

BSM-foam (sand)
BITUMEN DISPERSION

Tiny bitumen “pieces”

Particles < 0.075 mm
(# 200 sieve)

± 20°C

± 100°C
3. Aggregate Types

- Natural Gravel CBR>25%
- Crushed Gravel CBR>45%
- Graded Crushed Stone
- 100% RAP
- 50% RAP + GCS
- Recycled Materials

3. Recycled Materials
4. Grading requirements

Cumulative % passing

0.08 0.15 0.3 0.6 1.18 2.36 4.75 6.7 9.5 13.2

Sieve size (mm)

Foam

Emulsion
Optimisation of grading curve

Indirect Tensile Strength (kPa)

- Emulsion: 3.3% bitumen
- Foam: 3.5% bitumen

Without blending
With 10% fines blend

Bar chart showing the indirect tensile strength for Emulsion and Foam with and without blending.
Moisture: Durability

**FOAMED BITUMEN**
- Poorly graded
- Well graded

**EMULSION**
- Well graded
5. Bitumen content

<table>
<thead>
<tr>
<th>BSM Class</th>
<th>Aggregate</th>
<th>Bitumen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSM 1</td>
<td>&gt;75% RAP + Crush agg</td>
<td>1.6 – 2.1</td>
</tr>
<tr>
<td>BSM 1</td>
<td>&gt;25% RAP + Crush agg</td>
<td>1.8 – 2.5</td>
</tr>
<tr>
<td>BSM 1</td>
<td>&lt;25% RAP + Crush agg</td>
<td>2.0 – 3.0</td>
</tr>
<tr>
<td>BSM 2</td>
<td>Natural Gravel (CBR&gt;45%)</td>
<td>2.2 – 3.5</td>
</tr>
<tr>
<td>BSM 3</td>
<td>Natural Gravel (CBR&gt;25%)</td>
<td>2.5 – 4.0</td>
</tr>
</tbody>
</table>

(Wirtgen Recycling Manual, 2012)
Aggregate Mixing Temperature

Foam > 25ºC

Foam 15ºC
Emulsion 10ºC

Foam <15ºC
Emulsion<10ºC
Aggregate Temperature vs Particle coating (BSM-foam)

Jenkins, 2000
7. Moisture Regime (mix & compact)

**EMULSION**
- Bitumen coating (thin films)
- Some partial coating

**FOAMED BITUMEN**
- Bitumen dispersion selective
- Partial coating

Optimum Fluids Content

70% to 90% of OMC
MOISTURE DURABILITY

HVS Cape Town on BSM

Water introduction into 2.3% foamed bitumen stabilised base
8. Behaviour = Granular type

Resilient Modulus of BSM-foam (BC = 2%)
Stress dependency (triaxial)

Resilient moduli 75C-0 blend

Not main purpose

Mix:
- 1% cem
- 0% cem

BSM-emulsion
BSM-foam
Visco-elastic properties of BSM-foam

Flexural stiffness [MPa]

Rutting

HMA

Fatigue cracks

Tref = 20C

BSM

Rutting

HOT T or Slow Traffic

COLD T or Fast Traffic

Reduced frequency
Validation (100% RAP Foamed Mix)

Repeated Load

Perm anent axial strain [%]

σ1

σ2

60°C

50°C

40°C

Number of load repetitions [-]
10. Active Filler: Purpose?

- Improve adhesion
- Improve dispersion
- Modify plasticity
- Increase stiffness & strength
- Accelerate curing

Emulsion

- Breaking time
- Improve workability

Foam

Dispersion!
Influence of Active Filler

Strength and flexibility

Foamed bitumen, Strain
Cement, Strain*
Foamed bitumen, UCS
Cement, UCS*

Cement < 1%?

CSIR
Can 1.5% cement work?

BSM-foam + 1.5% cem using cracked CTB
2 years of traffic
Mix Design Testing

Cemented strength

Bituminous

It’s undeniable: More cement = more strength!
It’s undeniable: More cement = more strength!
11. Time Dependency Mr (field) versus cure

N7 PSPA Mr Analysis over 7 Months

- B1-B3
- B4-B6
- Poly. (B4-B6)
Conclusions

• Many combinations of aggregates can be used (continuous grading)
• BSMs ≠ asphalt
• BSM is granular with higher cohesion and shear strength
• Flexibility is NB! Active filler content needs to be restricted
Thank you

Roads & Enviro!