Introduction to Bitumen Stabilised Materials BSMs

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SARF Course on BSMs

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Hot
In Place
Cold
In Plant

In Place ↔ Hot ↔ Cold ↔ In Plant
What defines a BSM?

- Bitumen
- Cement
- Rut resistant
- Strongly cemented
- Lightly cemented
- Unbound: Crushed stone / gravel / soil
- Stress dependent
- Fatigue resistant
- Less economical
- FBS (Aus): Quick Lime
- FBS (NZ)
- BSM (RSA)
- HMA
- Fatigue resistant
- Rutting

1% 2% 3% 4% 5%
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

Painting

BSM-emulsion

Spot-welding

BSM-foam
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
- 50% RAP + GCS
- 100% RAP

Recycled Materials
4. Grading requirements

![Graph showing cumulative % passing for different sieve sizes with lines for Foam and Emulsion.]
Optimisation of grading curve

Indirect Tensile Strength (kPa)

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

Graph showing:
- **Without blending**
- **With 10% fines blend**
Moisture: Durability

FOAMED BITUMEN

EMULSION

Poorly graded
Well graded
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 > 25°C

Foam 15°C

Emulsion 10°C

Foam <15°C

Emulsion <10°C

√

OK

X
Aggregate Temperature vs Particle coating (BSM-foam)

Aggregate Mixing Temperature (degC)

Maximum Particle Size (mm)

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

![Graph showing stress dependency with bulk stress on the x-axis and resilient modulus on the y-axis, with data points for different mixes: A-75C-0, B-75C-0, C-75C-0, BSM-emulsion, and BSM-foam. The graph includes a note: Not main purpose.]
Visco-elastic properties of BSM-foam

HMA

Fatigue cracks

T_{ref} = 20C

Rutting

Equiv

HOT T or Slow Traffic

Reduced frequency

Equiv

COLD T or Fast Traffic

BSM
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

Cement < 1%?
Can 1.5% cement work?

BSM-foam + 1.5% cem using cracked CTB
2 years of traffic
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)

Mr (MPa) vs. Time (days)

- Moisture
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!