Bitumen Stabilised Materials: Will theory and practice ever meet?

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Acknowledgements
- Alan Lynch (main author) Royal Haskoning DHV
- SANRAL through SAPDM aka “Godzilla”

Theory versus Practice

Skills Gap
- technology growing gap
- status/skills of the operator physical involvement

Human Resources Theory vs Practice
- Researcher
- Contractor

Early South African pavements
Technical Challenges
- Reflective Cracking
- CEMENT STABILISATED BASE
- Selected subgrade layer
- 40mm HMA SURFACING
The South African “inverted” pavement

**The Concept**

- **Cement Stabilised Subbase**
- Selected subgrade layer
- **40mm HMA Surfacing**
- **Crushed Stone Base**
- **Higher Compaction**
- **Higher Mr**
- **Water!!!**

The South African “upside-down” pavement

**The Upgrade**

- **Bitumen Stabilised Base**
- Selected subgrade layer
- **40mm HMA Surfacing**

**Distress Mode?**
- Unbound
  - Permanent deformation (shear/ruts)
- Bound
  - Fatigue (cracking)

**Durability??**

**Key Characteristics**

**Bitumen Stabilised Materials**

1. Non-continuously bound (bitumen saturation)

   - ITS
   - ITS<sub>ei</sub>
   - BSM Binder Content

2. Deformation resistance

   - Shear stress
   - Friction angle
   - Higher Cohesion
   - Mohr-Coulomb

3. Moisture resistance

   - Shear stress
   - Effect of Moisture
   - Cohesion Loss<sub>ei</sub>
   - Normal stress
   - C = Cohesion
   - μ = Friction angle
**4. Stress dependency (BSM-foam)**

- Foamed Bitumen = 2% in CDW

![Graph showing stress dependency](image)

**5. Visco-elasticity (BSM-foam)**

- Fatigue cracks
- Rutting

![Graph showing visco-elasticity](image)

**6. Flexibility vs Cement% (BSM-foam)**

- Strength and flexibility
- Cement < 1%?

![Graph showing flexibility vs cement%](image)

**7. Time and moisture dependency (BSM-emulsion)**

- Evolutionary...
- Durable?
- Time and moisture dependent

![Graph showing time and moisture dependency](image)

**BSM is a material with multiple personalities!**

- Deformation Resistant
- Flexible...
- Stress dependent
- Evolutionary...
- Time dependent
- Non-continuously bound?

**Can 1.5% cement work?**

BSM-foam + 1.5% cem using cracked CTB: 2 years of traffic
3. Material Performance

Closing the loop

Awareness

Implement

Acquire knowledge

Develop tools

Ref: K Jenkins
PhD Univ Stell
Mulusa, Univ Stell 2009
250mm CIPR: 3% Foam 1% Cem

90mm Asphalt

In-situ recycled crushed stone base material
NB: 1% cement and 2.3% foamed bitumen
SB: 1% cement and 3% bitumen emulsion

N7 Cape Town
2002 Rehab and HVS TRIALS

Mr back-calc vs time (N7)

Mr versus Base Layer Index

Trial Section R35 2012 - 2013

200mm Cemented Base SB

Days since Construction

Average Stiffness

Rainfall (mm)

Prime

Asphalt

Cape Seal

Traffic

0 50 100 150 200 250 300 350 400

200mm BSM Foam (2.4%b, 1%c) SB

Days since Construction

Average Stiffness

Rainfall (mm)

Prime

Asphalt

Cape Seal

Traffic

0 50 100 150 200 250 300 350 400

200mm BSM Foam (2.4%b, 1%c) NB

Days since Construction

Average Stiffness

Rainfall (mm)

Prime

Asphalt

Cape Seal

Traffic

0 50 100 150 200 250 300 350 400

175mm BSM Foam (2.4%b, 2%c) NB

Days since Construction

Average Stiffness

Rainfall (mm)

Prime

Asphalt

Cape Seal

Traffic

0 50 100 150 200 250 300 350 400

200mm BSM Emulsion (2.4%b, 2%c) SB

Days since Construction

Average Stiffness

Rainfall (mm)

Prime

Asphalt

Cape Seal

Traffic

0 50 100 150 200 250 300 350 400

200mm BSM Emulsion (2.4%b, 1%c) NB

Days since Construction

Average Stiffness

Rainfall (mm)

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Traffic

0 50 100 150 200 250 300 350 400
**Back-calc vs Core triaxial**

![Graph showing back-calculated stiffness vs core triaxial stiffness]

**Seasonal stiffness variation**

![Graph showing seasonal stiffness variation]

**Seasonal stiffness variability**

![Graph showing seasonal stiffness variability]

**BSM-foam**

![Graph showing BSM-foam stiffness]

**200mm Cemented (2%c, 1%l) NB**

![Heatmap showing spatial and temporal variation]

**200mm BSM foam (2.4%b, 2%c) NB**

![Heatmap showing spatial and temporal variation]
BSMs Mr change: Effective Long Term Stiffness

Equivalent Stiffness (Mpa)

Years

0 1 2 3 4 5 6 7 8 9 10

1% cem CTSB
1% cem G5SB

Closure
Economical BSMs

Lower BC
Improve QC
Reduce variability
Operator training
Mix Design upgrades
Structural Design upgrades

“Gadgets”
Data management
Skills requirement
Prolific n° variables
Difficult to simplify
Closing loop is a longitudinal study

Thank you!