Bituminous Cold-Mix Technology and Pavement Design

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Topics of this Presentation:

• Some history, project background
• Motivation of development approach (focus on structural design)
• Materials classification task details
• Structural capacity assessment details
• Conclusion
Some History…

- Recycling with emulsion and foam was done from the early 1970’s

- Initially fairly primitive & often applied to less highly trafficked roads by experienced designers
Some History…

First deep cold-in place recycling with Emulsion in 1994
Some History…

Prototype tested in South Africa - 1996

CIPR with Foam from 1996 onwards
Existing Cold-Mix Guidelines

• Emulsion materials

• Foamed bitumen materials
  ➢ TG2 Interim Guideline (2002)

Guidelines widely used, but need to

• Modernize & Improve
• Place foam and emulsion on equal footing
• Create a single, combined guideline
• Address need for paradigm shift in SA
Bituminous Cold-Mix Guidelines

• Project initiated in 2005 to address deficiencies in existing guidelines
• Focus on mix design and structural design elements
• Limited time-frame: short term deliverable
  ➢ Somewhat novel structural design approach adopted

Findings and methods will be incorporated into a larger, on-going pavement design development project (SANRAL sponsored)
Project Constraints

- Reasonable knowledge base of performance (long-term and accelerated loading), but …
- Not very detailed information, no fundamental material properties
- Current M-E design method has deficiencies

- Adopted a Heuristic or Knowledge-based pavement design approach
- Simplified design method, more emphasis on correct materials assessment, mix design and construction
Pavement Design Elements


Practitioner/Human Domain → Research/Software Domain → Practitioner/Human Domain
Pavement Design Elements

Traditional ME Research Approach: Focus mainly on model and software development. Determining inputs, implementation and knowledge transfer is often neglected.
Vision for Medium Term Outcome: Develop a practical design method that combines the best elements of current design methods, and incorporates best practice elements of mechanistic analysis, field testing and construction
Knowledge Based Approach

• Gather all available field performance data
• Distil best elements of mechanistic analysis
• Validate and refine for robustness
• Develop clear, strong linkage to field testing and specifications

To Date:
• 23 Field sites with construction, maintenance & performance info
• 7 HVS Sites (22 test sections) with construction & performance
The Design Process

Materials Classification

- FWD
- Test Pits
- Visuals
- DCP
- LAB

Capacity Assessment

- 200 mm BSM 1
- 130 mm C4
- > 200 mm G6
- CBR 7-15%

Specifications

Mix Design

- Shear Strength
- Durability
- Flexibility

Adopt aspects of Certainty Theory
Materials Classification Using Certainty Theory

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Systematic way of combining diverse types of evidence to reach a consistent, rational conclusion. Also teaches young engineers the key factors affecting materials.
The Design Process

Materials Classification

Capacity Assessment

Specifications

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Materials Classification
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Development Approach

- Range of Traffic Accommodated
- Rut situation, RQ situation
- Cracking situation
- Need for rehabilitation

System Performance Indicators

Design Parameter for Layer

- CBR 7-15%
- > 200 mm G6
- 130 mm C4
- 200 mm BSM 1

Reps to Failure ??
Reps to Failure ??
Reps to Failure ??
Development Approach

- Range of Traffic Accommodated
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- Cracking situation
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System Performance Indicators

System Behaviour Indicator ???

Area = Shear Potential “Fingerprint”

Octahedral Shear Strain

200 mm BSM 1
130 mm C4
> 200 mm G6

CBR 7-15%
Capacity Assessment Example

1. Material Classes
   - 150 mm BSM2
   - 150 mm C4
   - 150 mm G6
   - 150 mm G7
     - CBR 7-15%

2. Subgrade Class

3. Subgrade LTES
   - 97 MPa
   - 100 MPa

4. Adjust for region & subgrade cover

5. Assign modular ratio’s and Maximum Emods
   - MR = 4, $E_{\text{Max}} = 550$
   - MR = 3, $E_{\text{Max}} = 450$
   - MR = 1.8, $E_{\text{Max}} = 325$
Capacity Assessment Example

6. Determine Effective LTES for each layer

Octahedral Shear Strain

Vertical Compressive Strain on Subgrade = 237 microstrain

$\sum = 3.77$

550 MPa
450 MPa
175 MPa
97 MPa

Linear Elastic Theory
Handling Reliability

Category A Roads (95% Reliability)

Category B Roads (90% Reliability)
CONCLUSION

• Project is ongoing, 90% of technical work to be completed in March, 2008

• Efforts dedicated to Mix Design not covered, but this is a significant component (Project Leader: Prof Kim Jenkins)

• Aspects of the methodology to be incorporated in the broader revision of the SA Pavement design method
Thank you very much for your attention!