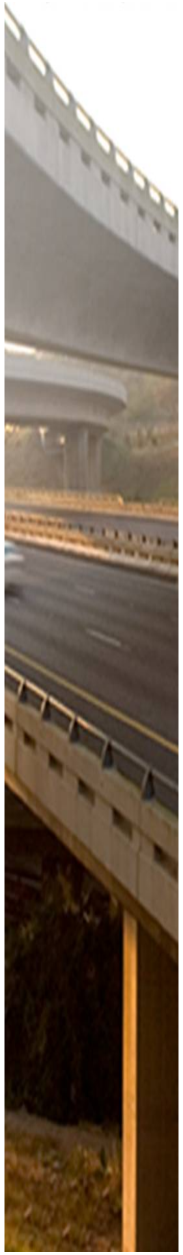

Development of resilient response and damage models for HMA.

Prepared for presentation at the 18th RPF

Pretoria, November 2009

By: Erik Denneman

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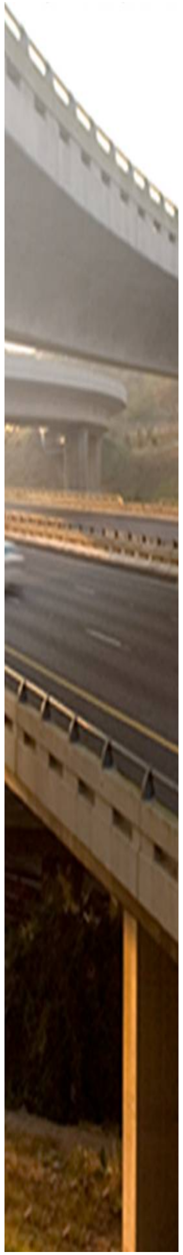
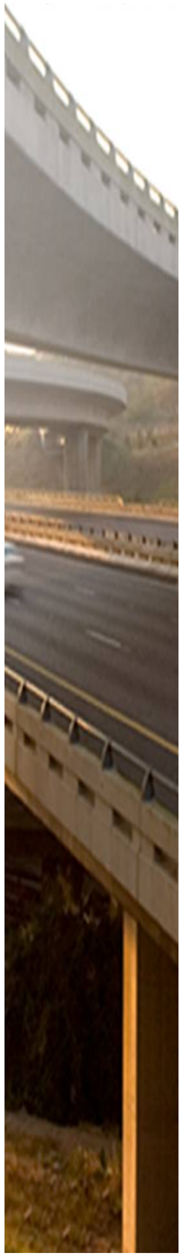
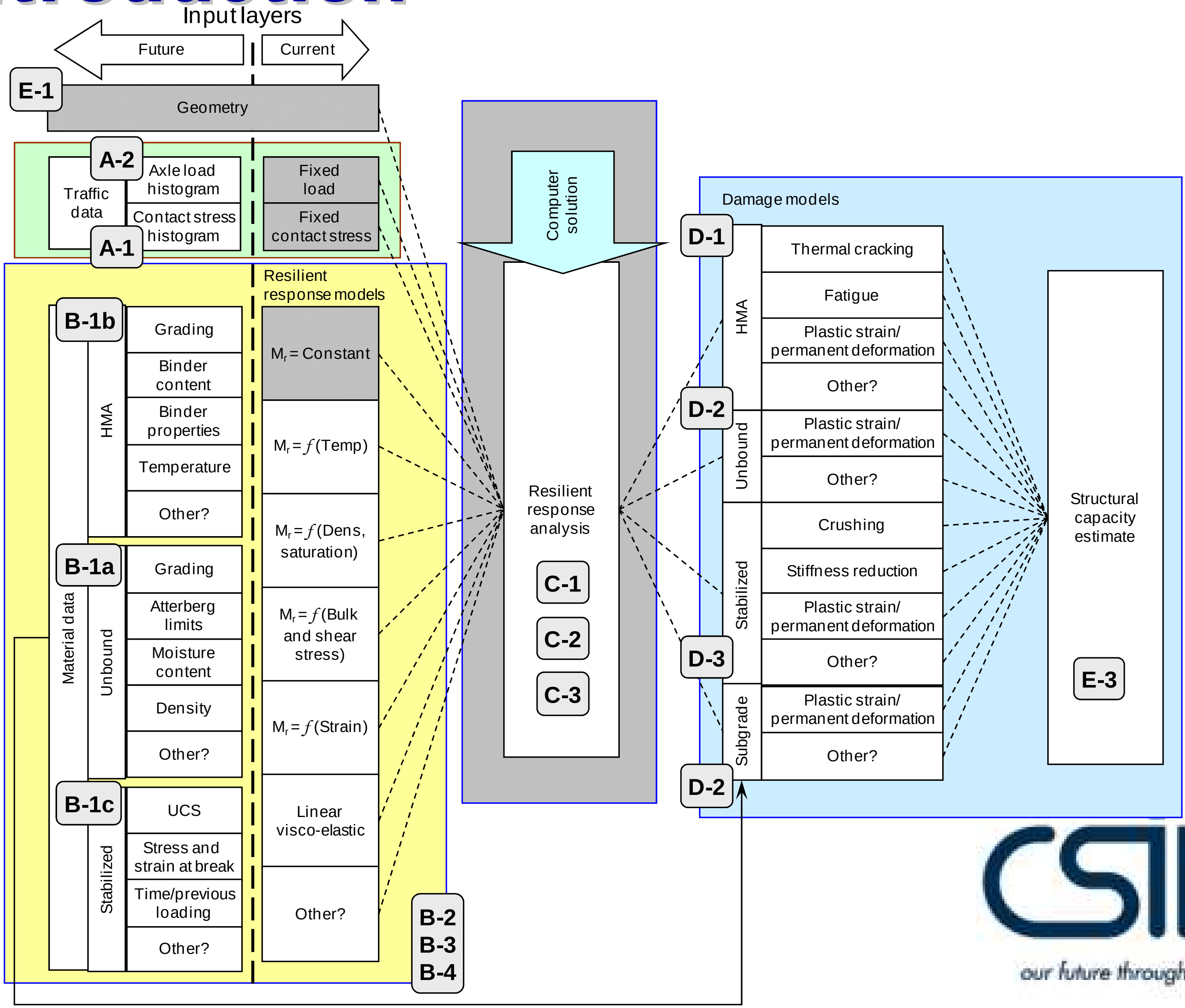


Presentation structure

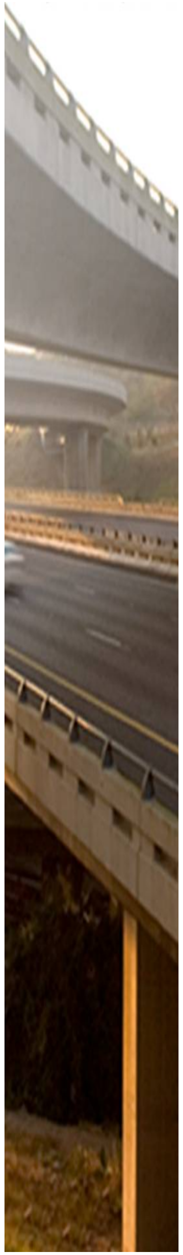
- Introduction,
- State of the art in M-E design of HMA and the availability of models for SAn practise,
- Components of the envisaged design method,
- Structure of laboratory test program,
- Test results: by Dr. Joseph Anochie- Boateng



Introduction



State of the art in HMA design



- Three components:
  - Environment,
    - Traffic load, speed, temperature.
  - Resilient response,
    - Complex modulus as a function of age, density, grading, binder type, frequency, etc.
  - Damage models,
    - Rutting: as a function of stiffness, or based on repeated load test,
    - Fatigue: as a function of stiffness, or based on beam test results.

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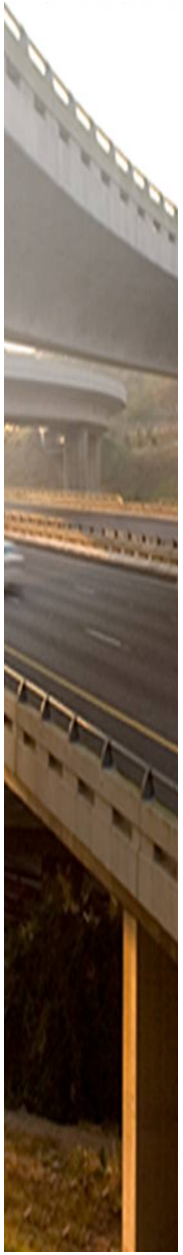
Current HMA design models



- HMA design in South Africa mostly based on reactive specifications.
- ME design:
  - Environment:
    - Load: E80s, loading time (10Hz), average temperature
  - Resilient response
    - Default values
  - Damage models
    - No rutting model,
    - One size fits all fatigue relation

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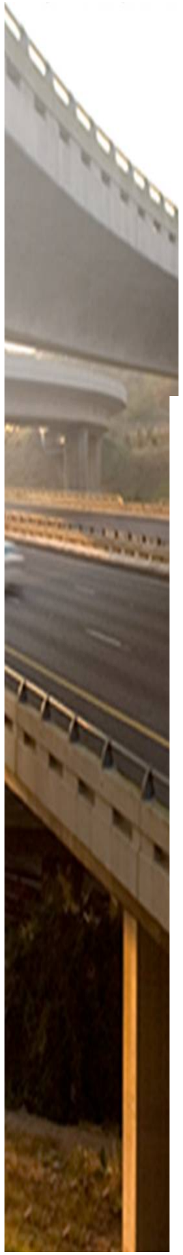
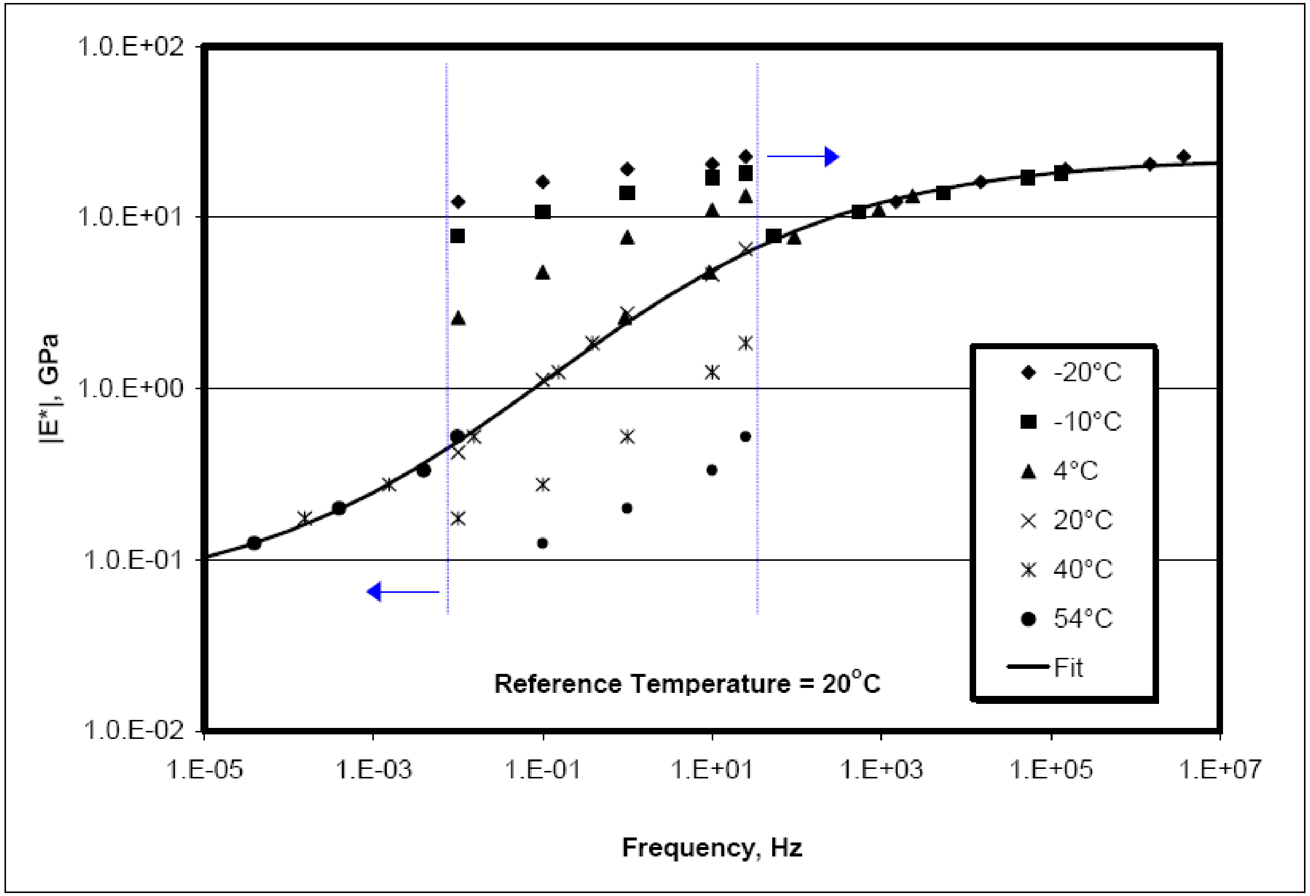
Current HMA design models

- Resilient response:

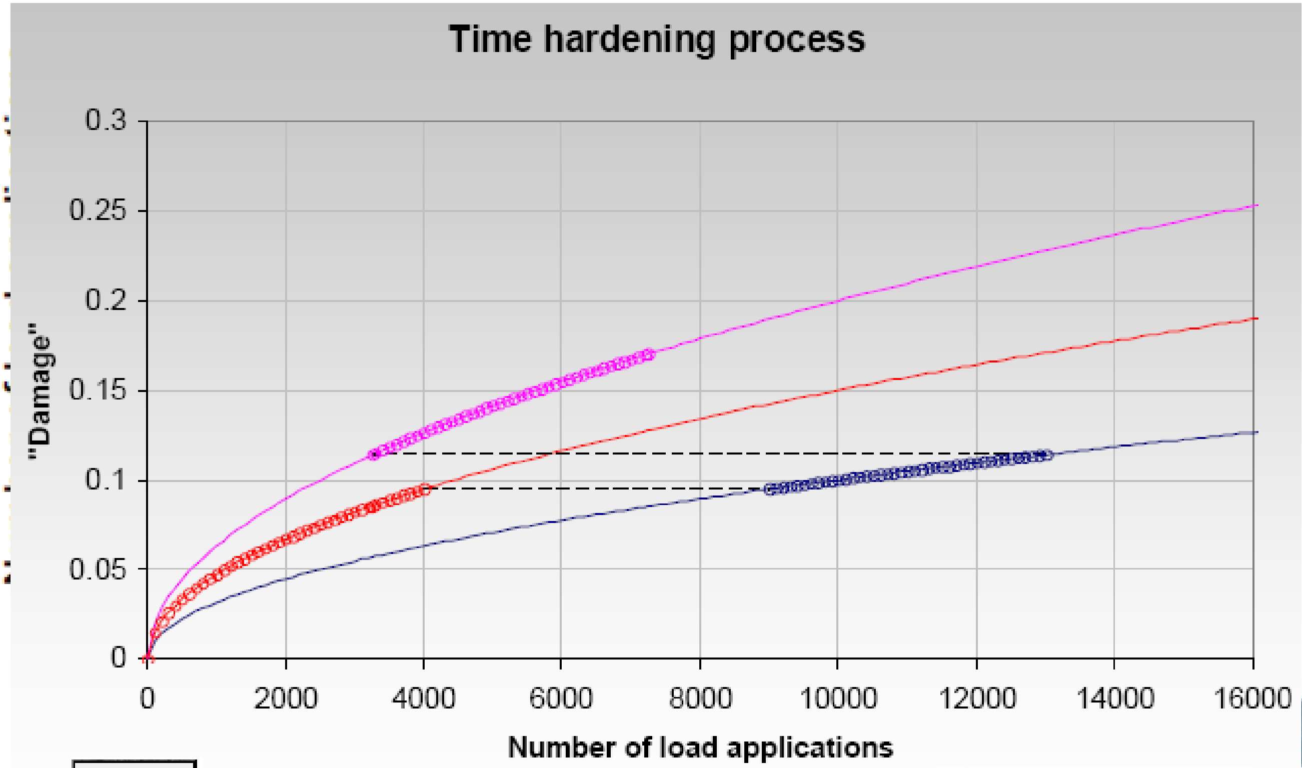


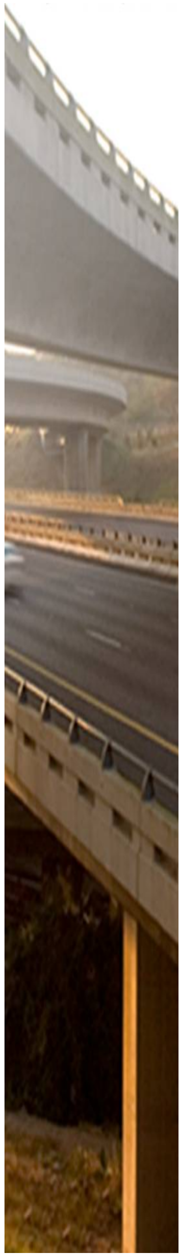
Mater grading	ion
	ed
	0 C
Gap-grad	200
	300
	400
Continuc graded	300
	400
	750



Current HMA design models

- Fatigue & Rutting





Envisaged M-E design for HMA

- Different levels of analysis depending on client requirements and risk.
  - Level 1: Full material characterization,
  - Level 2: Some material characterization,
  - Level 3: Use of default values
  - Level 1:
    - G* binder characterization,
    - Complex modulus frequency sweep on mix,
    - Repeated load testing for fatigue and rutting,
    - Modelling based on full set of results.

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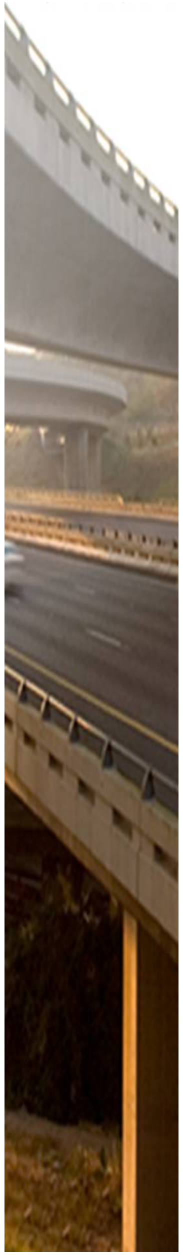

Envisaged M-E design for HMA

- Level 2 (tentative):
  - G* binder characterization,
  - Complex modulus frequency sweep on mix,
  - Use of stiffness values to model rutting/fatigue damage
- Level 3:
  - Use default values for G* binder,
  - Predict complex modulus for mix (Witczak, Hirsch type relation)
  - Use of predicted stiffness values to model rutting/fatigue damage

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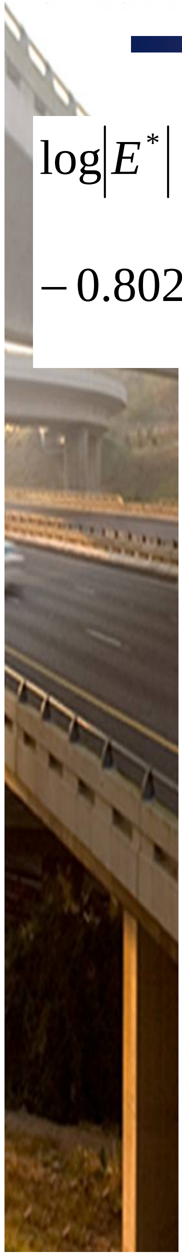
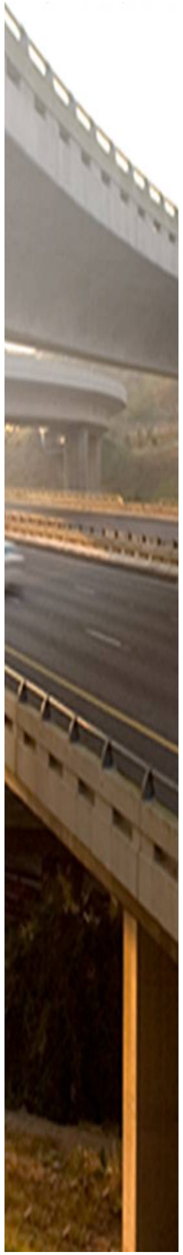


Dynamic Modulus

$$\log\left|E^*\right| = 3.750063 + 0.02932\,P_{200} - 0.001767\left(P_{200}\right)^2 + 0.002841\,P_4 - 0.058097\,V_a$$
$$- 0.802208\frac{V_{beff}}{\left(V_{beff} + V_a\right)} + \frac{\left[3.871977 - 0.0021\,P_4 + 0.003958\,P_{38} - 0.000017\left(P_{38}\right)^2 + 0.005470\,P_{34}\right]}{1 + e^{\left(-0.603313 - 0.313351\log f - 0.393532\log\eta\right)}}$$

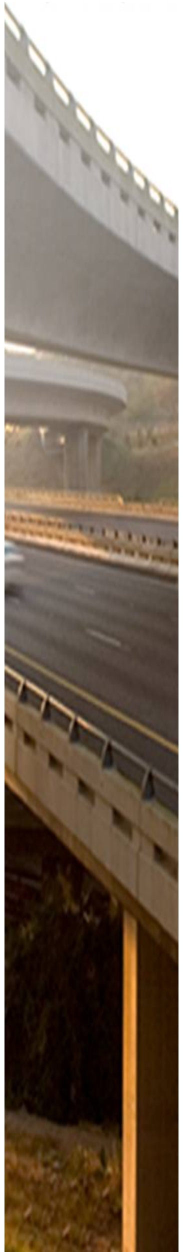
$\lvert E^*\rvert$	= asphalt mix complex modulus, in 10^5 psi (145 psi = 1 MPa);
η	= binder viscosity, in 10^6 poise [10 Poise = 1 pa.s];
f	= load frequency, in Hz;
V_a	= % air voids in the mix, by volume;
V_{beff}	= % effective bitumen content, by volume;
P_{34}	= % retained on ¾-in. [19.0-mm]
P_{38}	= % retained on 3/8-in. [9.5-mm]
P_4	= % retained on No. 4 [4.75-mm]
P_{200}	= % passing No. 200 [0.075-mm]



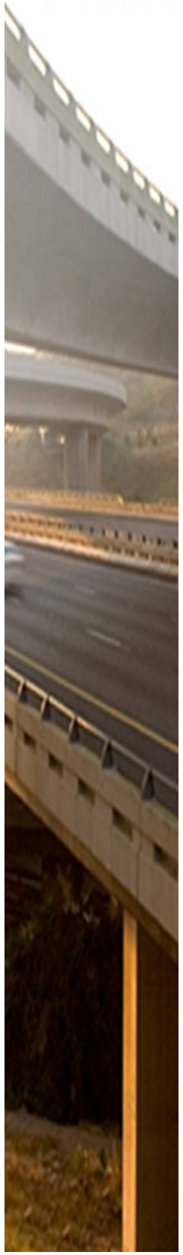
HMA research effort

- Selection/development of appropriate test protocols,
- Laboratory testing,
- Model development,
- Field validation.

Laboratory test program



- 5 (+1) mixes:
  1. BTB, 40/50 pen binder,
  2. Coarse continuous, AE2 binder,
  3. Medium continuous, AE2 binder,
  4. Bitumen rubber,
  5. Medium continuous, 60/70 binder,
  6. (+HiMA)
- Progress:
  - Mix 1 testing completed,
  - Mix 2 & 3 in progress



Sample Preparation:

- Binder testing:
  - Binder sourced at the plant => RTFOT, PAV
  - Binder recovered, from the field (aging),
  - Binder recovered from laboratory samples.
- HMA mix preparation:
  - Initial plan: compact plant produced mix,
  - Revised plan: Produce mix from components,
  - Conditioning of samples:
    - Short term aging to simulate production aging,
    - Long term aging to simulate 5-10 years in-service aging.

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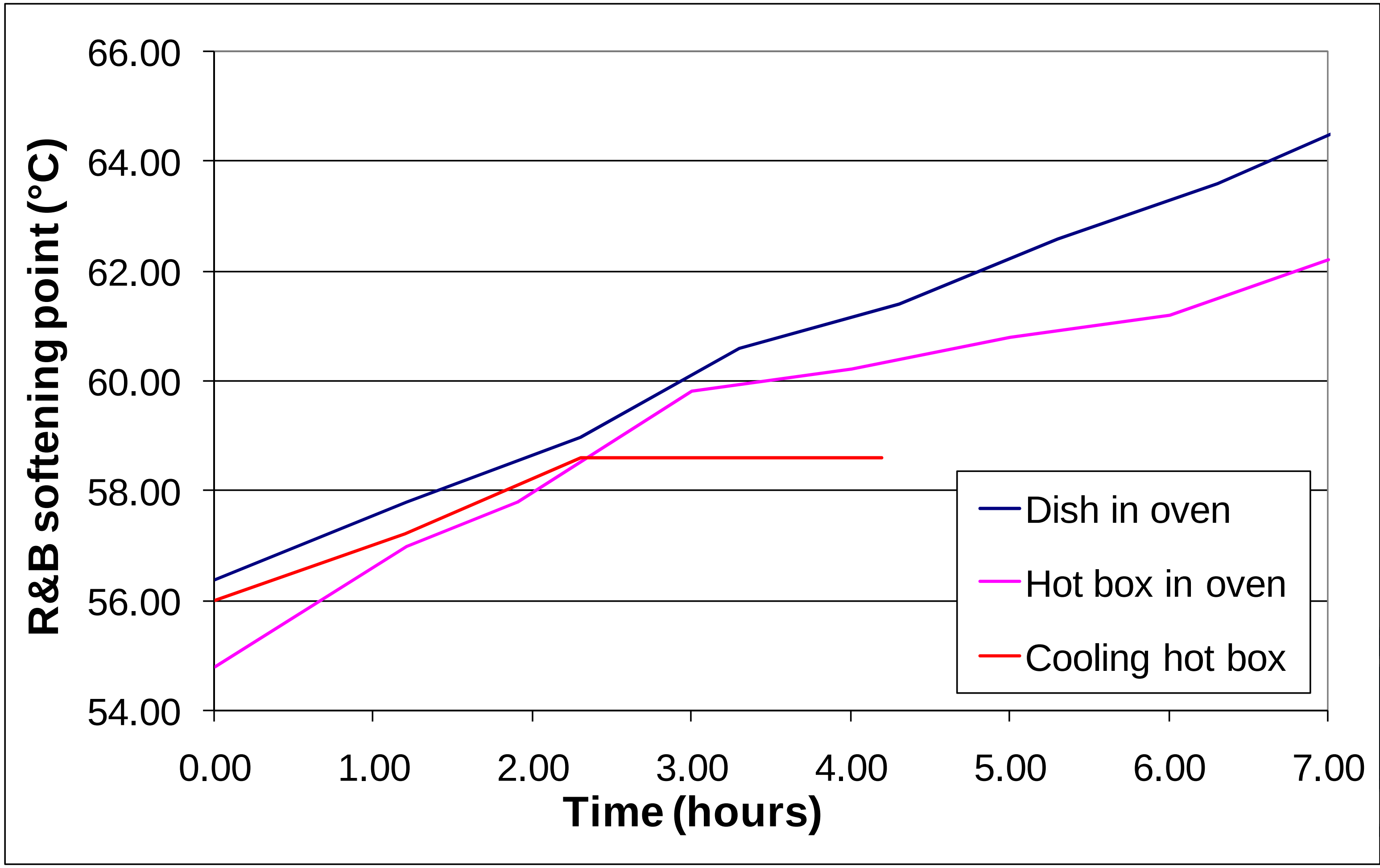
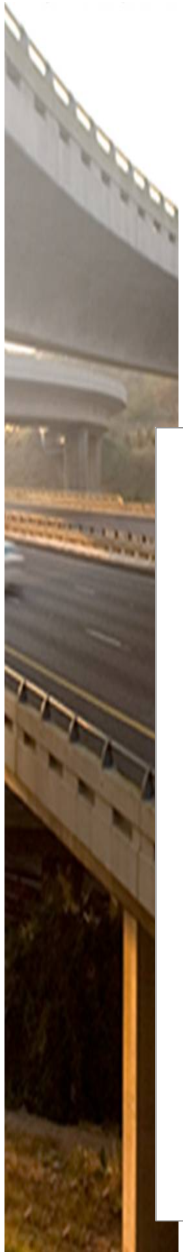
Sample Preparation:

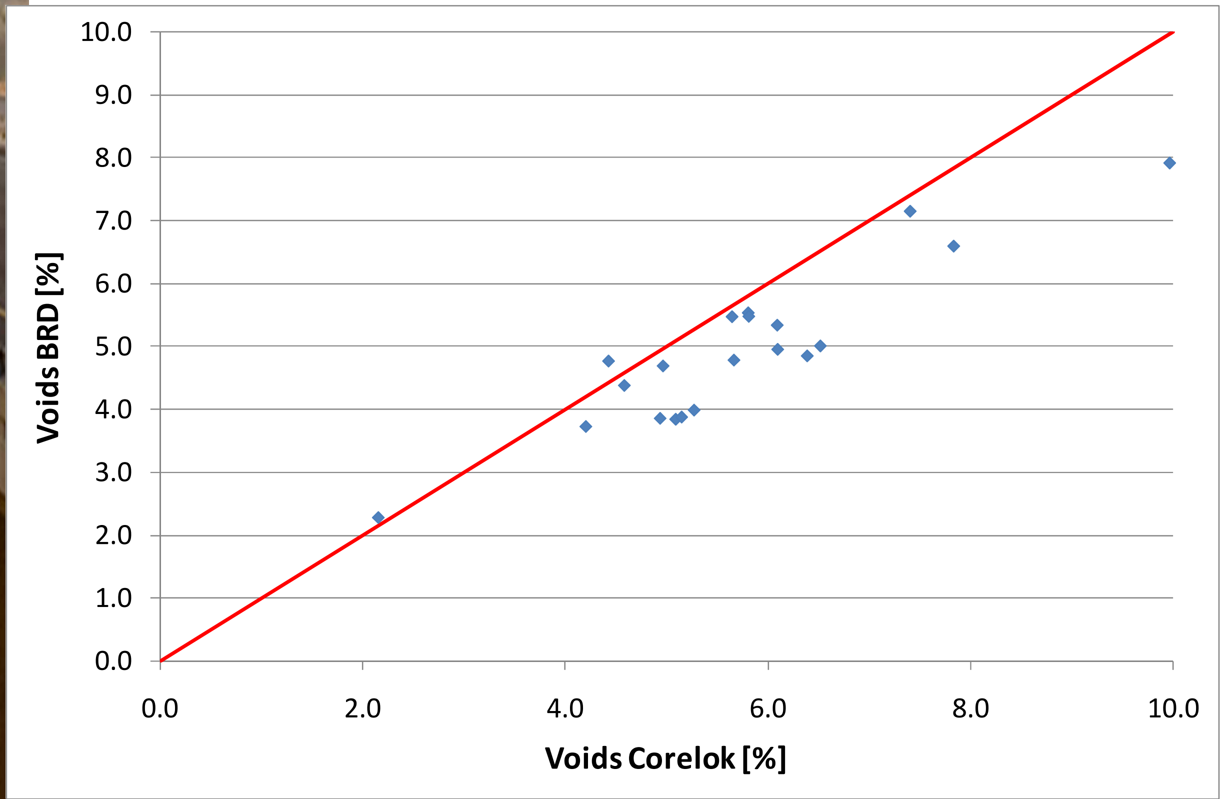
- Binder aging in hot-box



Density determination



- Conventional BRD vs Corelok



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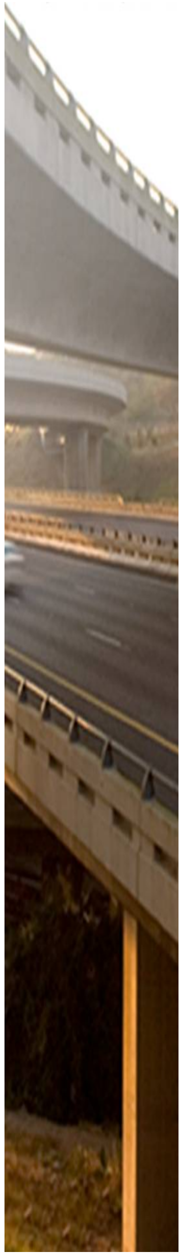

Summary

- Process is on schedule,
- International best practise adapted for local conditions,
- The models will allow different levels of assessment,
- Method will be as simple as possible, but no simpler than that.