SOUTH AFRICAN PAVEMENT DESIGN METHODS: THIN SURFACINGS

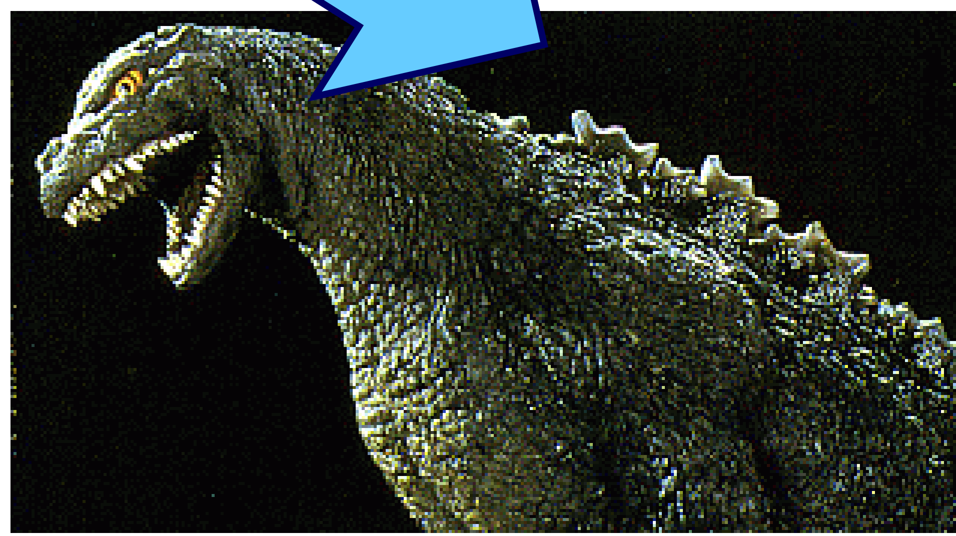
Improved Damage Models for Bituminous Materials (Project PB/2006/D-1): Part 2 – Thin Surfacings

Progress: RPF May 2012

Dr TI Milne

SAPDM aka Godzilla

A Family Matter



Thin Surfacing Seal Design Method
Junior Godzilla

THE SOUTH AFRICAN NATIONAL ROADS AGENCY

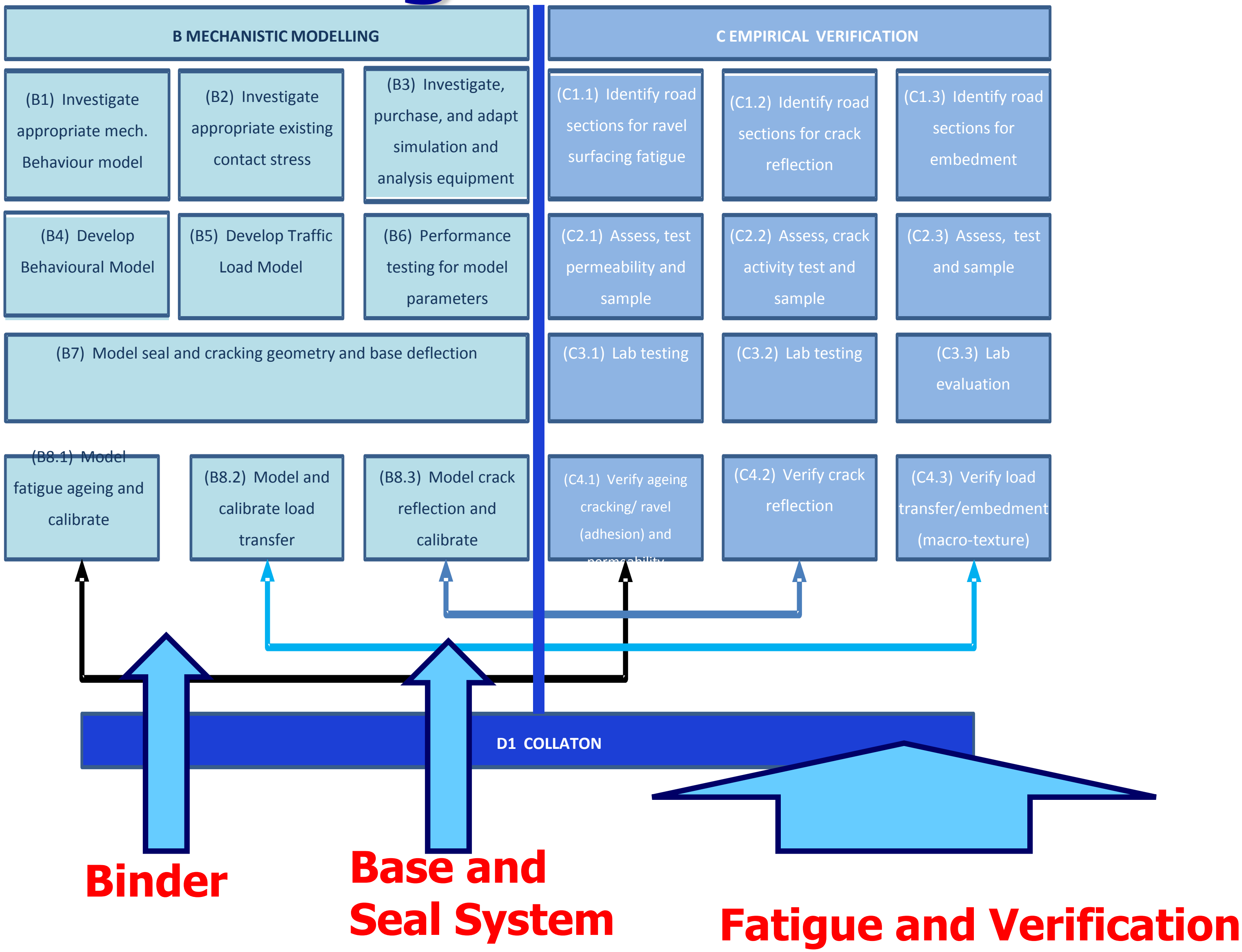
Sheila

Godzilla's daughter?

Acknowledgements

Prof K Jenkins (SU)
Prof W Steyn (UP)
Prof A Visser (UP)
Dr M de Beer (CSIR)
G van Zyl (SU and MyCube)
E Mukandile (UP)
J Gerber (SU)
B Verhaeghe (CSIR)
L Kannemeyer (SANRAL)
SAPDM Materials Cluster
CSIR and SASOL

Project WBS : Performance Modelling



Progress as at RPF May 2011

Inception phase: March 2010 to April 2011

- **COMPLETE**

Seal Modelling: commence skills transfer May 2011

- **CURRENT**

Lab testing: commence skills transfer May 2011

- **CURRENT**

Progress as at RPF May 2011….

- Bitumen characterisation: Lab tests: commence July 2011
- Base characterization: Lab tests: commence July 2011
- Traffic modelling: commence September 2011
- Field assessment: commence July 2011
- Completion scheduled: end 2013/mid 2014

Progress as at RPF May 2012

Inception phase: March 2010 to April 2011

- **COMPLETE**

Seal Modelling: commence skills transfer May 2011, ongoing

- **CURRENT**

Lab testing: protocols and skills

- **COMPLETE**

Progress as at RPF May 2012….

- Bitumen characterisation: Lab tests: commence July 2011 : Commenced December 2011

  CURRENT

- Base characterization: Lab tests: commence July 2011 : Commencing Currently

  !!!!!

- Traffic modelling: commence September 2011

  Input **COMPLETE**

  Modelling **CURRENT**

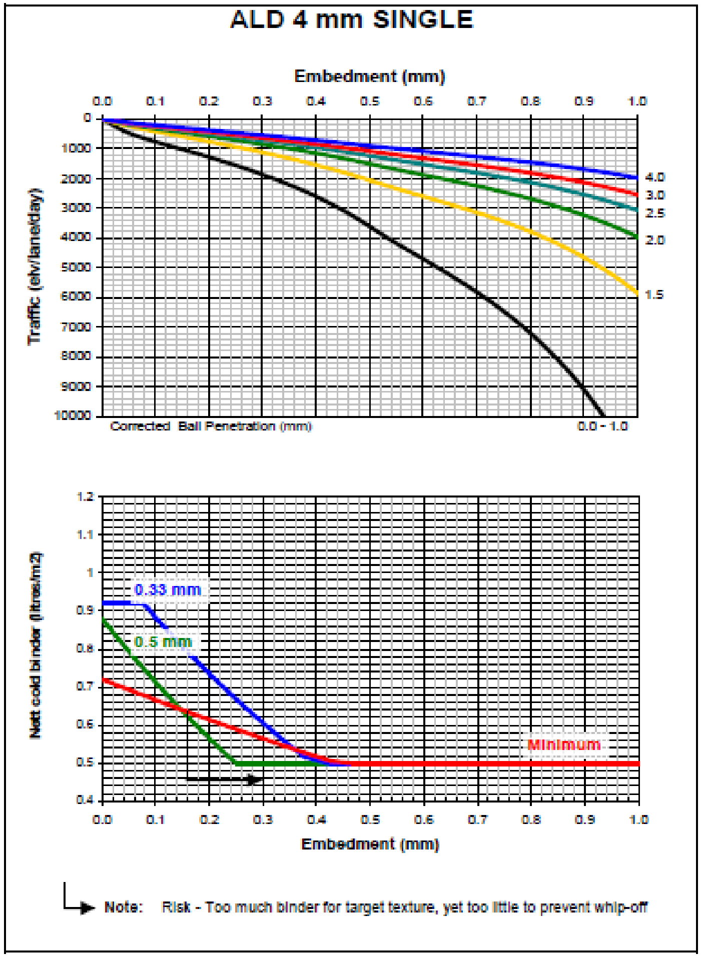
- Field assessment: commence July 2011 : Commenced September 2011

  CURRENT

- Completion scheduled: end 2013/mid 2014

Desired Outcomes

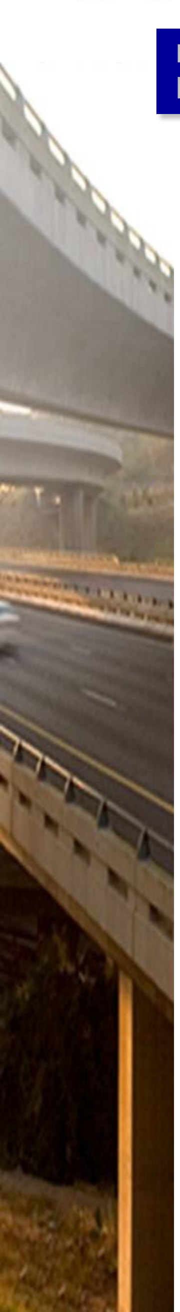
DESIGN CHART FOR SINGLE SEALS: 4mm ALD

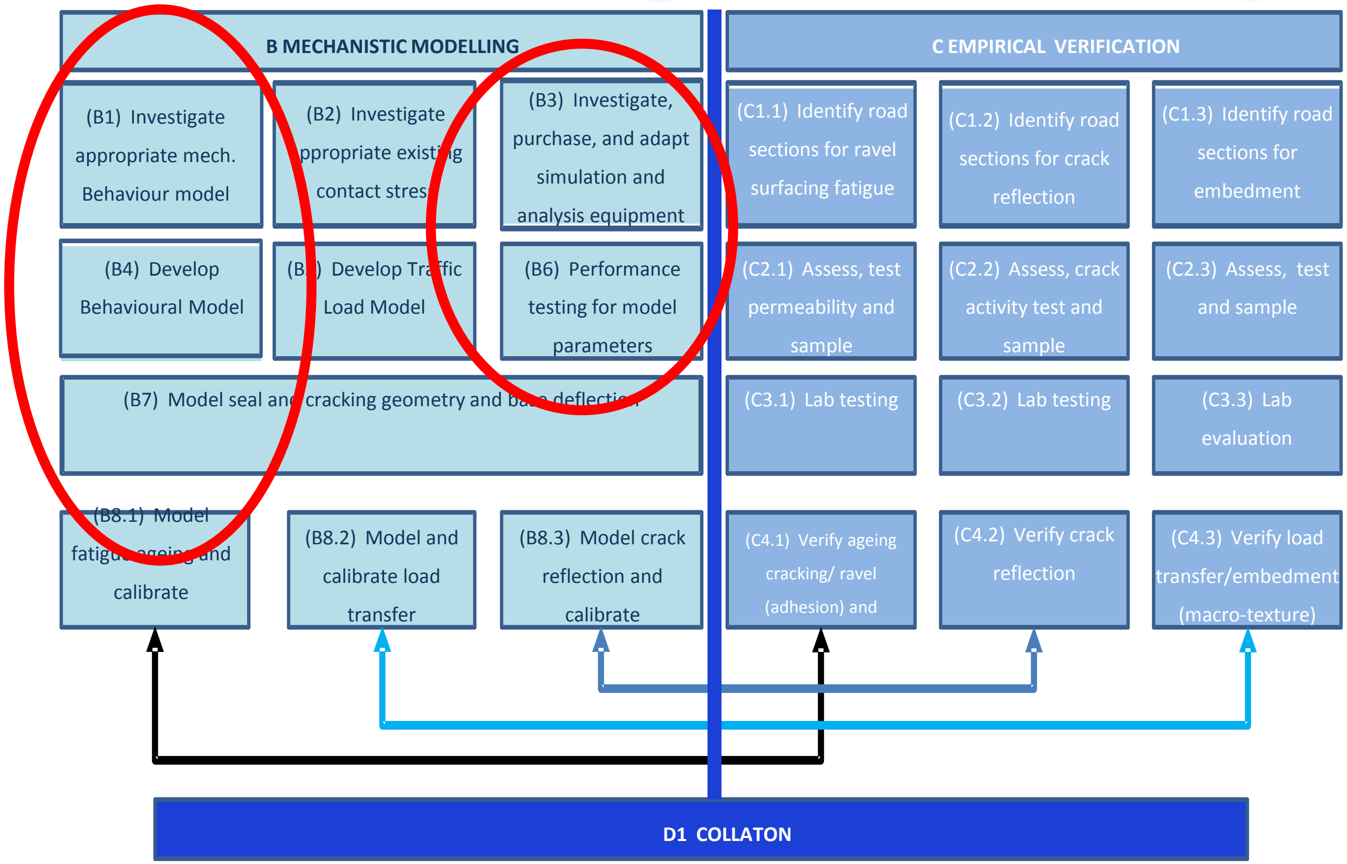


Desired Outcomes….

- Design curves for :
  - Specific traffic loading
  - Climate
  - Base type
  - Seal type
  - Binder types (Straight/Modified)
  - Aggregate type and size (Acidic/Basic)
- Using modelling for "performance testing", incl ageing, fatigue
- Design tool for specific high end seals
- Associated laboratory tests to reflect actual characteristics of binder, and selection of applicable curve

Performance Modelling : Binder Damage and Response





Binder Damage and Response Modelling, Adhesion

Rheological and adhesion characterisation of bituminous road seal binders for mechanistic design methods

Bitumen Tests

- Binder Preparation tests
  - Aging of fresh bitumen:
    - using Pressure Aging Vessel (PAV)
  - Water conditioning of Sample
    - Using Vacuum Vessel
  - Bitumen mastic preparation
    - Mastic= binder, sand and cement
  - Bitumen extraction from site seals:
    - using SABITA Manual 29.

Bitumen Tests….

- Binder and Adhesion Characterisation Tests (using DSR)

  Test done on **fresh binders and aged binder** and on **extracted binder** from site.

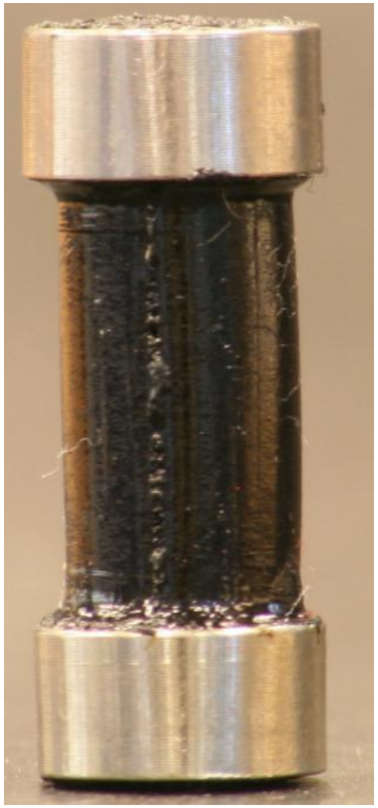
  - Binder film shear response tests
  - Binder/Mastic column fatigue tests
  - Stone column adhesion test
  - for
- Master curves
- Binder fatigue model
- Adhesion Model

Bitumen Tests....

- Binder Film shear response test

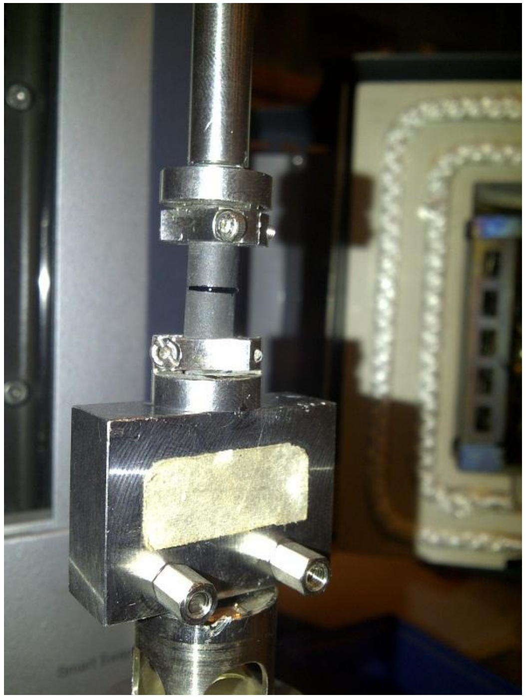
Bitumen Tests….

- Binder/Mastic column fatigue tests



Bitumen Tests….

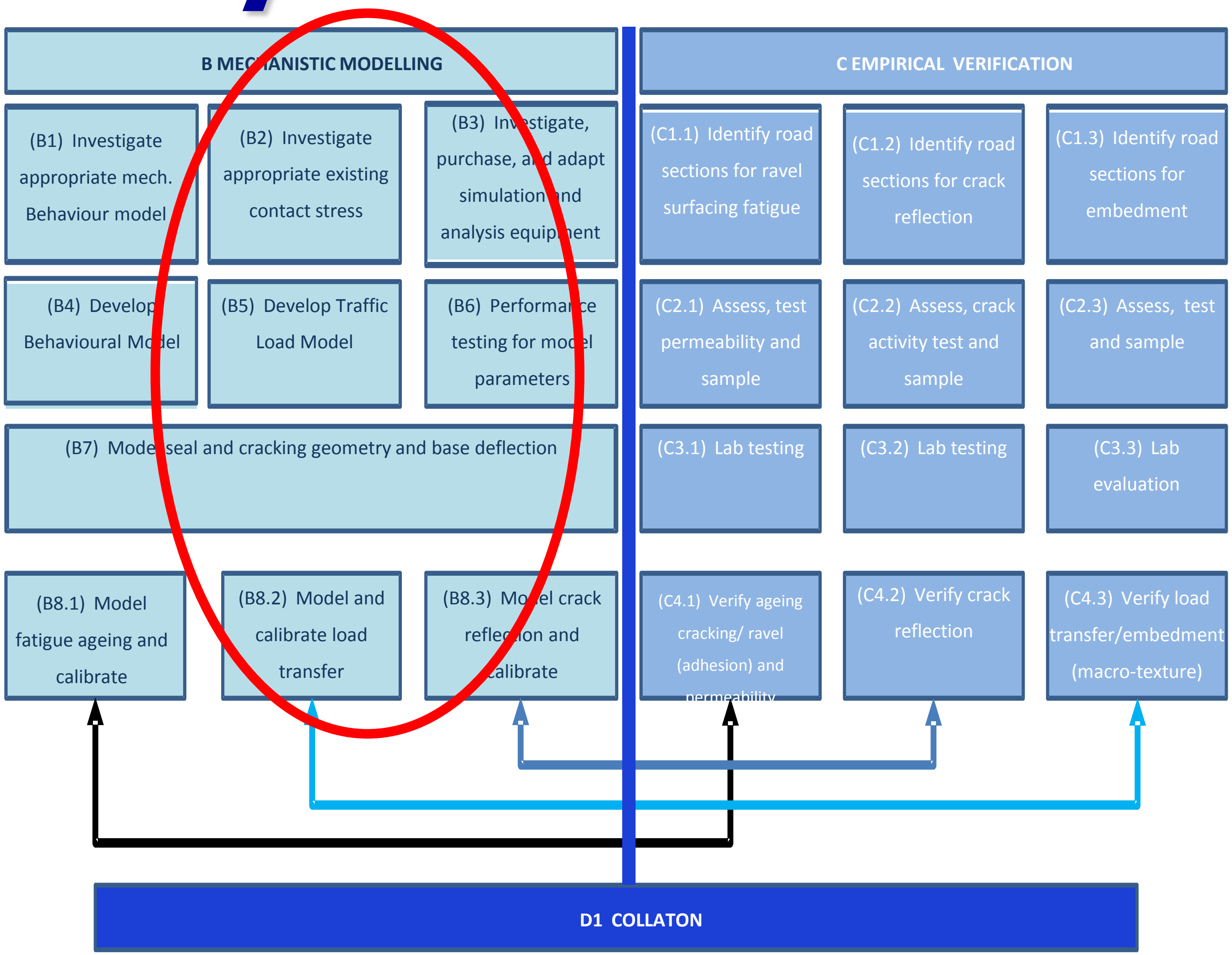
- Stone column adhesion test



Current Progress

- Development of test protocols
  - Binder extraction
  - DSR tests for Binder characterization
  - Confirmation of binders and compilation of test stock
  - Confirmation of aggregate, coring for DSR and SU adhesion tests
  - Confirmation of ageing tests and protocol
  - Interaction with Bitumen Specification Working Group

Performance Modelling : Seal System

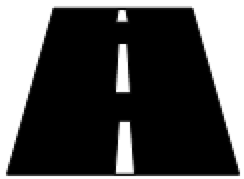
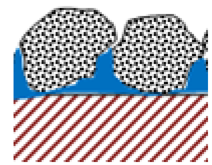
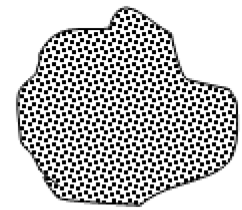
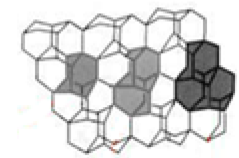


Base Damage and Response Modelling, Seal System Performance Model

Modelling the Seal

- Modelling scales

Table 1.1 Order of pavement design scales

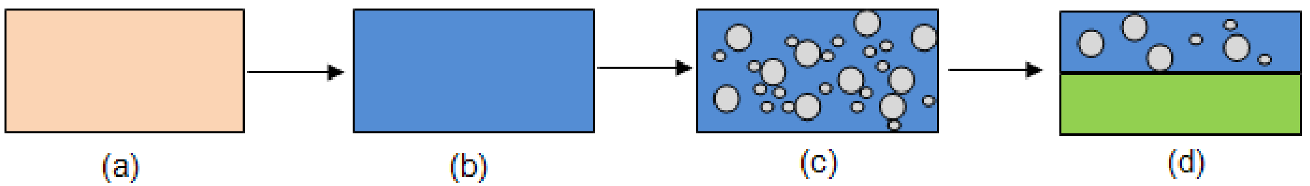
	Global	Macro	Meso	Micro	Nano
Graphical Representation					
Geometry & Material	Real road (full scale)	Individual layers of homogeneous/ elastic materials	Individual particles with laboratory testes properties	Single aspect of a particle is considered	Structure of individual particle

Software

- Abaqus
- Matlab

Modelling the Seal….

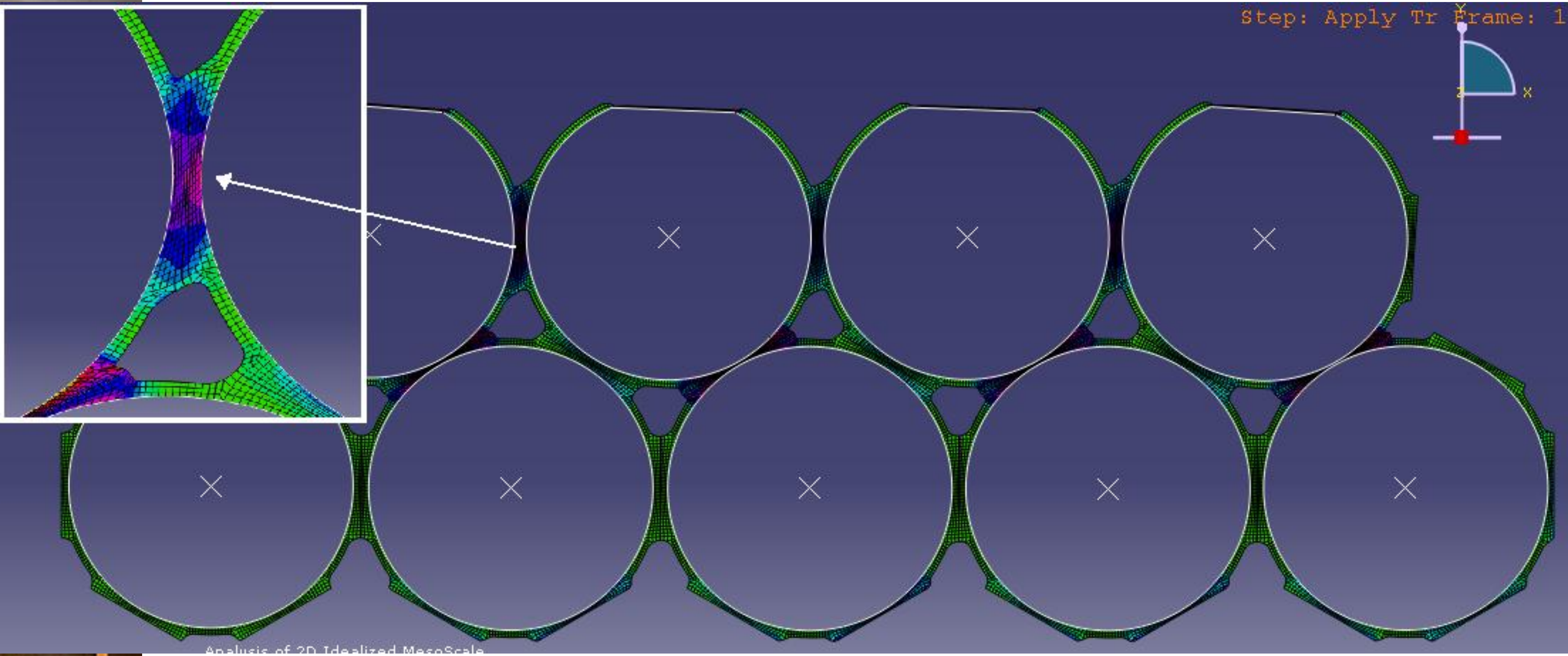
- Response model development (G1/2 base)
  - Incremental development using CT-Scan geometry



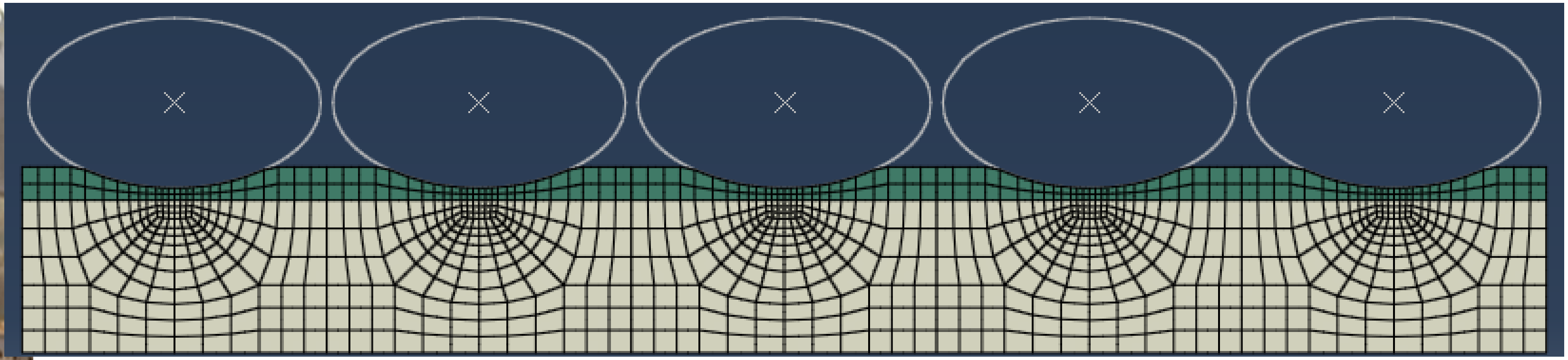
- (a) Linear elastic, homogeneous, isotropic base
- (b) Hyperelastic, homogeneous, isotropic base
- (c) Hyperelastic, heterogeneous, iso/anisotropic base
- (d) Dual system able to portray permanent deformation

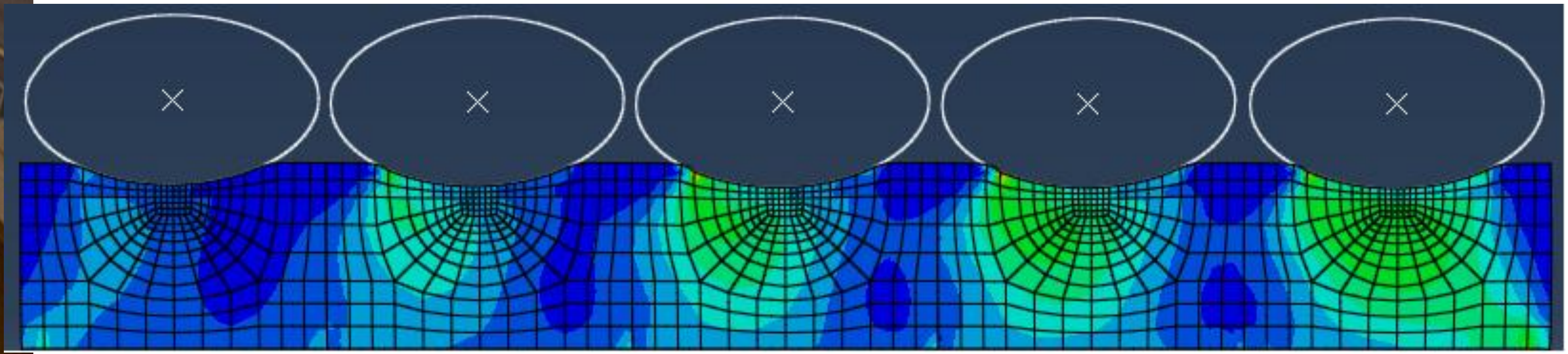
Modelling the Seal….

- Ideal seal structure exercise (2 layers of stone)



Modelling the Seal….



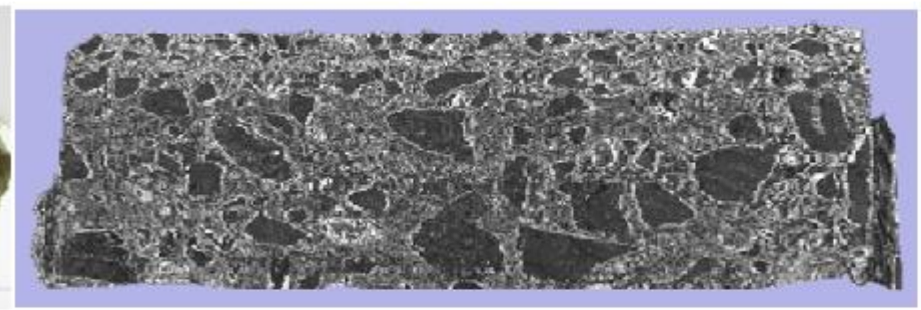


Modelling the Seal….

- Granular base geometry establishment
  - Extracting in-situ samples

Modelling the Seal….

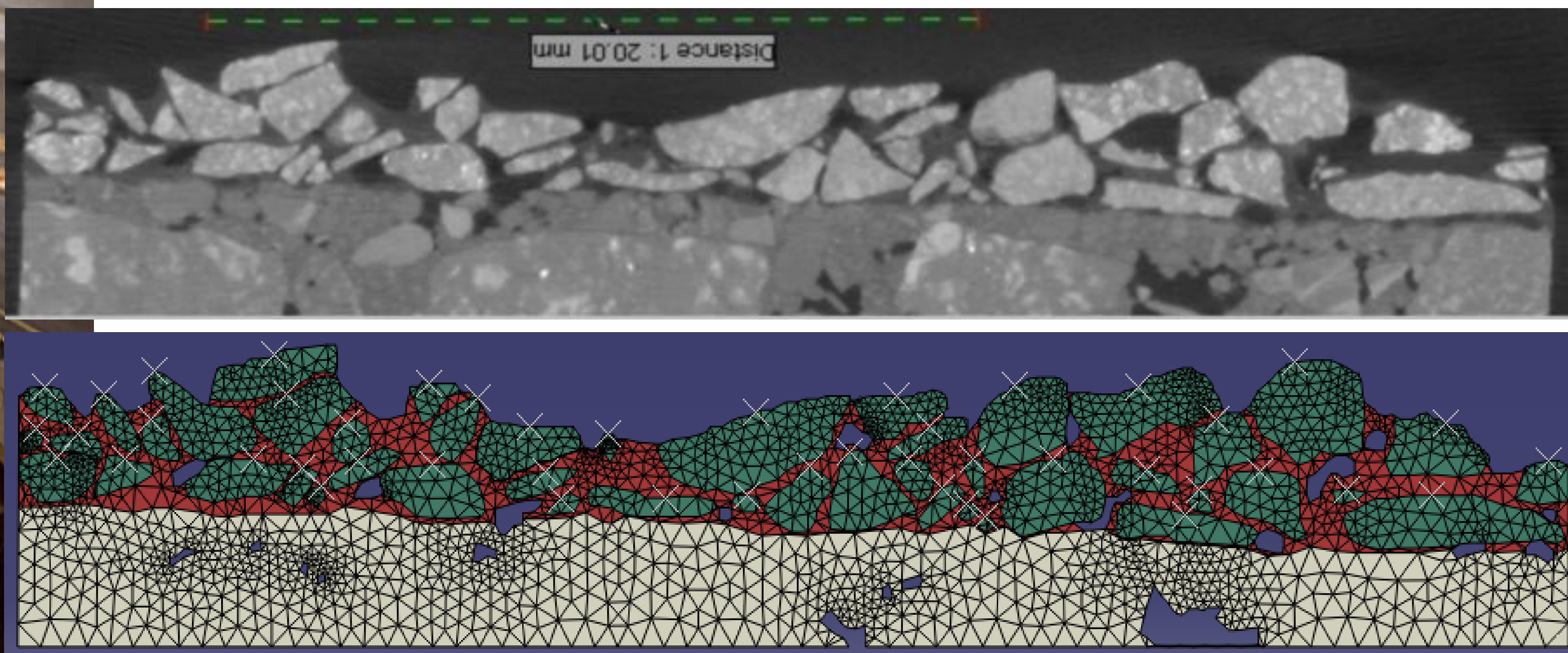
- Granular base geometry establishment
  - Extracted sample & representative CT-Scan



  - Reseal on G5 base

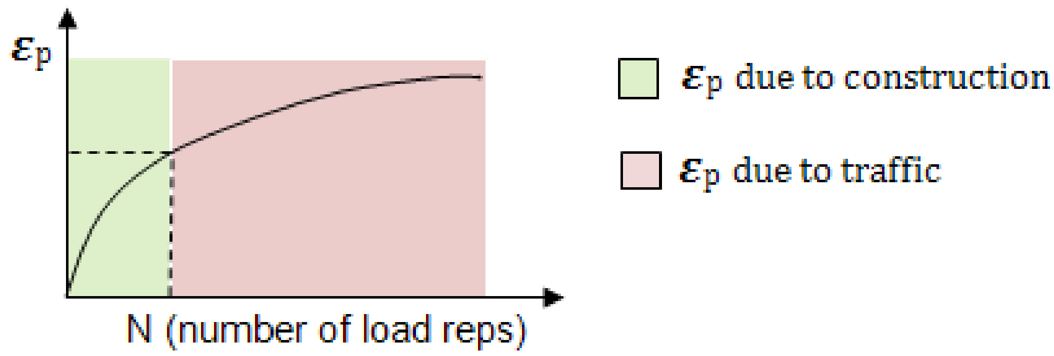
Modelling the Seal….

- 2D CT-Scan meso-scale model



Current Focus Points

- Seal stone embedment data

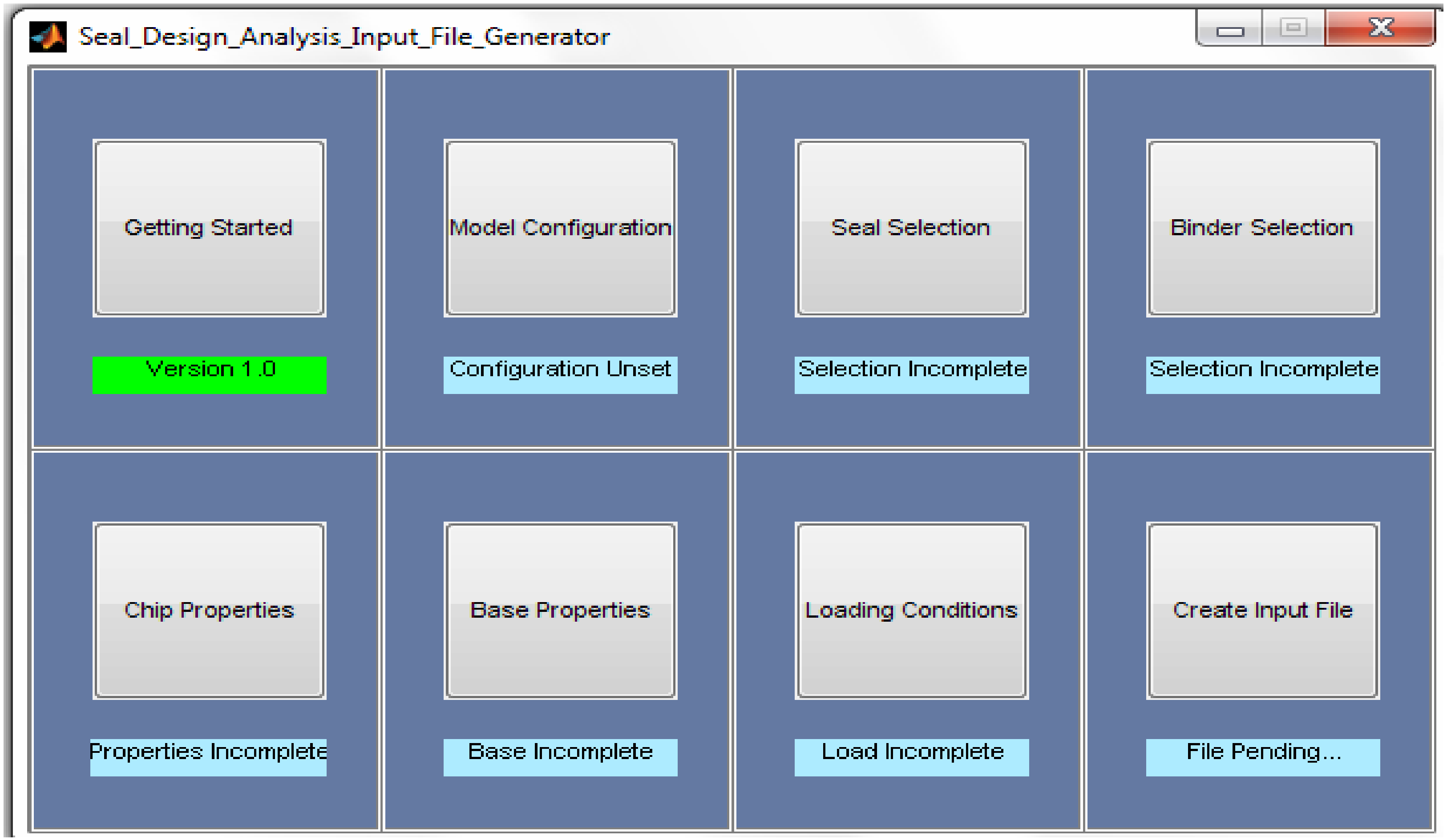


  - At which stage and phase does mechanical damage due to traffic originate?

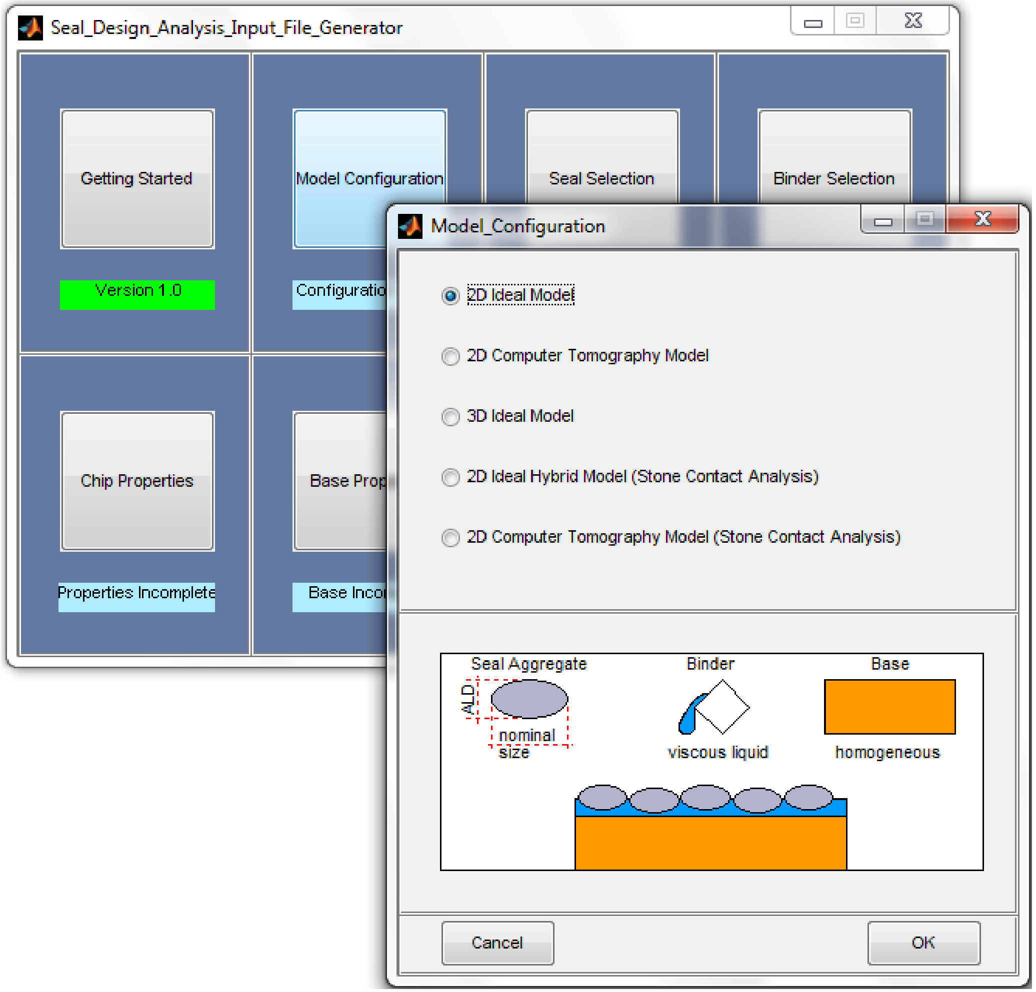
- Access to accurate granular material (G1/2) Lab data.
  - E.g. Triaxial, repeated load CBR, effect of moisture etc.

Seal Performance Model

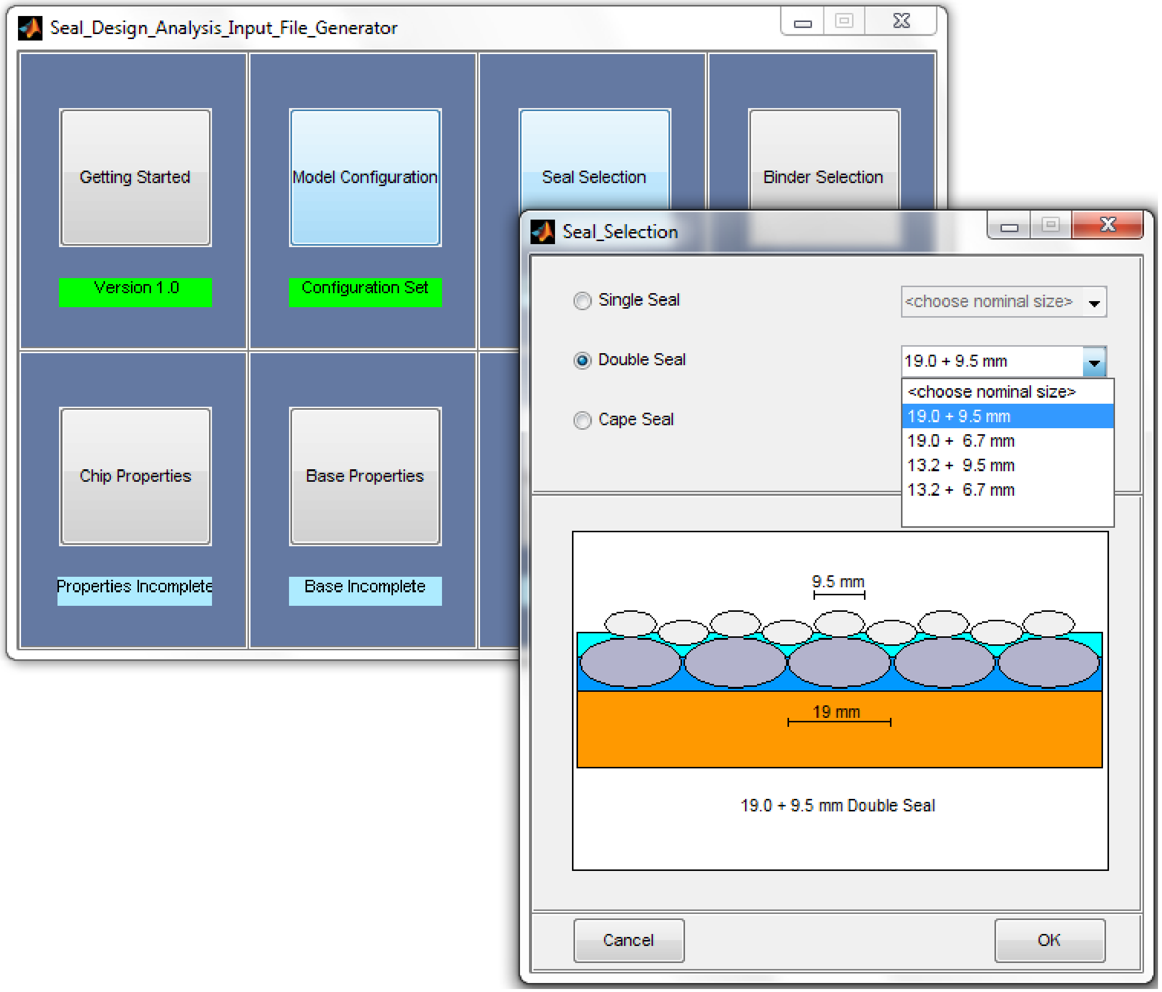
Model Main Interface



Seal Performance Model ….
Model Configuration

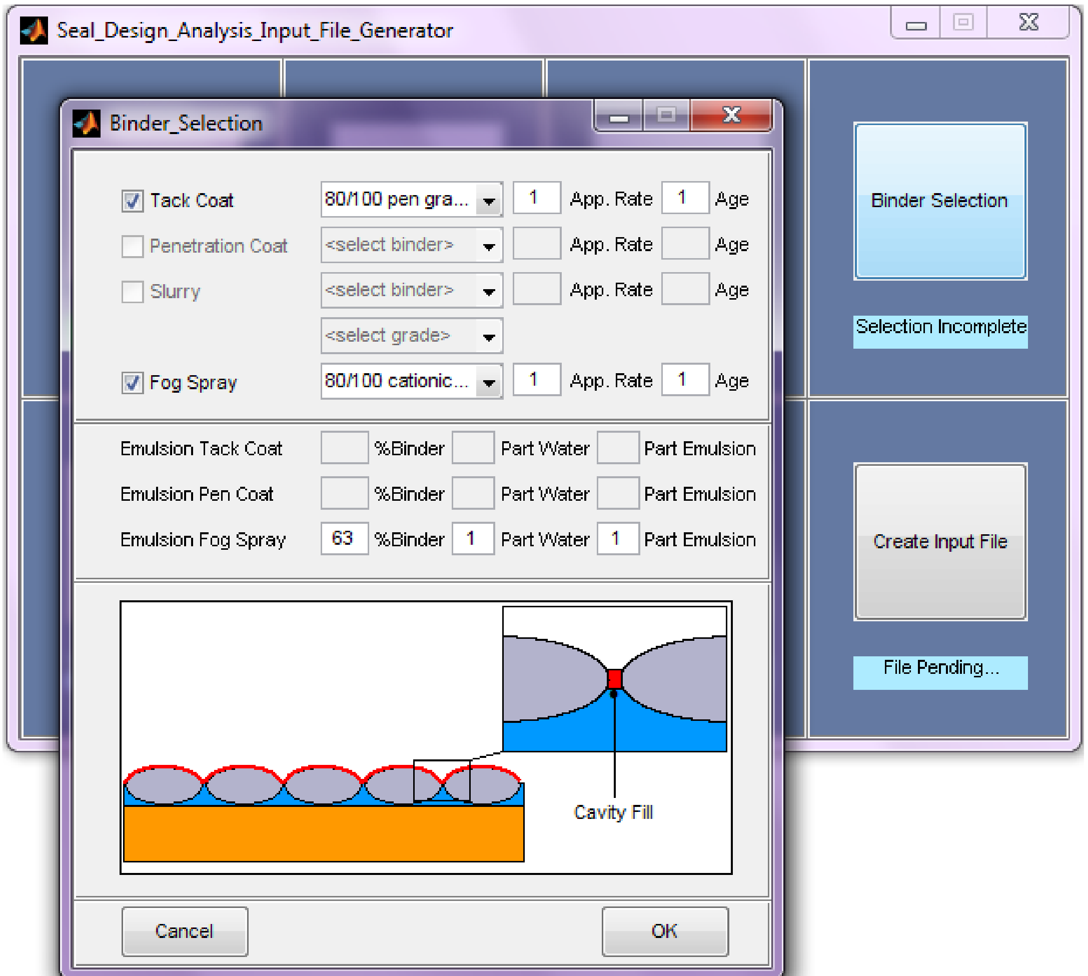


Seal Performance Model ….
Seal Selection



Seal Performance Model ….

Binder Selection

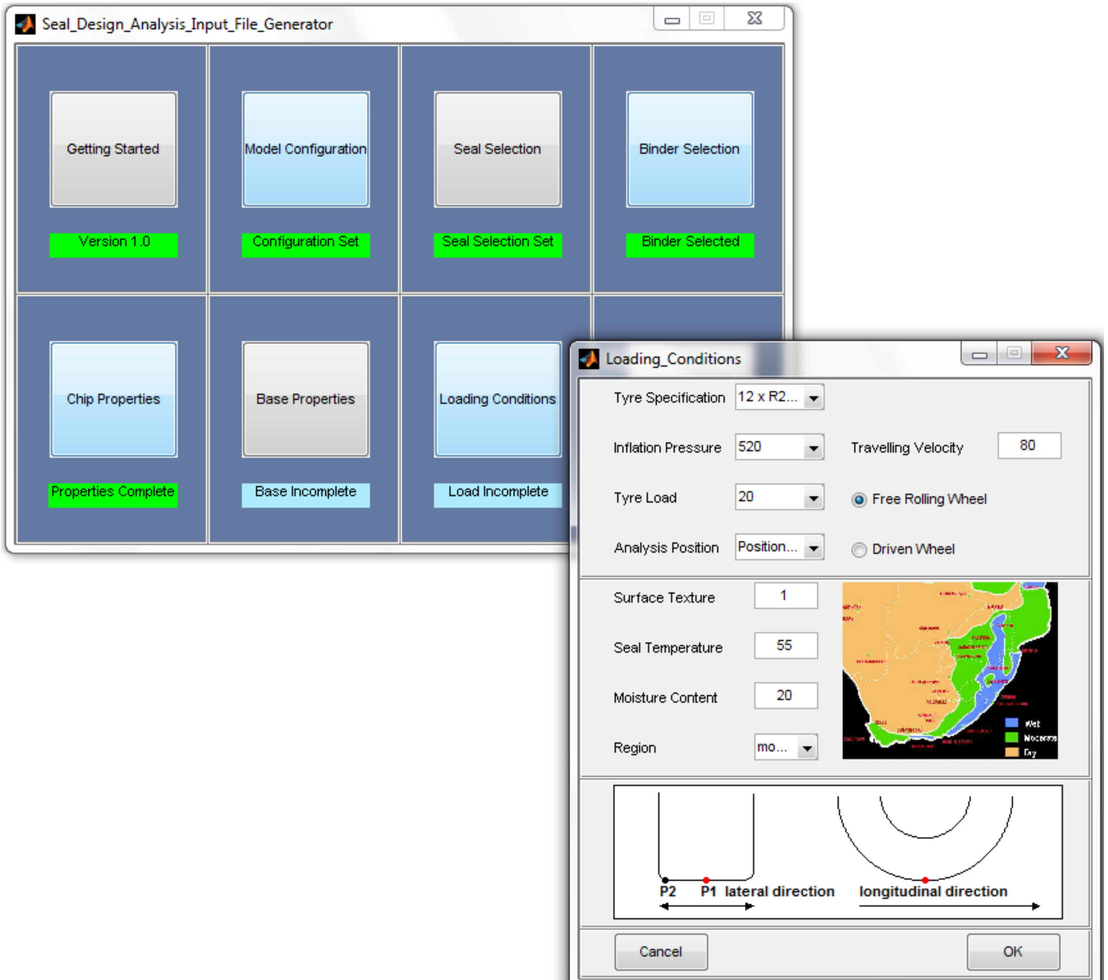


Seal Performance Model ….

Stone 'Chip' Properties

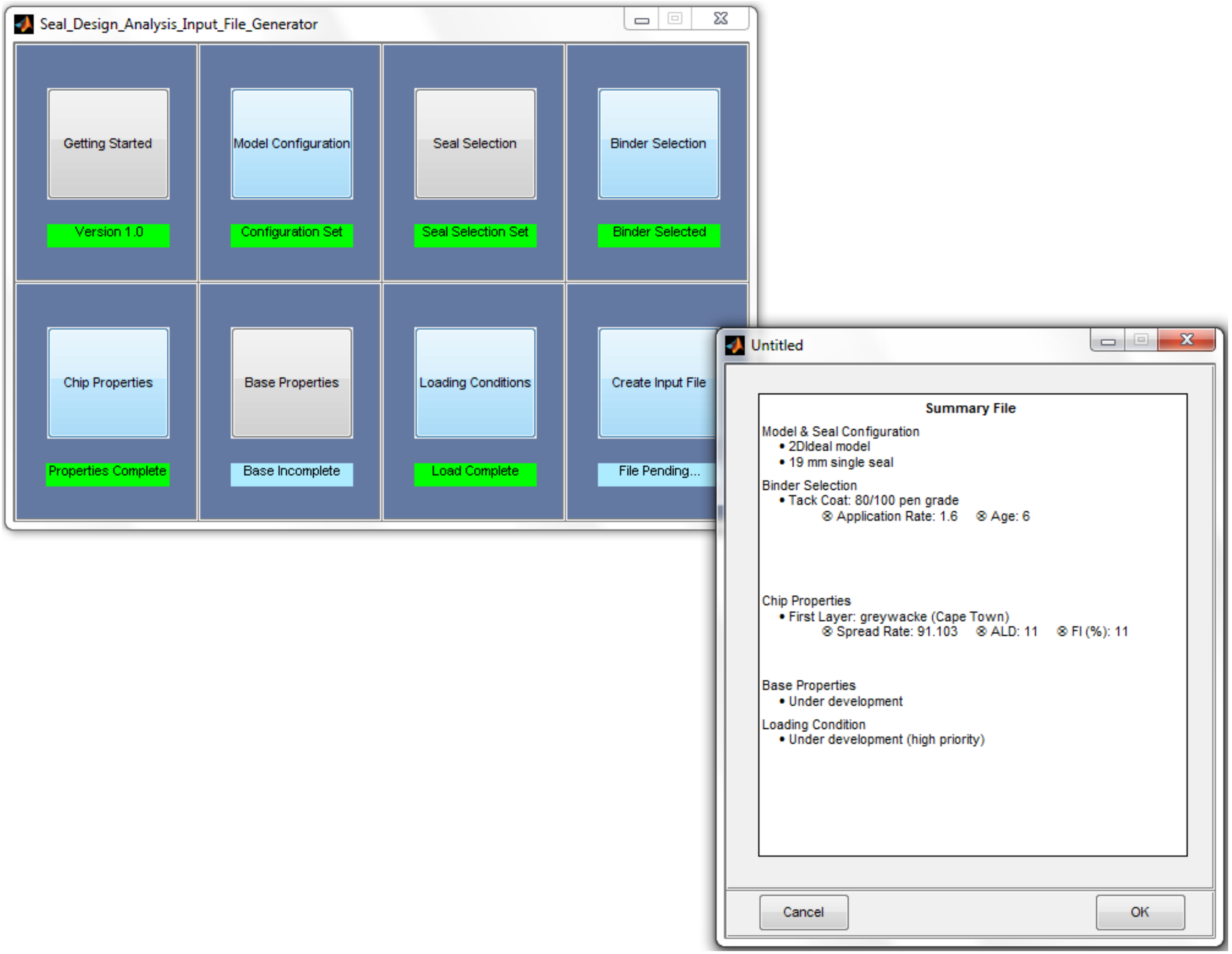
Seal Performance Model ….

Loading Conditions



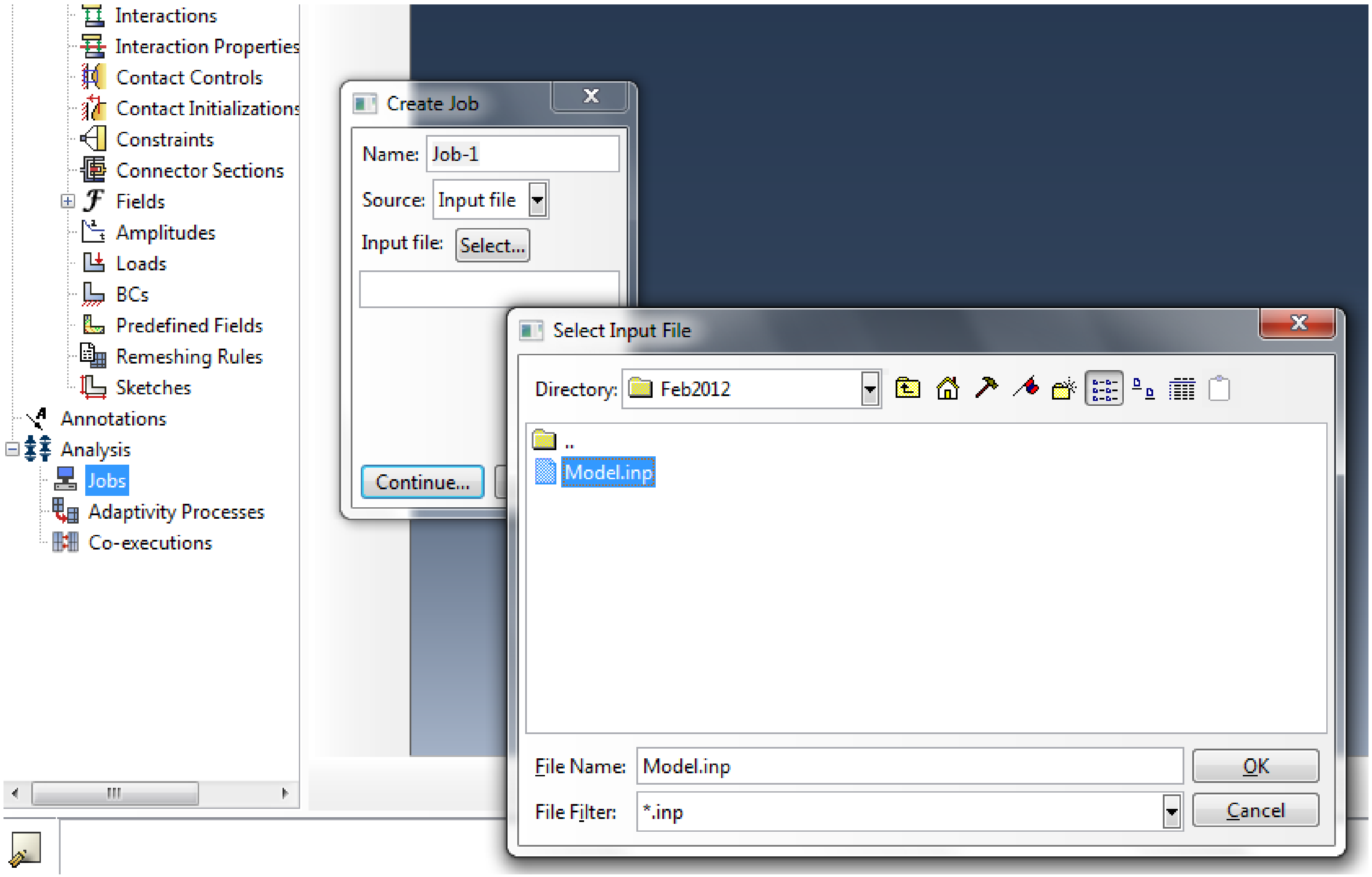
Seal Performance Model ….

Abaqus Input File



Seal Performance Model ….

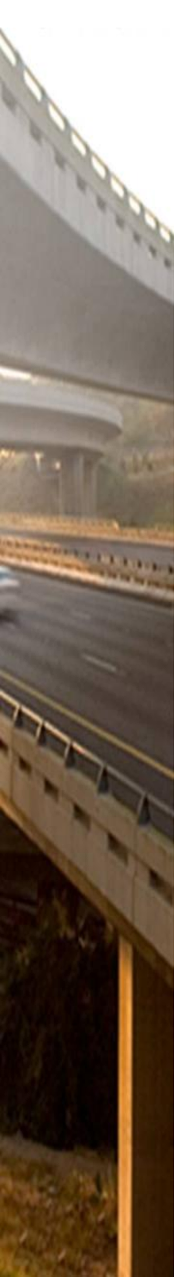
Import Input File

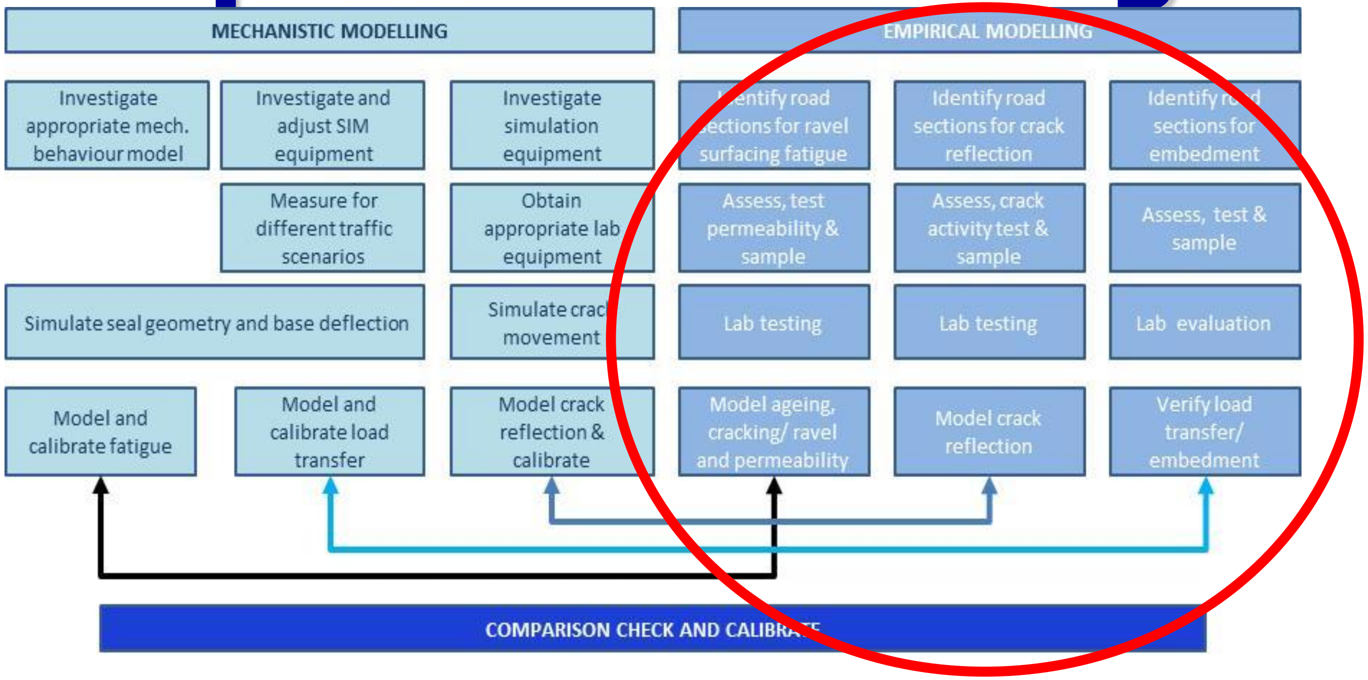


Current Progress

- Development of seal performance model
  - Input file design approach
  - Includes seal design criteria
  - Includes base response model(s)
  - Incorporates refined SIM traffic loading model
  - Forms foundation of mechanistic seal model development
- More field sample extractions
- Base material response model
  - (Development continues)
- Development of tyre loading model

Empirical Modelling





Model ageing, cracking/ ravel and permeability

Model crack reflection

Verify load transfer/ embedment

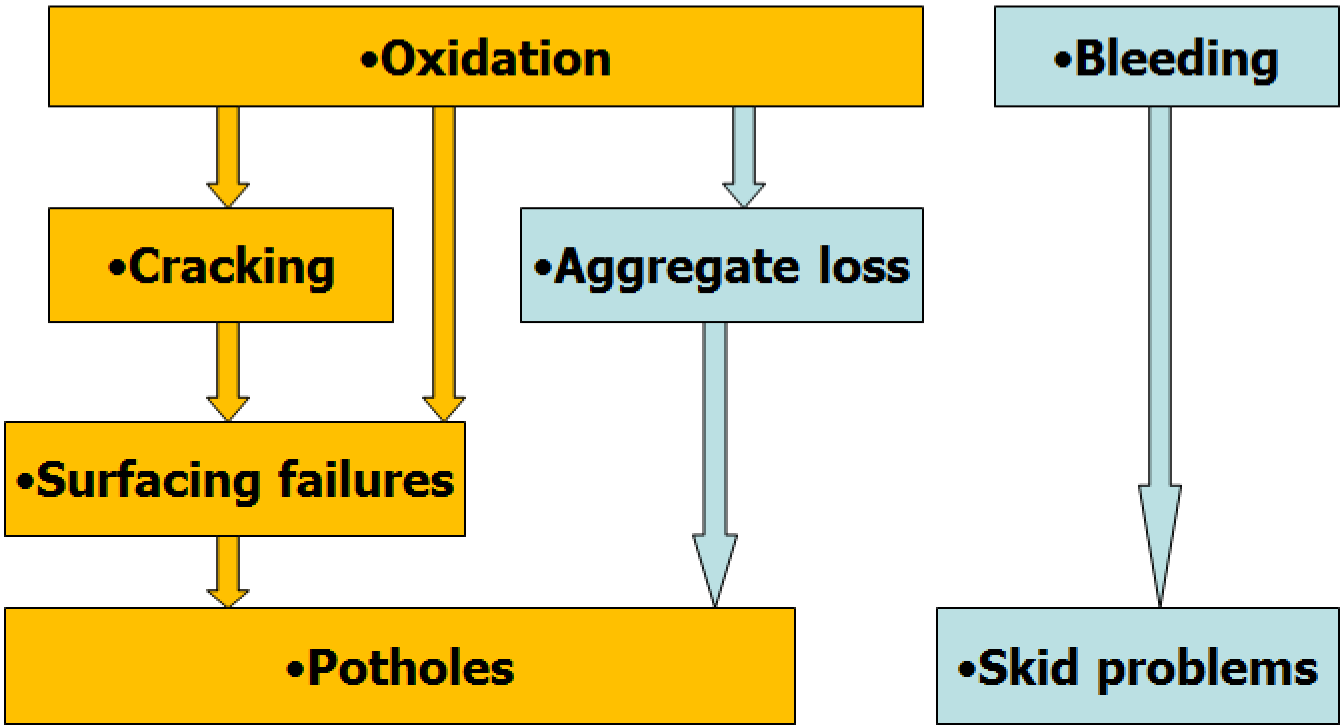
Fatigue (Cracking) and Field Verification

Study Phases

- Phase 1 (Existing models, matrix, hypothesis,data)
- Phase 2 (Confirm data, mark and assess sites)
- Phase 3 (Sampling, testing, database)
- Phase 4 (Modelling)

Scope of Verification

- **Surfacing** (Wearing course – if well constructed).



Field Sampling Matrix

Seal Performance C1 Progress Report.pdf - Adobe Reader

File Edit View Window Help

28 / 31 169% Comment

Table 2 Seal and binder types

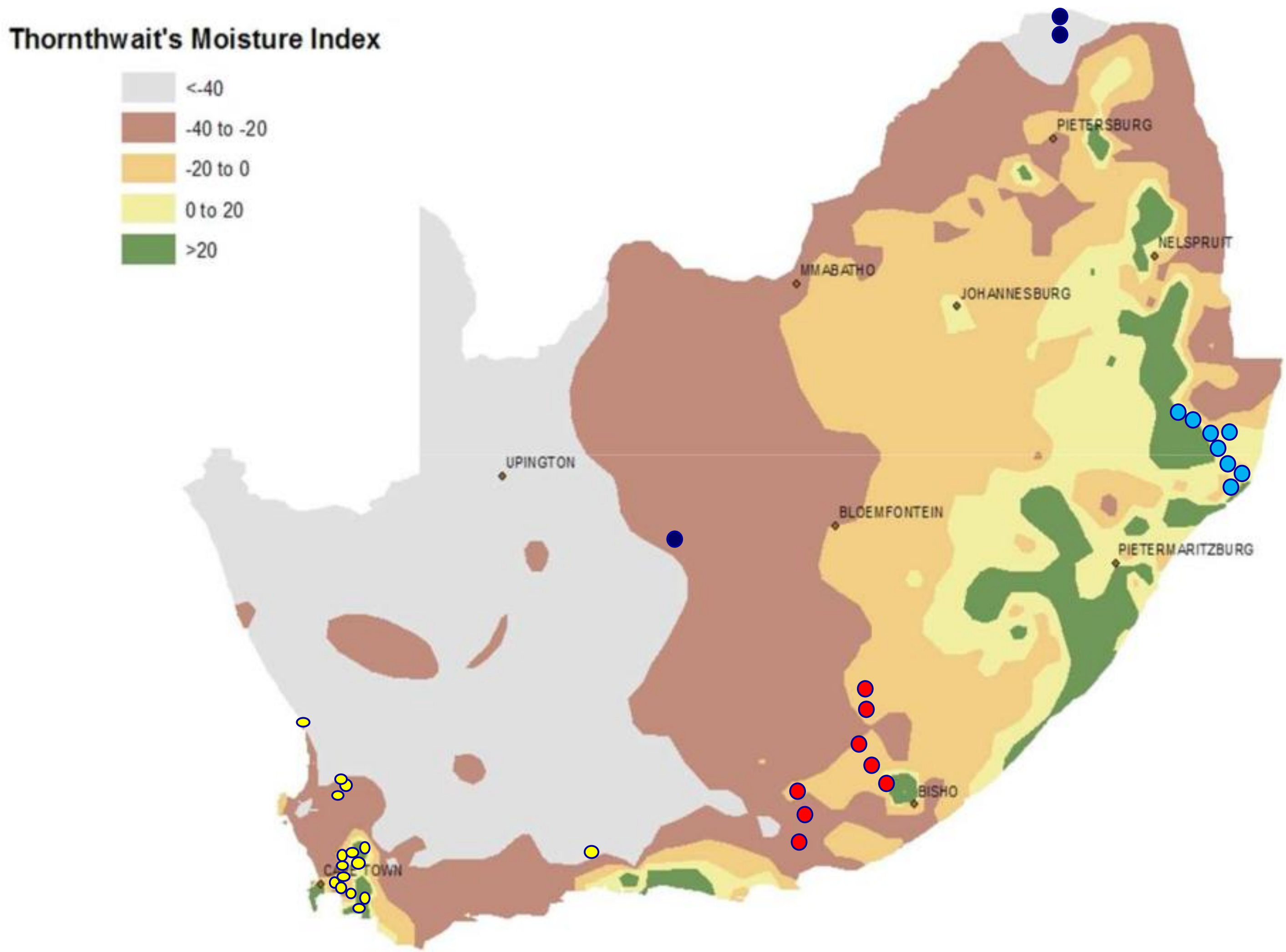
		Conv Binder	Mod Binder	Total
Multiple Stone	13mm + 7mm	6	6	12
	19mm + 7mm+ 7mm		7	7
	19mm + 9mm	1		
	Sub-Total	**7**	**13**	**20**
Cape Seals	19mm Cape Seal	10	0	10
	13,2mm Cape Seal	1	0	1
	Sub-Total	**11**	**0**	**11**
Single Stone	13mm Single Seal	2	1	3
	9mm Single Seal	1	0	1
	Sub-Total	**3**	**1**	**4**
	Total	**21**	**14**	**35**

Seal type, binder type, climate, traffic, base

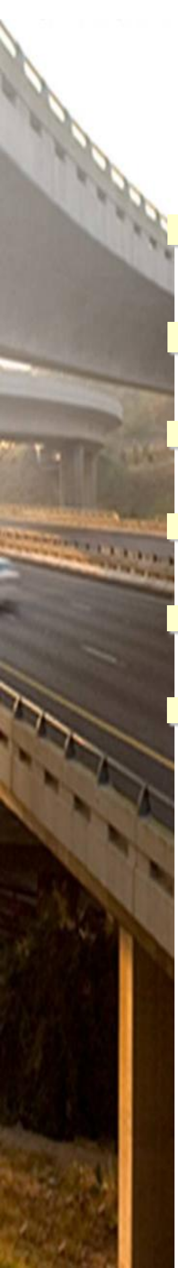
Base type

EN 21:11 07/05/2012

Data Set 1: Final Sections (35)



Data Set 2: WCPG (HDM4 Cal Sections)



- 37 Road Sections remaining
- 500 m Segments (Assessments 50m both sides)
- Assessments according to HDM4 and TMH9
- Pavement structure, reseal history, FWD, RQ and Rut
- Since 1996
- Latest assessment (2011) now captured

Assessments Recorded

- Detailed visual
  - (10m – Shoulder, OWT, between and IWT)
- Photographs of each defect type
- Texture measurement
  - (Wheel track, outside wheel track)

MR00188 + 22.96 24.70 519 19mm Cape S 15 1996 Durbanville km 23.5 S33o43'26 E018o41'47.7 1 Paarl Boland to be res

	Surfaced Shoulder					Outer wheel track					Between wheel tracks					Inner wheel track				
	Croc pattern	Long C	Trans v C	Agg Loss	Fattiness	Croc pattern	Long C	Transv C	Agg Loss	Fattiness	Croc pattern	Long C	Trans v C	Agg Loss	Fattiness	Croc pattern	Long C	Trans v C	Agg Loss	Fattiness
10	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
6	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	3	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0
23.5 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0		1	0

	SS	OWT	BWT	IWT
Texture	2.08	1.59		
Diam (m	175	200		

Process

- Sampling
  - Verified / adjusted sampling process and repair



  - Safety
  - Sample marking
  - Transport & storage

Process….

- Sampling
  - New seals or high surface temperature
    - Slab disturbed (crack)
    - Smaller samples
      - (700x500) into 2 or 3
      - Binder recovery (50ml)
      - MTS (200x 200)

Process….

Additional Testing Required

- Radius of curvature
  - Benkelman Beam
  - (Base condition and pavement response of sample pavement)

Current Progress

- Phase 1 (Existing models, matrix, hypothesis,data)
- Phase 2 (Confirm data, mark and assess sites)
- Phase 3 (Sampling, testing, database)
- Phase 4 (Modelling)

Concluding Remarks

- Model materials characterization will be within the Bitumen Spec Working Group suite of tests (DSR, PAV)
- Performance model will be used to generate design curves
- Performance model will be calibrated and verified (Fieldwork)
- Seal model is an integral part of the SAPDM

Questions