Mechanistic-Empirical Structural Design Models for Emulsified Bitumen Treated Materials

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Background

- TG2 for foamed bitumen treated materials
  - Published in September 2002
  - Uses mechanistic-empirical structural design
- Emulsified bitumen treated materials
  - SABITA Manuals:
    - » *Manual 14: GEMS (1993) and 21:ETB (1999)*
  - Manual 21: ETB, no mechanistic-empirical design models
    - » *Catalogues based on DCP design method, validated by empirical catalogues*
  - Lots of field experience

Terminology

- Previous differentiation between
  - Modification: 0.6 – 1.5% residual binder
  - Stabilisation: 1.5 – 5 % residual binder
  - Artificial
    - » *based on what is put in, not on behaviour achieved*
- Move away from differentiation between modification and stabilisation
  - Performance based material classification
  - Refer to material as
    - » *"emulsified bitumen **treated** material" (EBTM)*
  - One design method for all EBTMs

Structural design models: What is required?

- HVS
  - Pavement behaviour and pavement performance data
    - » *Identify distress mechanisms*
  - Data
    - » *Resilient moduli (initial and reduction)*
    - » *Permanent deformation*
  - Tight control and accurate measurement of variables

- Laboratory
  - Engineering, mechanical and durability data
  - Preferably for same material as HVS tests

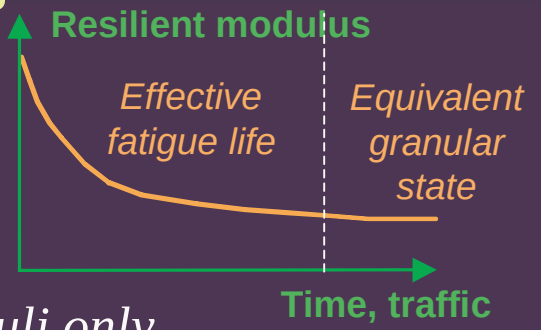
    ➡ *Material classification and structural design*
- What do we have?

HVS Tests

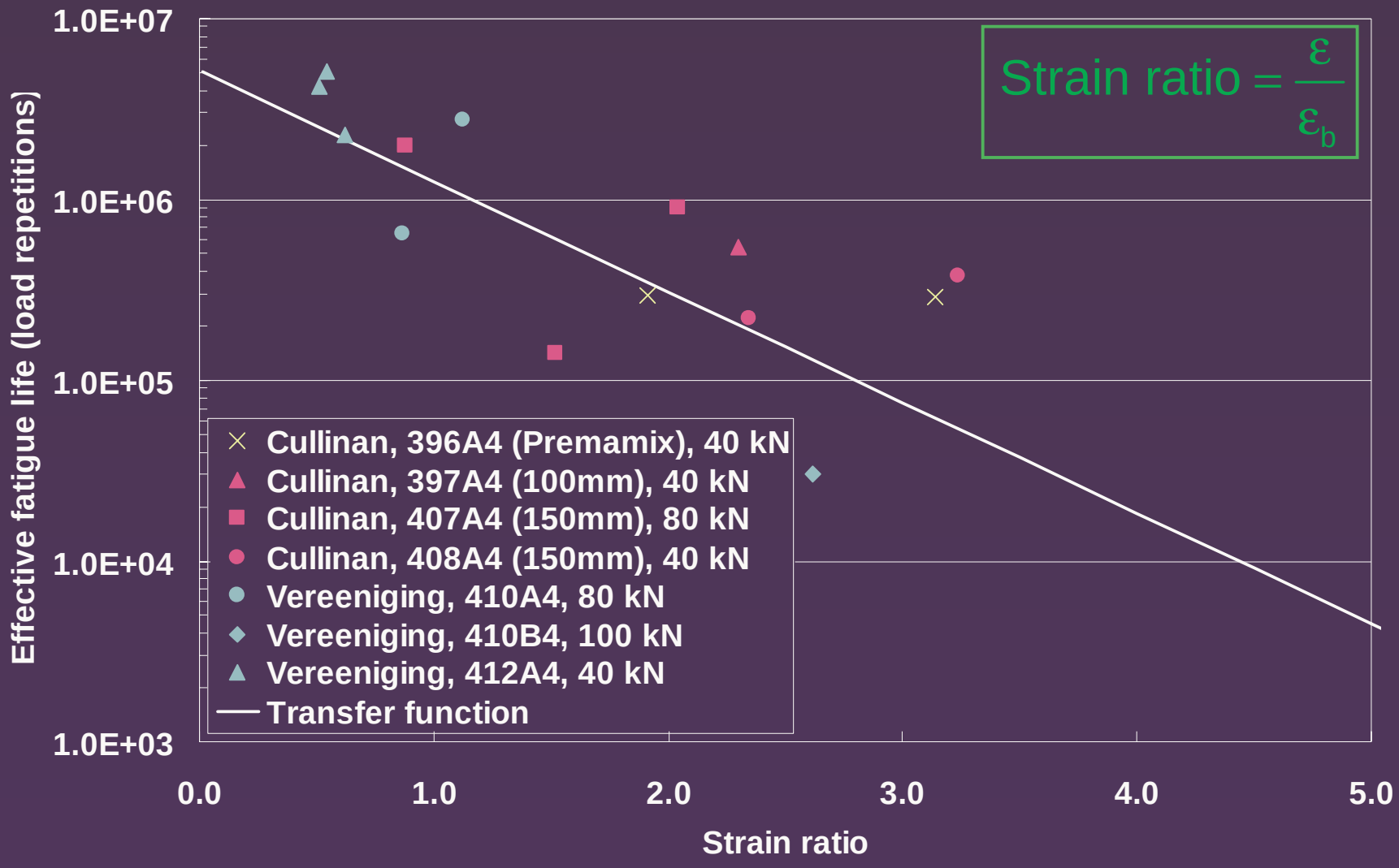
HVS Tests	Heilbron (P9/3)	Cullinan (D2388)	Vereeniging (P243/1)
Date	1992	2000	2001
Construction	Conventional	Labour	DISR
Material	weathered dolerite	sandstone congolomerate	ferricrete
Material class	G4/G5	G5	G7
Residual binder	0.6, 1.2, 1.8%	0.9%	1.8%
Filler	2.5% lime*	1% cement	2% cement
HVS sections	5	4	2
Lab tests			
Beam	✗	✓	✓
Triaxial	✗	✓	✓
UCS & ITS	✗	✓	✓
*lime pretreatment			

Appropriate transfer functions

- Selected from observations of HVS tests
- Effective fatigue
  - Initial resilient moduli reduce under load
  - Reduce to an “equivalent granular state”
    - » *Equivalent to granular material in resilient moduli only*
    - » *Not necessarily in loose, particulate state*
  - Related to flexibility
- Permanent deformation
  - Permanent deformation accumulates during test
  - Long time period than effective fatigue
    - » *Therefore Phase 2 of pavement life*
  - Related to shear strength

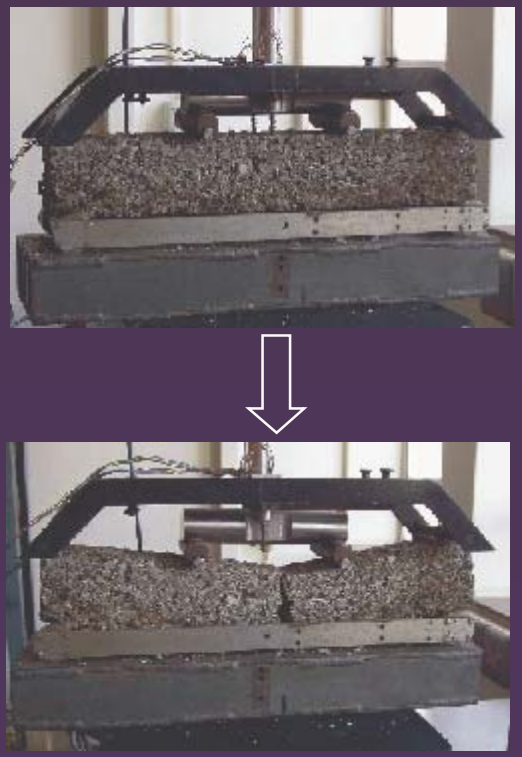


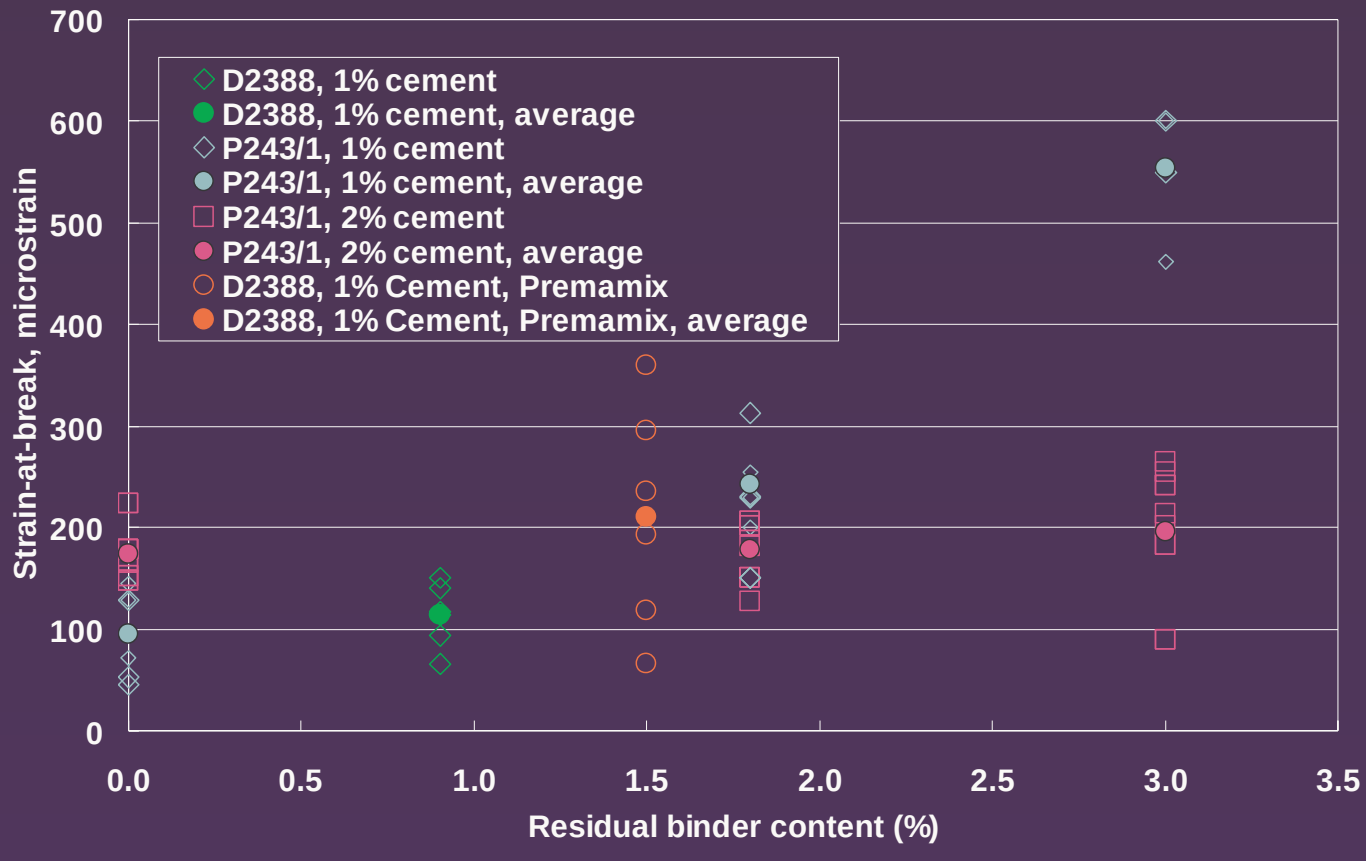
Effective Fatigue



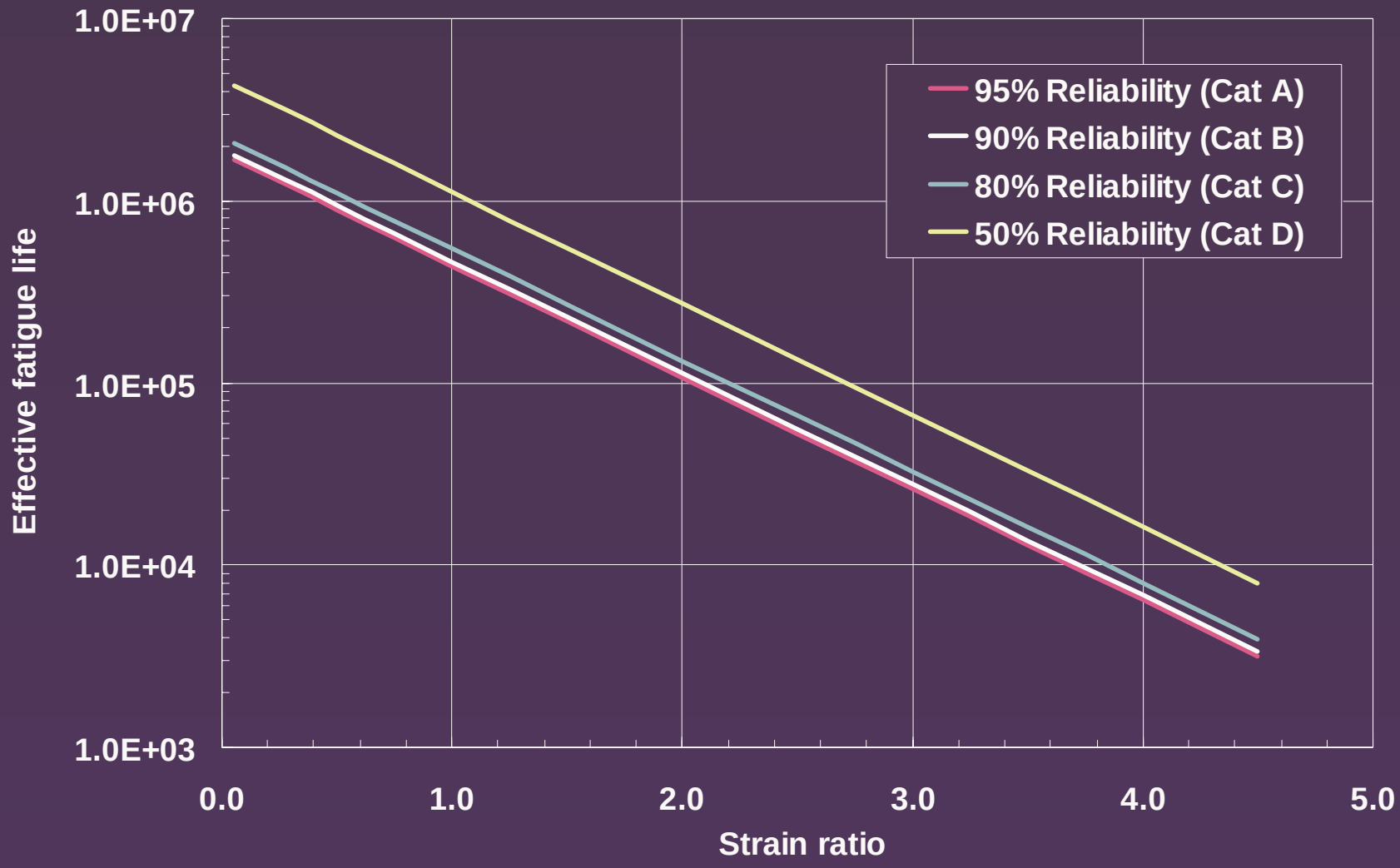
Flexibility

- Increases with increasing binder content
  - If cement content not too high

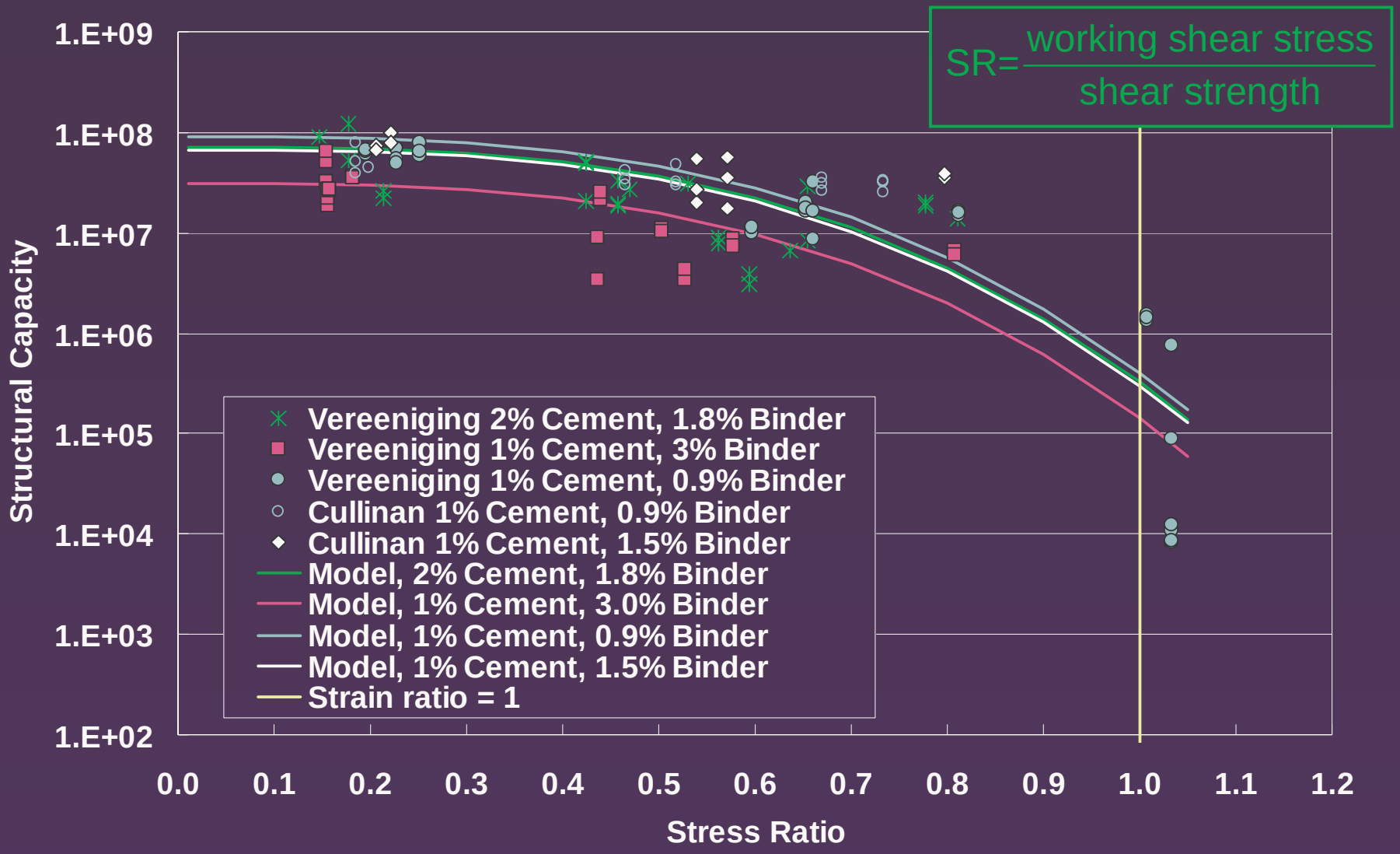




Effective Fatigue

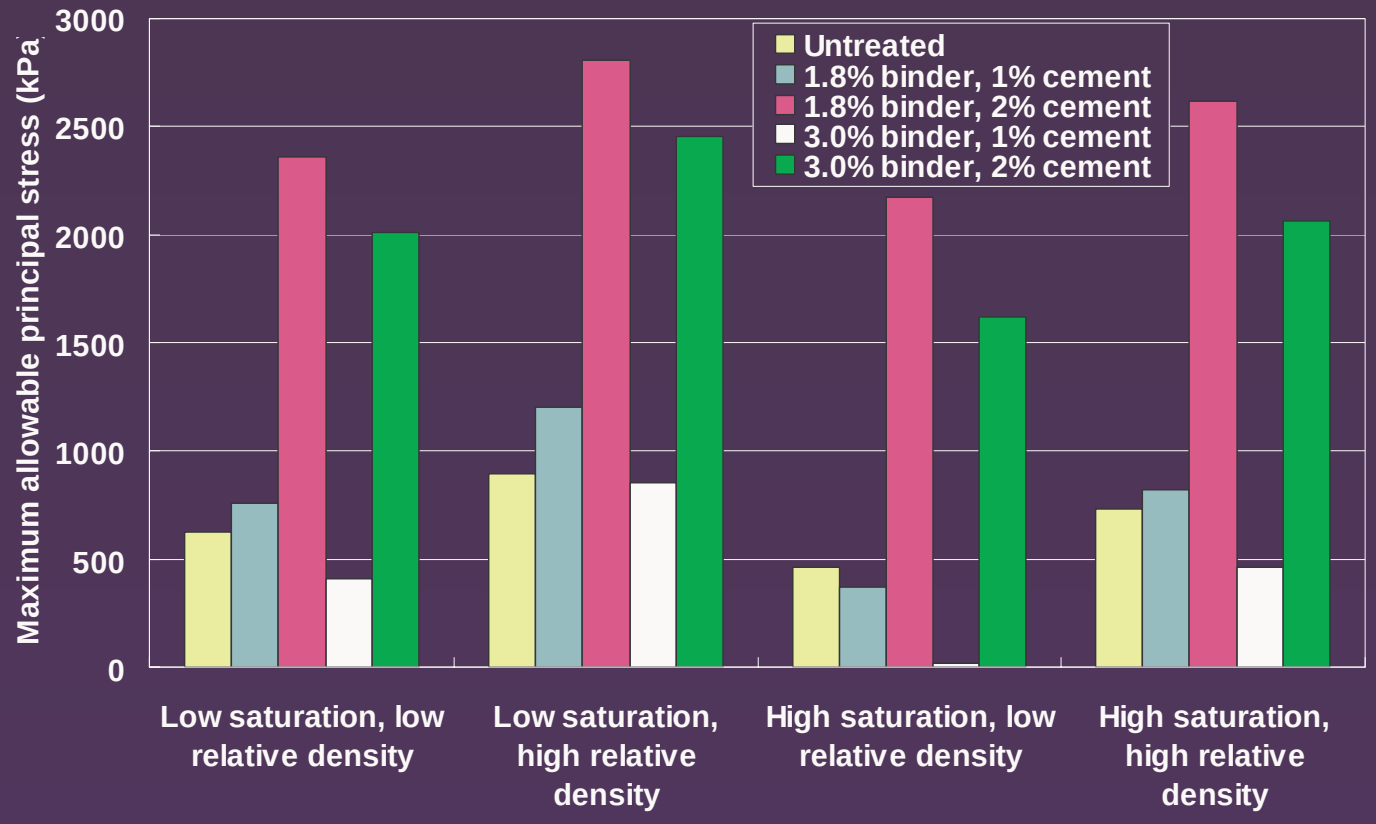


Permanent deformation model: Lab

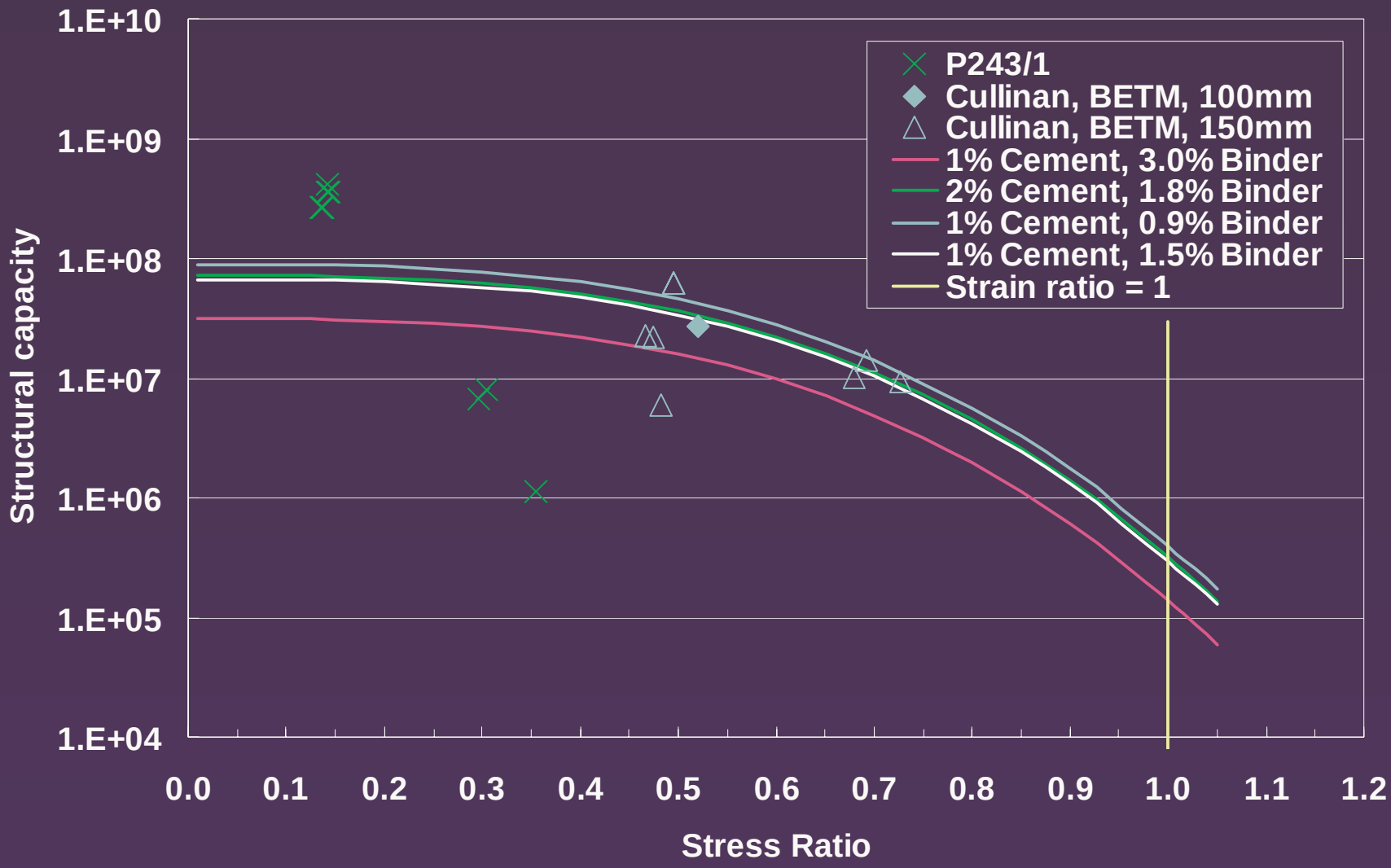


Shear strength (resistance to PD)

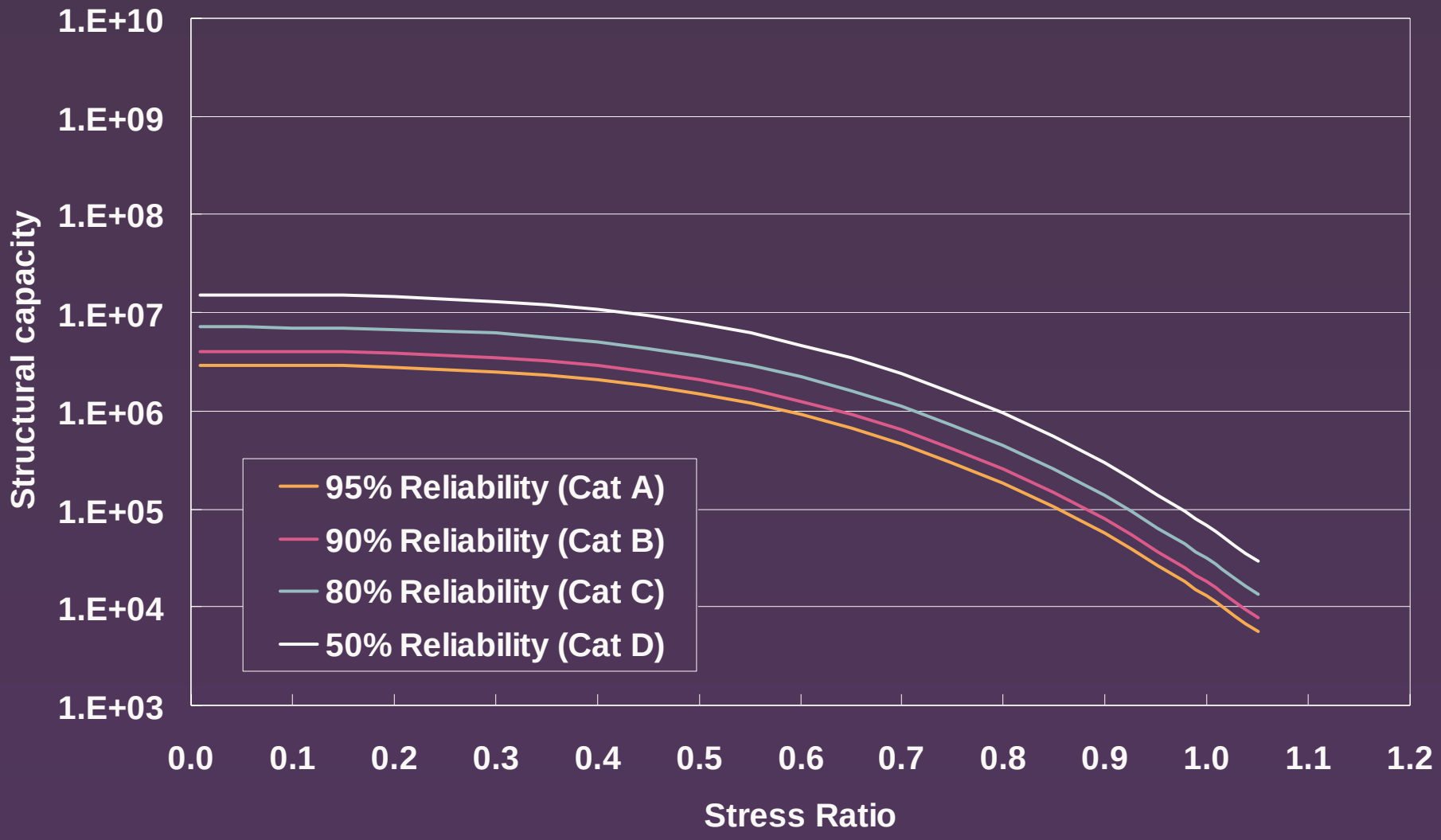
- Increase shear strength
  - Increase in relative density
  - Increase in cement content
- Decrease shear strength
  - Increase in saturation
  - Increase in binder content



Permanent deformation model: Lab with HVS data



Permanent deformation transfer function

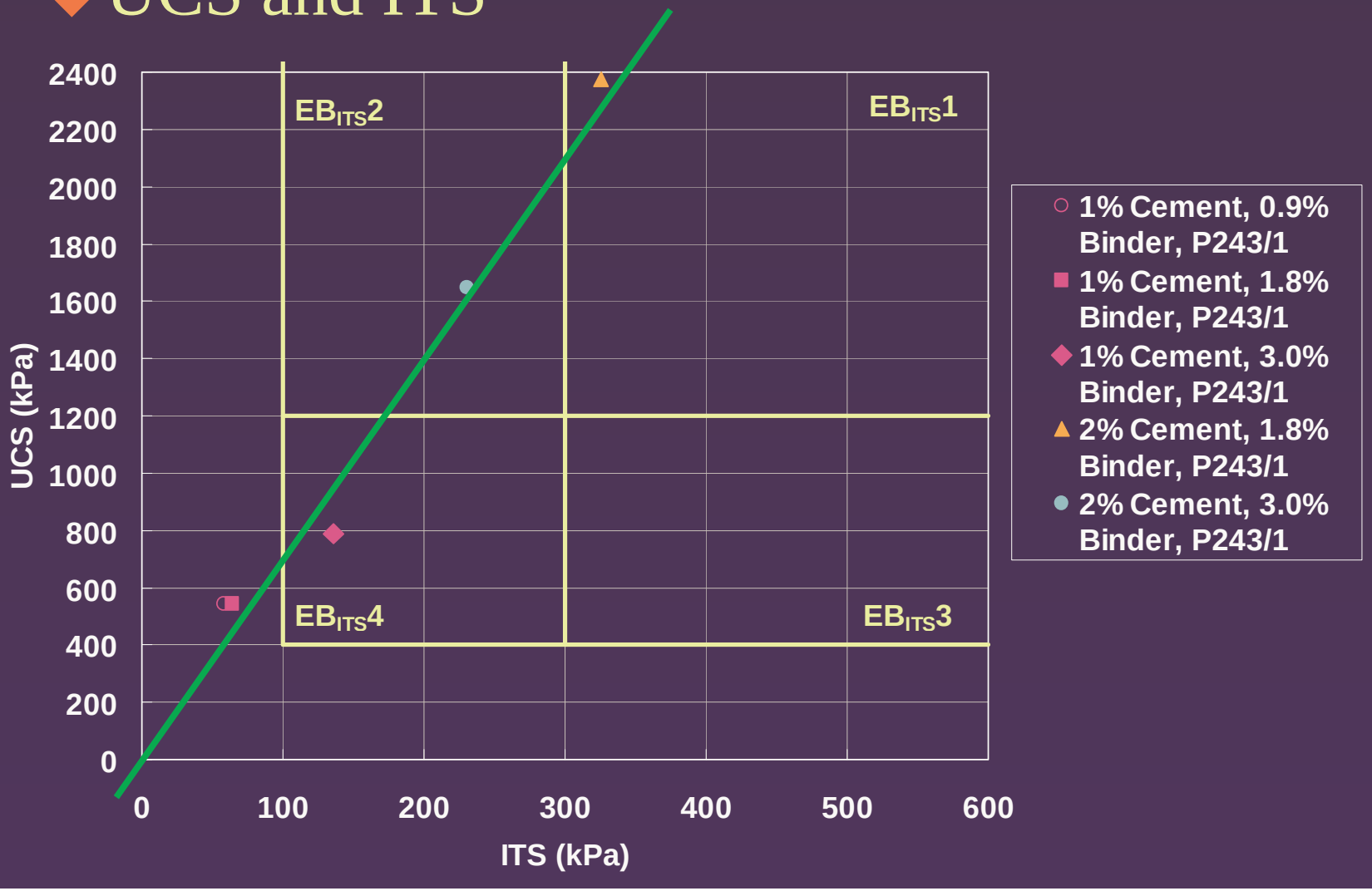


Material classification

- Must capture structural behaviour
  - Flexibility
  - Resistance to permanent deformation
- Investigating UCS, ITS and ε_b
  - UCS and ε_b seem to work well for EBTMs to date
  - Needs further refinement

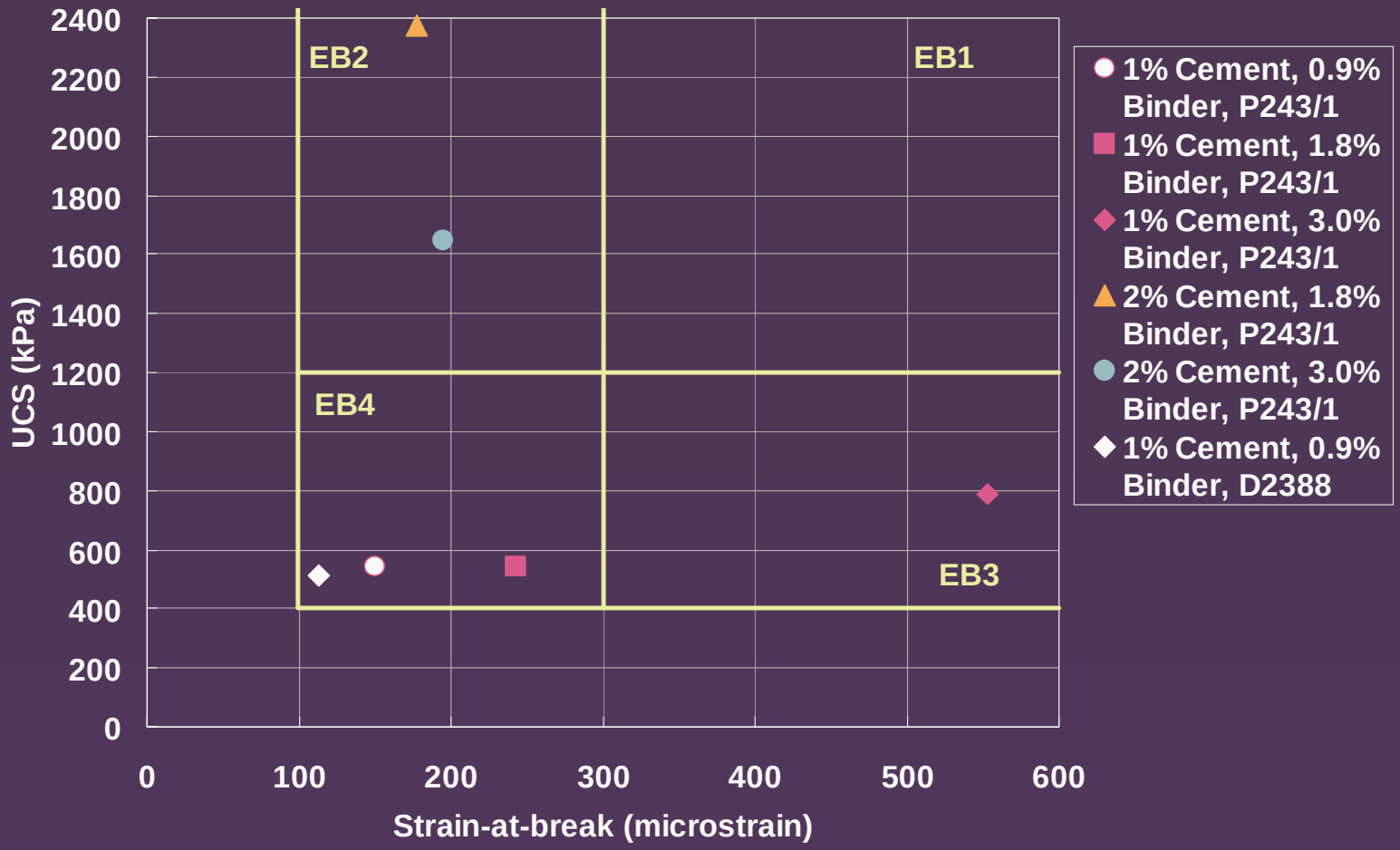
Material classification

- UCS and ITS



Material classification

- UCS and strain-at-break



Catalogue: New construction

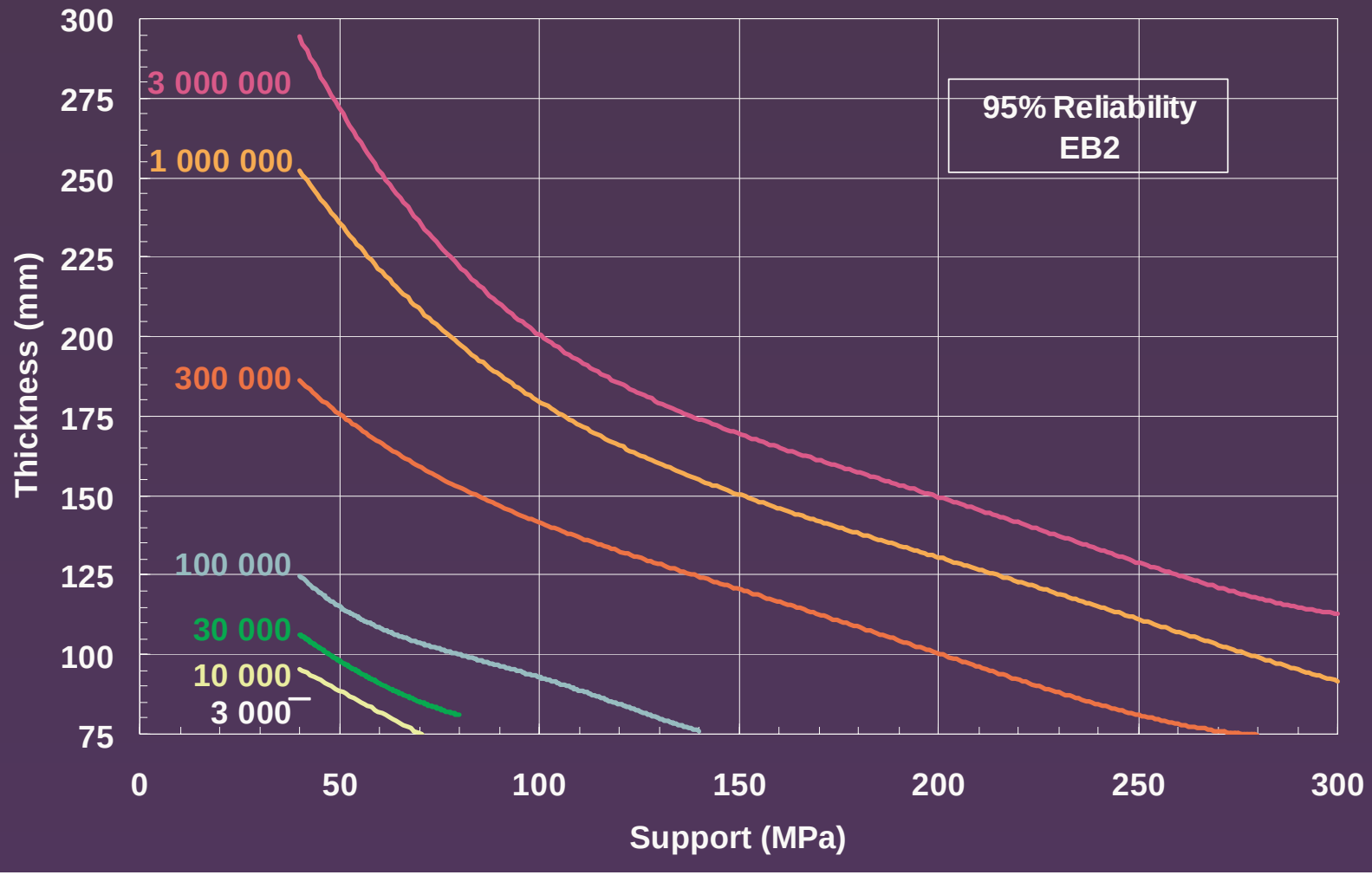
NEW CONSTRUCTION: EMULSIFIED BITUMEN TREATED BASE (EB2)

ROAD CATEGORY	PAVEMENT CLASS AND DESIGN BEARING CAPACITY (80 kN AXLES/LANE)										Foundation
	ES0,003 0,1-0,3x10 ^{4}	ES0,01 0,3-1,0x10 ^{4}	ES0,03 1,0-3,0x10 ^{4}	ES0,1 3,0-10x10 ^{4}	ES0,3 0,1-0,3x10 ^{6}	ES1 0,3-1,0x10 ^{6}	ES3 1,0-3,0x10 ^{6}	ES10 3,0-10x10 ^{6}	ES30 10-30x10 ^{6}	ES100 30-100x10 ^{6}	
A: Major interurban freeways and roads. (95 % approximate design reliability)						SEAL 150 EB2 150 C4 SEAL 200 EB2 200 G6	30AC 150 EB2 200 C4* 30 AC 200 EB2 200G6				150 G7 150 G9 G10
B: Interurban collectors and major rural roads. (90 % approximate design reliability)					SEAL 100B2 100 C4 SEAL 125 EB2 125 G6	SEAL 125 EB2 150 C4 SEAL 175 EB2 175 G6	30 AC 150 EB2 175 C4 30 AC 200 EB2 200 G6				
C: Lightly trafficked rural roads and strategic roads. (80 % approximate design reliability)				SEAL 100 EB2 100 G6	SEAL 100B2 100 C4 SEAL 100 EB2 125 G6	SEAL 125EB2 125 C4 SEAL 175 EB2 175 G6	30 AC 125 EB2 175 C4 30 AC 175 EB2 175 G6				
D: Light pavement structures, rural access roads. (50 % approximate design reliability)				SEAL 100 EB2 100 G8							150 G9 G10

SYMBOL A DENOTES AG, AC, OR AS. SYMBOL S DENOTES S2 OR S4
A0, AP may be recommended as a surfacing measure for improved skid resistance when wet or to reduce water spray.
* Minimum thickness for structural capacity. Construct in two lifts increasing thickness for ease of construction, if necessary.

Design Charts: Rehab design

- Design charts (EB2, 95% reliability)



Conclusions and recommendations

- Now have ME structural design models
  - Effective fatigue
    - » *Dependant on flexibility*
  - Permanent deformation
    - » *Density and saturation, additives often more important than load*
- Material classification
  - UCS and strain-at-break
- Design catalogues and charts
  - Pavement designs similar to those recommended by consultants, and developed by DCP design method
- Foamed and emulsified bitumen
  - Essentially same structural capacity

What's next?

- ETB laboratory testing (EB1?)
- Strain-at-break test
- Compactability study
  - Foamed and emulsified bitumen
- Field validation
- Guideline document, TG3 ?
- All HVS and associated laboratory testing reports
  www.gautrans-hvs.co.za
- Questions?