

Research of BSMs' influence on their Design

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Road Pavements Forum

RPF

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Purpose: Question the Design and Performance of BSMS

- **Industry developments / SAPDM**
- **Research findings**
- **SW(OT) analysis of TG2 (2009)**
- **Need for revision of TG2 ?**

A photograph of a suburban street with a paved road, sidewalks, and houses with trees. A large semi-transparent grey arrow points from the bottom left towards the center of the road. On the road, there is a white-painted sign that says "COOL". Overlaid on the arrow is the text "OR BACK TO" in white, bold, sans-serif font.

**OR
BACK TO**

COOL

Role of Active Filler
vs
Bitumen
in BSM

Purpose of Active Filler

- Improve dispersion PRIMARY
- Reduce moisture damage REASONS
- Modify plasticity
- Increase stiffness & strength
- Accelerate curing

Emulsion

Foam

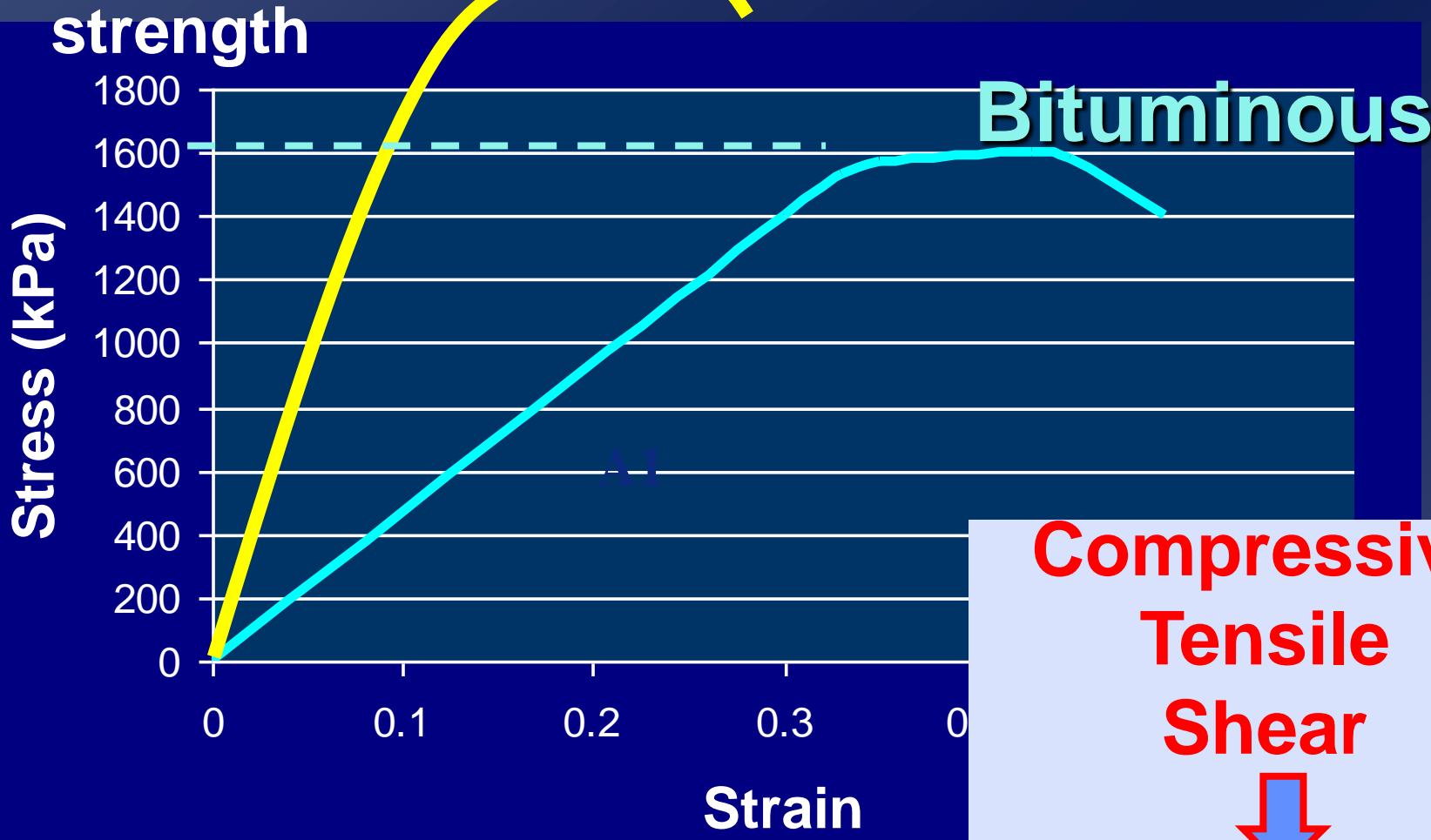
- Breaking time
- Improve workability

Dispersion!

Mix Design Testing

Cemented

Bituminous



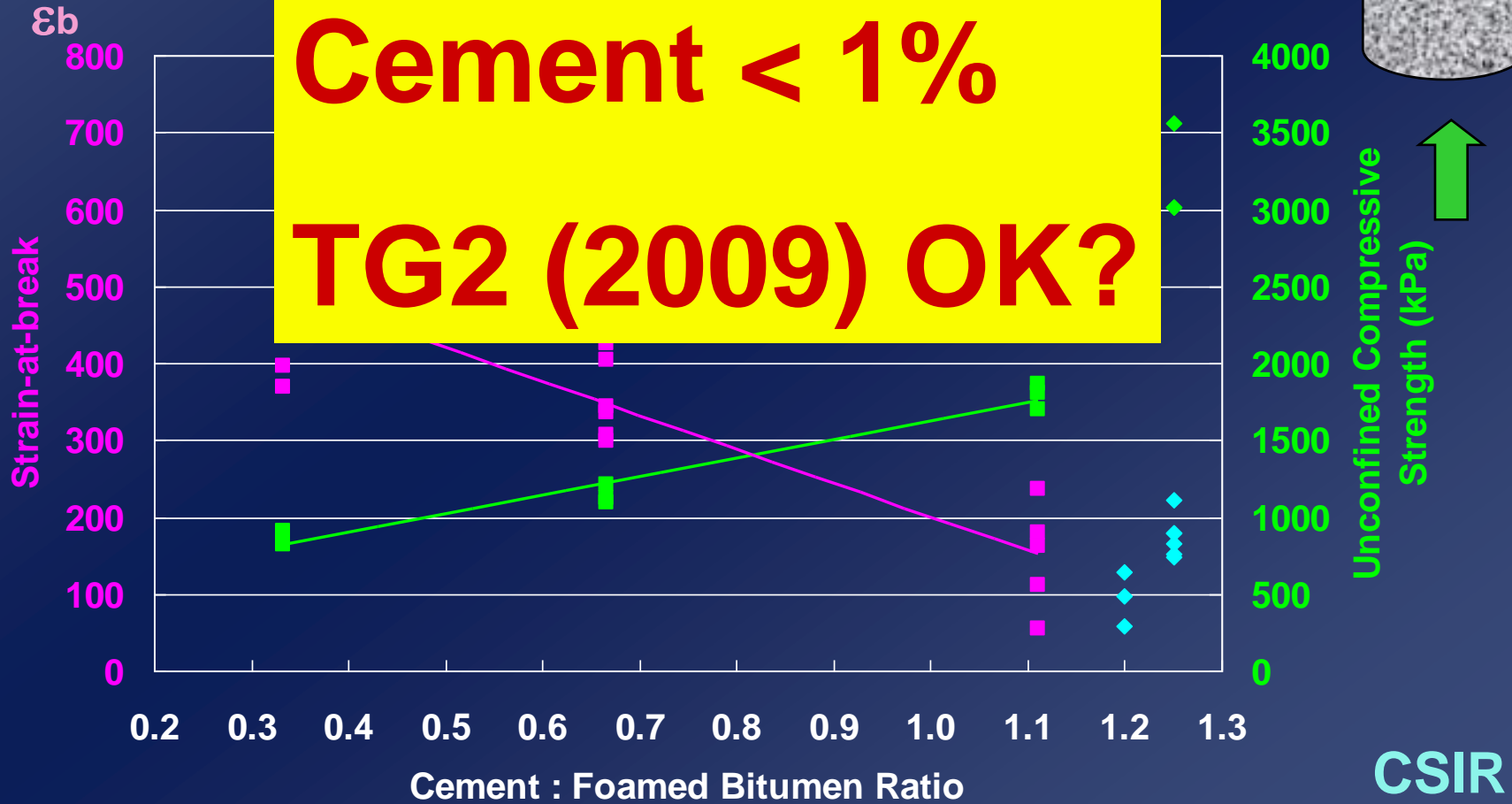
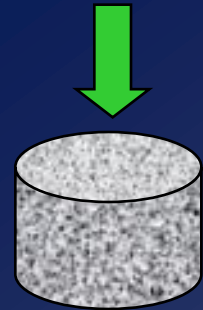
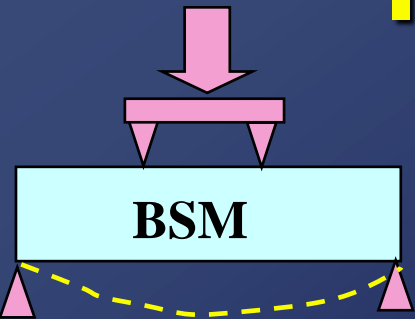
**Compressive
Tensile
Shear**



It's undeniable: More cement = more strength!

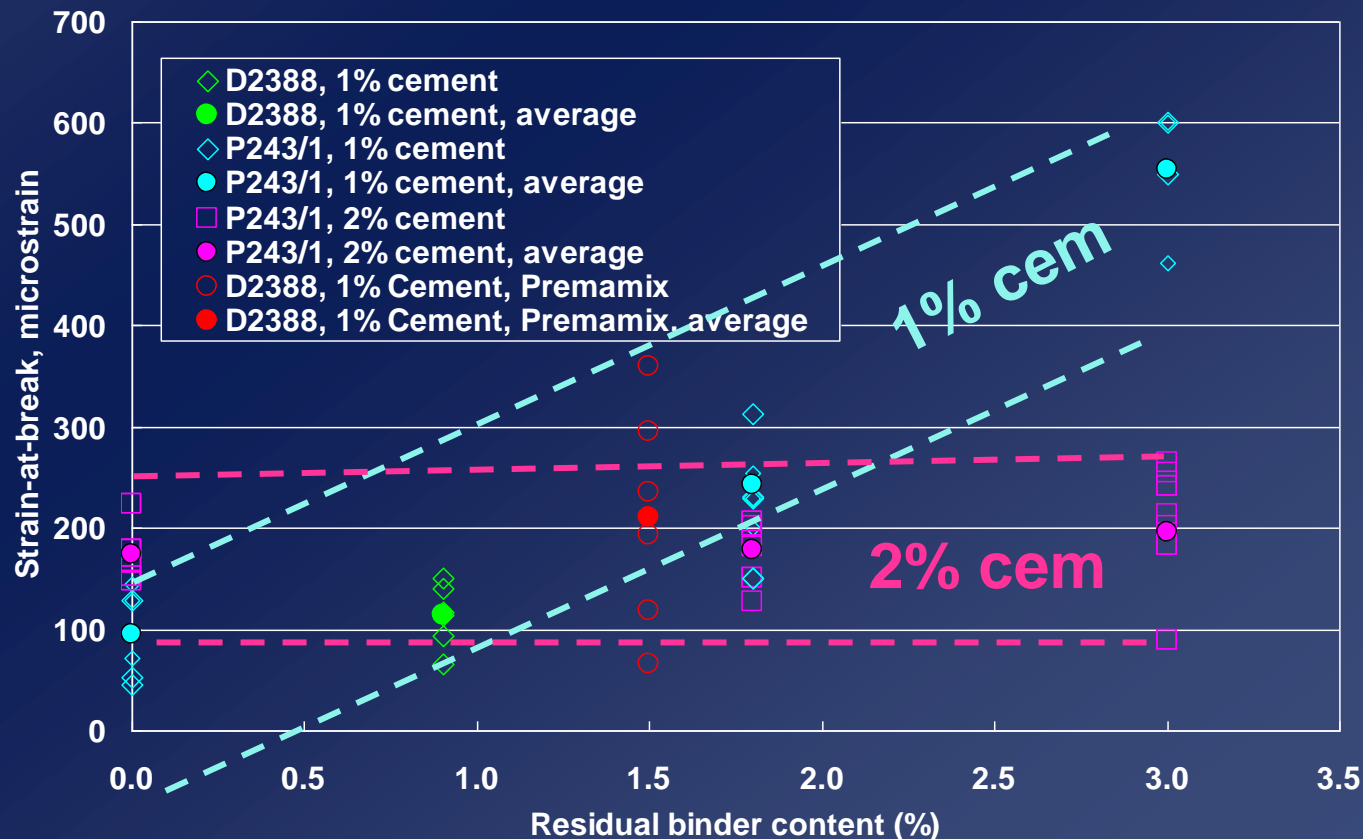
Influence of Active Filler BSM-foam

Strength and flexibility



Influence of Active Filler BSM-emulsion

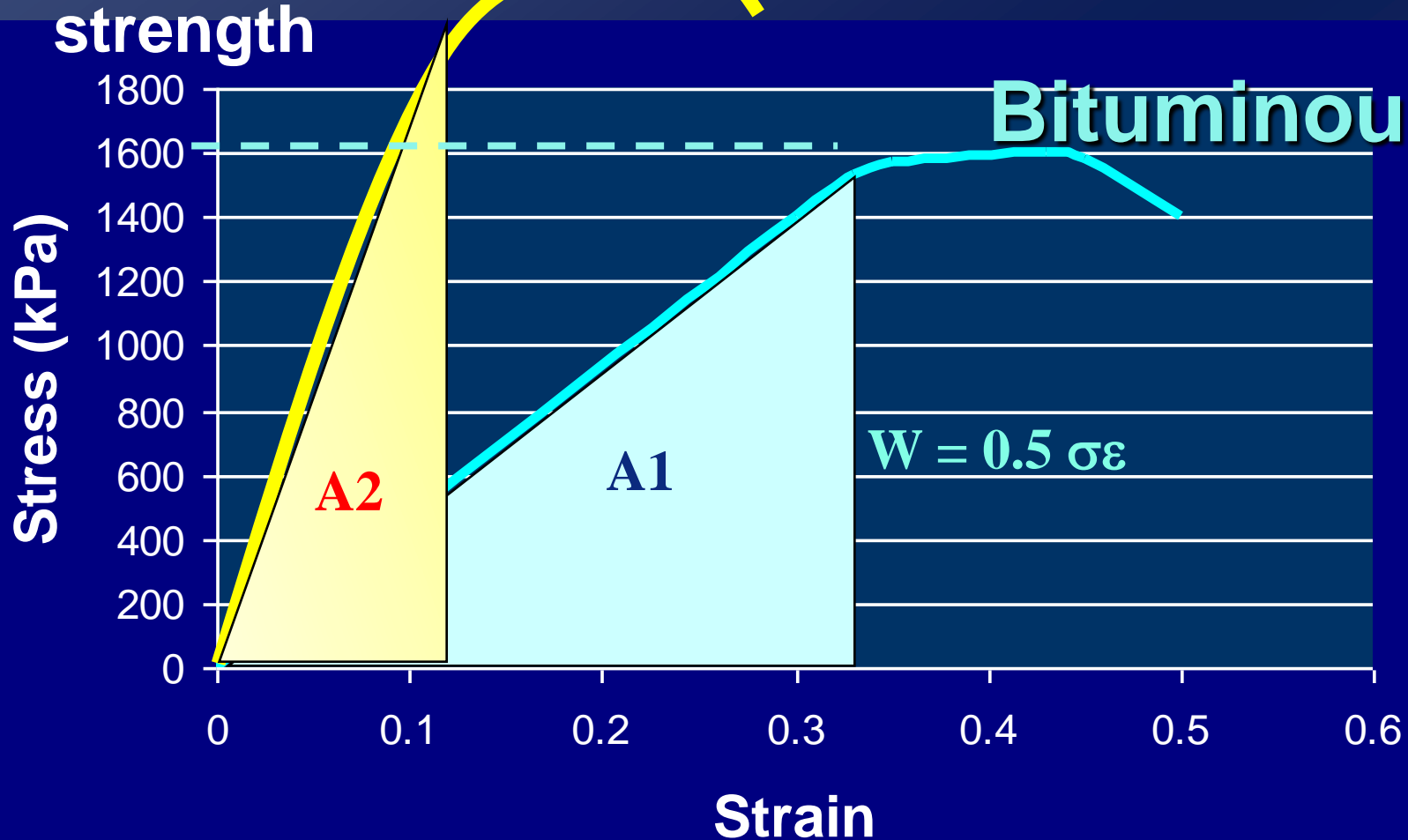
- Increasing ϵ_b with increasing bitumen %
 - If cement content not too high (CSIR)



Dissipated Energy

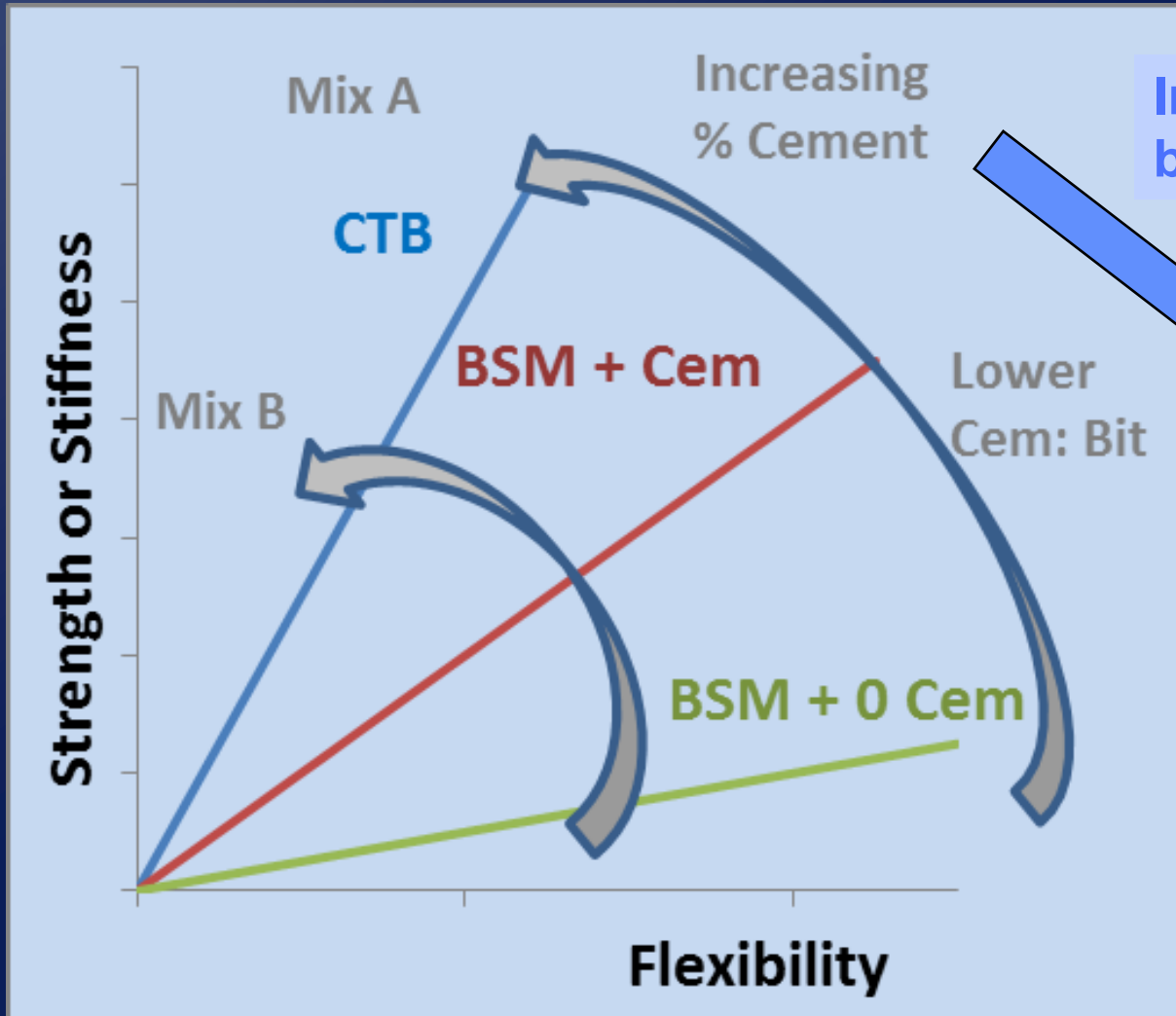
Cemented

Bituminous



Need **accurate** displacement measurements for flexibility
OR limit cement content!!

Strength vs Flexibility



Can 1.5% cement work?

BSM-foam + 1.5% cem
using cracked CTB (China)





After 2 years of traffic

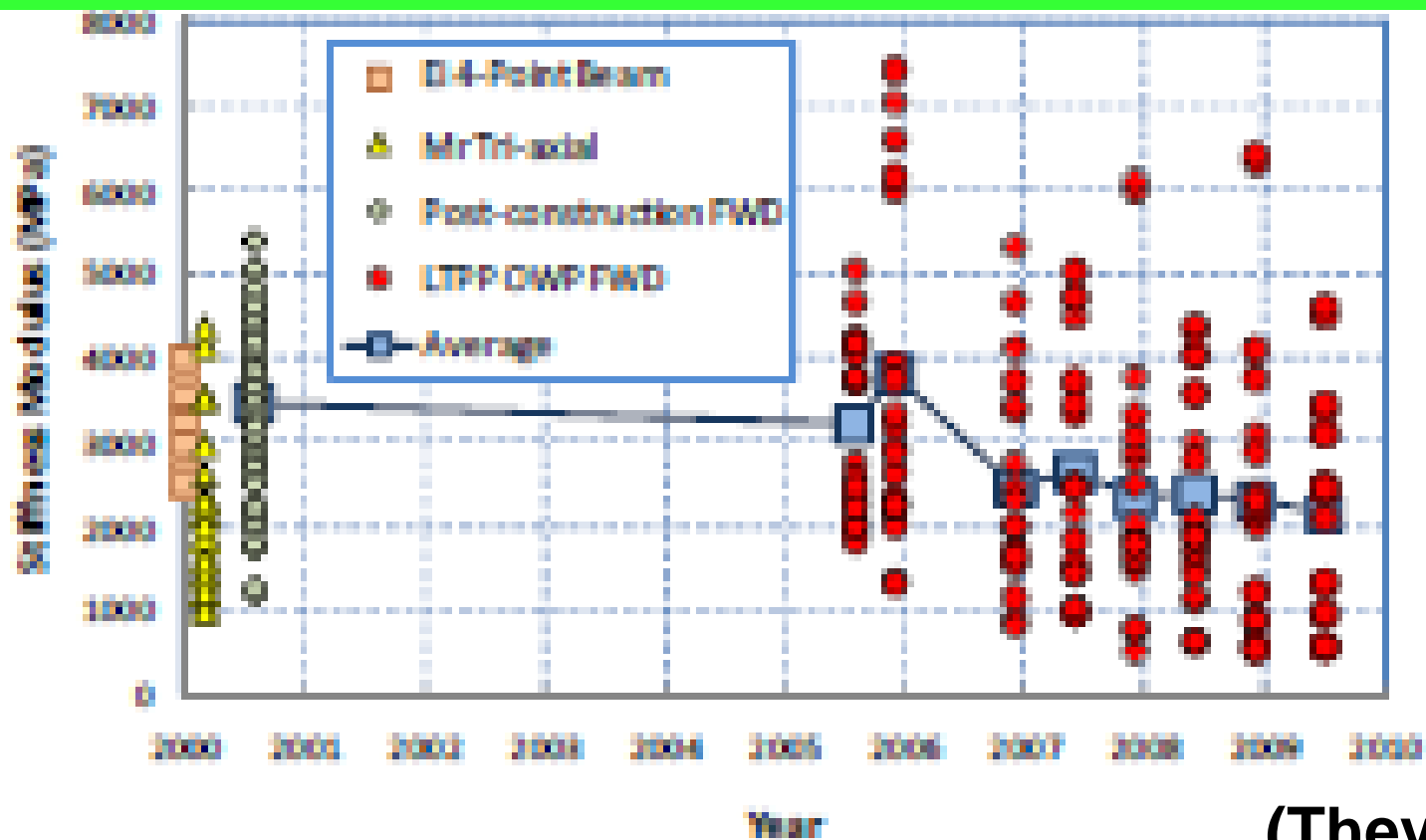
No signs of reflective cracking

But look at support!

Look at traffic too!

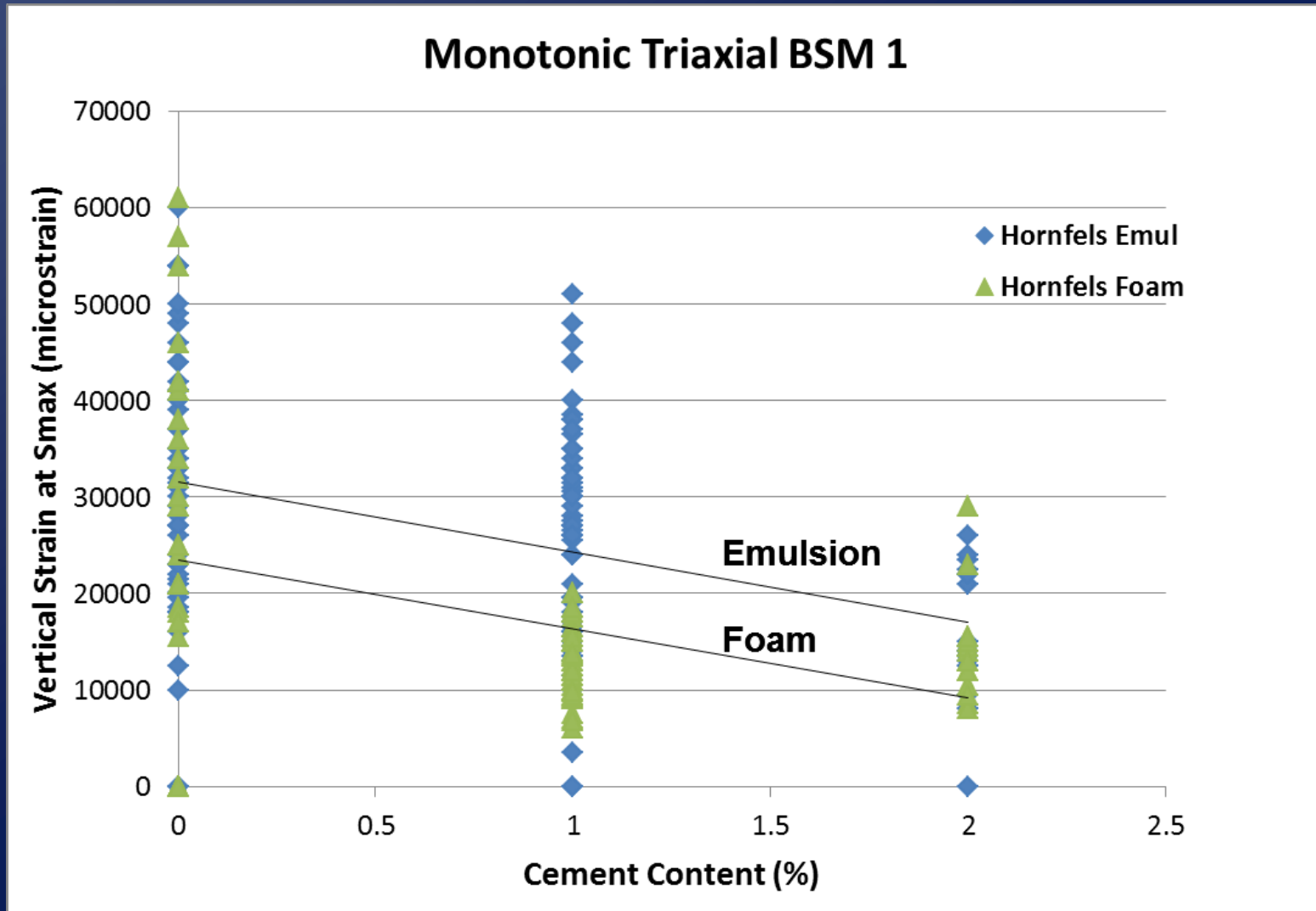
P243: BSM-foam 1.8% bit 2% cem

Is this a compelling reason to add more cement?
P243=Low traffic! So, need for more info from R35



(Theyse)

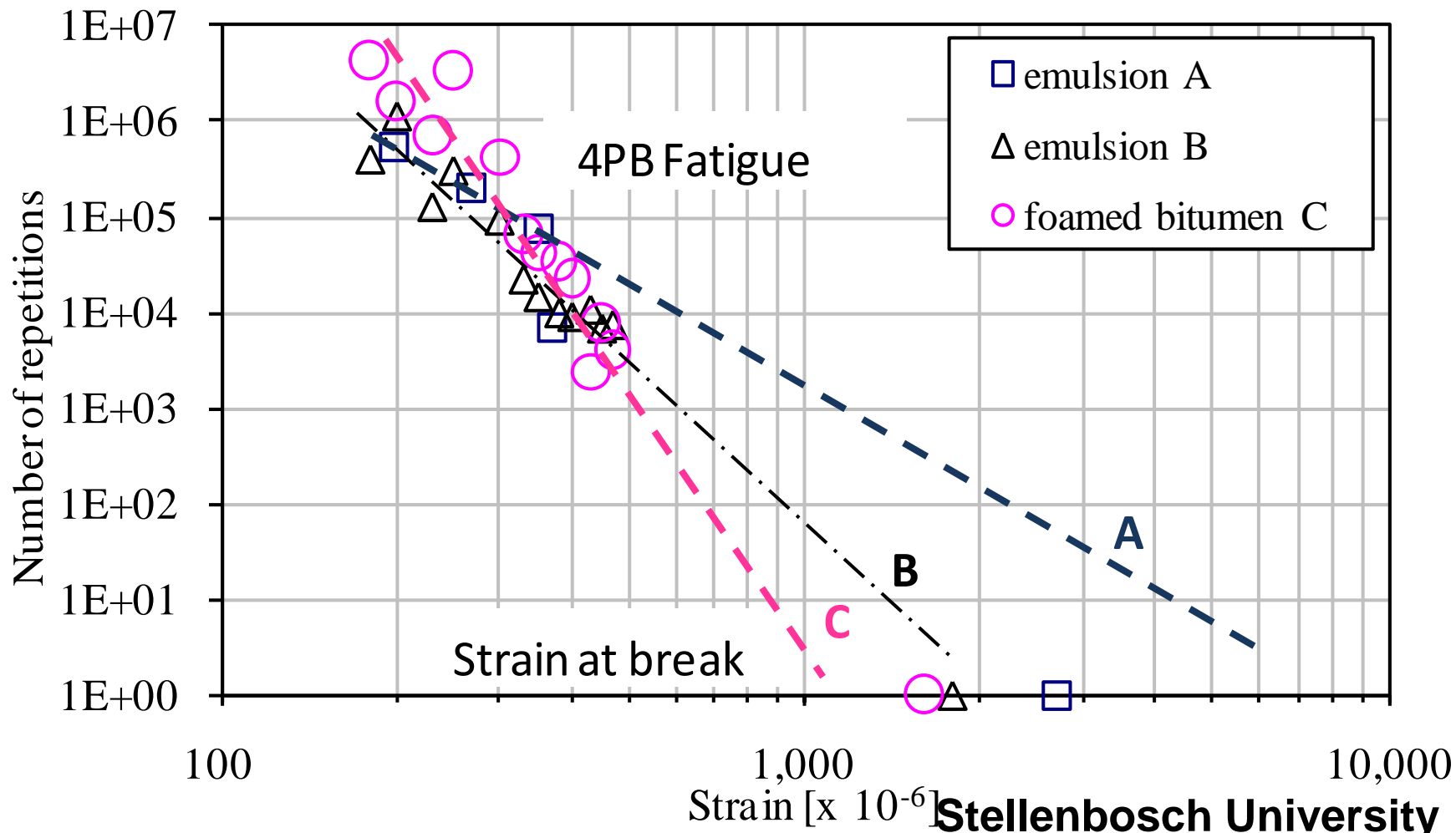
Triaxial data from Mix Design



Can refine by separating data based on σ_3 , but COV still high

Strain-at-break vs Fatigue

25%RA & 0%Cem



Can Flexibility be measured using Mix Design Tests?

Displacement at σ_{ult} :

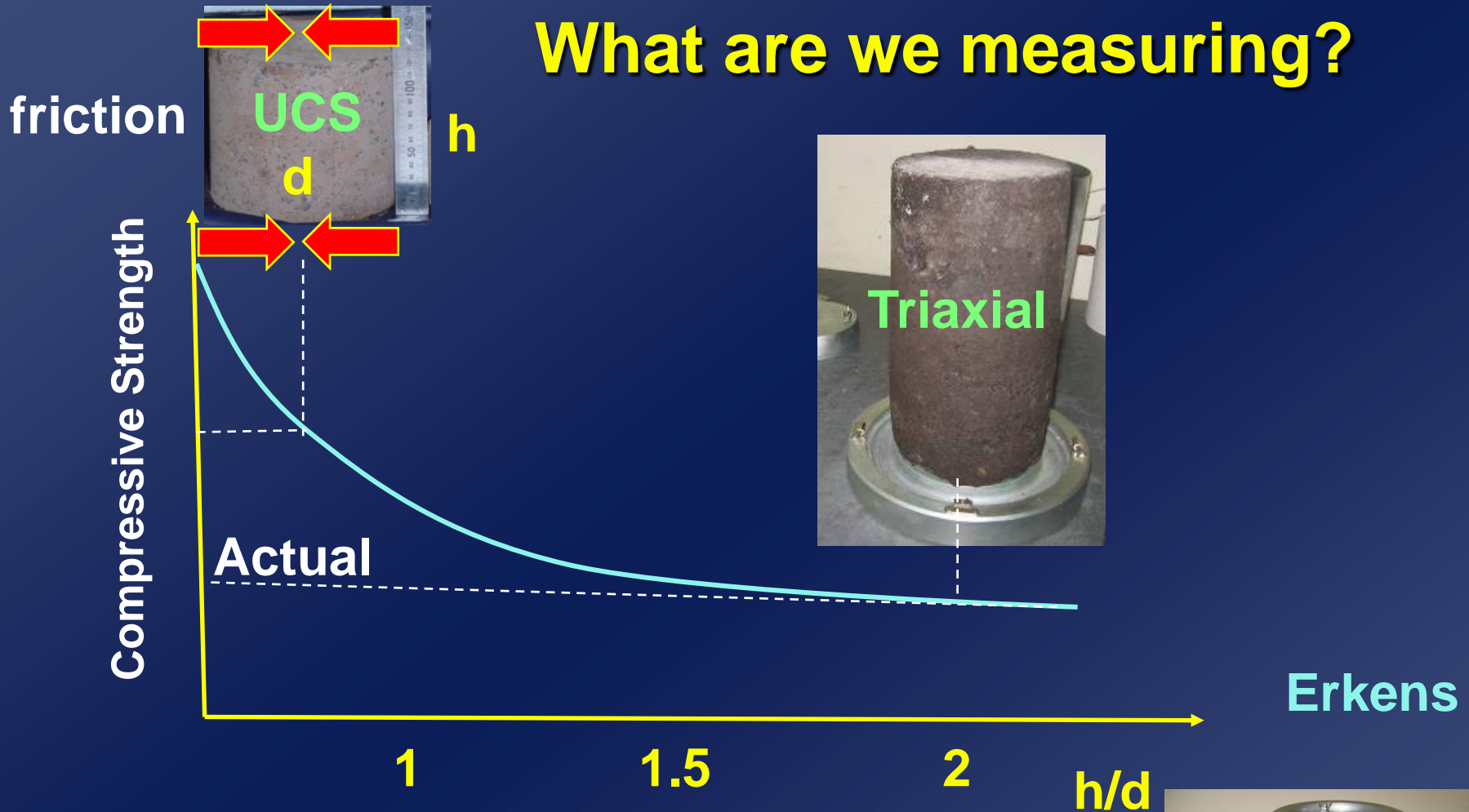
- ITS and UCS highly variable
- Triaxial tests
 - more potential as flexibility surrogate
 - more data analysis needed (SAPDM)
- Can't specify a flexibility parameter
- Still useful as “report only” for experienced practitioners

NOT

**NEW ϵ_B
TESTER**
maybe solution

Test Selection

What are we measuring?



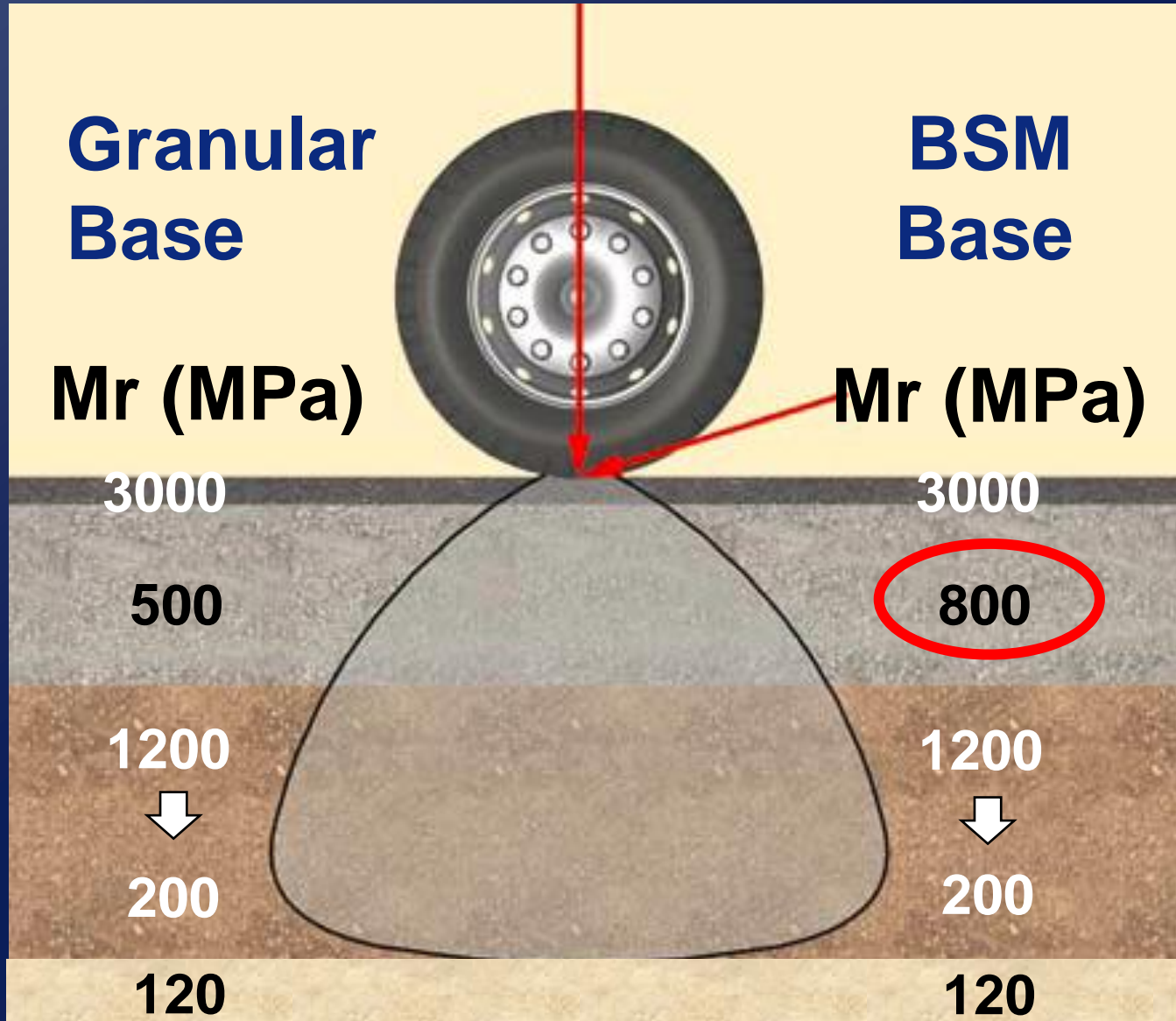
TG2 (2009) introduced triaxial:

- Shortcomings UCS – shear props
- Currently used for > 3 MESA designs



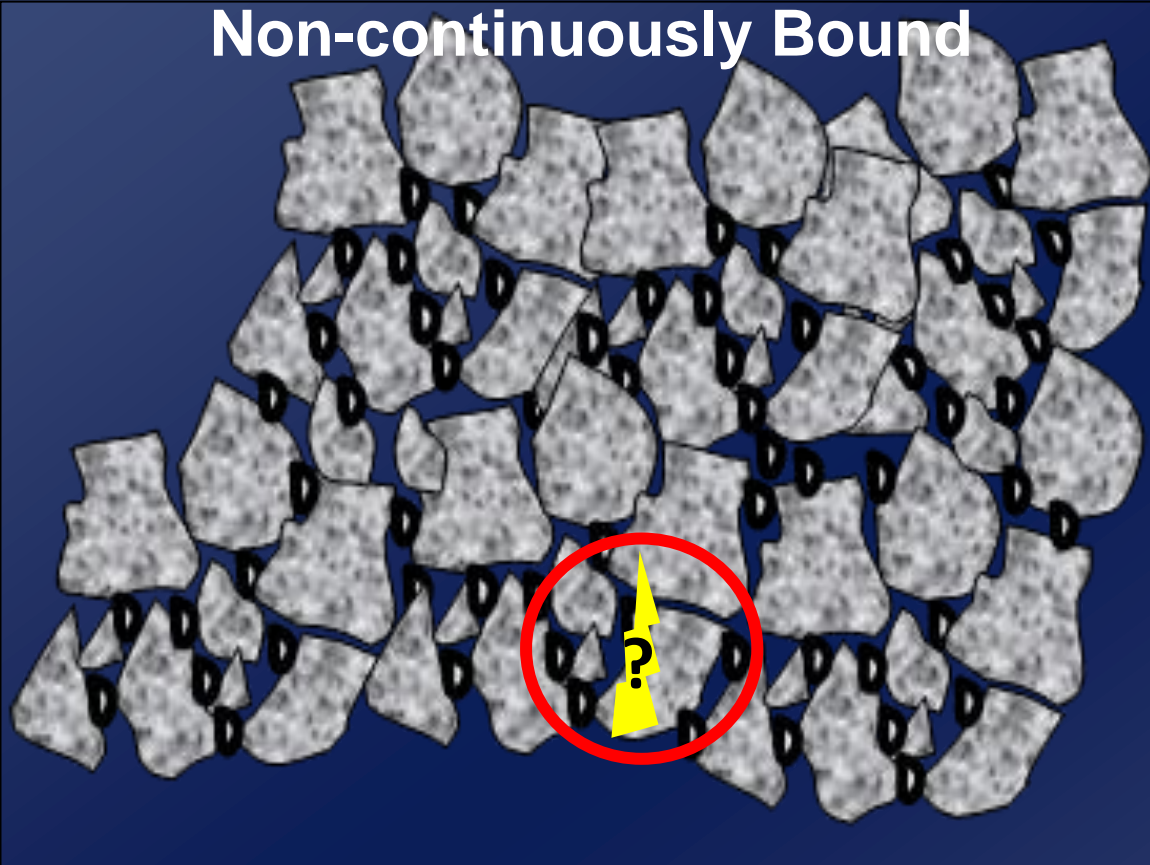
BSM STIFFNESS & DESIGN

Pavement Balance

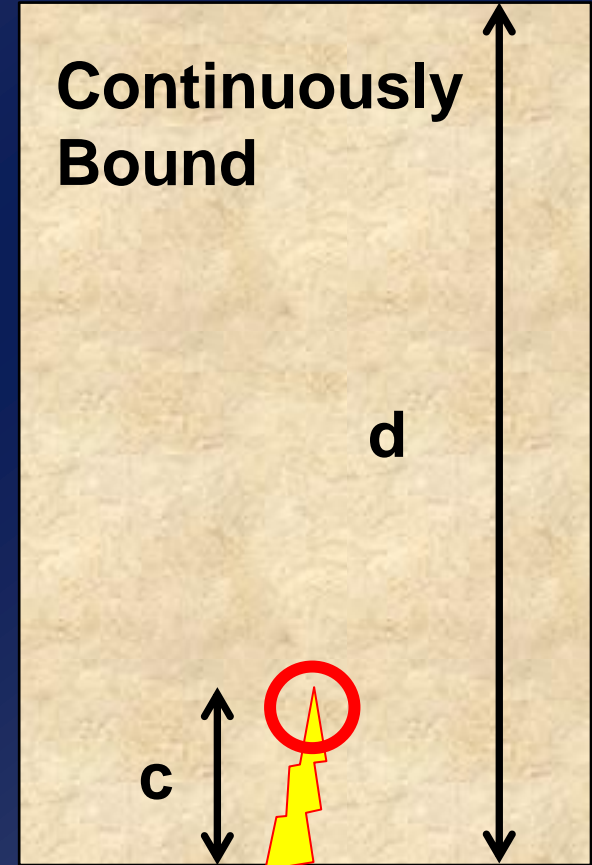


Fracture Mechanics

Non-continuously Bound



Continuously Bound

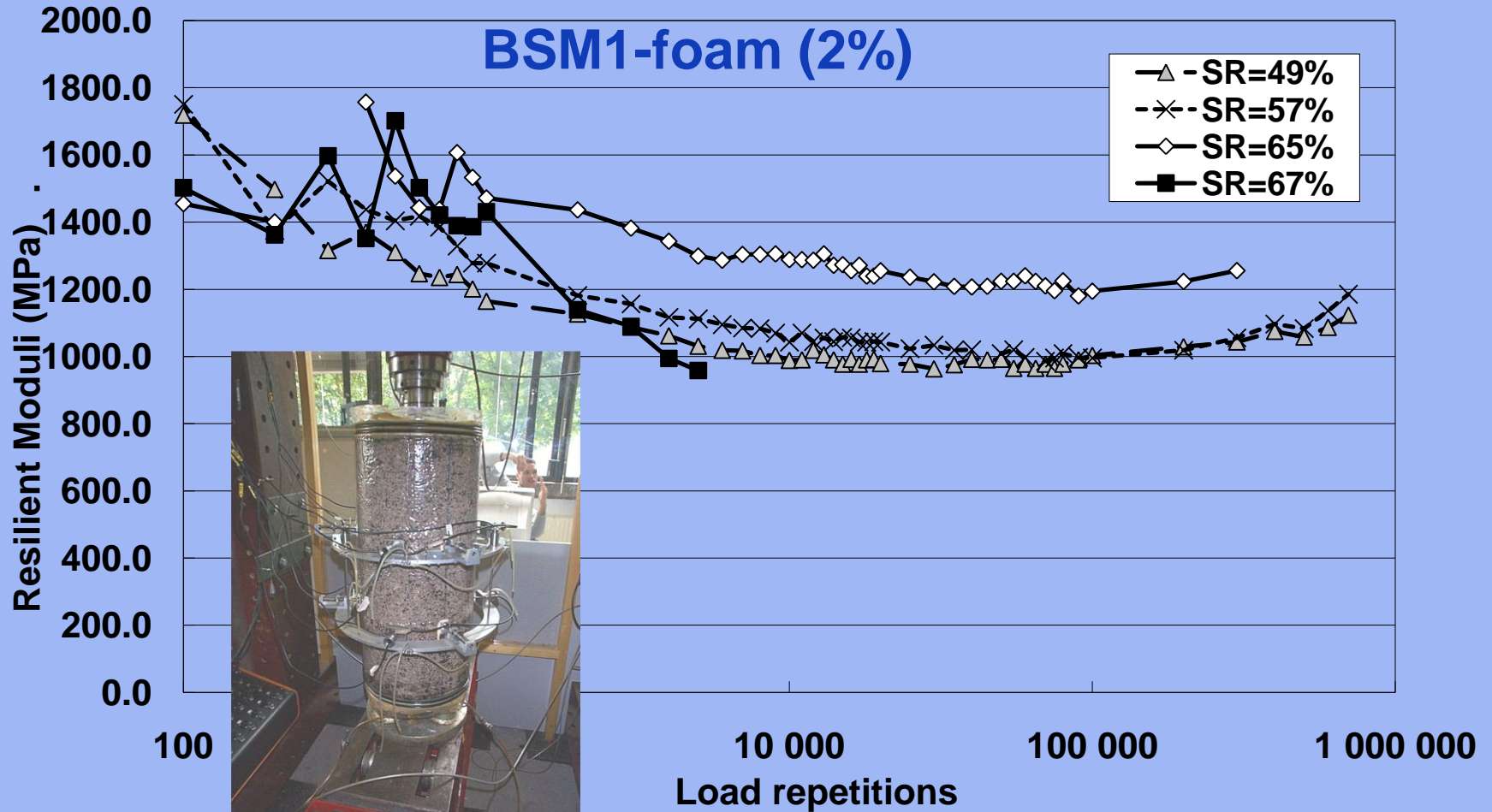


Paris' Law: $\frac{dc}{dN} = A.K^n$

Stress intensity factor at crack tip

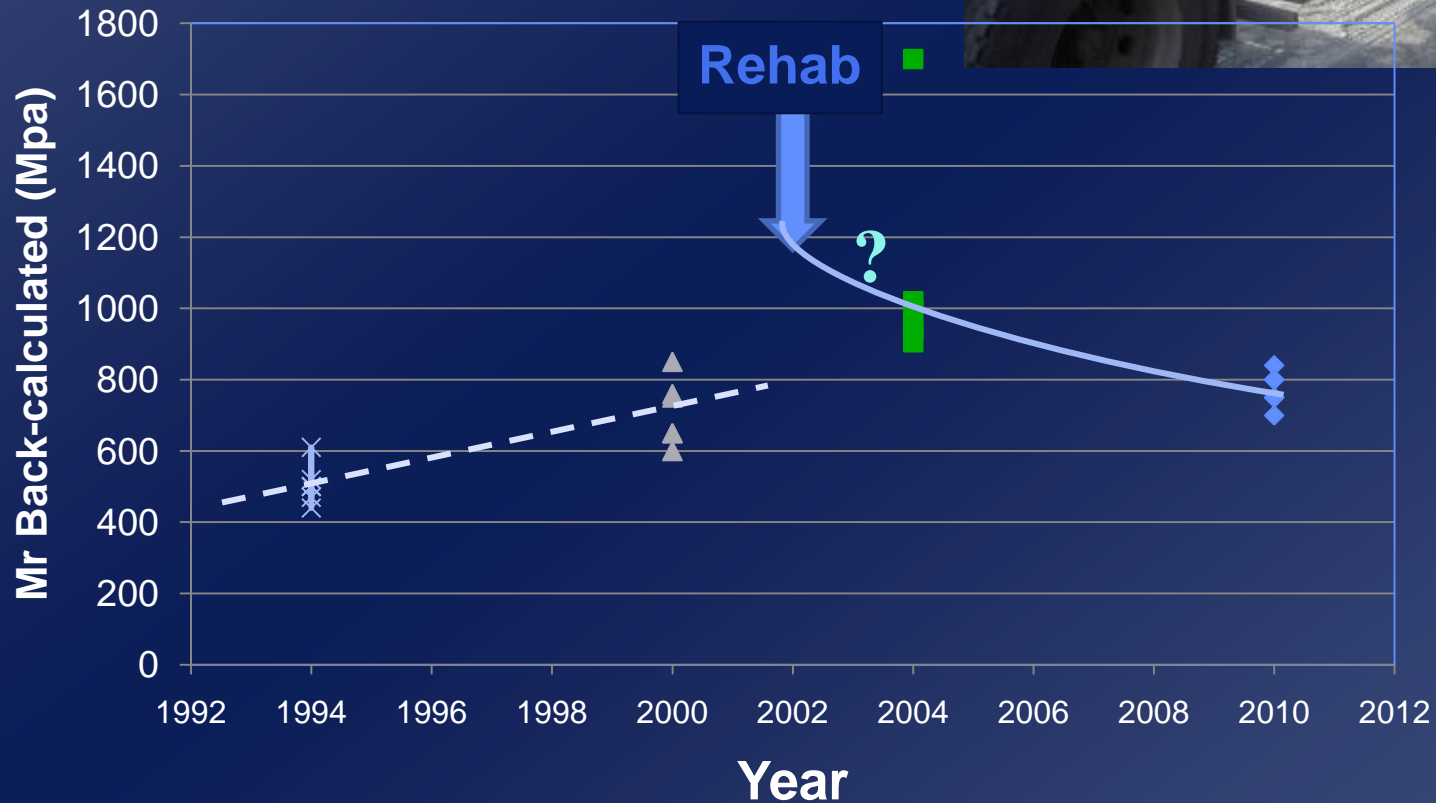
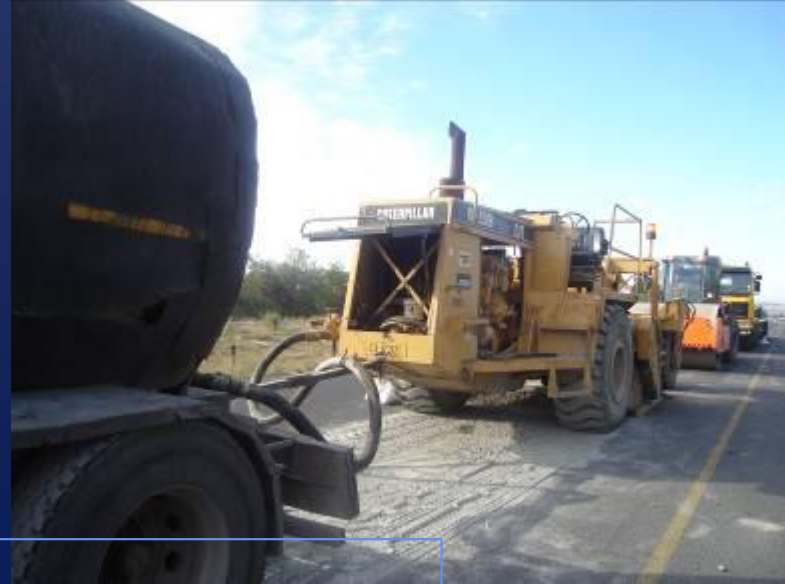
Increase in crack length / load cycle

Mr vs load repetitions (triaxial)



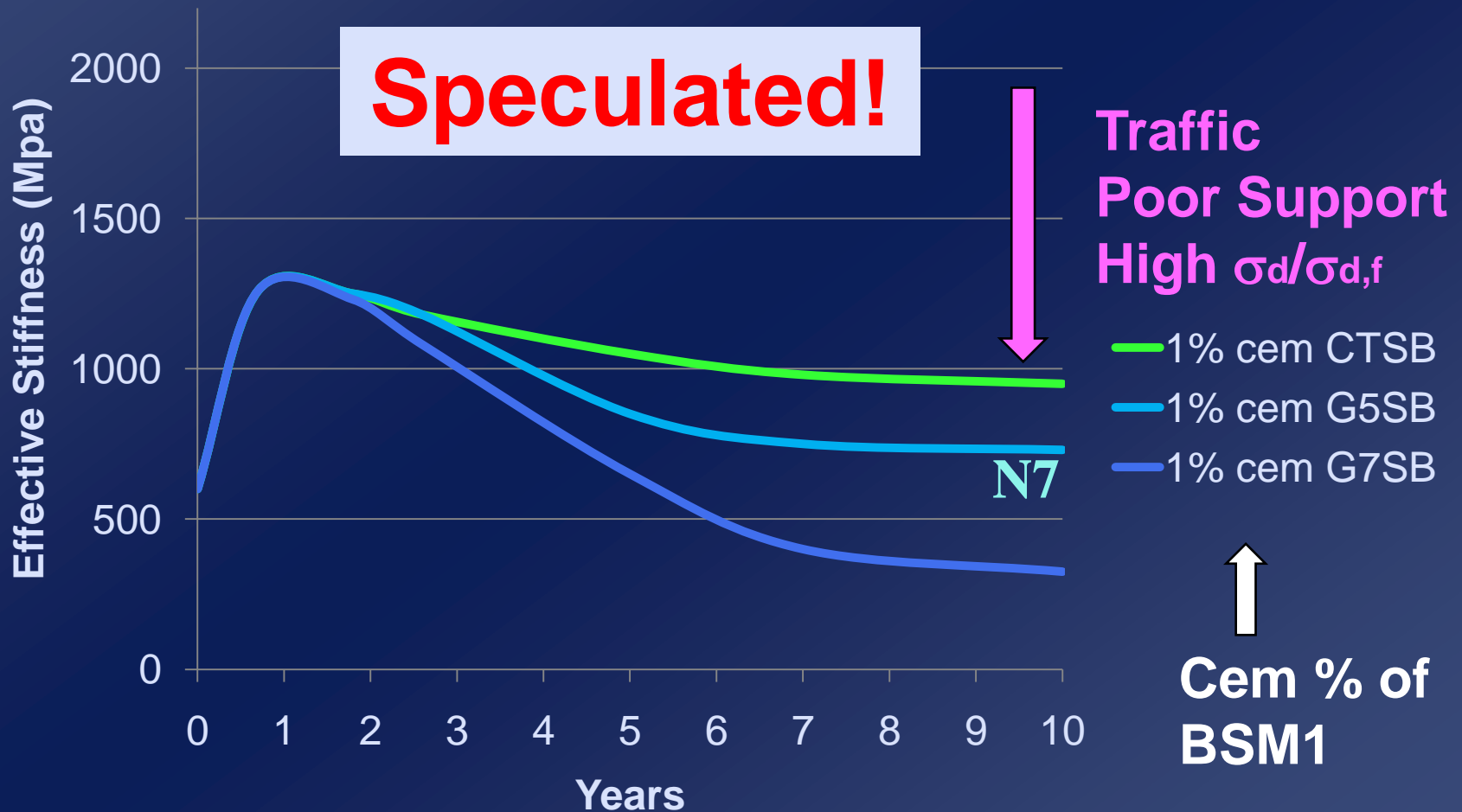
Mr vs time (N7) FWD back-calcs

90th Percentile



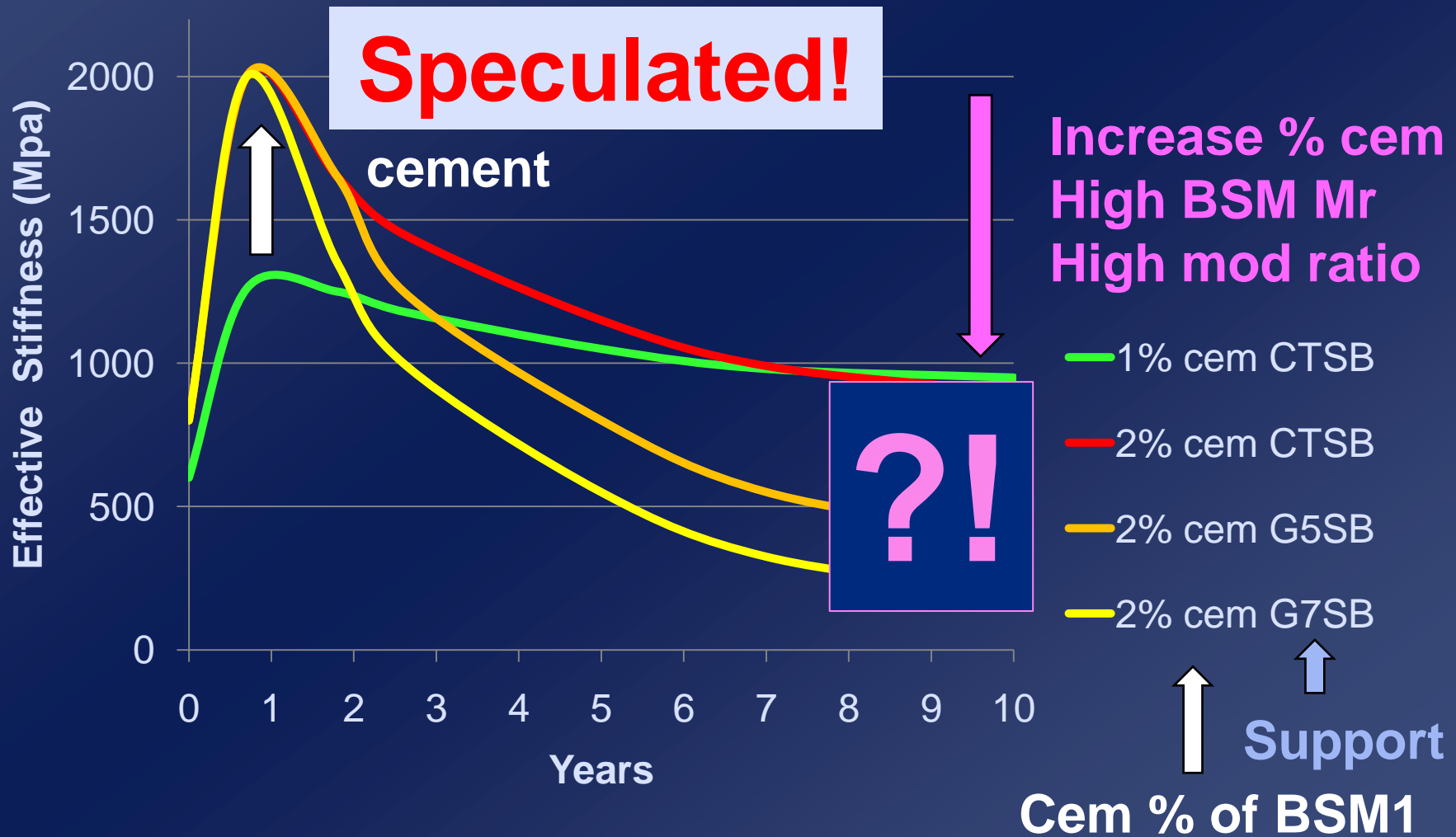
BSM1

In service behaviour of Mr Influence of support & traffic



In service behaviour of BSM

Influence of % cement



Conclusions

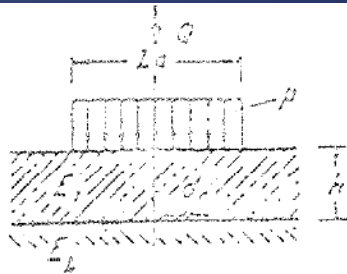
- **Active filler (cement) versus bitumen content must be considered!!**
- **Flexibility is an very important property, but difficult to measure**
- **More advanced test methods (triaxial) enhance link to performance**
- **Effective long term stiffness of BSMS – need greater range of data**
- **Insufficient basis to rewrite TG2 currently, but if SAPDM yields compelling data, then review later**

Thank you

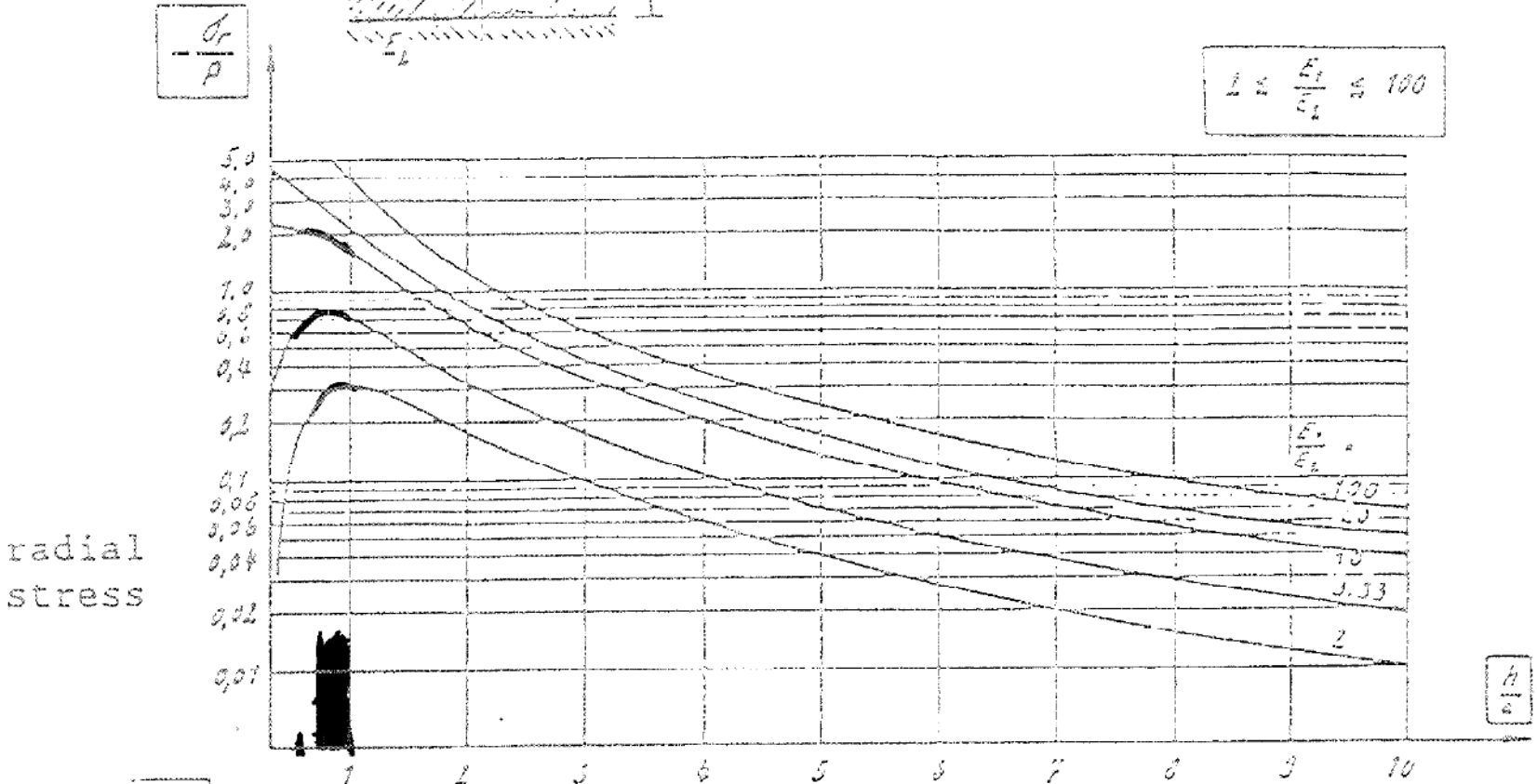
Questions??



Burmister $\nu_1 = \nu_2 = 0.5$



$$1 \leq \frac{E_1}{E_2} \leq 100$$



$$\frac{\sigma_r}{P}$$

$$\frac{\sigma_c}{P}$$

$$5.53 \leq \frac{h}{a} \leq 5$$