Long Life Pavement Design and maintenance: now and into the future

Brian Ferne, TRL

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UK pavement design and maintenance for long life

ICE and TRF Fellows Lecture

How Flexible Road Pavements Really Behave – The Paradigm Shift in our Understanding of Road Behaviour

Monday 28 May 2012

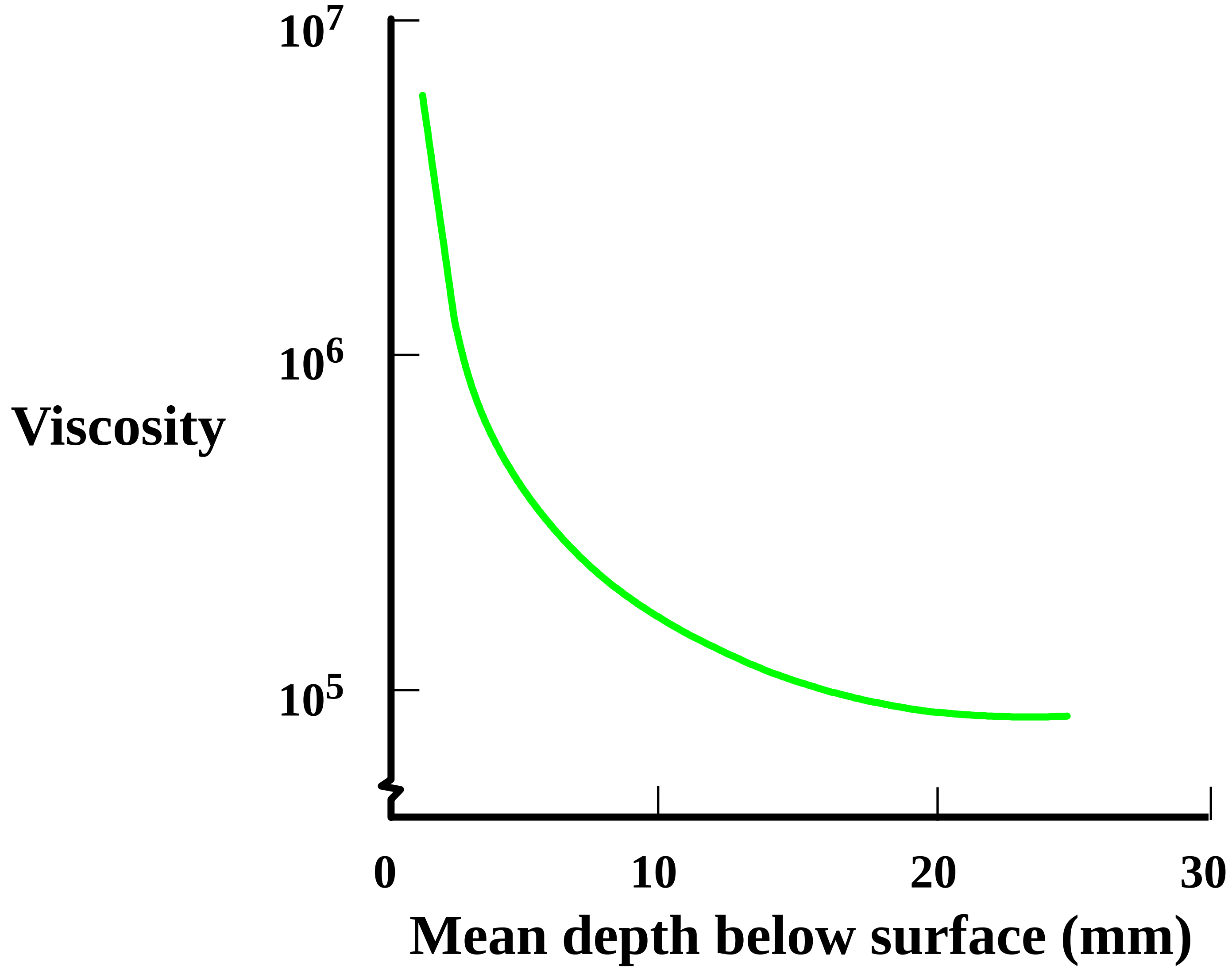
Institution of Civil Engineers

Outline of presentation

1. What is a paradigm shift
2. The previous pavement paradigm
3. TRLs research
4. The new paradigm
5. Corroborating research and acceptance
6. Implications for maintenance and pavement design
7. UK research
8. Long life pavements


5cms

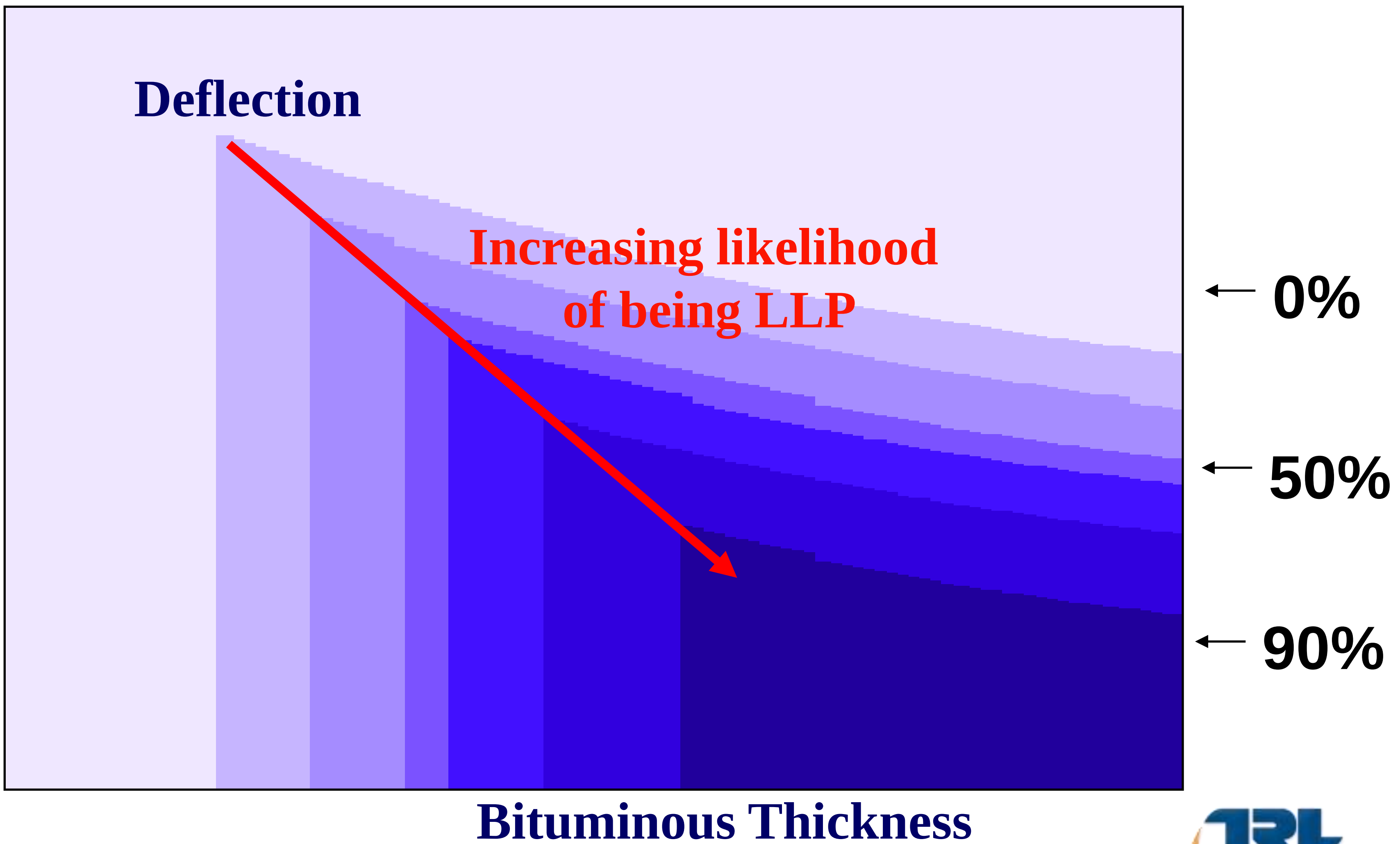
Bitumen viscosity versus depth after 24months exposure



IMPLICATIONS

- If cracks begin at the bottom, then when they appear at the surface, the road is seriously damaged and the whole surface, and usually the roadbase, needs replacing.
- If cracks start at the top then, when they appear, the appropriate remedial treatment is to mill off a thin layer and replace with another thin layer.
- Thus the cost of maintenance is reduced dramatically and the basic pavements are described as LONG LIFE
- However, we need to identify which pavements ARE long life
- For new design we no longer need to extrapolate the design charts

LIKELIHOOD OF PAVEMENTS BEING LONG LIFE



european

long-life

pavement

group

ELLPAG
(Formed in 2000)

is a FEHRL Working Group

(Forum of European National Highway Research Laboratories)

with support from CEDR

(Conference of European Directors of Roads)

Financial support to each laboratory is provided by their respective highway administration

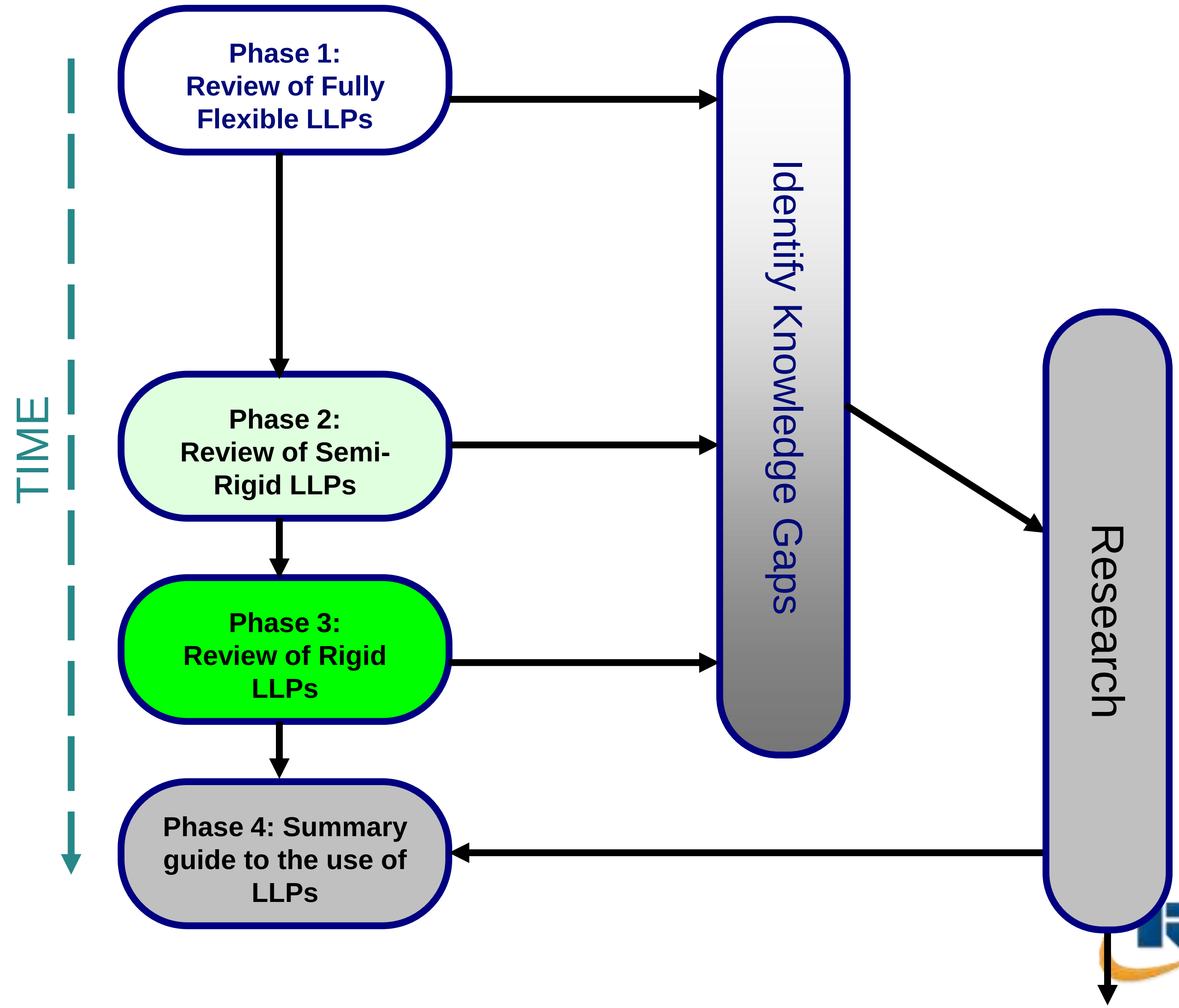
Four main aims of ELLPAG

With respect to long-life pavements:

- to determine best designs
- to determine economic benefits
- to understand deterioration mechanisms
- to encourage their use

With a particular emphasis on the needs of the structural support layers

Plan for the flow of the work of ELLPAG



Other ELLPAG Outputs

- Papers to conferences:
  - TRB2001, ISAP4, RILEM2004, EAPA2004, FeRRM2005, PP2006, ISCR2006, ACPSEM2007, Enviroroad 2009, TRA 2010, FERRM 11,
- Special Edition of IJPE on LLP's
- Cooperation with OECD, ECOSERVE, PIARC TC4.3
- etc

Where are we now?

Structural pavement design

New pavement design

- Thickness varies with traffic up to 80msa
- Limited by critical hor. and vert. strains i.e. fatigue and deformation criteria below 80msa
- Thickness constant above 80 msa
- Based on RR250 (and TRL615)

Maintenance design

- Potential long life pavement identified by measured deflection and asphalt thickness
- For determinate life pavements
  - Residual life estimates based on measured deflection and traffic carried.
  - Thickness of strengthening overlay determined by measured deflection and future traffic
- Imminent implementation of rational inlay/overlay design

Where are we now?
- What do we know?

- Fatigue not a major mechanism in the UK
- Structural deformation only on thin pavements
- No validated mechanistic models
- Mismatch between laboratory and field
- Deterioration initiates from built-in defects
- Deterioration plateaus above modest thickness

Where do we want to be?

Option/Stage 1: Focusing on HA's heavily trafficked network

HA network

- Entirely long life construction?

Structural design

- Based on meeting threshold critical responses whatever traffic level
- Based on minimal necessary design thickness plus risk allowance

New pavement design

- Assume new pavement material properties
- Design thickness so predicted responses meet thresholds
- Add thickness to provided acceptable level of risk

Maintenance design

- Measure in-service properties
- Design strengthening or reconstruction so predicted responses meet thresholds
- Add thickness to provided acceptable level of risk

Latest HA-funded research into Pavement Design

Feasibility study for a radically new approach to pavement design

2006-2008 Objectives

- Review and examine the reasonableness of current design methodology
- Identify shortcomings
- Propose development path
- Parallel HA/QPA/RBA project identified need for improved durability

Threshold Pavement Design Trials

2009/11 Objectives

- Establish critical pavement responses for threshold strength
- Design and construct trial in PTF
- Measure responses

2012+ Objectives?

- Traffic trial
- ……….

Conceptual Design Approach

Construction to exactly the threshold thickness would incur risk of early failure

- Variability in construction and materials
- Unexpected loading
- Unexpected climatic conditions
- Occurrence of top-down cracking,
- Durability issues. etc

Risk would need to be reduced for roads of greater:

- Strategic,
- Economic and
- Political importance

How do we get there –

What questions do we need to answer?

1. Why is it so difficult to predict pavement lives?

2. Does the threshold effect exist in pavements?

3. What are the critical stress and strain parameters?

4. What are the threshold levels below which life is ‘infinite’?

How do we answer the questions –

1. Why is it so difficult to predict pavement lives?

- Because we don't fully understand deterioration mechanisms?
- Because nominally similar pavements can have very different lives ?

1a. Why are pavement lives so variable?

- Because of variability in
  - Materials, mix temperature, paving operations, compaction levels, soil strength, environmental conditions (temperature, moisture)

Therefore usual policy is to design pessimistically to a high percentile.

Alternative is to design to median or similar level and then add extra thickness dependent on the acceptable risk level for each specific site conditions.

How do we answer the questions –

2. Does the threshold effect exist in pavements?

- Design trial in accelerated loading facility (PTF) to assess this concept.
- Carry out threshold pavement design trial.

However:

- Threshold levels determined in PTF do not necessarily apply to the real network.

How do we answer the questions –

3. What are the critical stress and strain parameters?

- Assume traditional parameters
  - Horizontal strain at bottom of asphalt
  - Vertical strain at top of subgrade

Or

- Assess which parameters best relate to pavement life in accelerated loading facility trial
  - Instrument PTF sections in comprehensive manner
  - Model these measurements to enable prediction of wider range of parameters
  - Traffic sections until failure
  - Identify parameters best related to life

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How do we answer the questions –

4. What are the threshold levels below which life is ‘infinite’?

- Calibrate the structural condition of the road network against the level of the critical parameters (e.g. strains) to define threshold values
  - For Strategic Road Network (SRN)
    - Estimate structural condition from available condition surveys e.g. TRACS data, GPR data
    - Estimate critical strains from network structural surveys (e.g. TSD)
    - Correlate strains with condition
  - Supplement with scheme level information
    - Estimate structural condition from scheme level investigations
    - Estimate critical strains from scheme level structural surveys (e.g. FWD)
    - Correlate strains with condition
  - Supplement with data from LA network with thinner, weaker roads

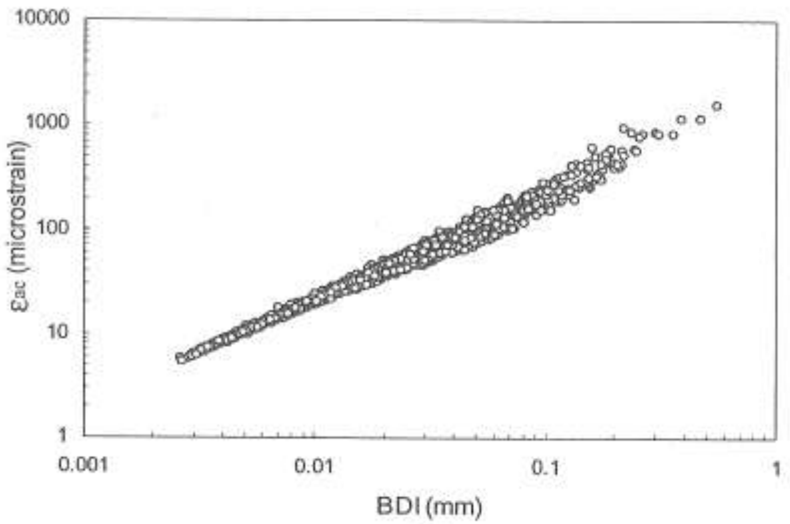
But how do you estimate strains from TSD and FWD?

Estimating strain from FWD measurements

There is much evidence to show that this method works well in principle. Studies by Christ van Gurp of KOAC and Richard Kim and colleagues at North Carolina State University (NCSU), USA for example.

Strain in the HMA vs (d_{300}-d_{600}) i.e. BDI

based on work by North Carolina State University (NCSU)



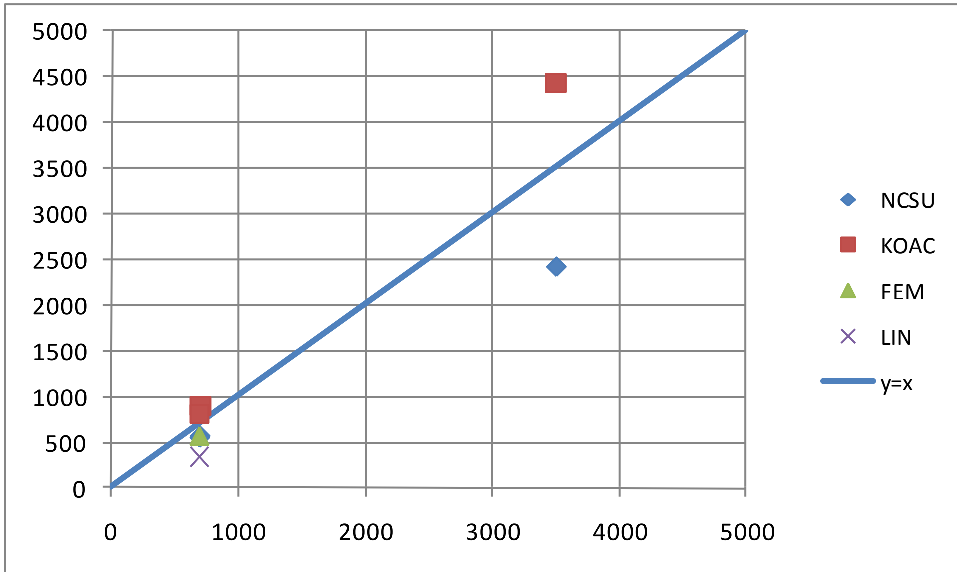
(a)

However, 'in principle', because there is a paucity of measured stress/strain data in real pavements, therefore the regressions have been carried out using stress and strain values derived from models.

Comparison of measured and predicted strains (2)

Subgrade strains

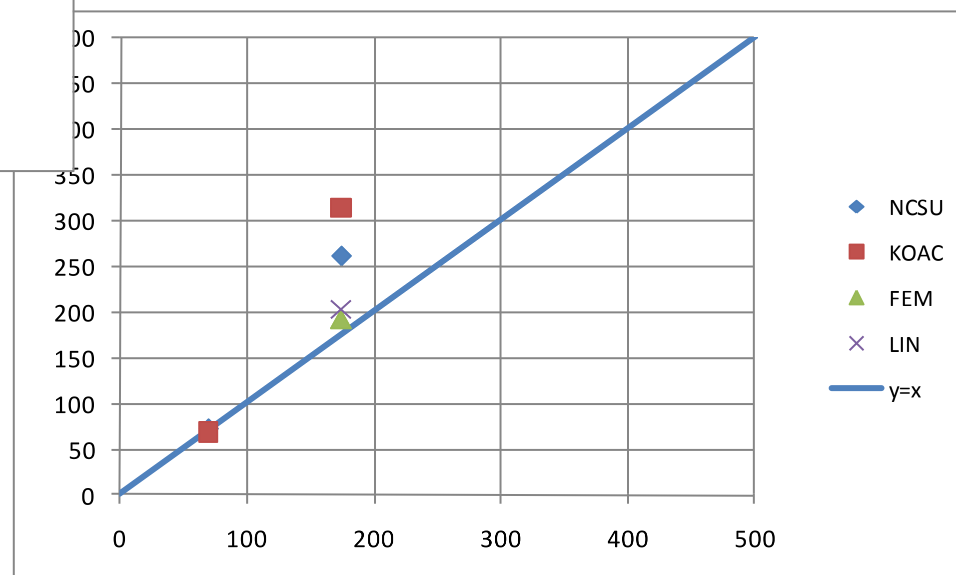
Predicted



Measured

Base strains

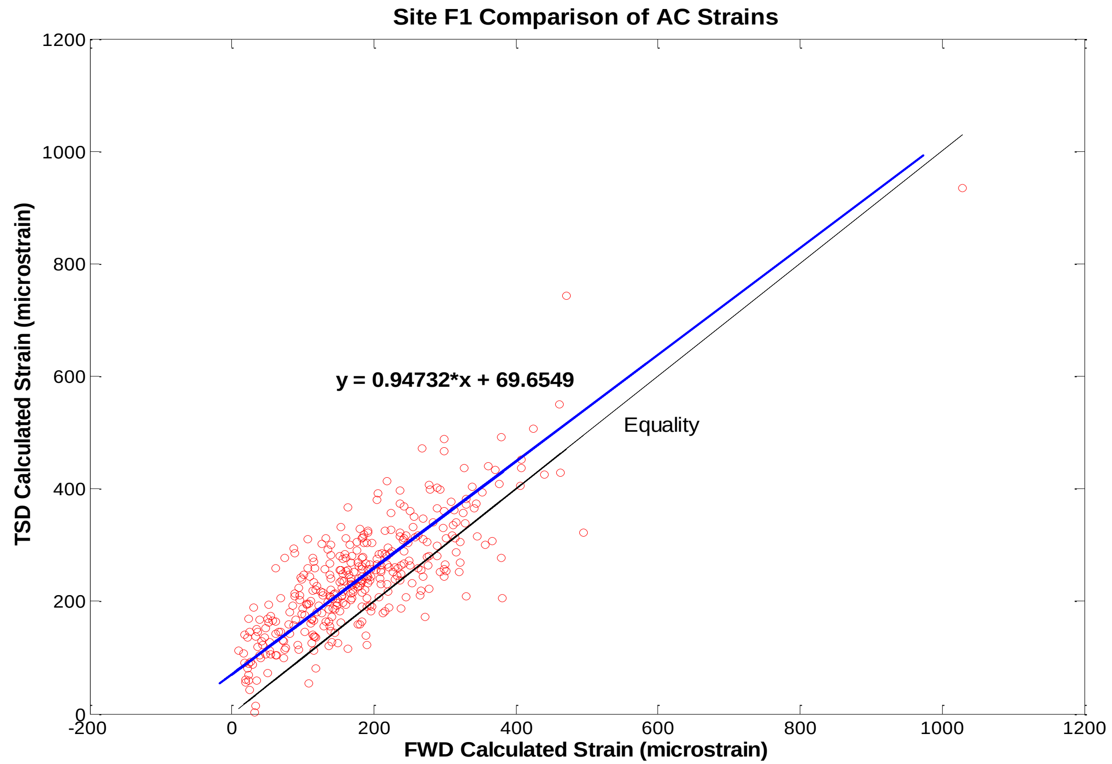
Predicted



Measured

Estimating strain from TSD and FWD measurements

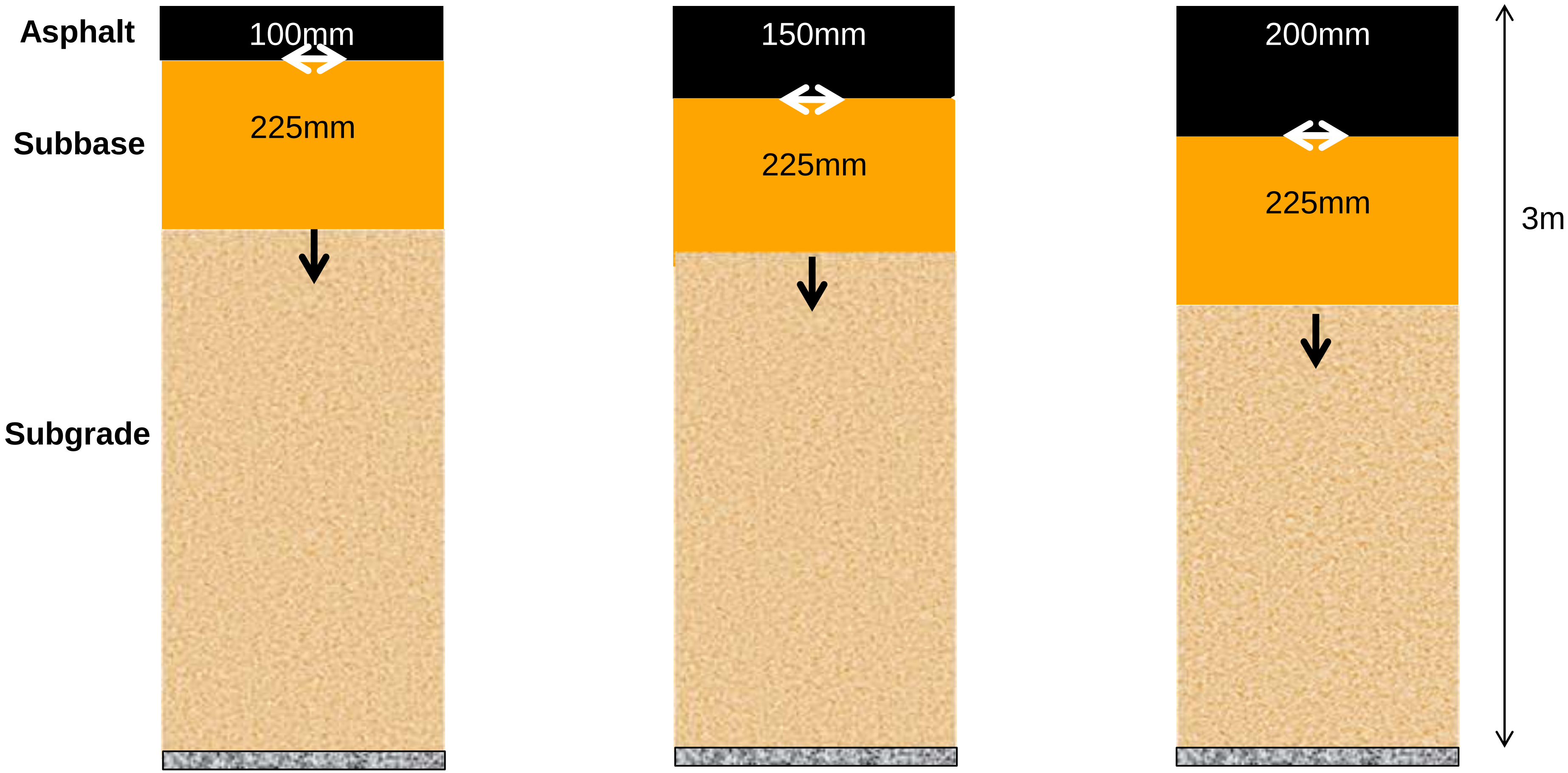
- Some early application of FWD principles to TSD measurements gave the following comparison between strains estimated from FWD and TSD on the same site



Strain at the bottom of the Asphalt Layer Estimated by TSD and FWD

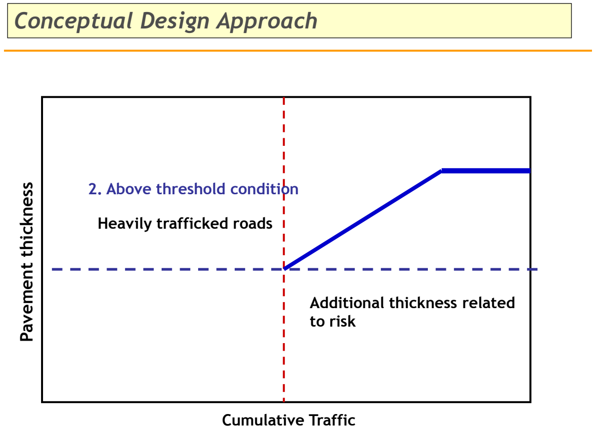
Proposed PTF trial

Three instrumented pavements



In summary:
How are we moving forward in the UK?

- Identifying threshold level for structural deformation
- Developing rationale for design above and below the threshold
- Risk assessment
- Implications for construction, condition assessment and maintenance



Thank you

Presented by Brian Ferne (bferne@trl.co.uk)

12 June 2012