Hot Mix Asphalt Concrete (HMA) Mix Designs

- Objective:
  - Develop an economical blend of aggregates and asphalt binders that meet design requirements
- Historical mix design methods
  - Marshall
  - Hveem
- New
  - Superpave gyratory

Requirements in Common

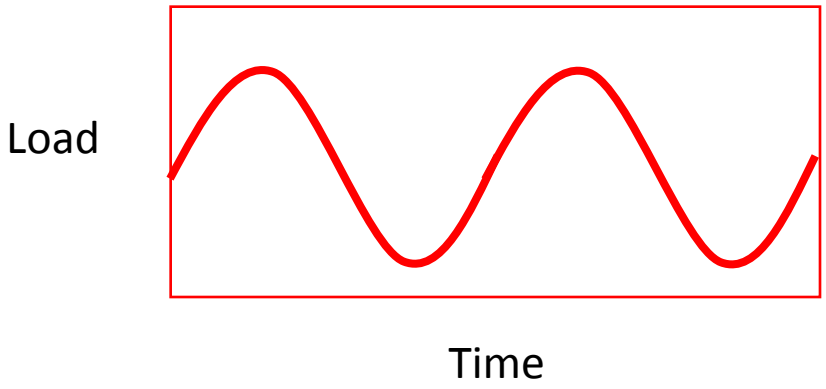
- Sufficient asphalt binder to ensure a durable pavement
- Sufficient stability under traffic loads
- Sufficient air voids
  - Upper limit to prevent excessive environmental damage
  - Lower limit to allow room for initial densification due to traffic
- Sufficient workability

Important for Predicting Pavement Performance

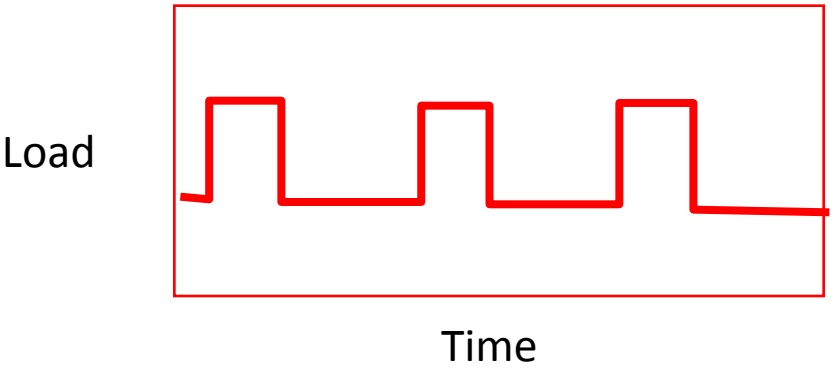
- Used to predict:
  - Critical stresses and strains
  - Fatigue cracking
  - Permanent deformation characteristics

General Terms

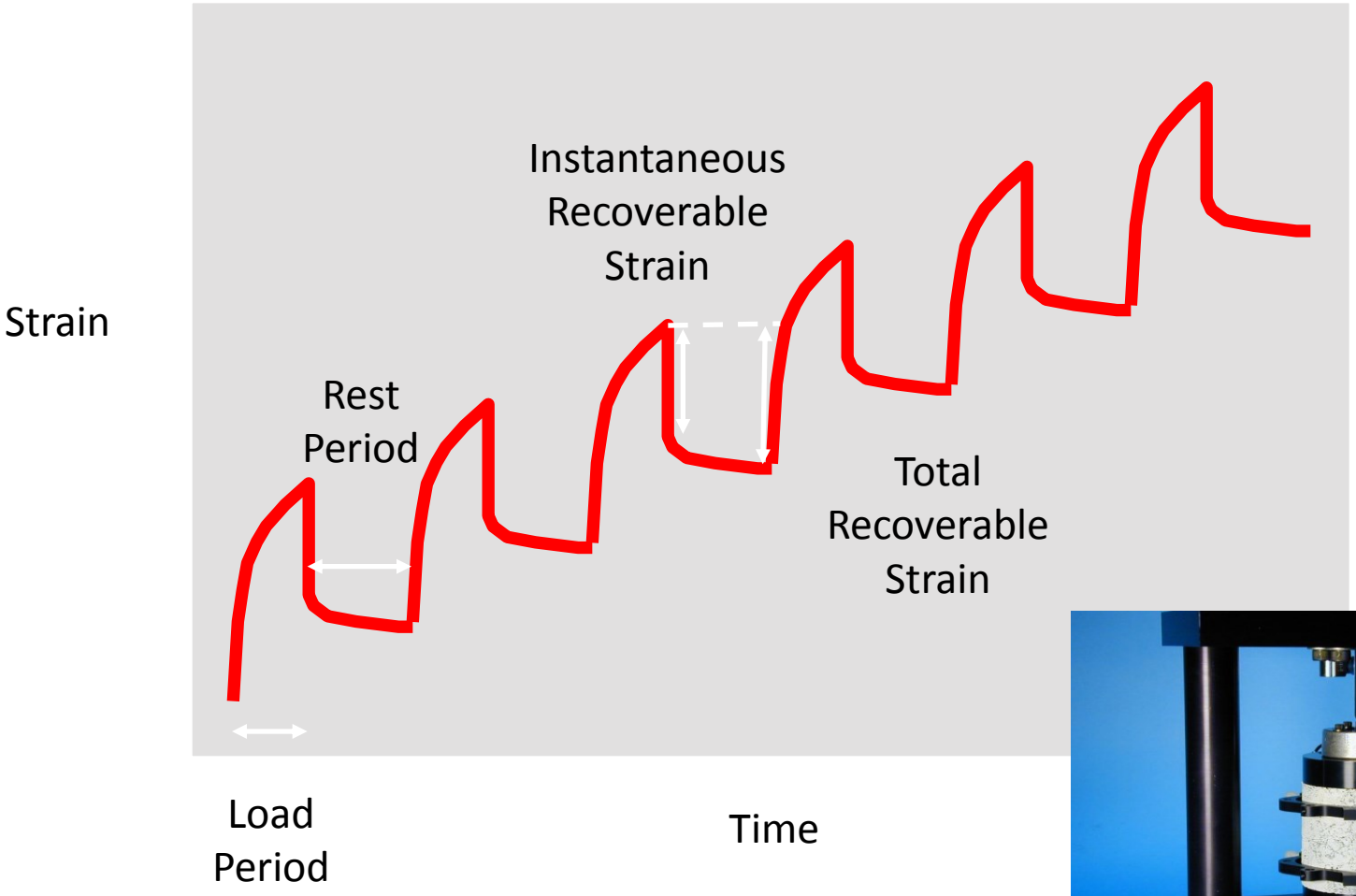
- Dynamic load
  - Load applied using a sinusoidal wave form

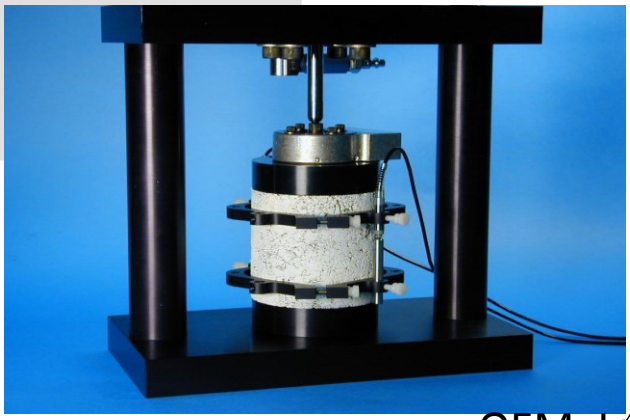


- Repeated load
  - Load pulse applied then removed
  - Rest period between loads



Resilient Modulus
Repeated Load





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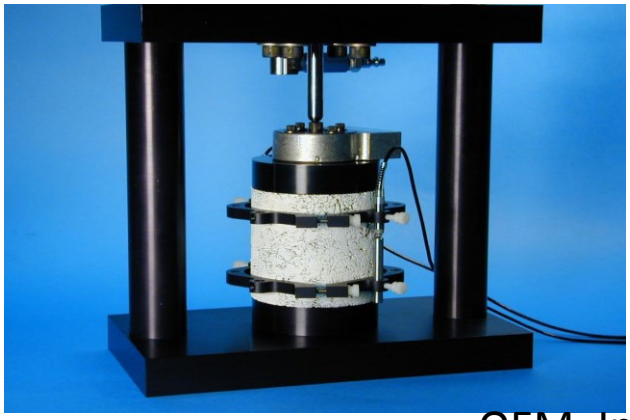
Stiffness

- Fundamental to the analysis of pavement response to traffic loading
- Various methods
  - Axial resilient (ASTM D3497)
  - Diametral resilient (ASTM D4123)
  - Flexural dynamic
  - Shear dynamic



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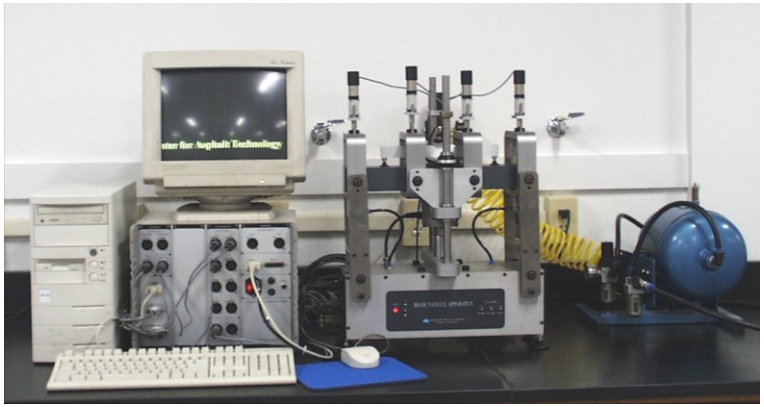
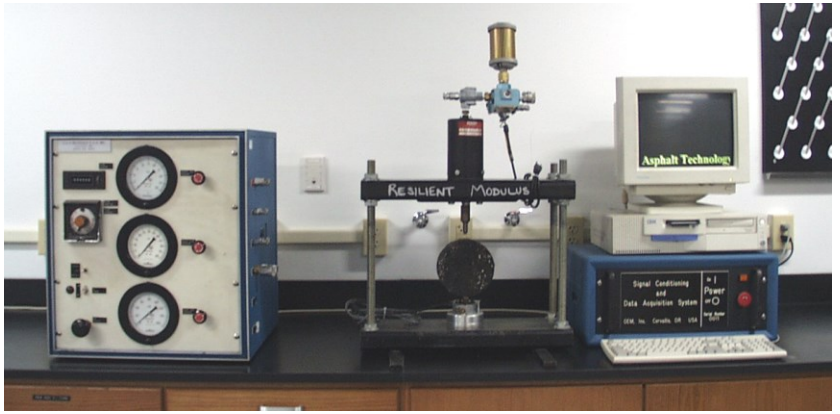
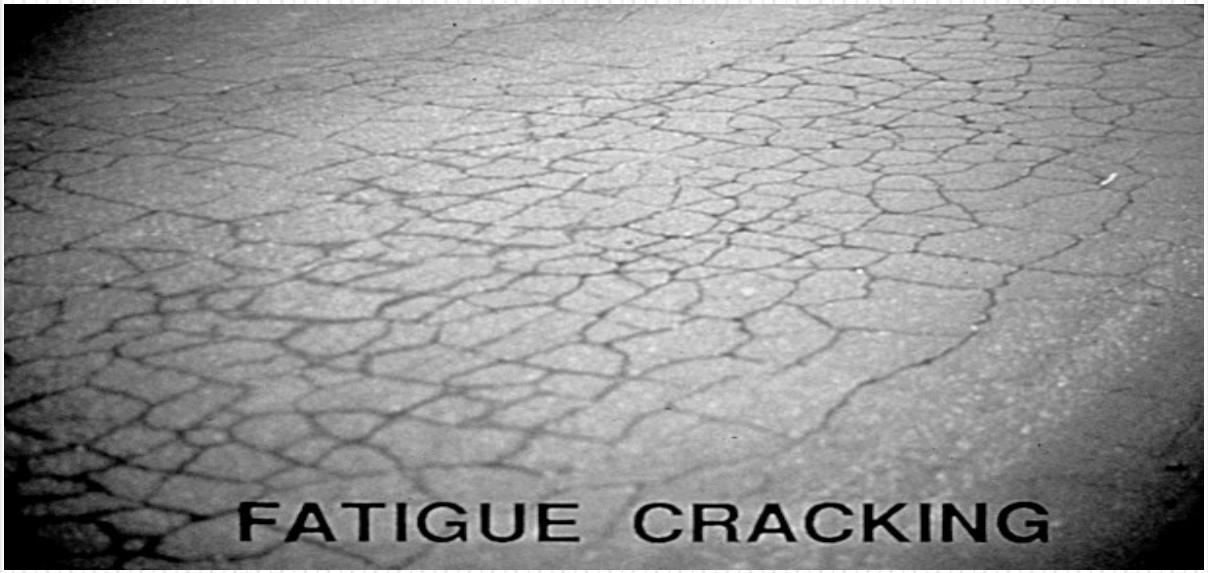


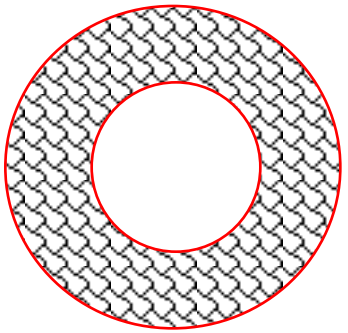


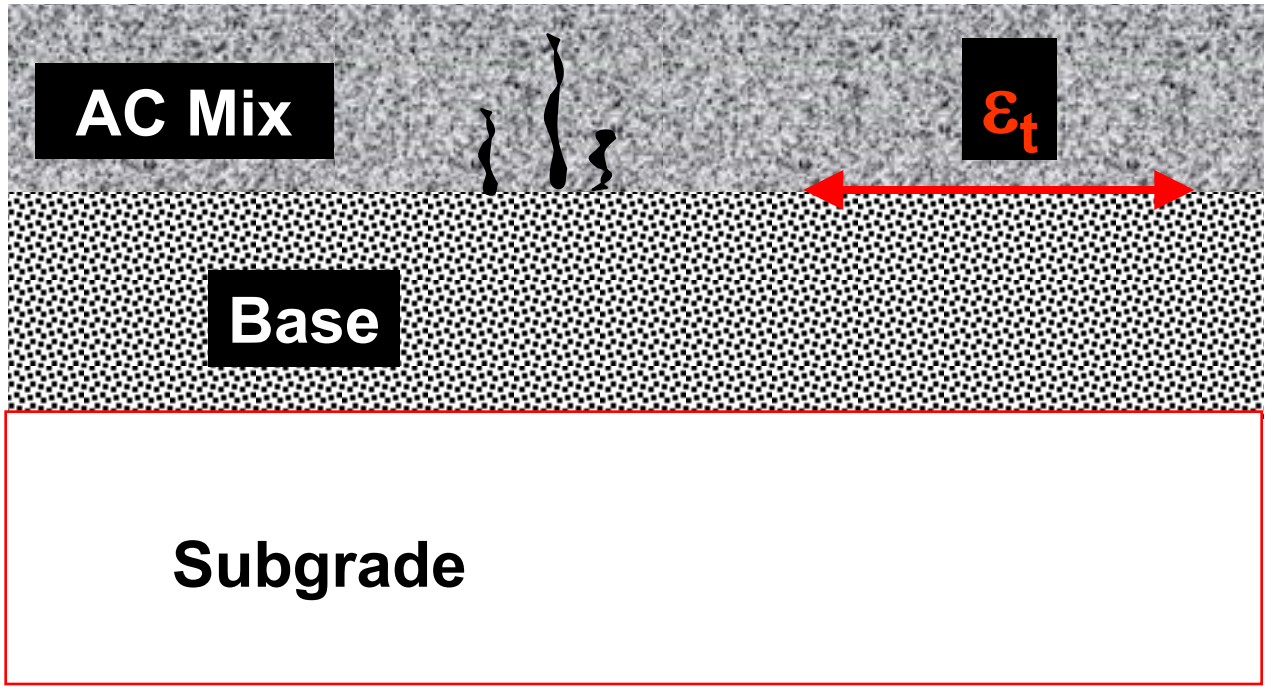
Fatigue Cracking Characteristics



Mechanisms

- Traditionally considered to start at the bottom and work up to the top
- Crack starts when tensile strain exceeds tensile strength of mix
- When cracks visible on top, full layer cracked

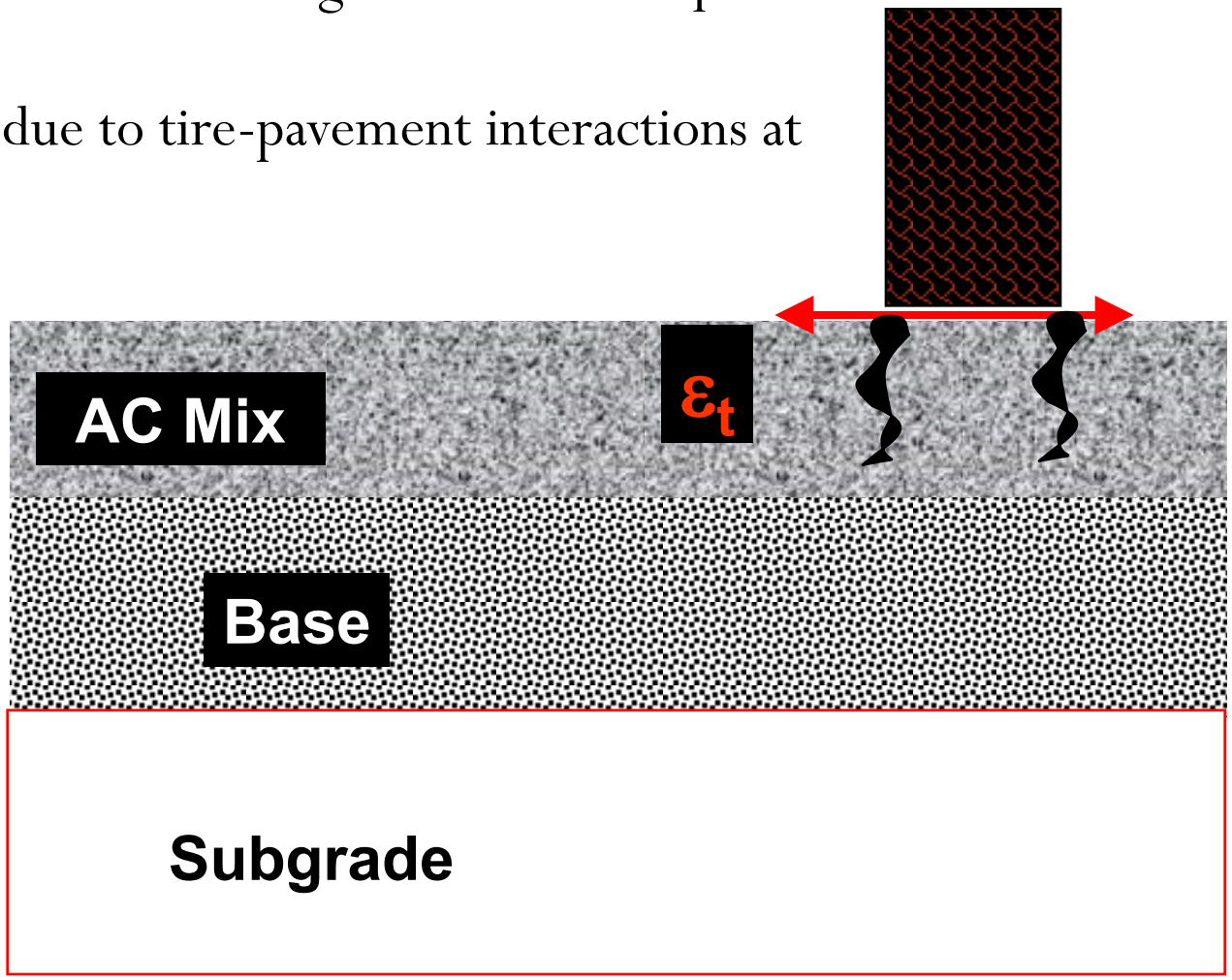




Longitudinal pavement profile

Mechanisms

- Recent observations of fatigue cracking that starts from the top at the outside edges of the wheel path
- Tensile stresses due to tire-pavement interactions at surface



Transverse pavement profile

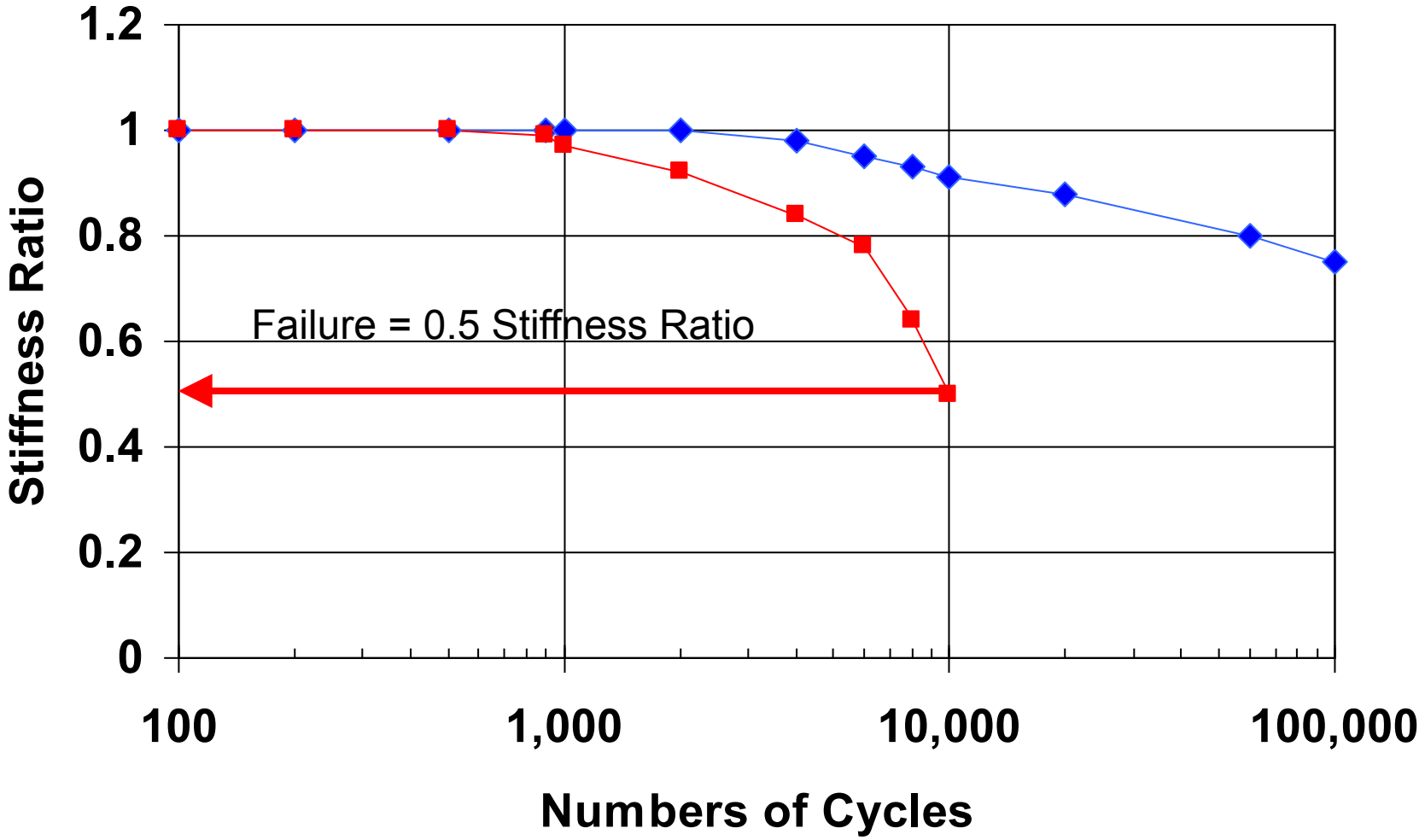
Fatigue Testing

- Most commonly used
  - Flexural beam
  - Cantilevered beam
- Others
  - Diametral fatigue
  - Notched beam

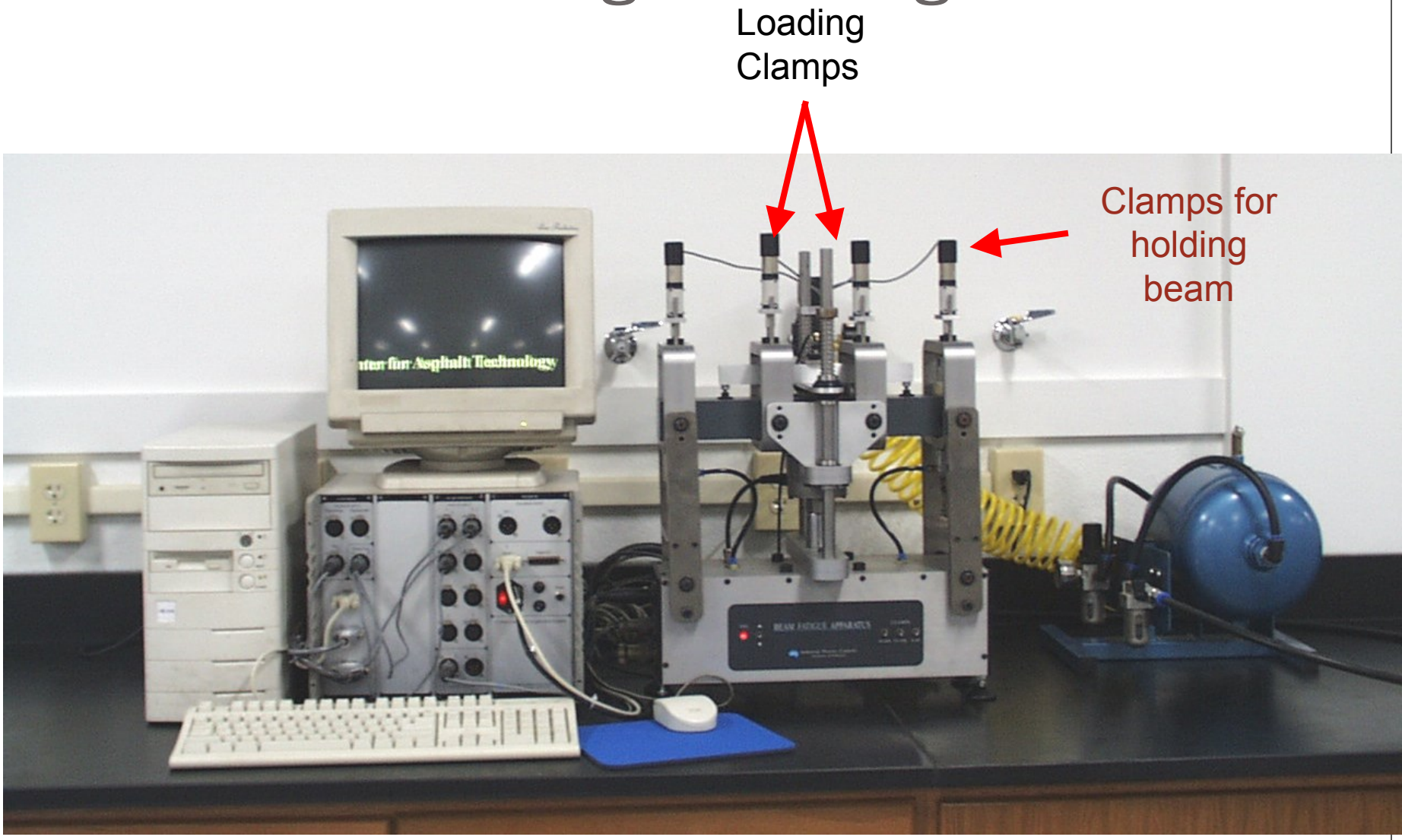
Flexural Beam Fatigue Testing

- Repeated load preferred to sinusoidal to permit stress relaxation
- Loading can be either constant stress or constant strain
- Failure = 50% loss of stiffness (controlled strain)

Determining Failure for Constant Strain



Flexural Beam Fatigue Testing



Permanent Deformation Characteristics

Test Methods

- Gyratory Shear Compactors
- Loaded Wheel Testers
- Simple Shear Tester
- Uniaxial and Triaxial

Loaded Wheel Testers

Asphalt Pavement Analyzer (APA)

Hamburg Wheel Tracking (HWT)

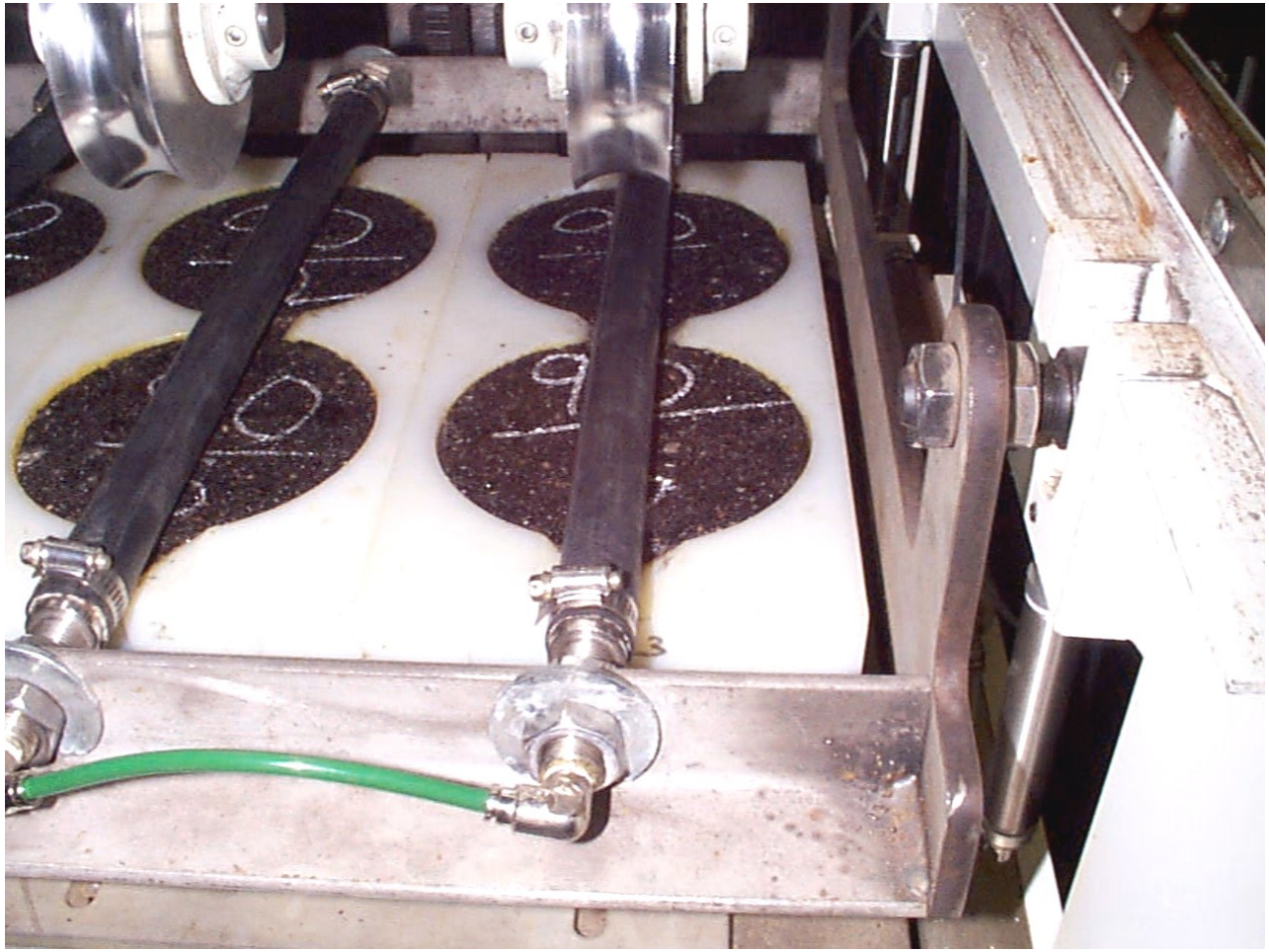
Purdue Wheel Tracker (PurWheel)

LCPC Wheel Tracker (LCPC)

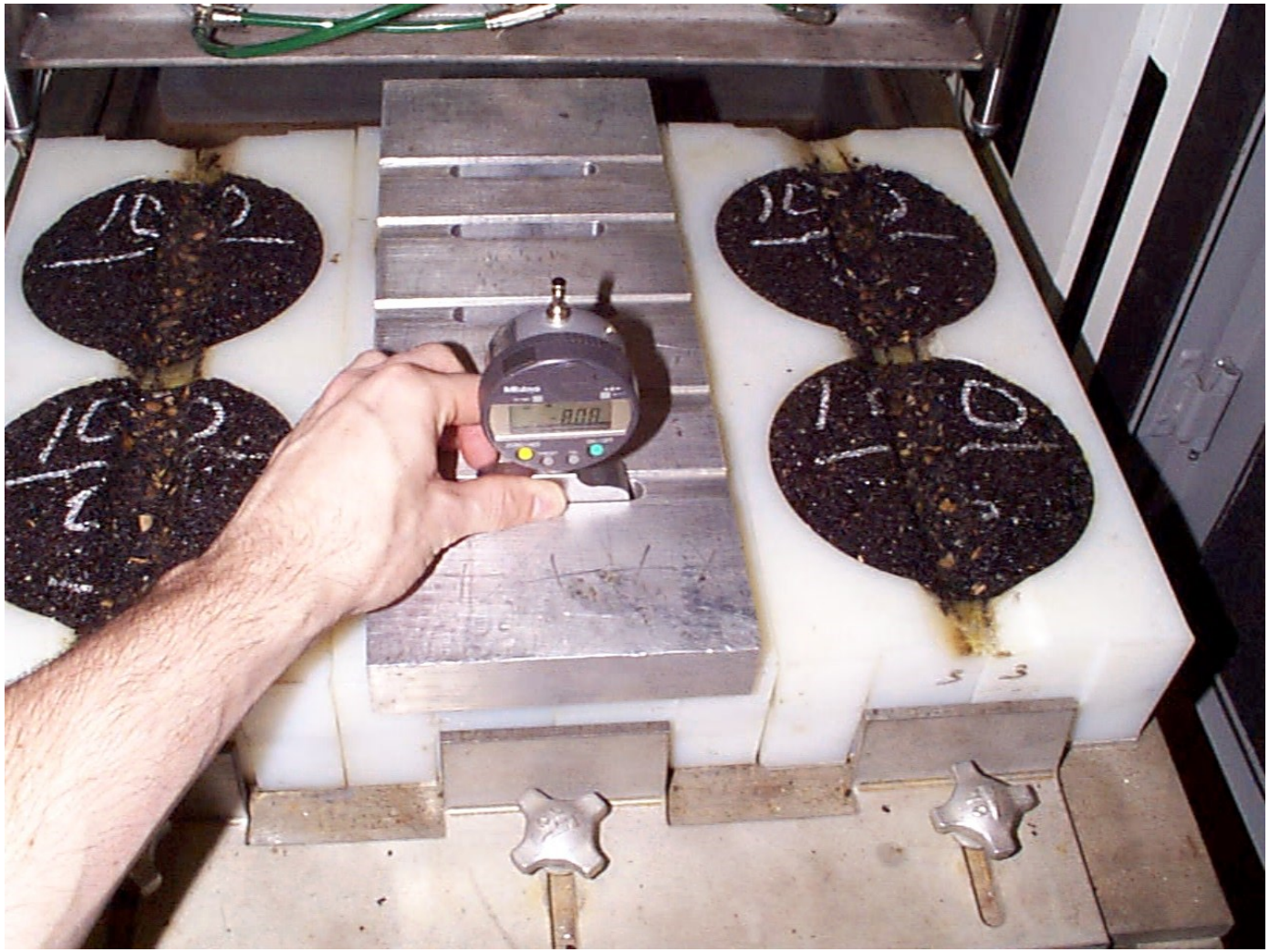
Mobile Load Simulator (MLS) - 1/3 scale

Asphalt Pavement Analyzer

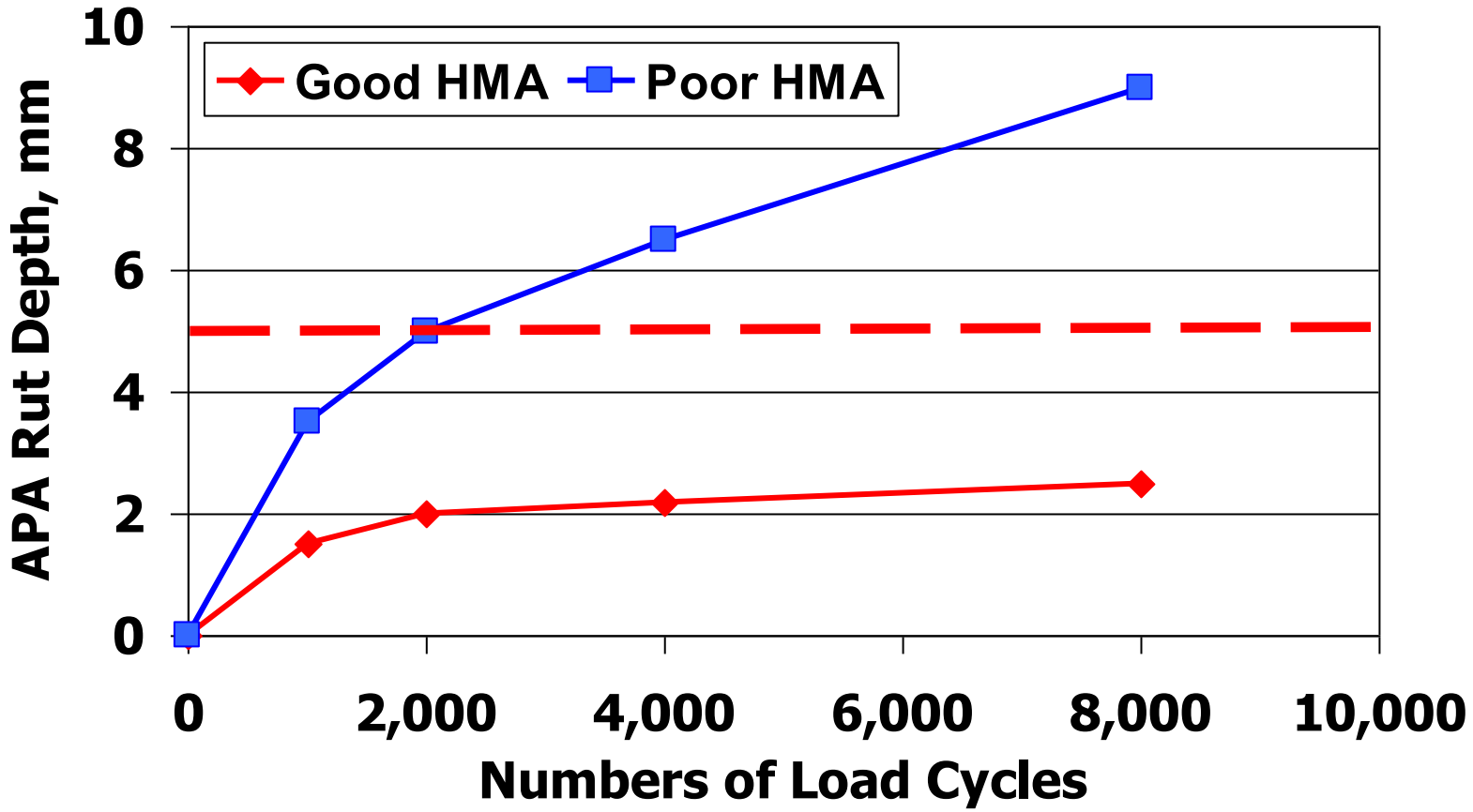
Asphalt Pavement Analyzer



Asphalt Pavement Analyzer

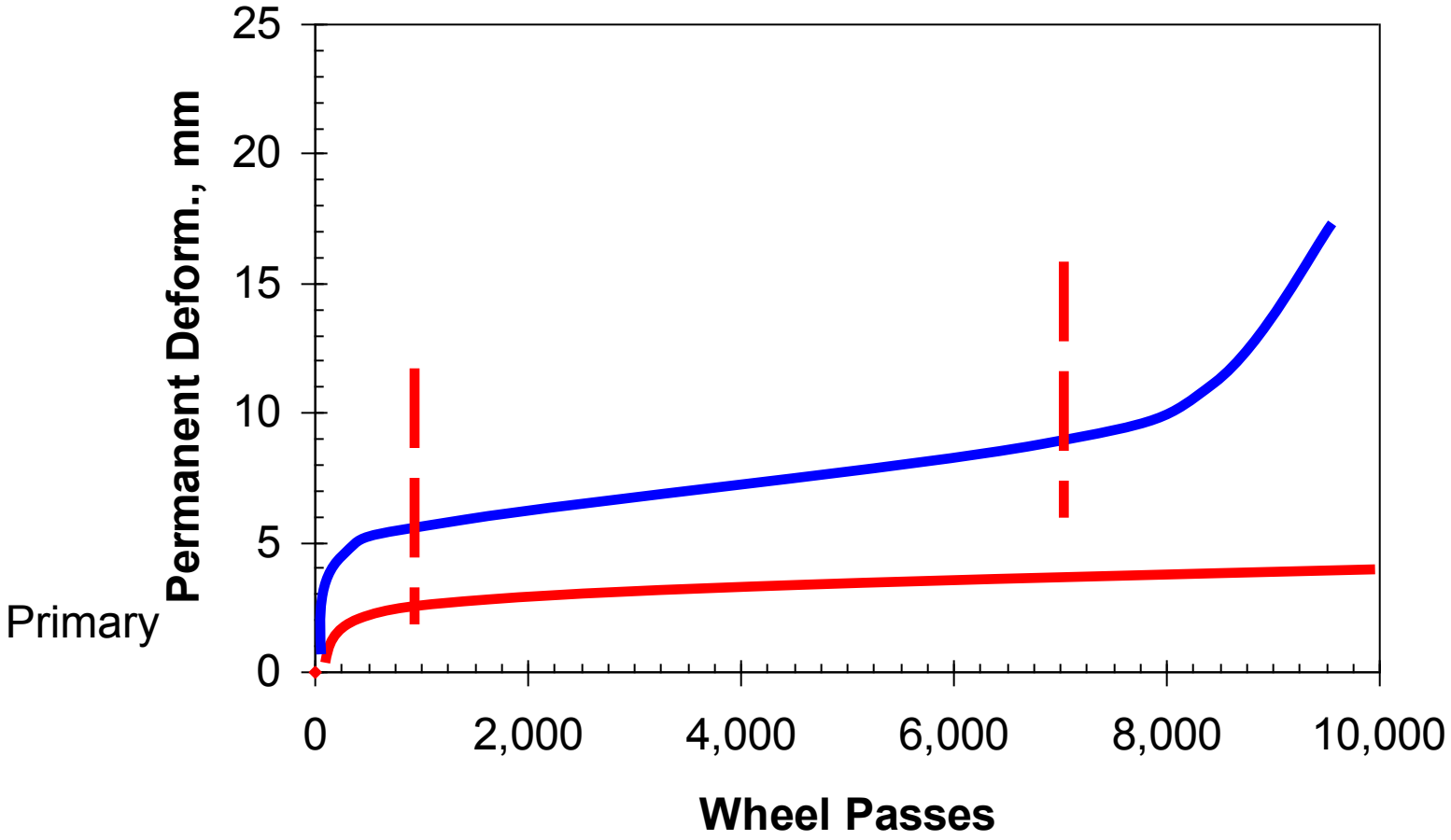


Typical APA Results



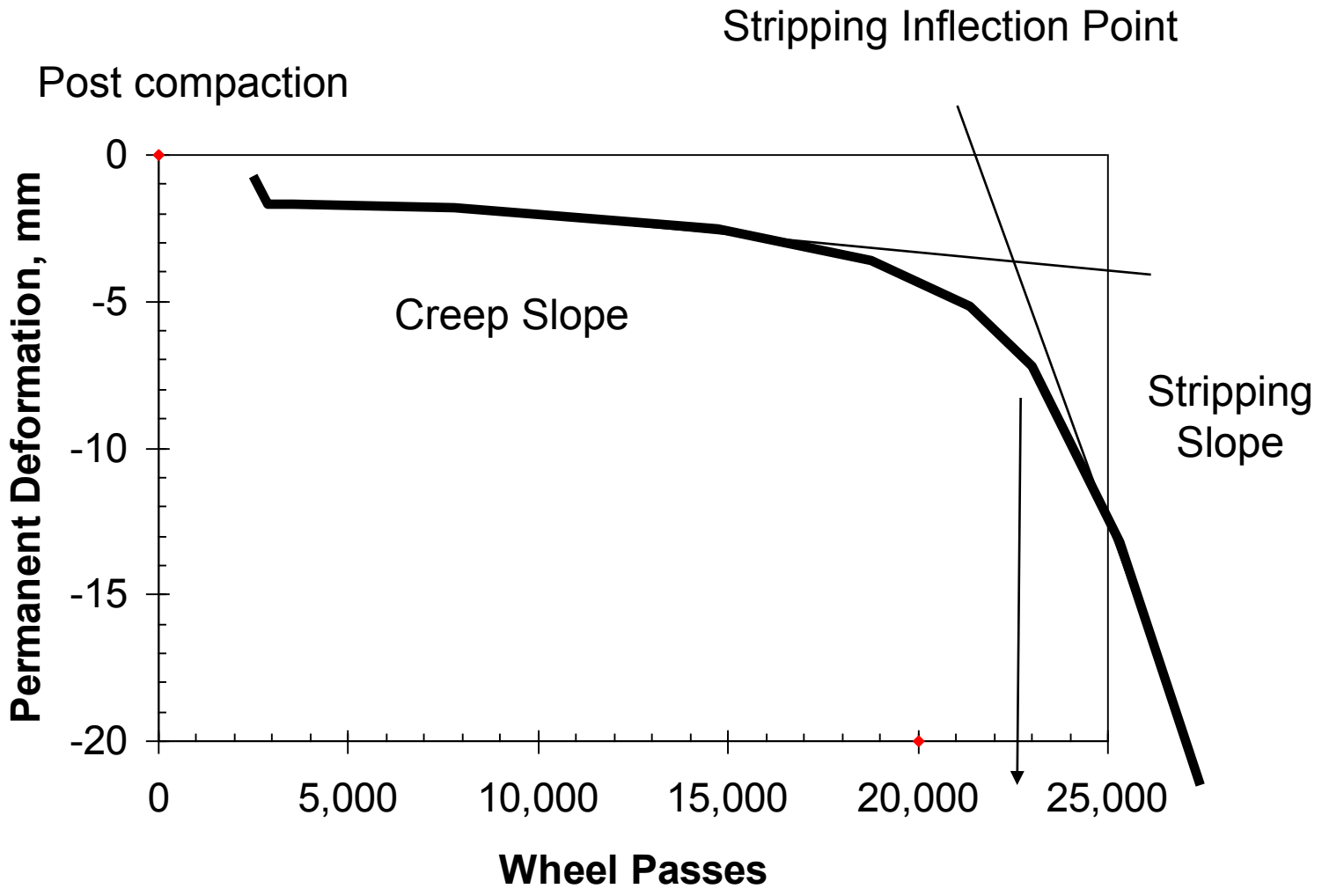
Asphalt Pavement Analyzer

- Three stages in deformation vs passes

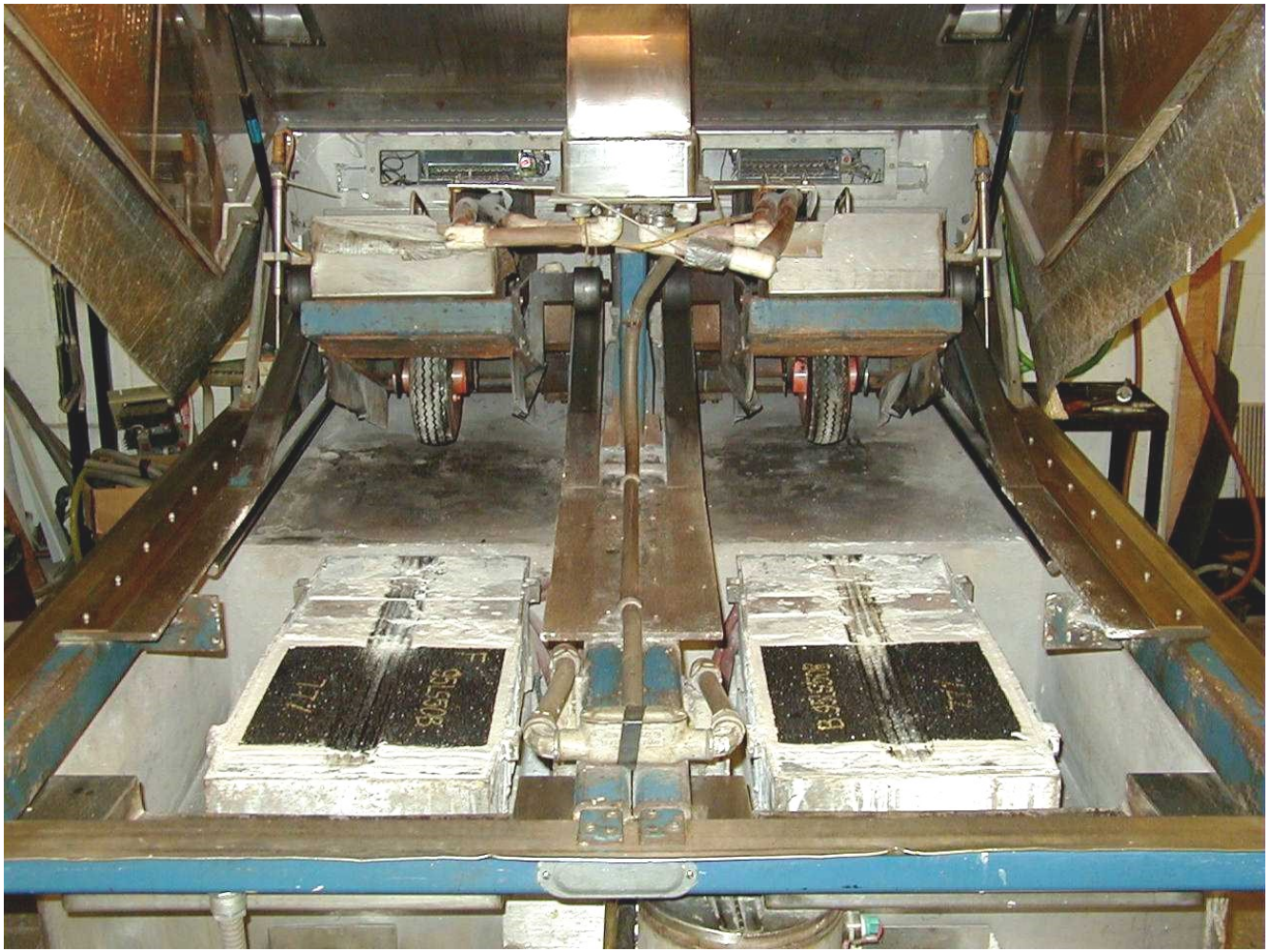


Hamburg

Use of Results



PurWheel

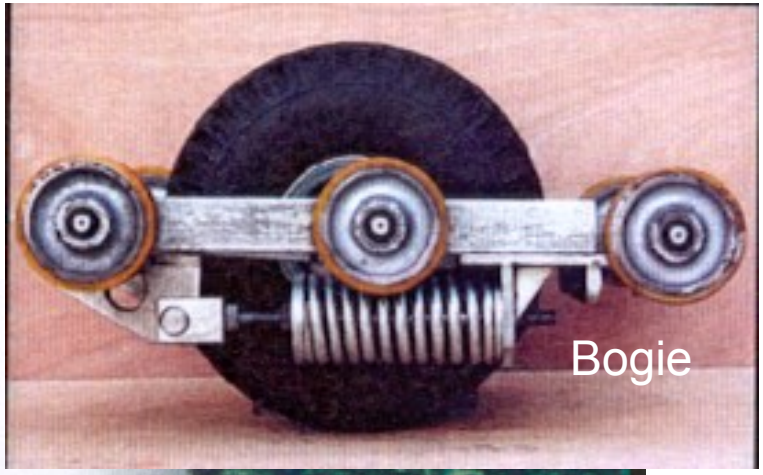


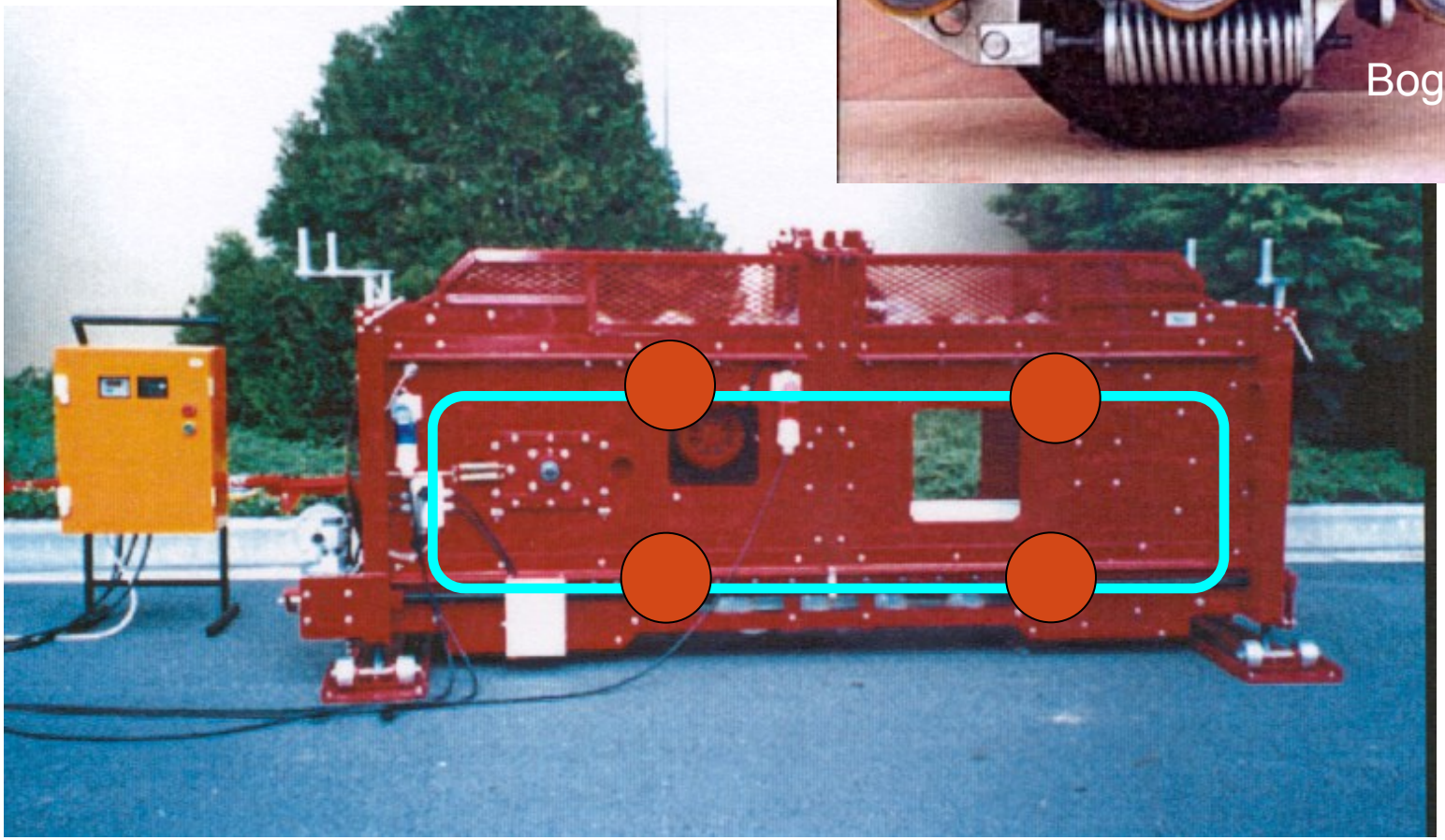
LCPC (French unit)

MLS (Full Scale)

MLS Test Systems CC, Rep. of South Africa
fpjm.@ing.sun.ac.za

MMLS





Simple Shear Tester (SST)

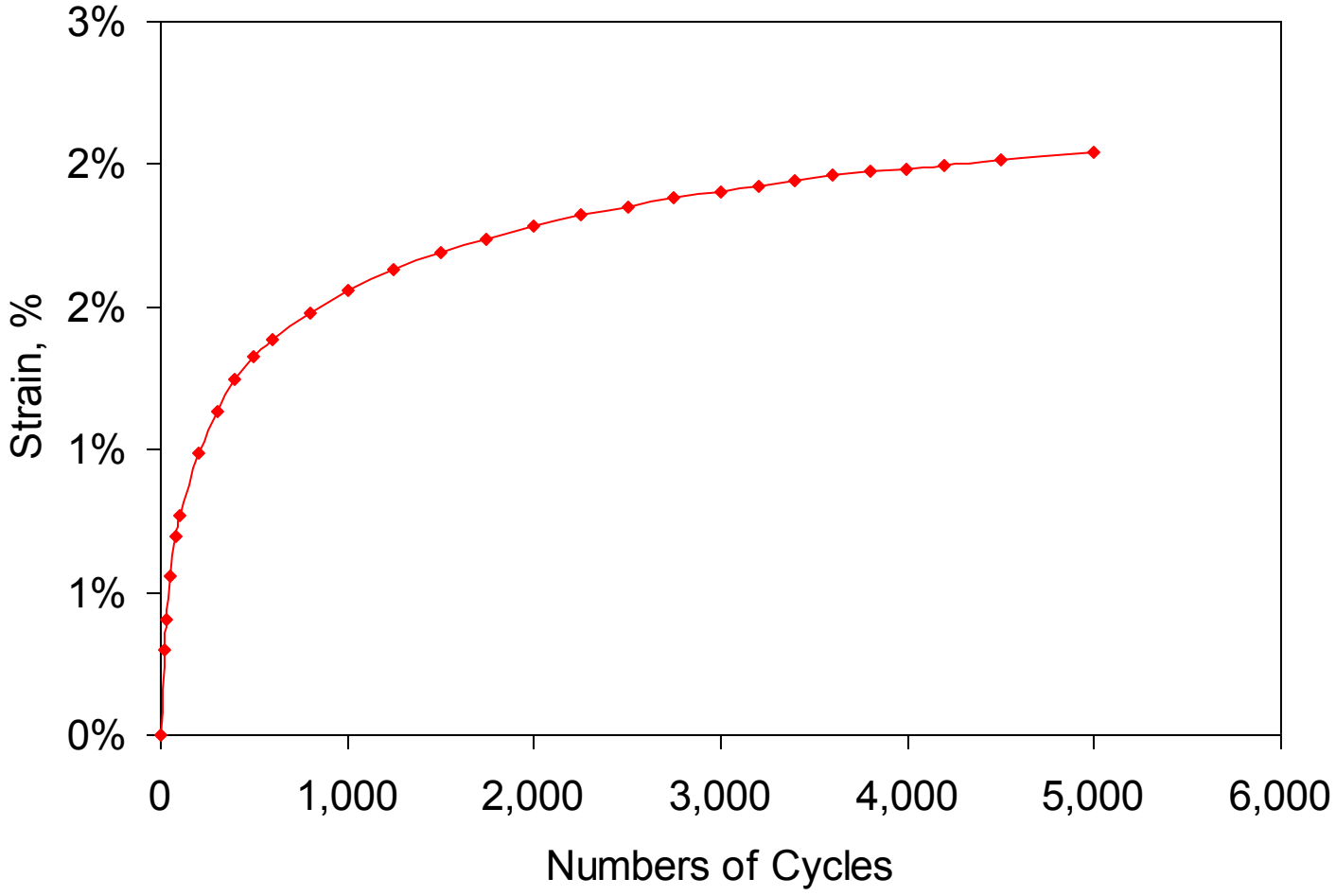
- Simple Shear Tests
  - Permits controlled rotation of principal axes of stress and strain
  - Assumes shear deformation rather than densification is the primary rutting mechanism

SST

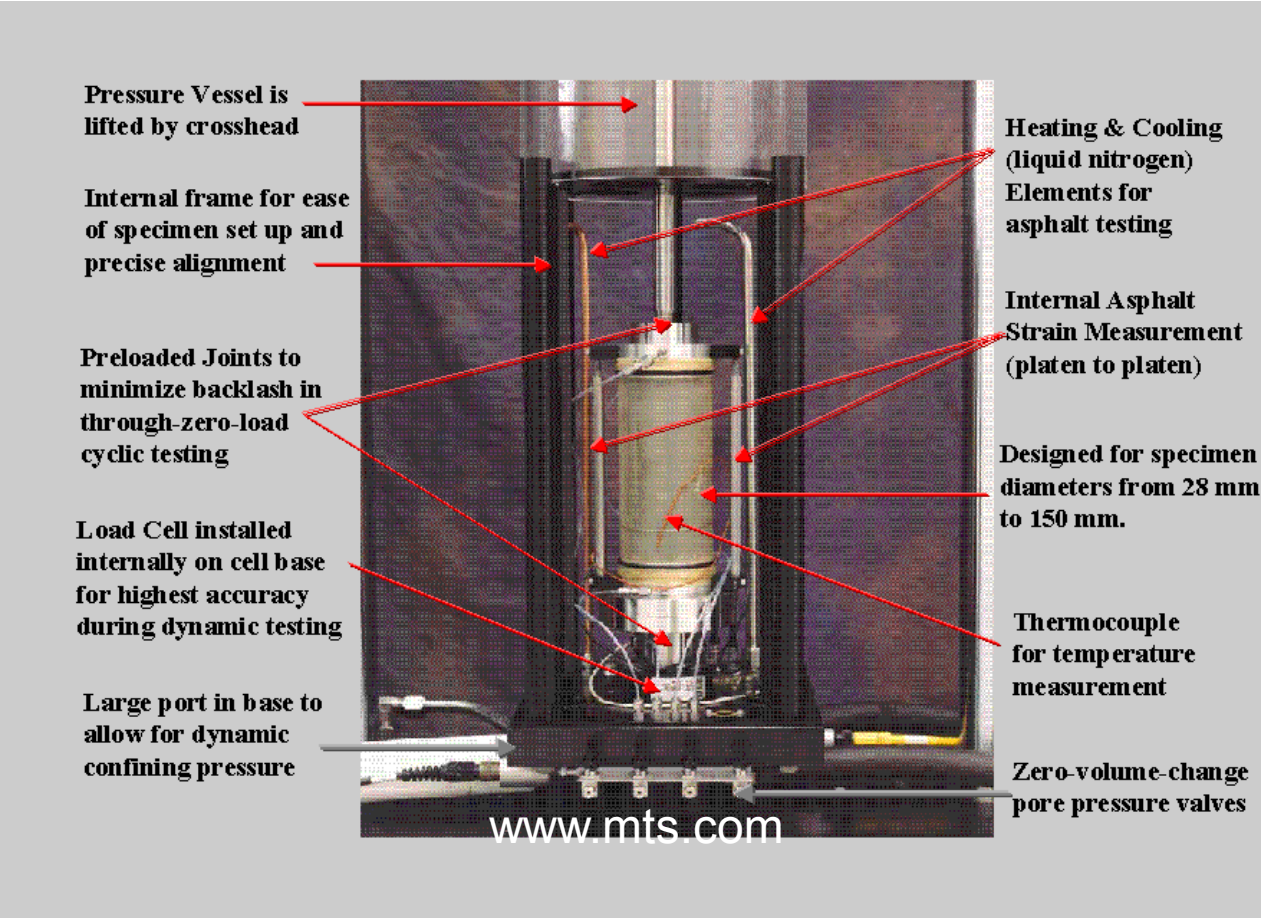
Empty chamber ready for sample

Sample mounted in chamber and ready to test

RSCH Sample Data



Uniaxial and Triaxial Testing

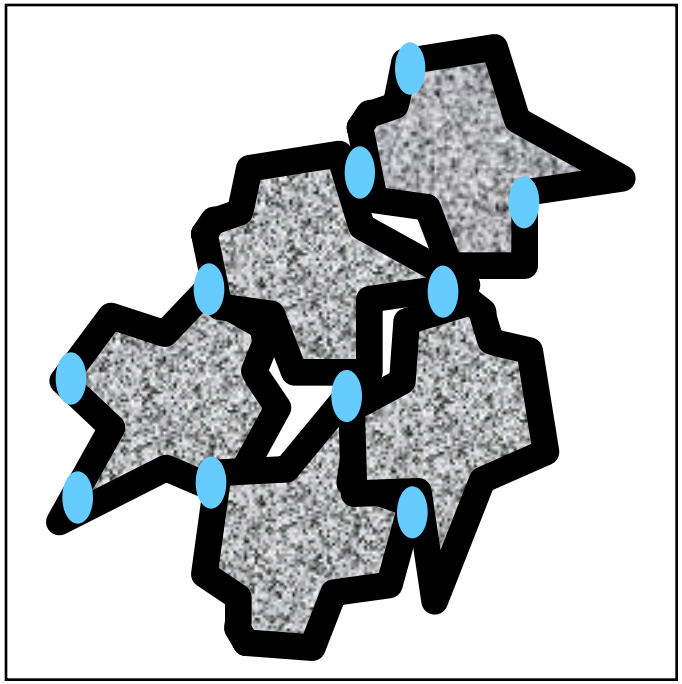


Moisture Sensitivity

Reasons for Damage

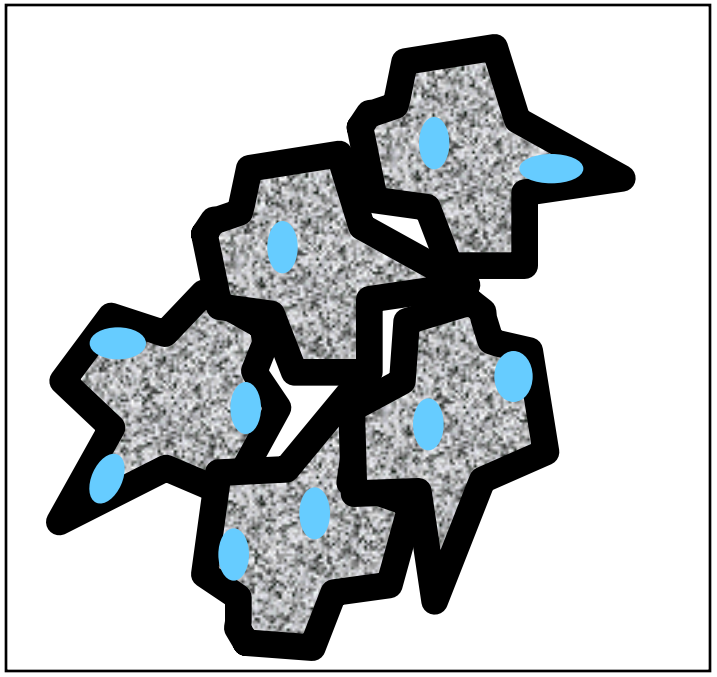
- Loss of cohesion in asphalt binder film
- Failure of adhesive bond

Loss of Cohesion (Spontaneous Emulsification)



- Inverted emulsion
- Aggravated by presence of emulsifiers
  - e.g. clays, additives
- Loss of stiffness and strength in asphalt binder

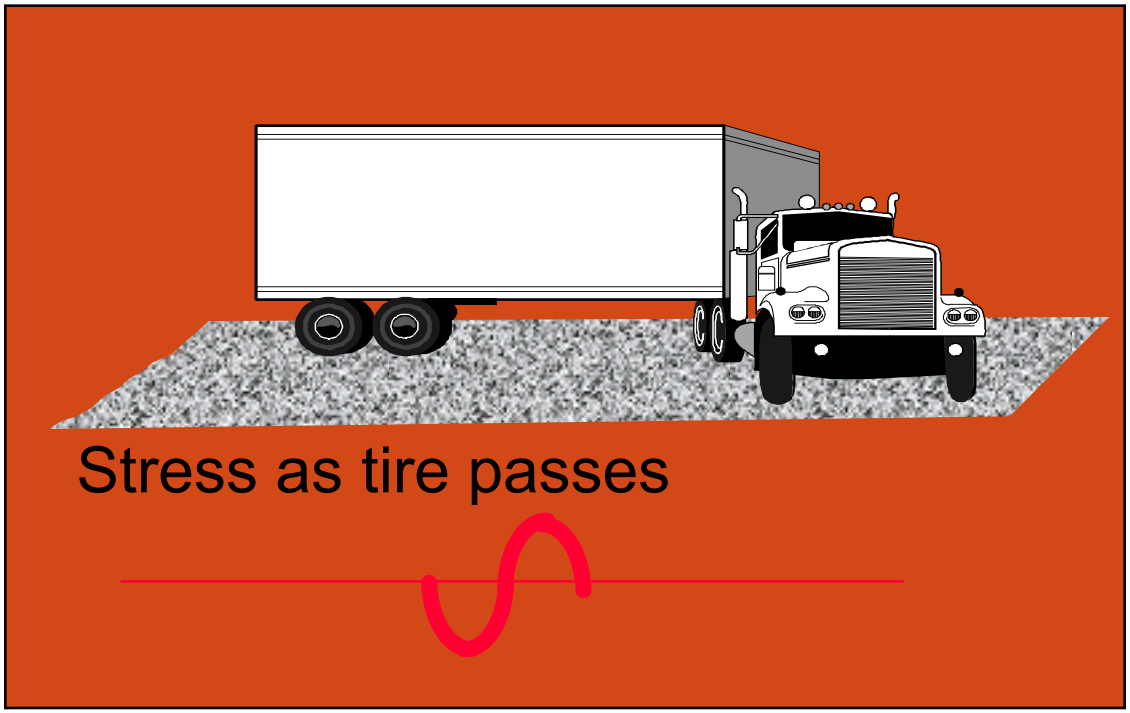
Loss of Adhesion
Moist Aggregates



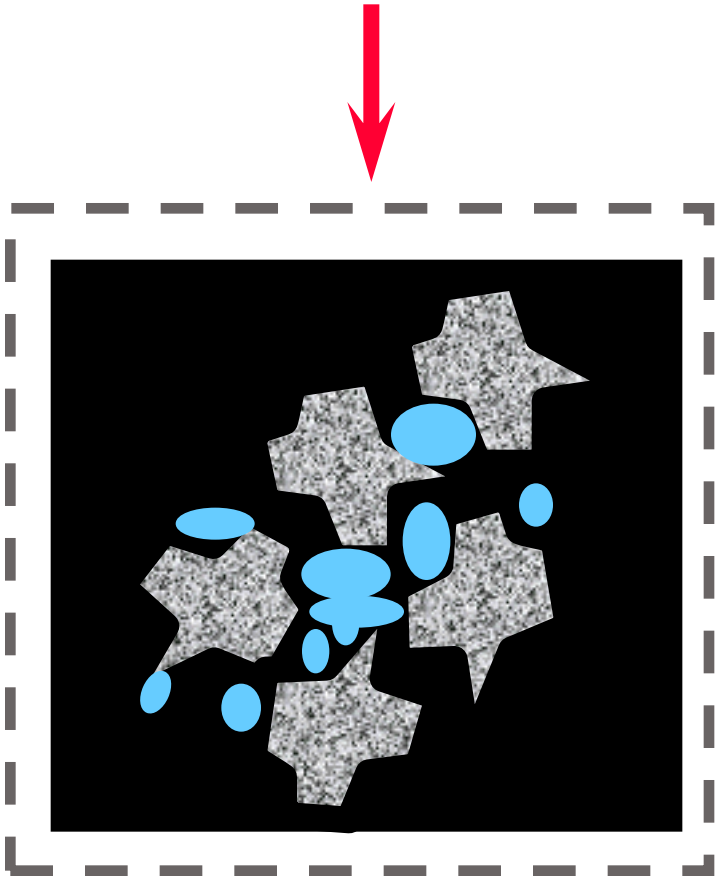
- Internal moisture disrupts asphalt binder film
- Most states have max. moisture content requirement on fresh HMA

Loss of Adhesion
Hydraulic Scour

- Traffic-induced movement of water "scrubs" asphalt binder off of aggregate



Loss of Adhesion
Pore Water Pressure



- Usually traffic-related
- Voids decrease and water is trapped
- Moisture gets “pressed” to aggregate surface through breaks in film