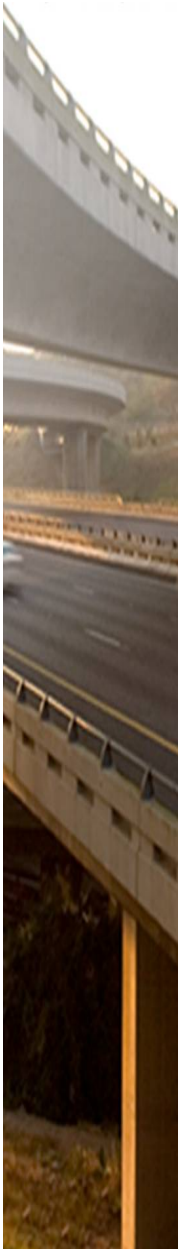


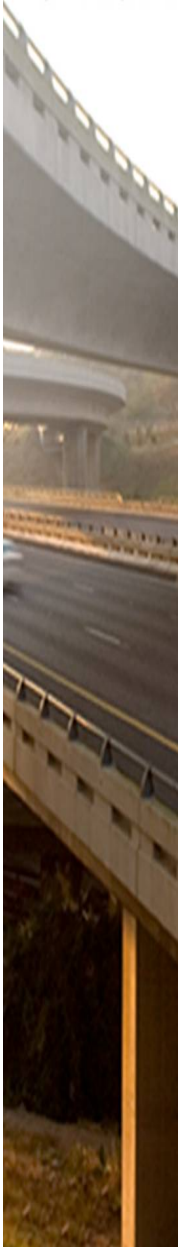
Development of Resilient Response and Damage Models for SAPDM

*18th Road Pavement Forum, CSIR International
Conference Centre, Pretoria, 10 – 11 September 2009*

Advanced testing & characterisation of asphalt materials

J Anochie-Boateng, CSIR Built Environment





Acknowledgements

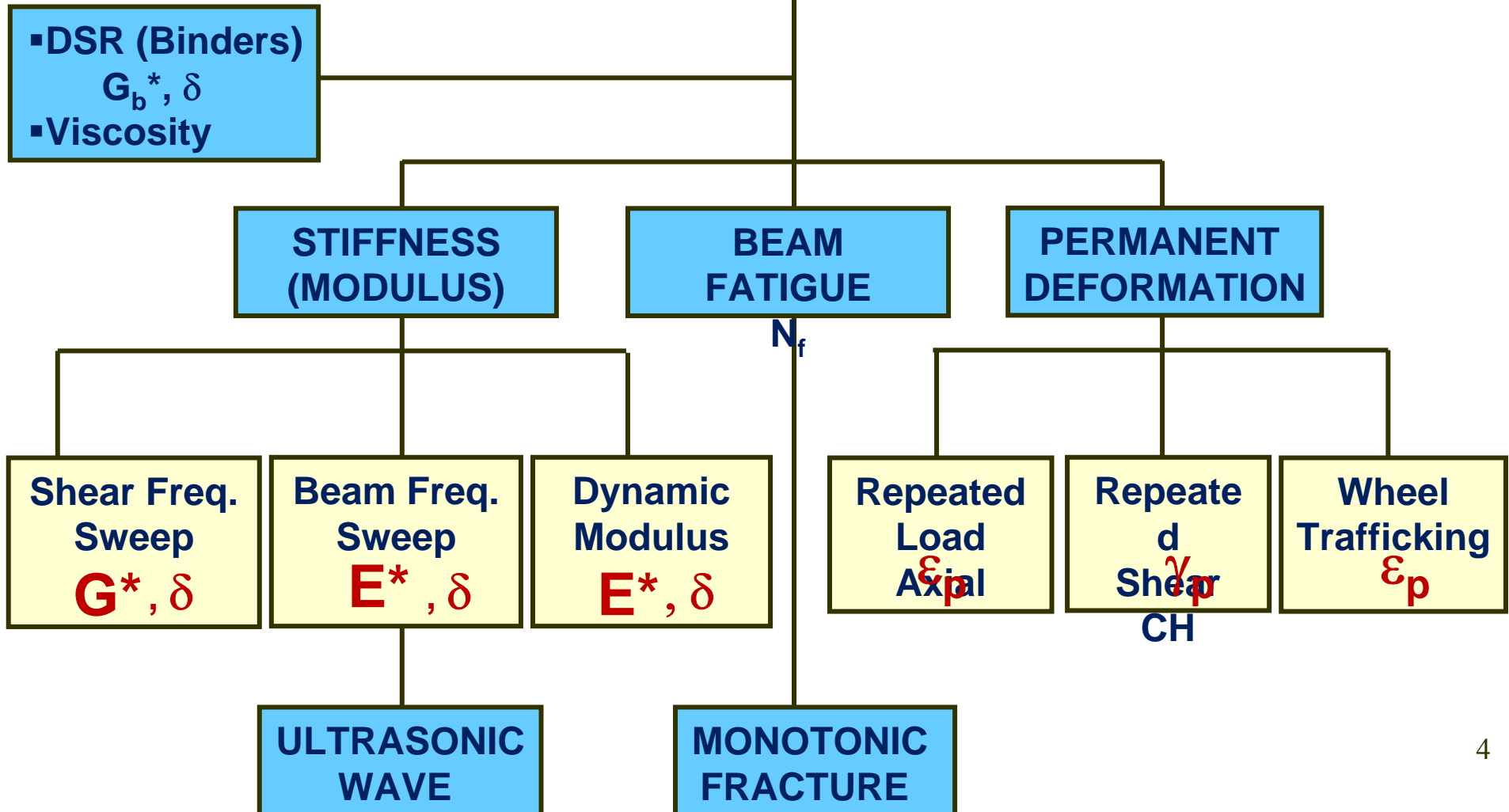
- **SANRAL**
- **SANRAL Material Cluster**
- **MUCH Asphalt**
- **Consultants/Resident Engineers**
- **CSIR HMA Group**

R&D Support for SA Pavement Design Method (SAPDM)

- Developing advanced test protocols for asphalt
- Establishing asphalt design parameters for typical South Africa mixes
 - Resilient response properties
 - Damage properties
- Modelling and calibration of resilient response and damage models for SA conditions and mixes

CSIR BE Pavement Materials Laboratory

Advanced Characterisation of Asphalt Materials



Dynamic Shear Rheometer Testing

- Test performed on original, RTFO and PAV processed binders
- Typical test temperatures for various devices range from 6 to 88C; angular frequency of 10 rad/sec (i.e., 1.59Hz)
 - CSIR BE conducts frequency sweeps at temperature range 20 – 70C and frequencies range of 0.001 – 80Hz
- Test provides fundamental properties: G_b^* & δ



Dynamic Shear Modulus & Perm Deform Testing

- Two tests conducted are:
FSCH, RSCH
- Sinusoidal shear strain of 0.01% is applied in FSCH
- Haversine shear stress is applied for 0.1s followed by 0.6s rest in RSCH
- Typical stress of 69 kPa & max surface pavement temperature are applied in both tests
- Test parameters: G^* , δ , γ_p

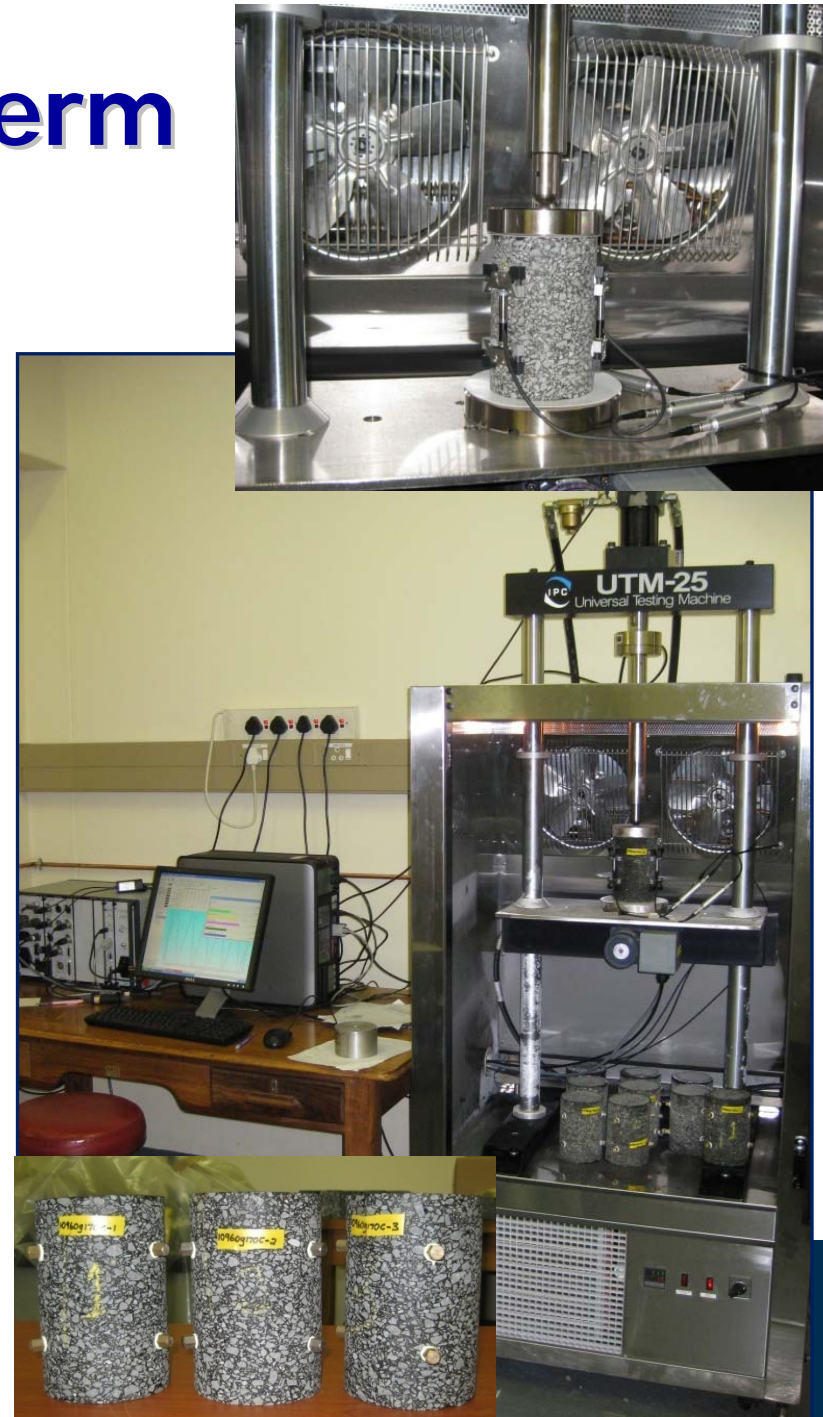


Dynamic Modulus & Perm Deformation Testing

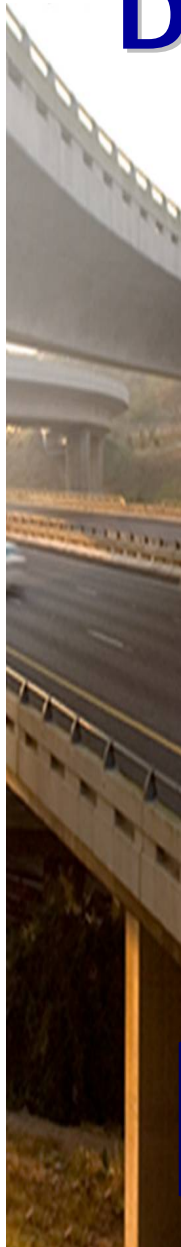
- Two tests conducted are: compression test for dynamic modulus and repeated load for permanent deformation
- Continuous haversine (sinusoidal) loading is applied for dynamic modulus
- Haversine loading of 0.1s followed by 0.9s rest is applied for plastic strain
- Test parameters: E^* , δ , ϵ_p

$D = 100 \text{ mm}; H = 150 \text{ mm}$

Gyratory samples of 150mm x 170 mm



Testing Conditions for Shear & Dynamic Modulus Tests – CSIR BE Protocol



Dynamic shear modulus

Freq Hz	Temp C
10	25
5	
2	
1	40
0.5	55
0.2	
0.1	

Permanent Shear Deformation

Stress (kPa)	69		
Temperature C	25	40	55

Dynamic modulus

Freq Hz	Temp C
25	-5
10	5
5	20
1	40
0.5	55
0.1	

Permanent Axial Deformation

Stress (kPa)	69	138	207
Temperature C	25	40	55

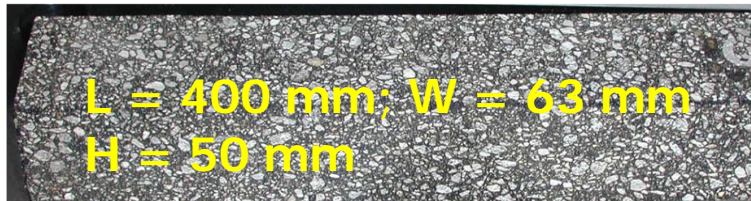
Beam Frequency Sweep & Fatigue Testing

- Used to estimate stiffness at critical strain anticipated in the pavement
- Tests the mix ability to withstand repeated bending which causes fatigue failure
- Failure $N_f = 50\%$ loss of stiffness (controlled strain)
- CSIR BE investigating N_f @ 30% loss of stiffness

Strain levels : 200, 400, 600, 800 $\mu\text{m}/\text{m}$

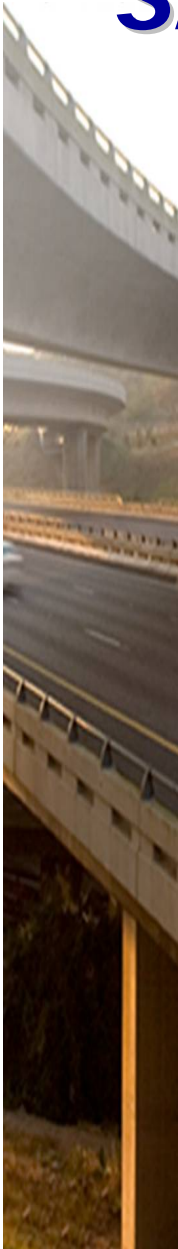
Temperature : 0, 5, 10, 20, 40, 55C

Frequency: 25, 10, 5, 1, 0.5, 0.1Hz



SANRAL Testing for SAPDM

- **Bituminous binder properties**
 - Viscosity
 - Complex shear modulus
- **Five South African mixes**
 - Resilient response properties
 - Damage properties



SANRAL SAPDM Asphalt Mixes

- **BTB with 40/50 PEN**
- **Coarse continuous with AE2**
- **Medium continuous with AE2**
- **Bitumen rubber mix**
- **Medium continuous with 60/70 PEN**
- **HiMA**

SANRAL Binder Testing Program

TEST	40/50 PEN BITUMEN		
	ORIGINAL	AFTER RTFO	AFTER PAV
DSR frequency sweeps	✓	✓	✓
PG spec (DSR)	✓	✓	✓
Brookfield Viscosity	✓	✓	✓
Other tests (PEN, SP)	✓	✓	✓

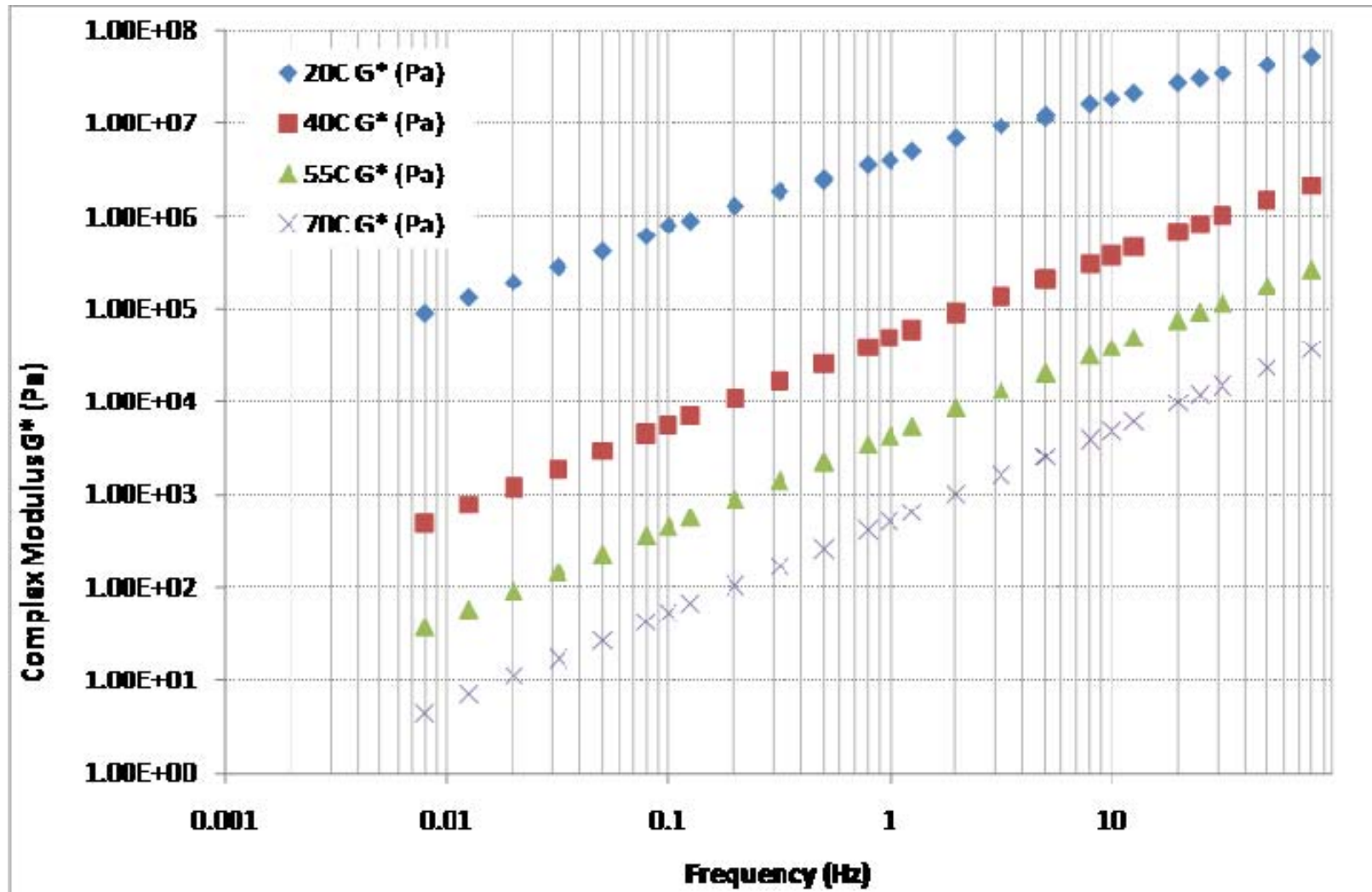
SANRAL Asphalt Testing Program



SAPDM Tests	Short -Term Ageing		Long-Term Ageing
	Design Voids	Field Voids	Design Voids
Dynamic Modulus	✓	✓	✓
Shear Permanent Deform	✓	✓	
Beam Fatigue	✓	✓	✓
Beam Frequency Sweep	✓	✓	✓

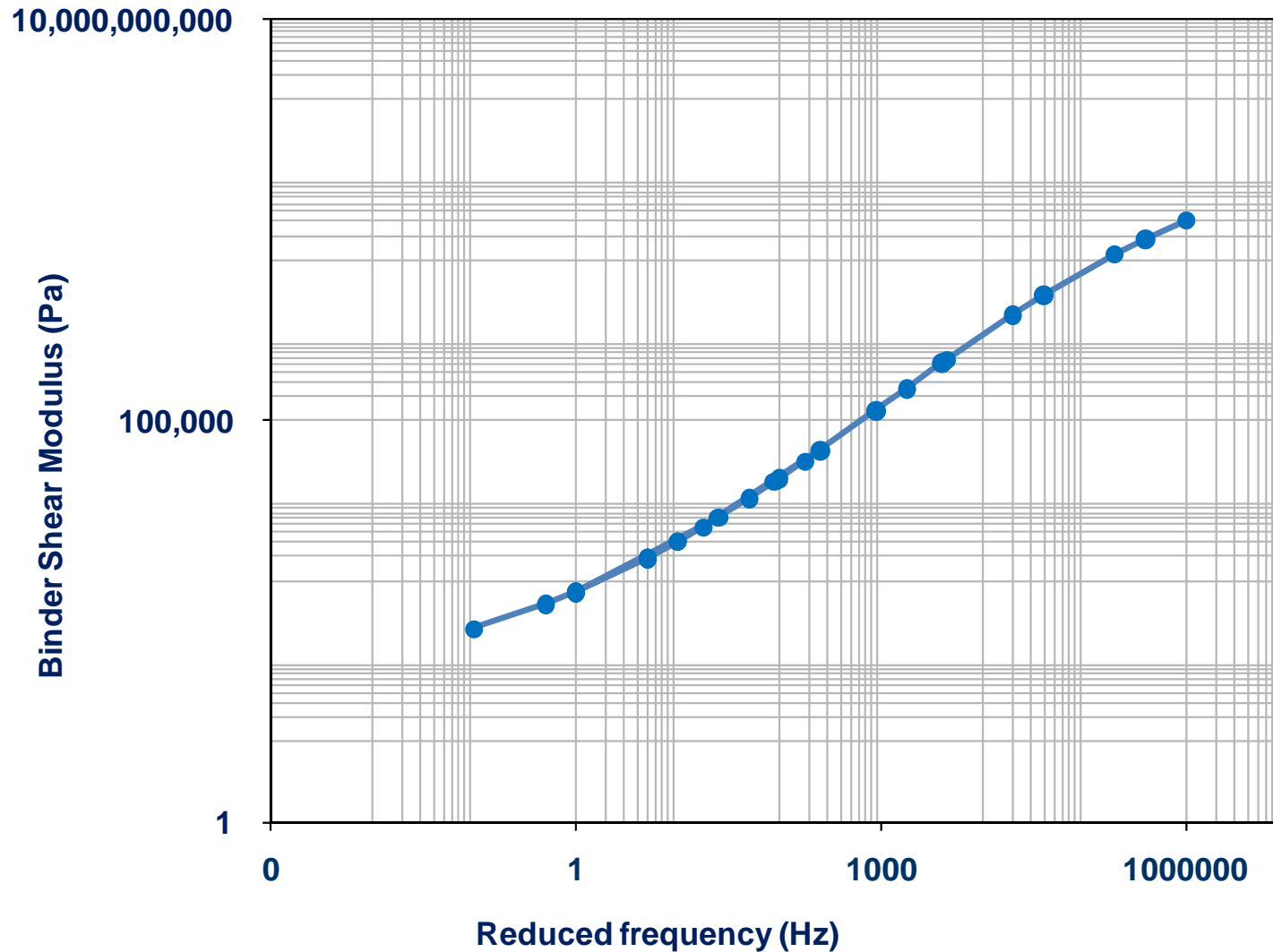
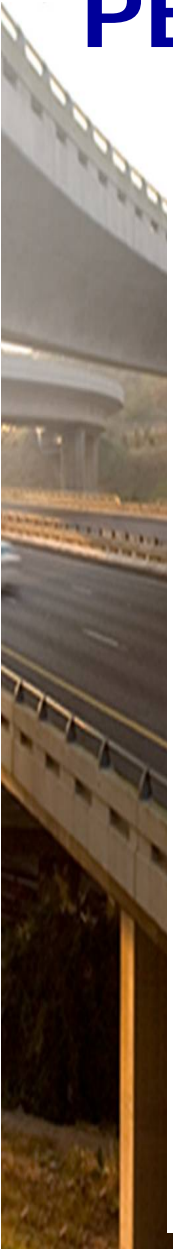
CSIR Parallel Tests		
Shear Dynamic Modulus	✓	✓
Ultrasonic Wave Modulus	✓	✓
Repeated load Perm Def	✓	✓
Monotonic Fracture	✓	✓

DSR Results for Original 40/50 PEN Bitumen

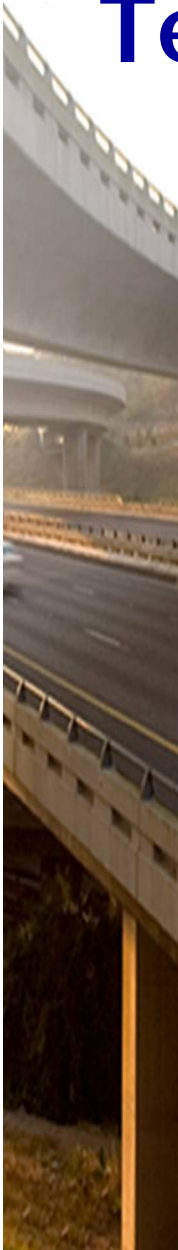
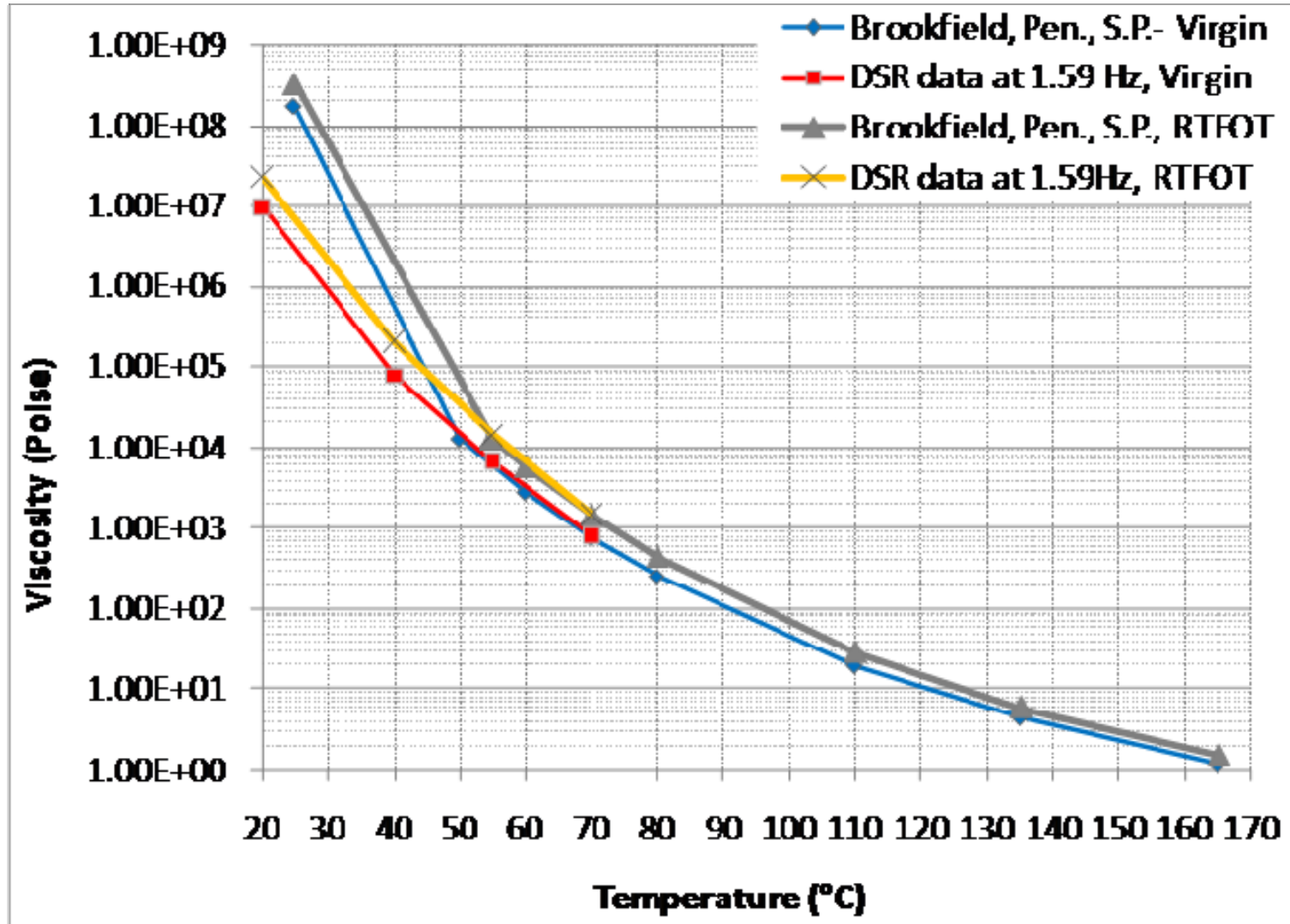




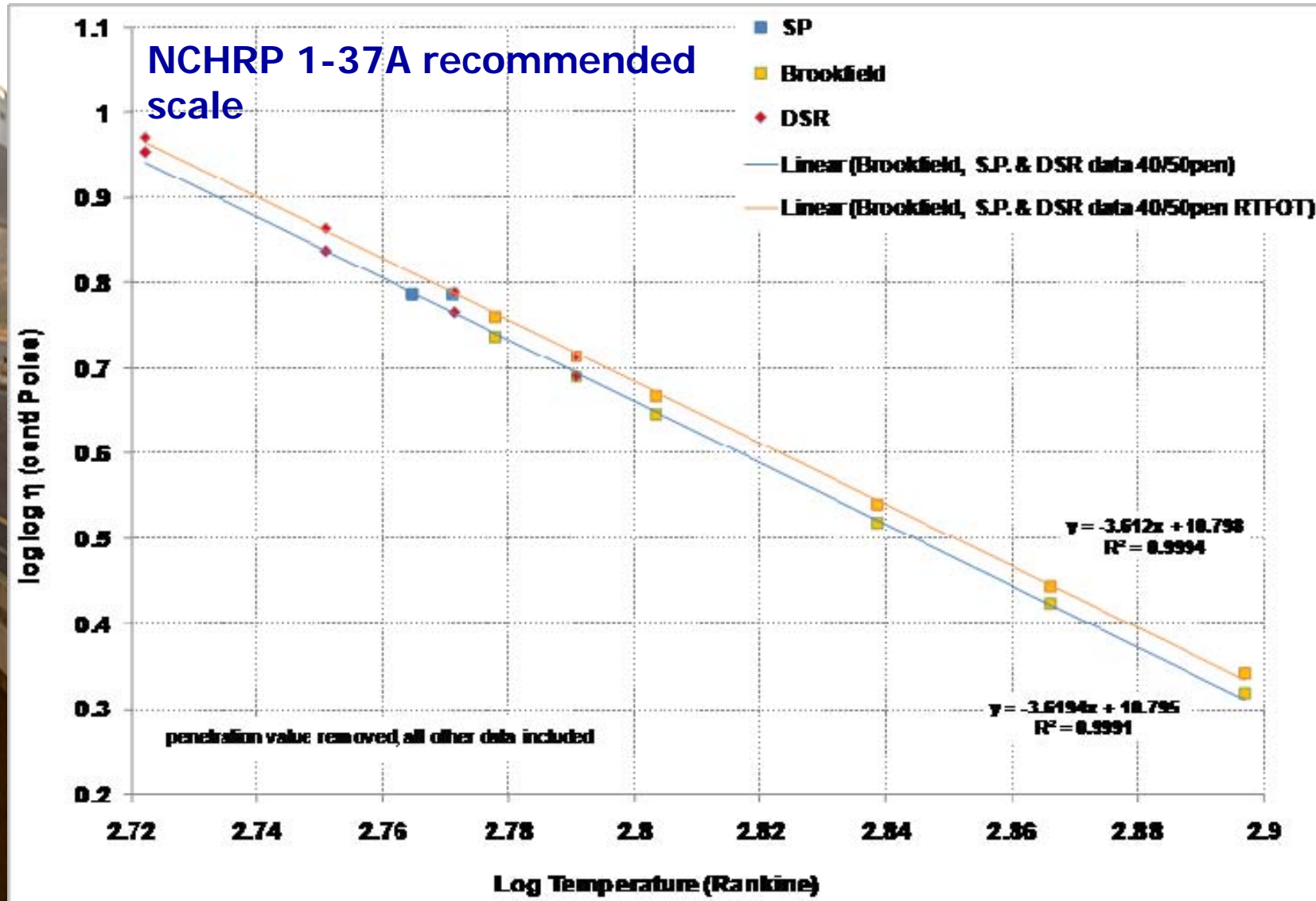
Master Curve for Original 40/50 PEN Bitumen



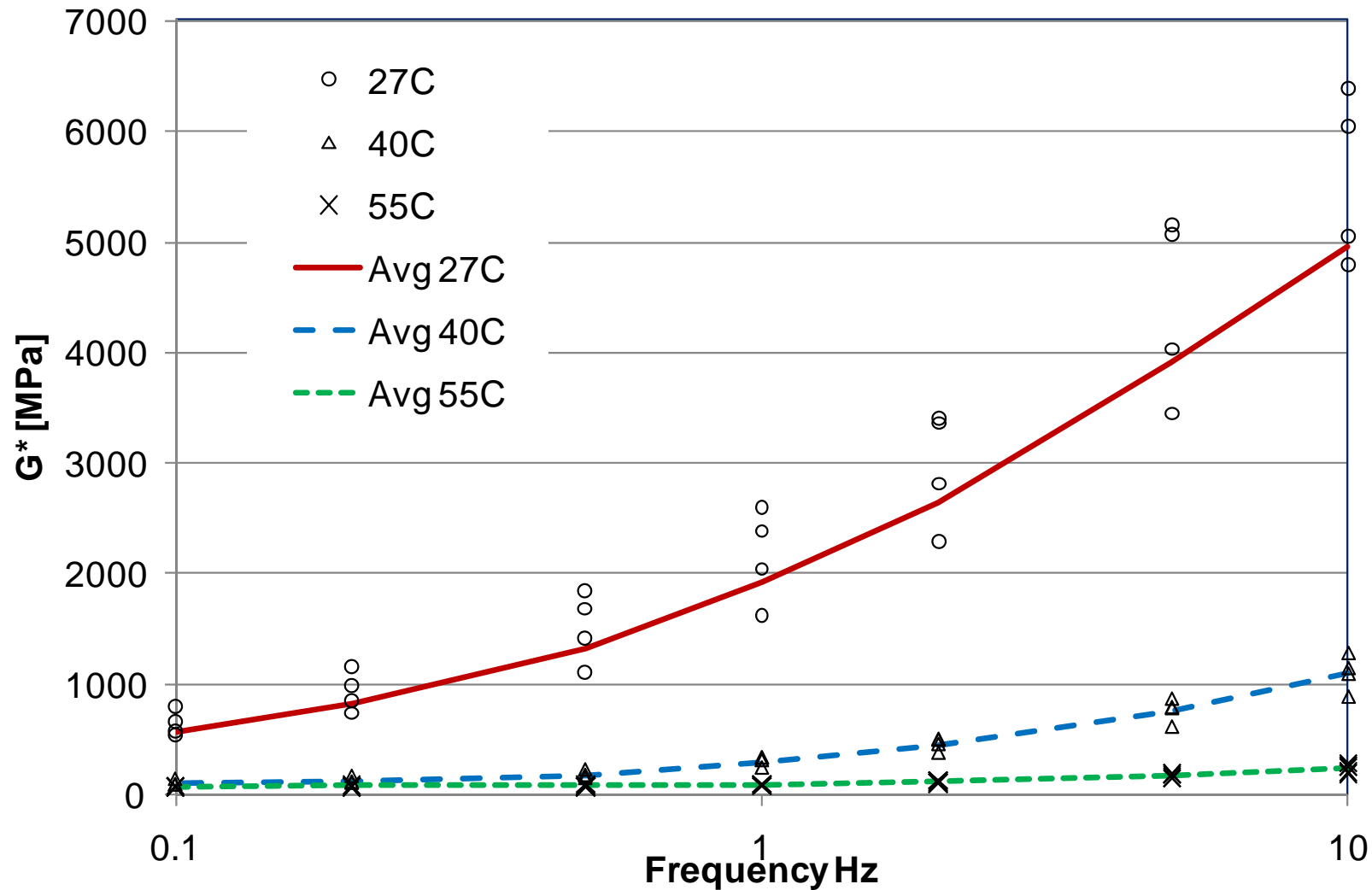
Viscosity Comparisons of Empirical Tests & DSR at 1.59 Hz



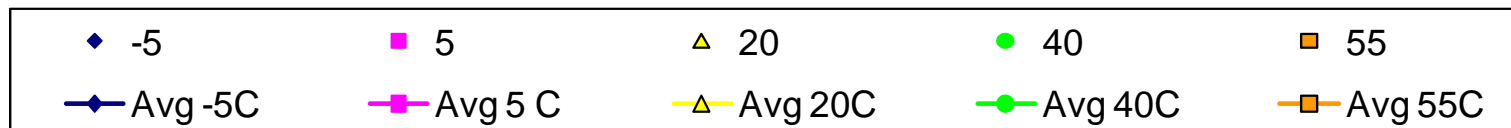
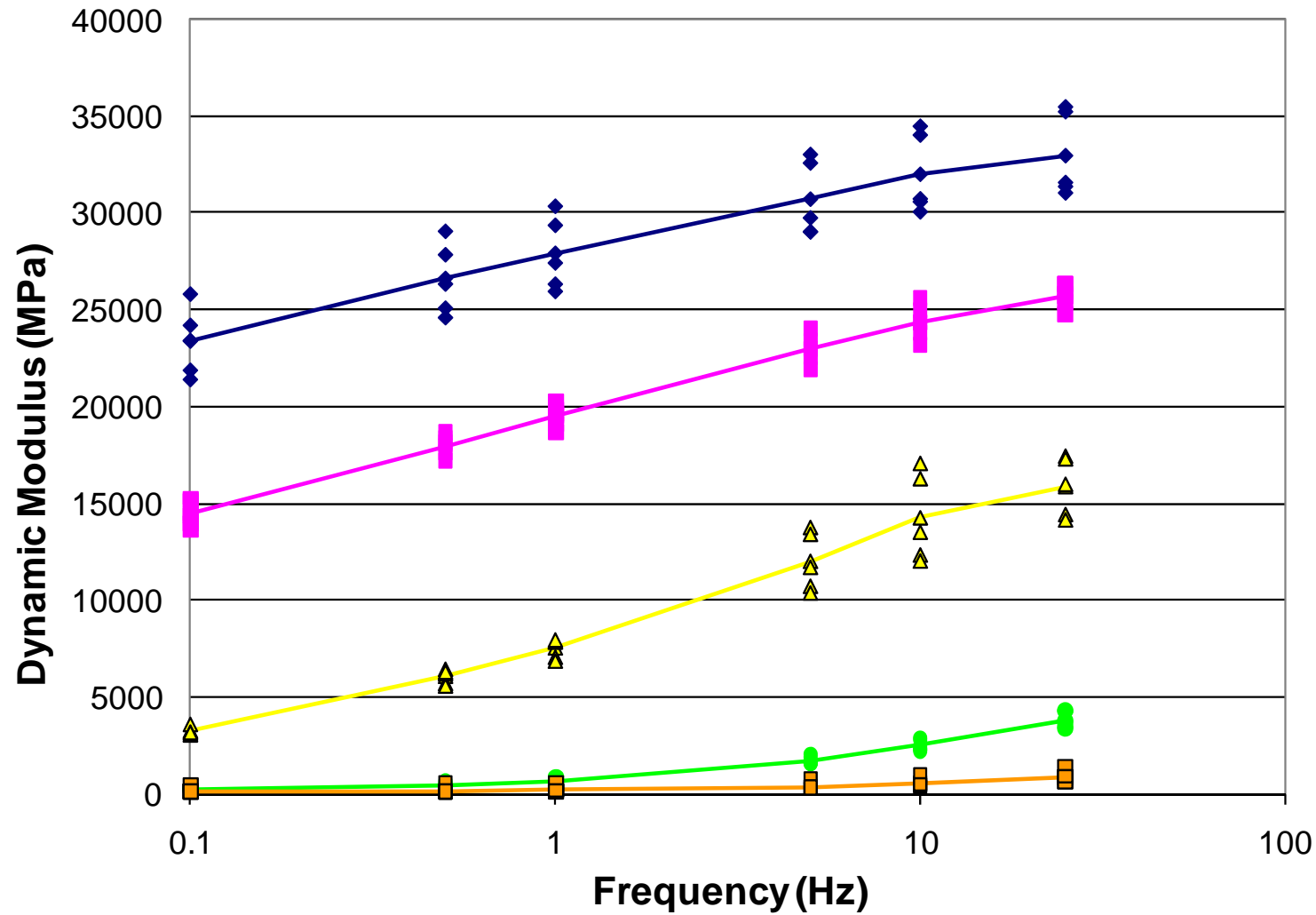
Viscosity-Temp Profile of Original & RTFOT 40/50 PEN Bitumen



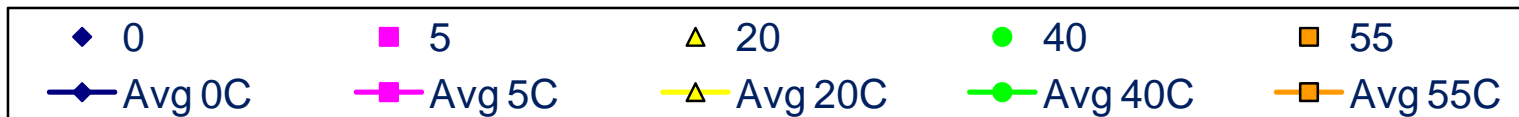
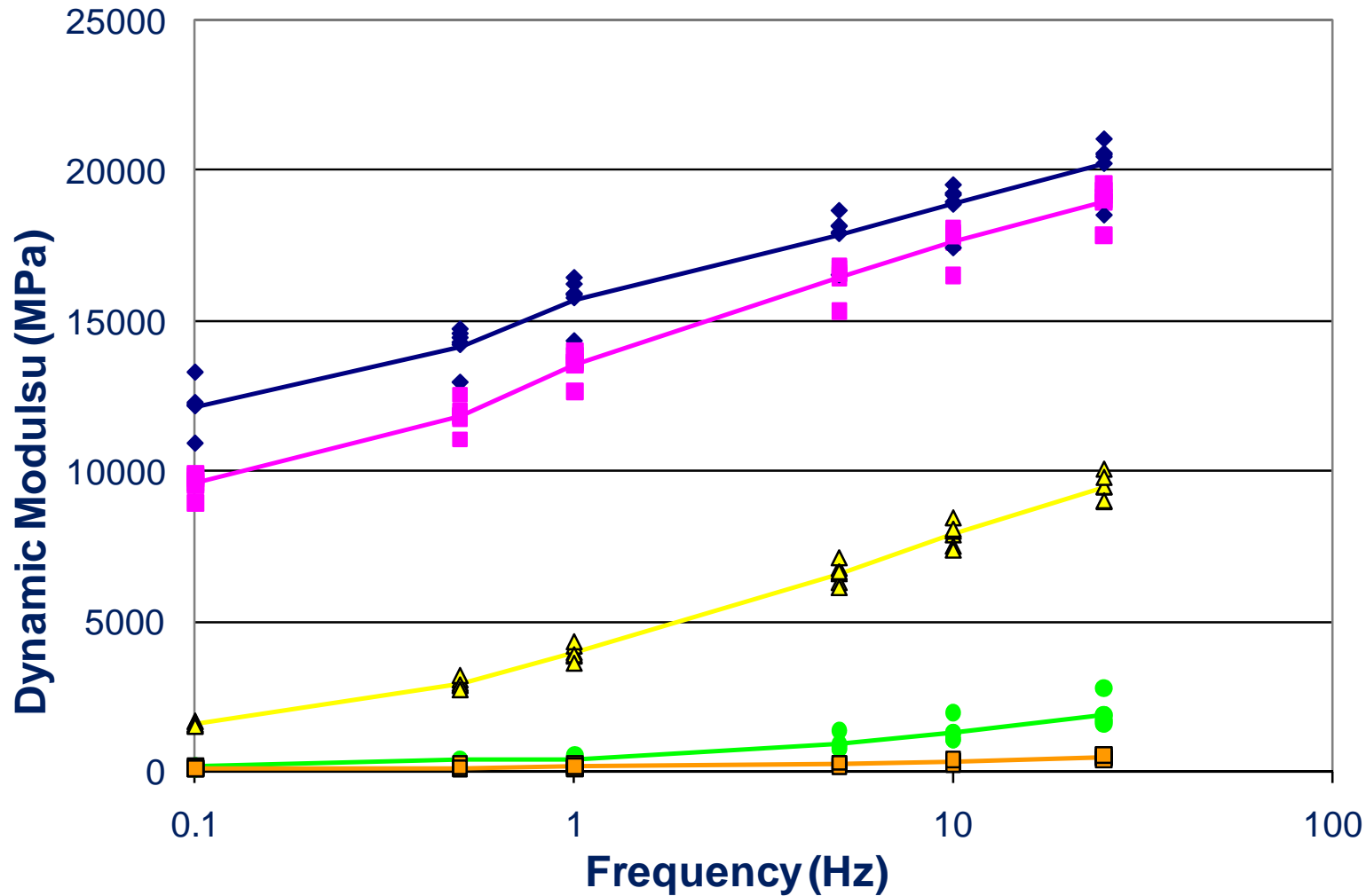
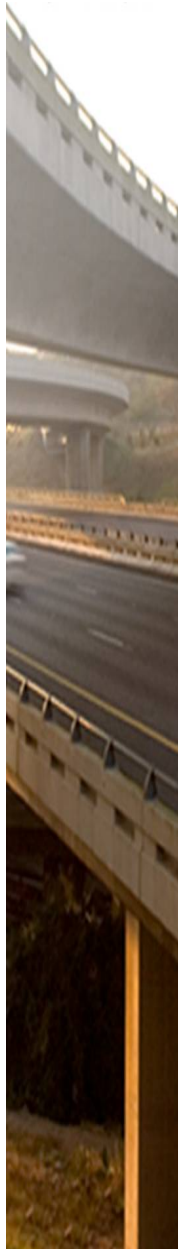
Results for Dynamic Shear Modulus Test



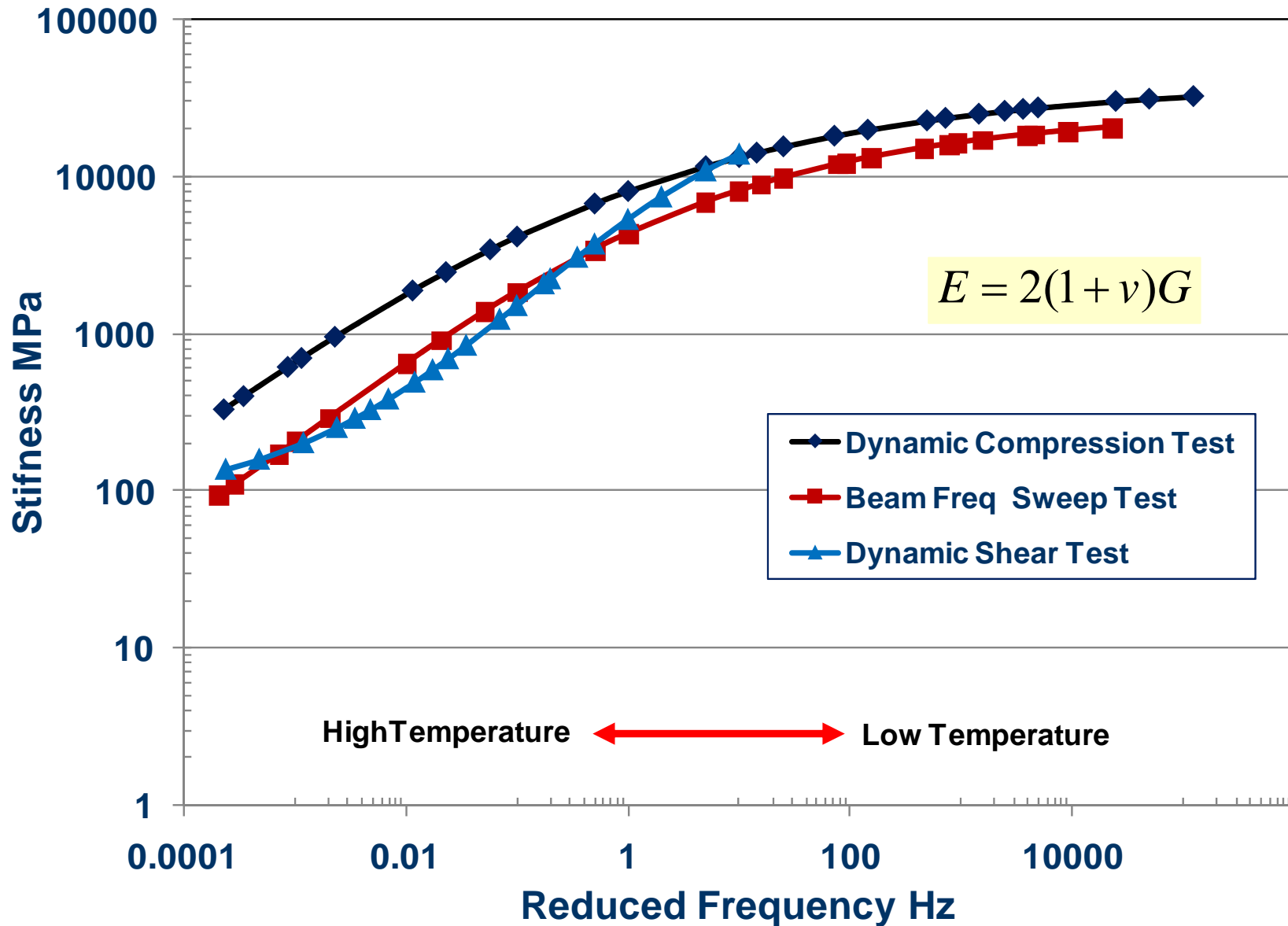
Results for Dynamic Modulus Test



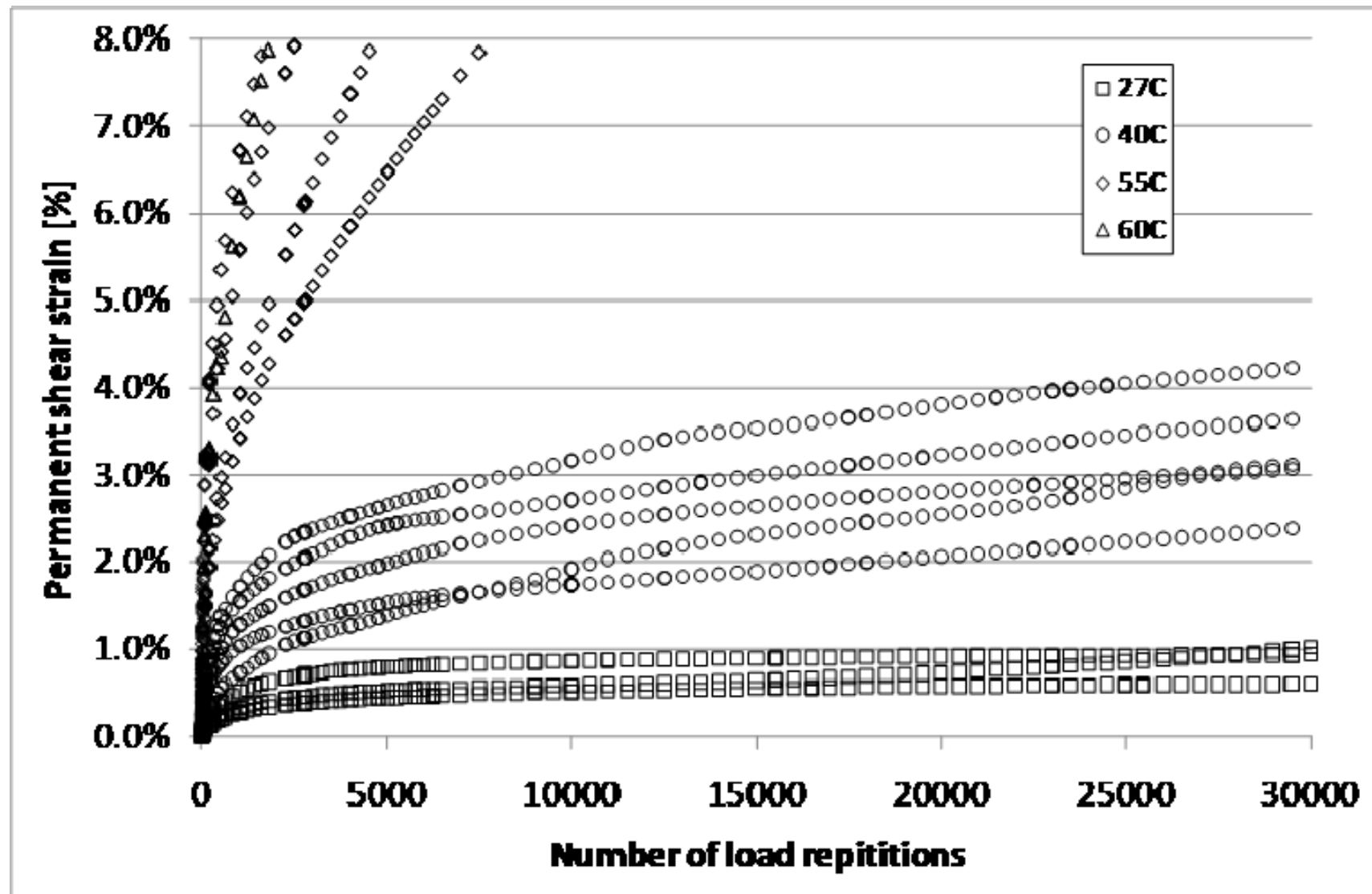
Results for Beam Freq Sweep Test



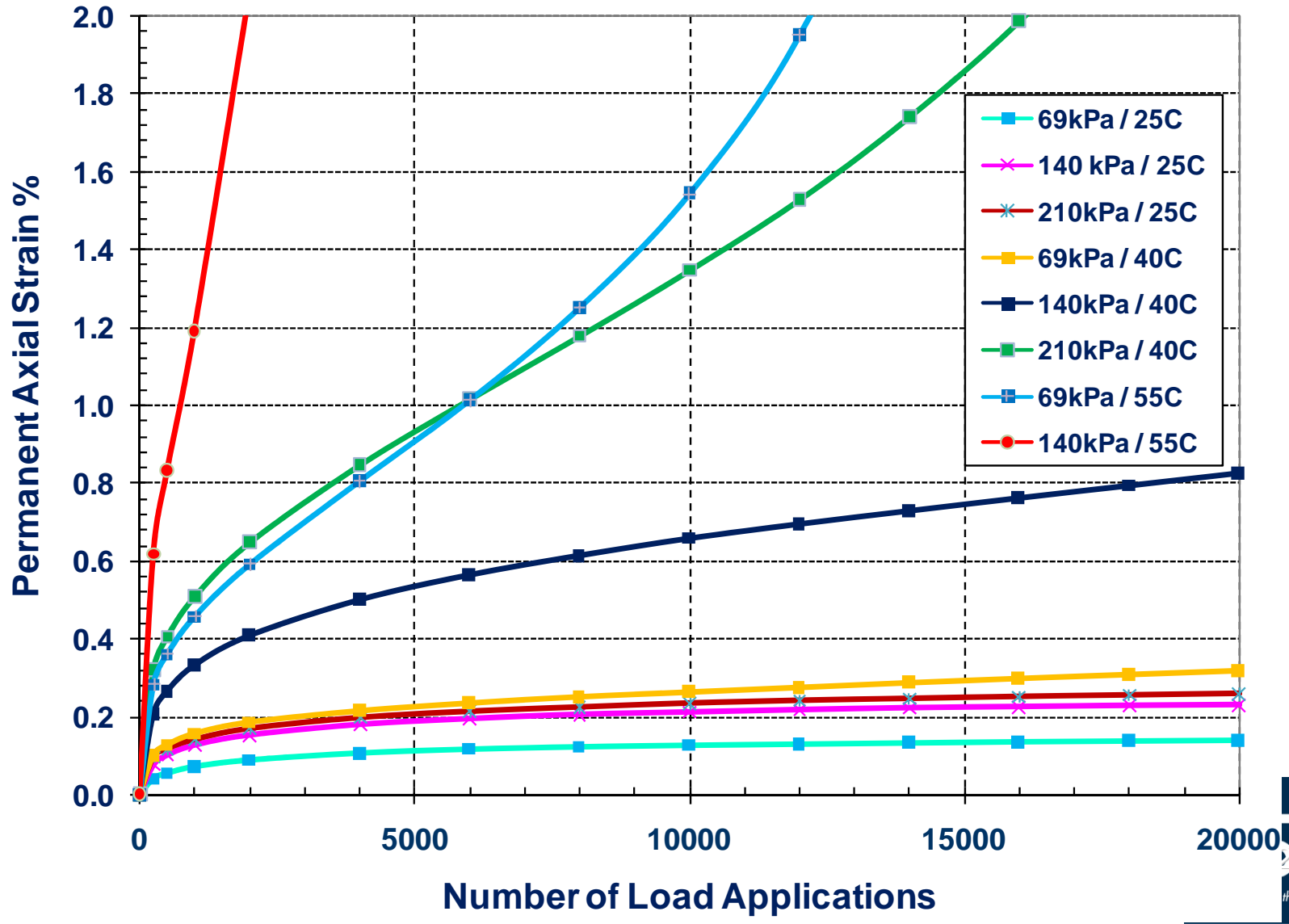
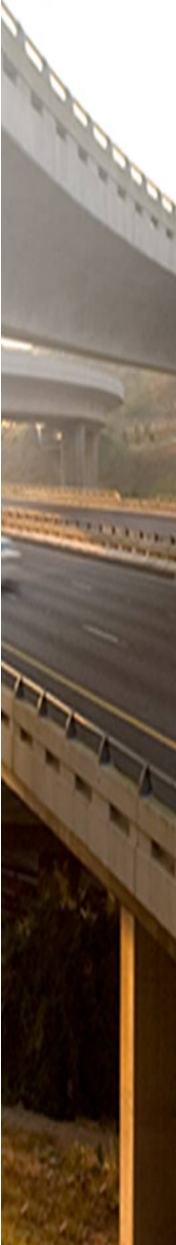
Master Curves for All the Stiffness Tests



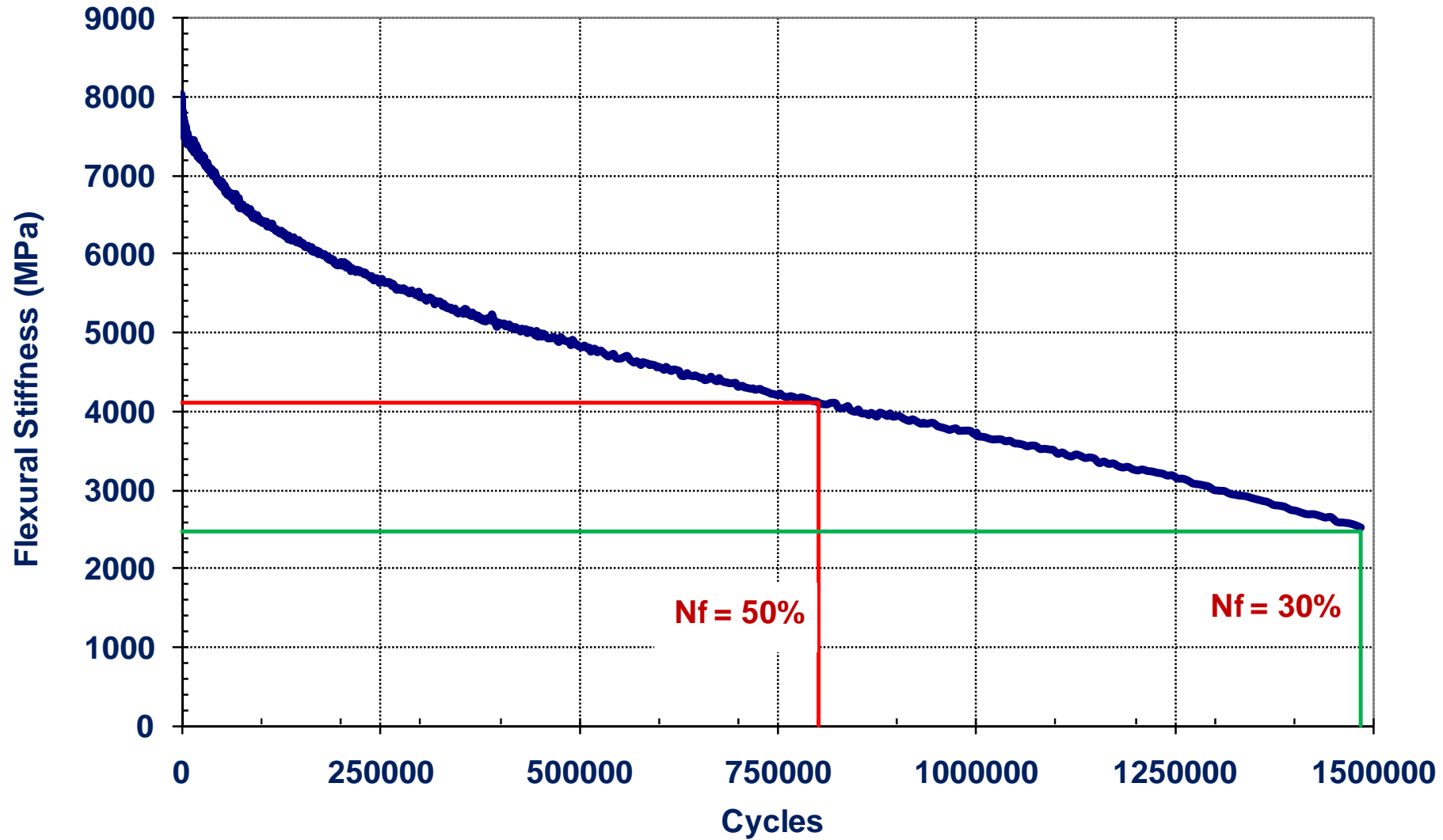
Repeated Shear Deformation Results



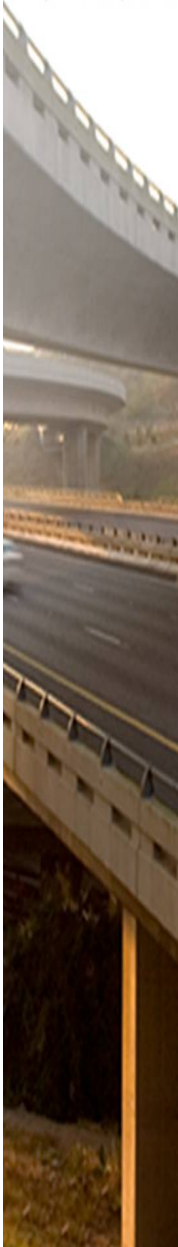
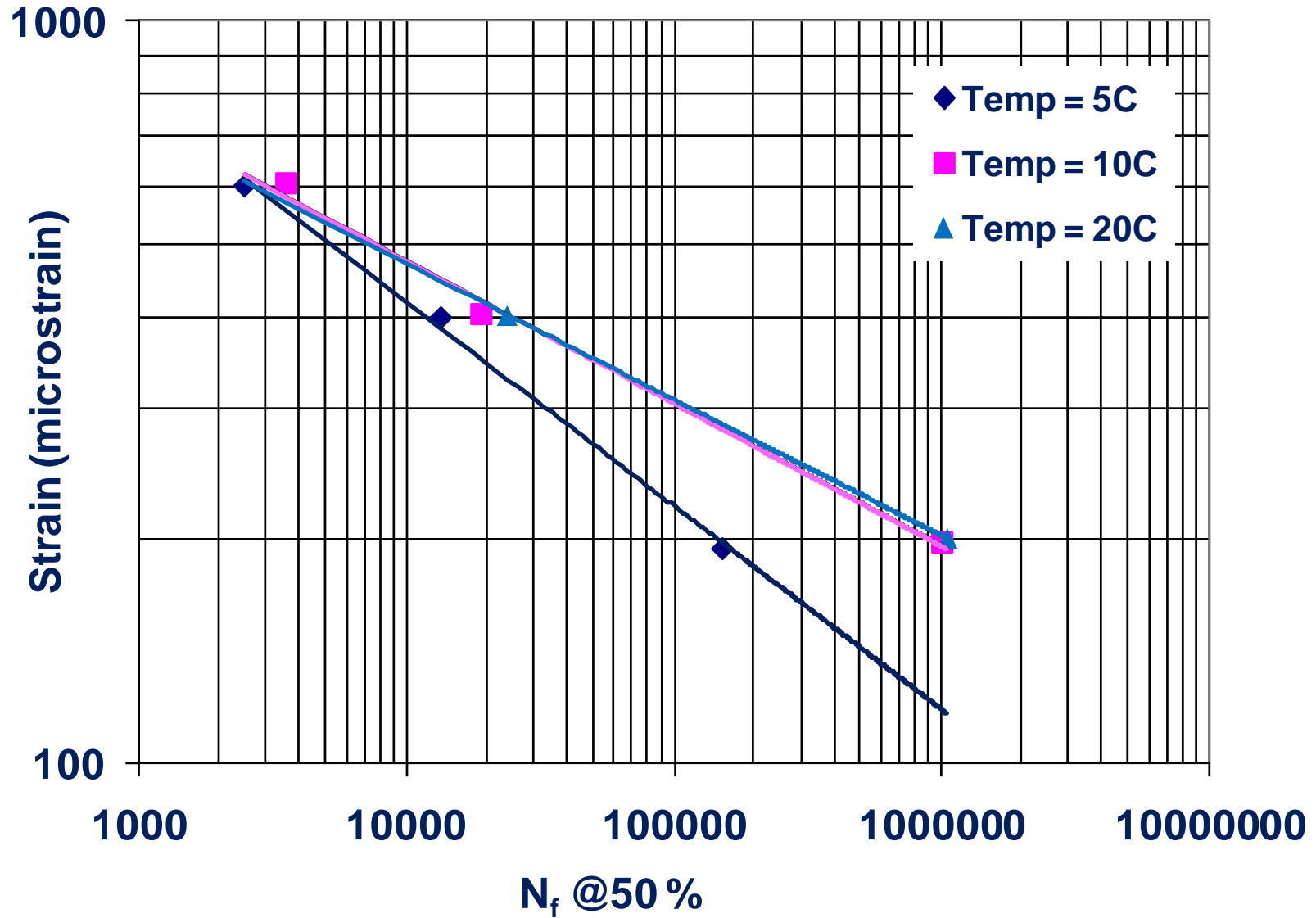
Repeated Axial Deformation Results



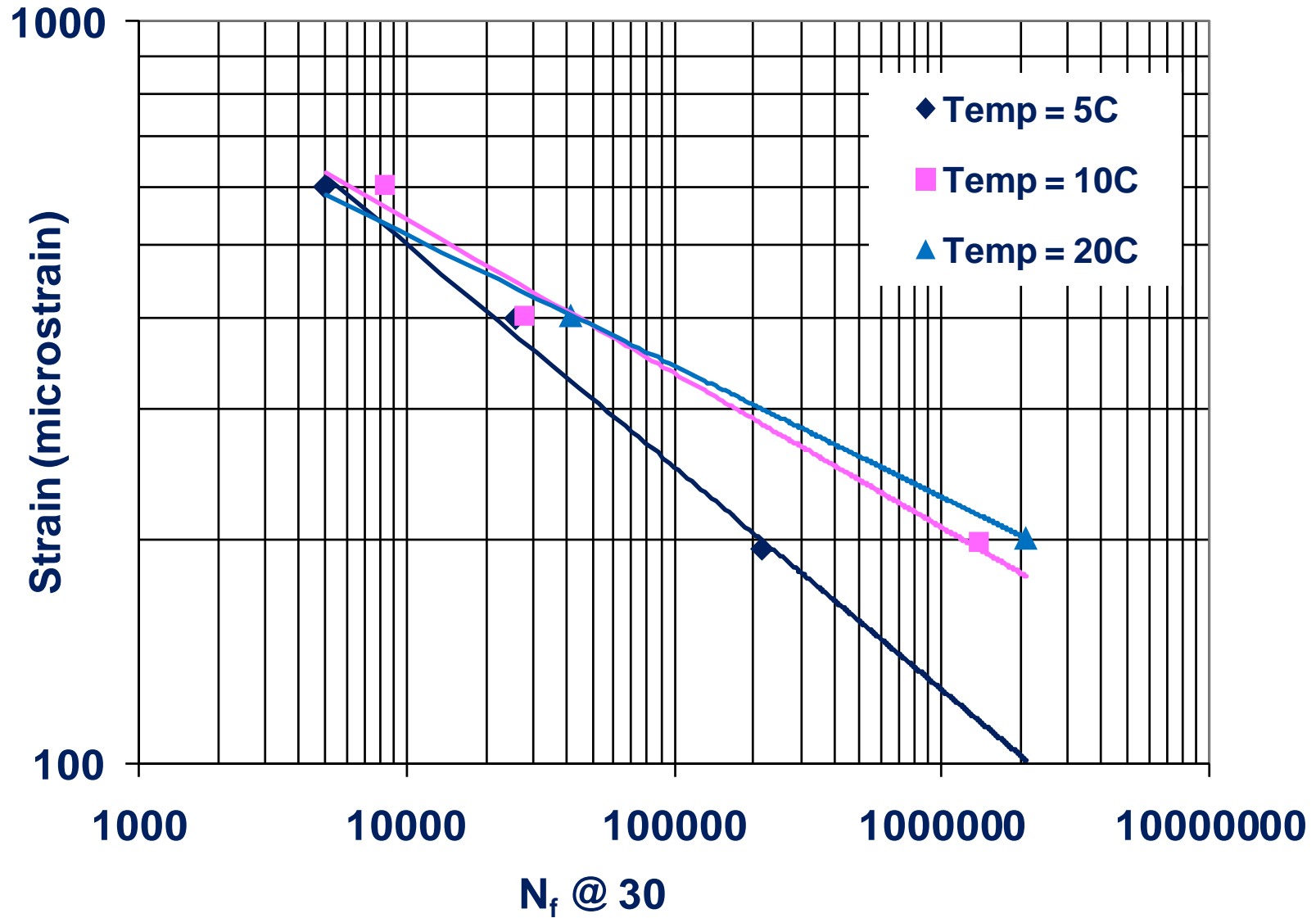
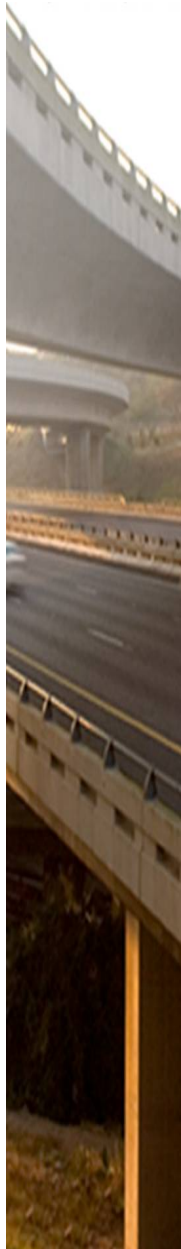
Fatigue Results at 20C & 200 $\mu\text{m/m}$



Beam Fatigue Results (1)

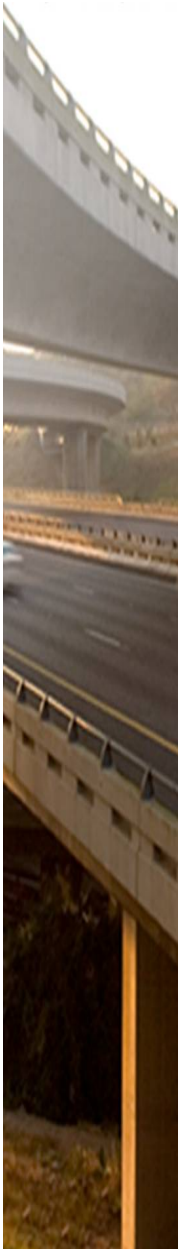


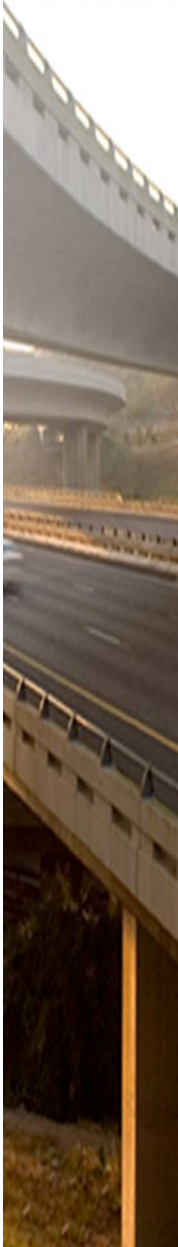
Beam Fatigue Results (2)



Results for what?

- **Resilient response models for SAPDM**
 - Elastic modulus models
- **Damage models for SAPDM**
 - Permanent deformation models
 - Beam fatigue models





END of Presentation

Discussion/Questions?