Simple Performance Test

Northeast Asphalt User/Producer Group
Ramon Bonaquist, P.E.
Advanced Asphalt Technologies, LLC

What is it?

- Test conducted on the mixture that indicates how it will perform
- Identify inferior mixes
  - Rutting
  - Cracking
- Design
- QC/QA Operations

Lots of Possibilities

- Gyratory Compactor
  - NCHRP 9-7 Field Procedures and Equipment to Implement SHRP Asphalt Specifications
  - NCHRP 9-16 Relationship Between Superpave Gyratory Compaction Properties and Permanent Deformation of Pavements In-Service

Lots of Possibilities

- Loaded Wheel Testers
  - Transportation Research Circular E-C016
  - NCHRP 9-17 Accelerated Laboratory Rutting Tests: Asphalt Pavement Analyzer
- SHRP Shear Test
  - NCHRP 9-7 Field Procedures and Equipment to Implement SHRP Asphalt Specifications
  - NCHRP 9-18 Field Shear Test of Hot Mix Asphalt

Lots of Possibilities

- Fundamental Tests
  - NCHRP 9-19 Superpave Support and Performance Models Management
    - Stiffness
    - Permanent Deformation
    - Creep
    - Strength
  - PennDOT Evaluation of Triaxial Strength
    - Indirect Tensile Strength

General Conclusion

- Many show promising correlation with pavement performance
- How do you select the best?
  - Fundamental versus Empirical
  - Mixture Design versus Quality Control
  - Specimen Preparation
    - Size
    - Lab compacted versus field sample
  - Equipment and Training Costs

Specific Projects

- NCHRP 9-19 Task C
  - Simple Performance Test Recommendations
    - Dynamic Modulus
    - Repeated Load Permanent Deformation
    - Creep
- NCHRP 9-18 Field Shear Test
  - QC Application
- PennDOT Triaxial Study
  - Indirect Tensile Strength

NCHRP 9-19 Task C

- University of Maryland and Arizona State University
  - Matt Witczak PI
  - Subcontractors
    - Fugro BRE
    - AAT
    - Heritage Research
- Fundamental Test

Candidate Simple Performance Tests

- (**12**) Stiffness and Deformation/Strength Related Tests
- Rutting Stiffness
  - Dynamic (Complex) Modulus - ASU
  - Dynamic (Wave Propogation) Modulus - ASU
  - Predicted Stiffness from Material Properties - ASU
  - SST-G* Complex Modulus - AAT
  - G*-Field Shear Tester - UMD
- Rutting Deformability
  - Triaxial Shear Strength - ASU
  - Repeated Load Permanent Deformation (Triaxial) - ASU
  - Repeated Shear Permanent Deformation - Hertiage
  - Static Creep / Flow Time - ASU
- Cracking
  - Indirect Tensile (Strength, Creep, Fatigue) - ASU
  - Dynamic (Complex) Modulus - ASU
- Over 80 Test Response Parameters

Experimental Sites

MnRoad

WesTrack

FHWA-ALF

FHWA-ALF

ALF Lane	Binder Type	Nominal Size, mm	Asphalt Content, %	Air Void Content, %	Rut Depth, (10,000 Passes) mm
5	AC-10	19.0	4.80	8.6	39.3
7	Styrelf	19.0	4.90	11.9	12.0
8	Novophalt	19.0	4.70	11.9	4.4
9	AC-5	19.0	4.90	7.7	48.1
10	AC-20	19.0	4.90	9.3	36.3
11	AC-5	37.5	4.05	6.0	22.3
12	AC-20	37.5	4.05	7.4	15.2

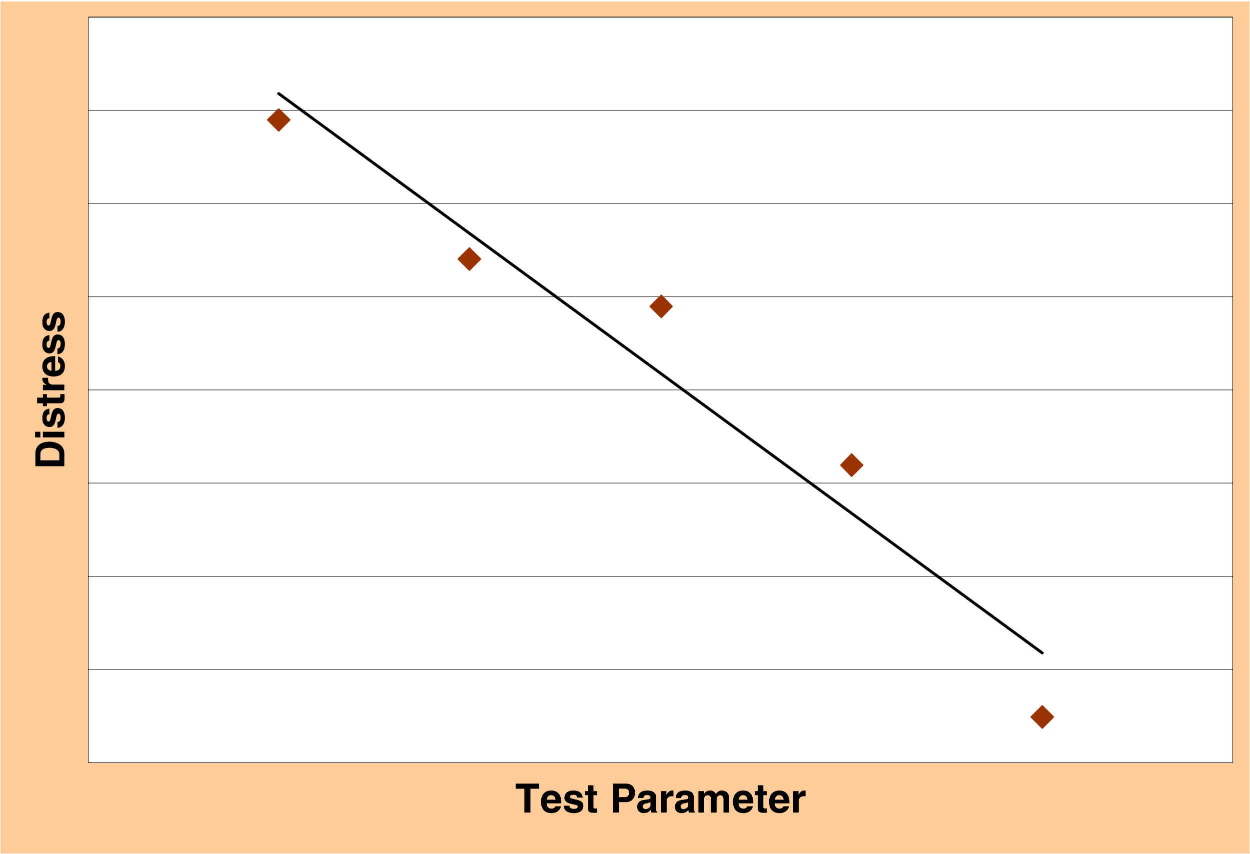
MnRoad

MNROAD CELL	BINDER TYPE	NOMINAL SIZE, MM	ASPHALT CONTENT, %	AIR VOID CONTENT, %	RUT DEPTH, (NOV 98)
16	AC-20	12.5	5.08	8.2	0.175
17	AC-20	12.5	5.45	7.7	0.205
18	AC-20	12.5	5.83	5.6	0.195
20	120/150Pen	12.5	6.06	6.3	0.67
22	120/150Pen	12.5	5.35	6.5	0.28

WesTrack

WesTrack Section	Binder Type	Nominal Size, mm	Asphalt Content, %	Air Void Content, %	Rut Depth, (1.5M ESAL) mm
2	PG 64-22	12.5 Fine	5.02	10.4	6
4	PG 64-22	12.5 Fine	5.24	6.6	7
15	PG 64-22	12.5 Fine	5.55	8.7	8
7	PG 64-22	12.5 Coarse	6.28	6.9	36
23	PG 64-22	12.5 Coarse	5.78	4.9	13
24	PG 64-22	12.5 Coarse	5.91	7.2	22

Compare Actual Performance to Measured Laboratory Response



Subjective Classification

Color	CRITERIA	R^2	Se/Sy
	Excellent	> 0.90	< 0.350
	Good	0.70 - 0.89	0.36 - 0.55
	Fair	0.40 - 0.69	0.56 - 0.75
	Poor	0.20 - 0.39	0.76 - 0.90
	Very Poor	< 0.19	> 0.90

Findings - Rutting

Test	Mode	R^2	Se/Sy	Rating	Selected
Modulus	Traixial	0.91	0.31	Excellent	x
	Shear	0.79	0.52	Good	
Repeated Load	Triaxial	0.90	0.36	Good	x
	Shear	0.88	0.39	Good	
Creep	Triaxial	0.91	0.32	Excellent	x

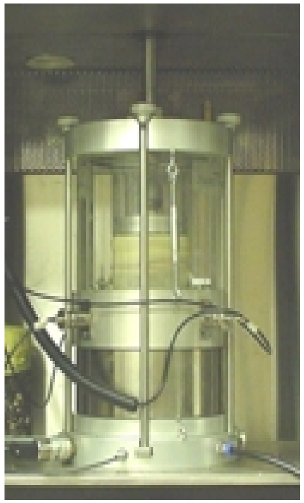
Clear Advantages

- Triaxial Modulus
  - Clear tie to 2002 Design Guide
    - Rational Limiting Stiffnesses
  - Indicator of Fatigue Cracking
    - Optimization
- Triaxial Creep
  - Simplicity of Testing Equipment
- Triaxial Repeated Load
  - Best represents actual loading

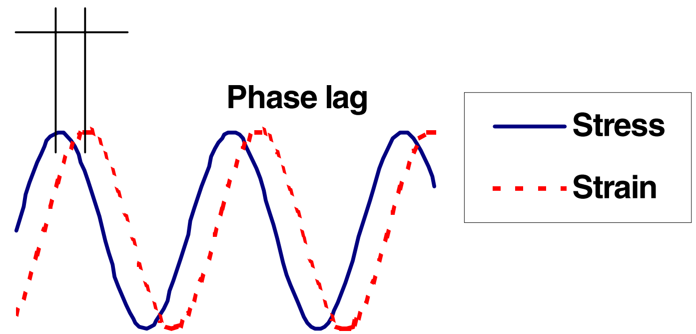
Disadvantage

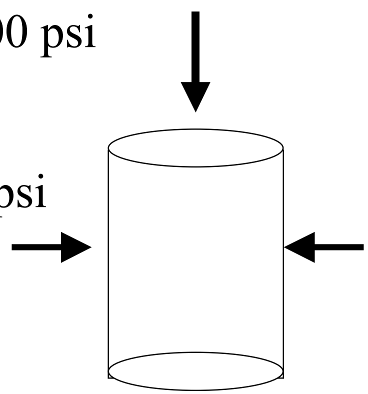
- Specimen Size
  - 100 mm Diameter by 150 mm High
  - Parallel Ends
- Needed to Ensure Fundamental Properties
- Sawed and Cored From Oversized Gyratory Specimens

E* -- Triaxial Complex Modulus Testing

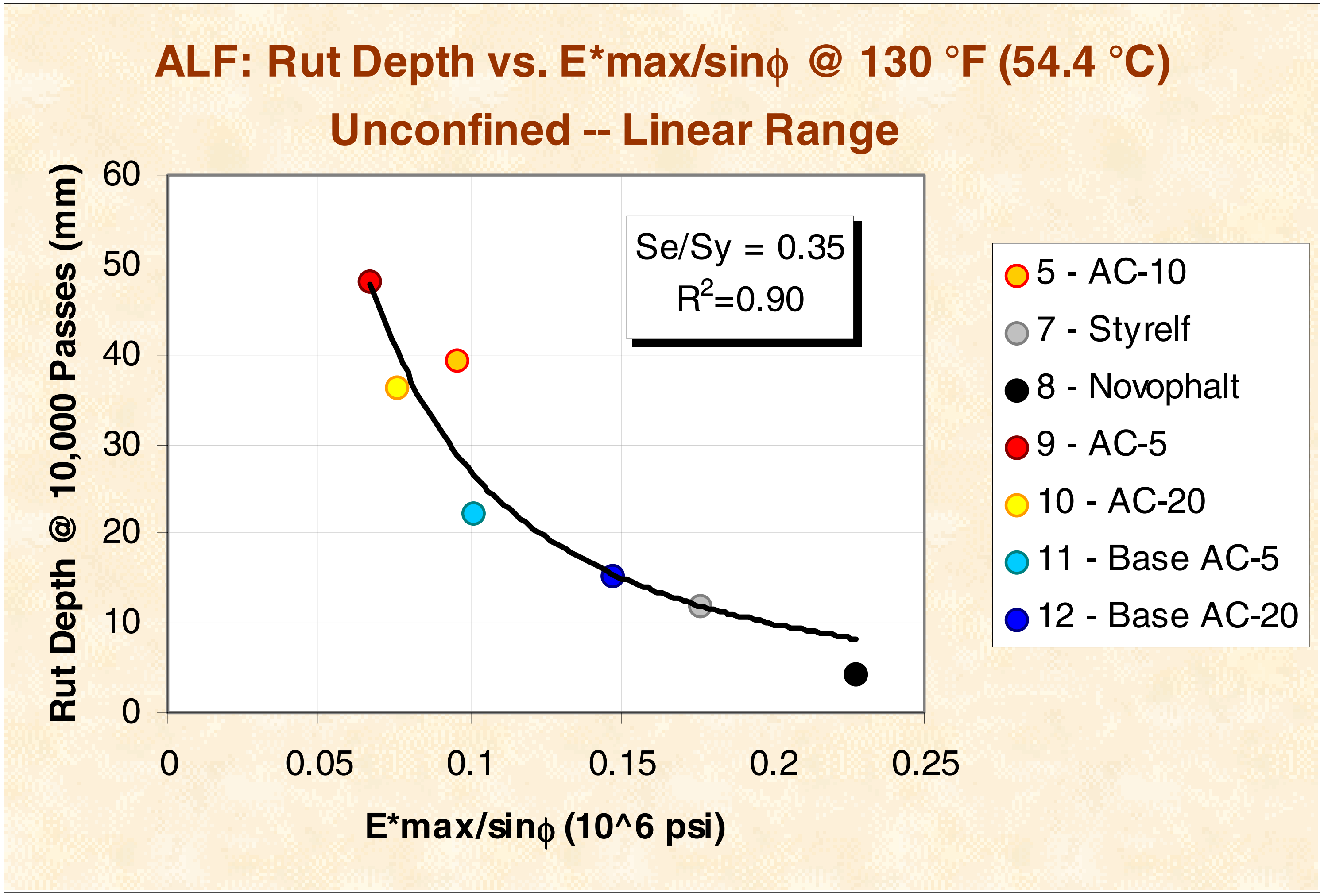


Phase Lag in Dynamic Loading

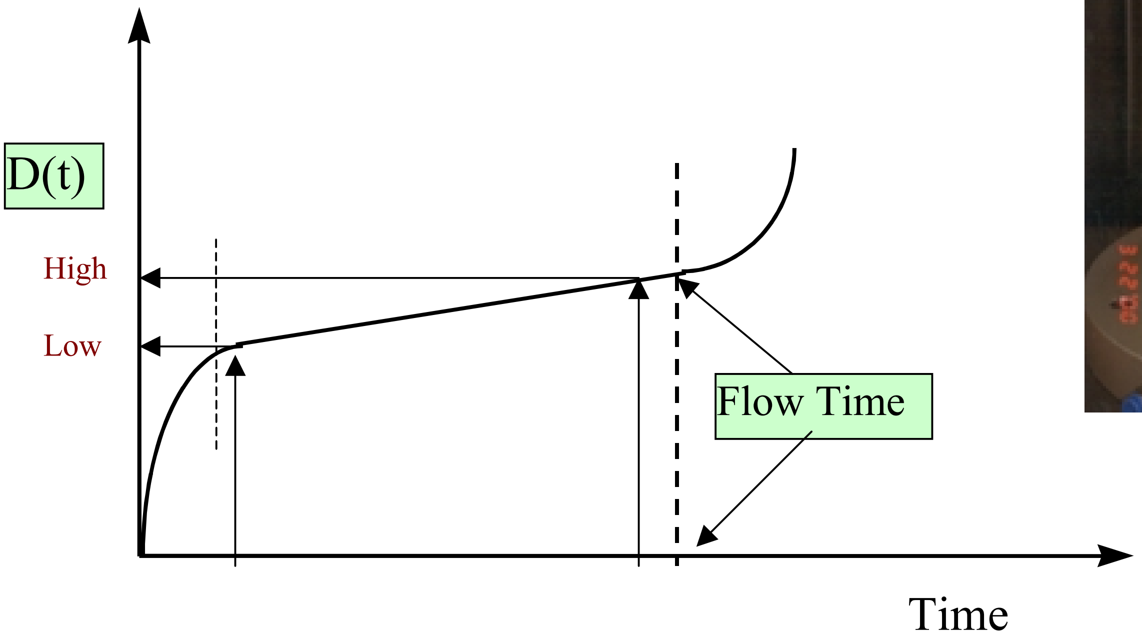


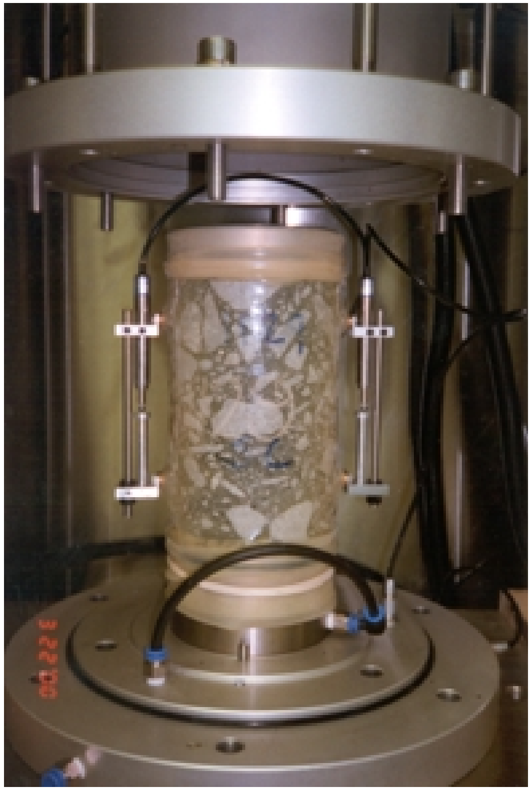


$$\left| E^* \right| = \frac{\sigma_0}{\varepsilon_0}$$

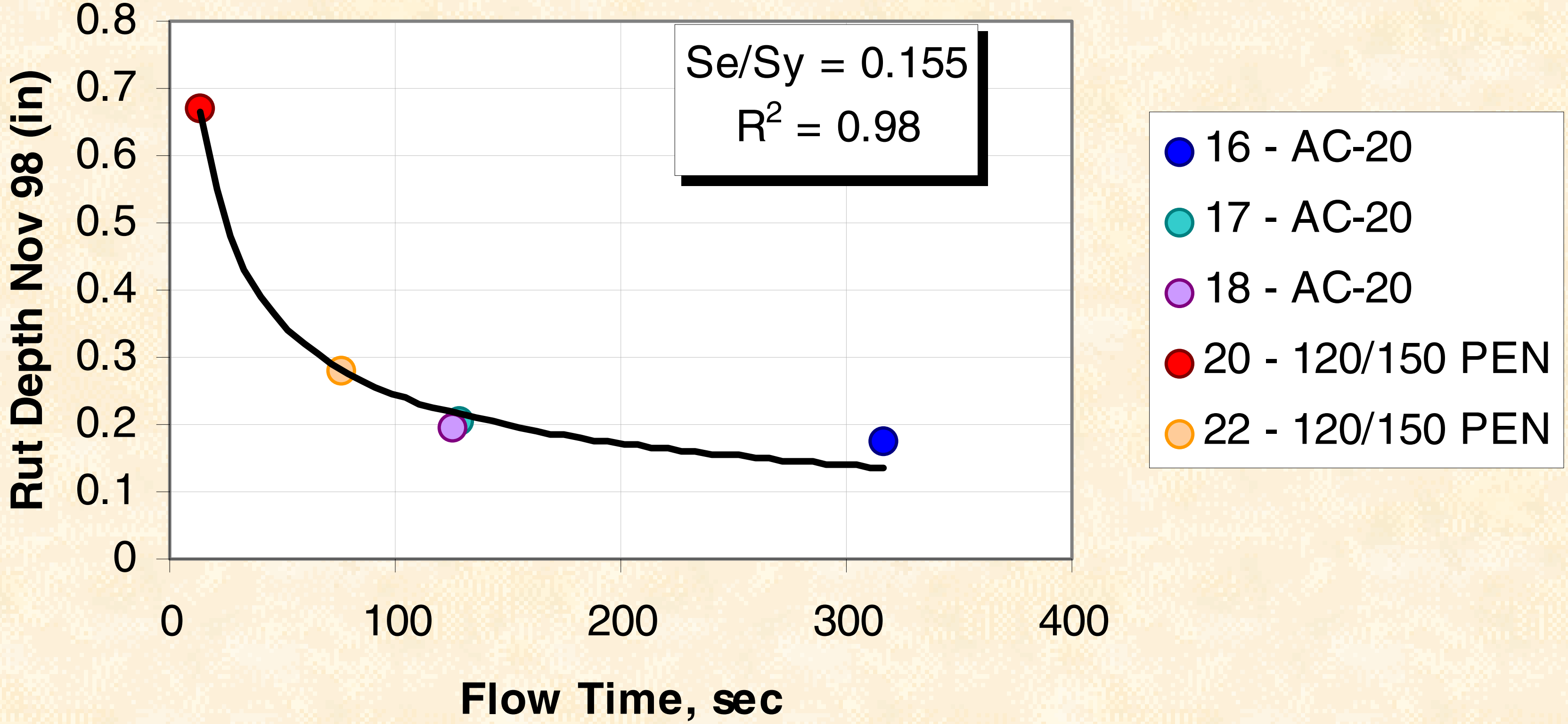

ALF: Rut Depth vs. E*max/sinϕ @ 130 °F (54.4 °C)
Unconfined -- Linear Range
Rut Depth @ 10,000 Passes (mm)
60
50
40
30
20
10
0
0
0.05
0.1
0.15
0.2
0.25
E*max/sinϕ (10^6 psi)
Se/Sy = 0.35
R^2=0.90
5 - AC-10
7 - Styrelf
8 - Novophalt
9 - AC-5
10 - AC-20
11 - Base AC-5
12 - Base AC-20

Creep - Flow Time Test

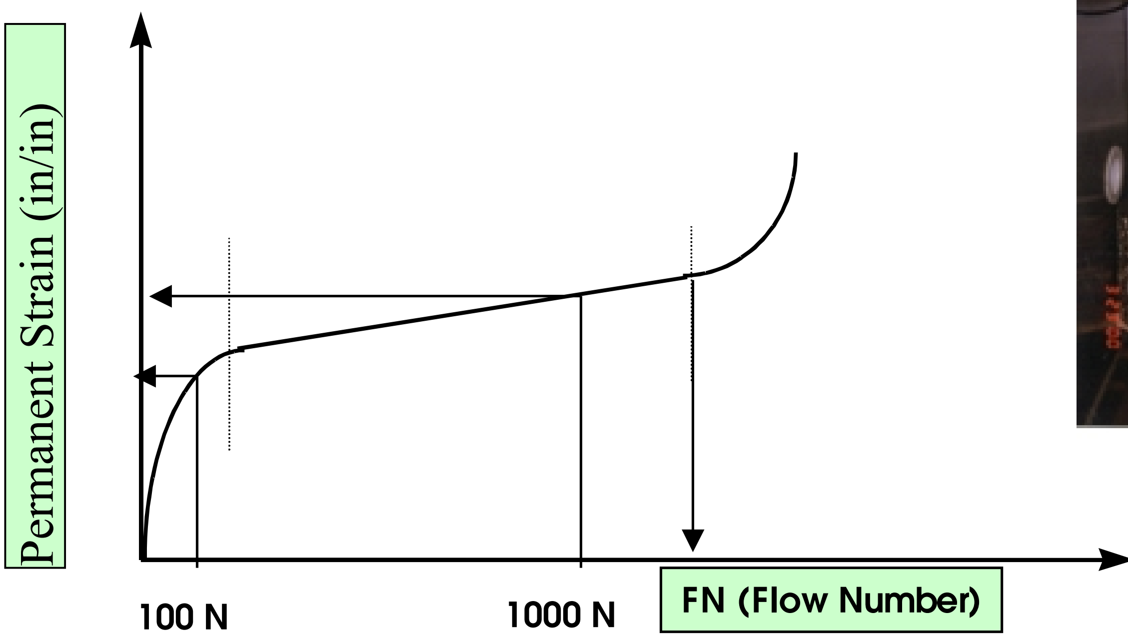


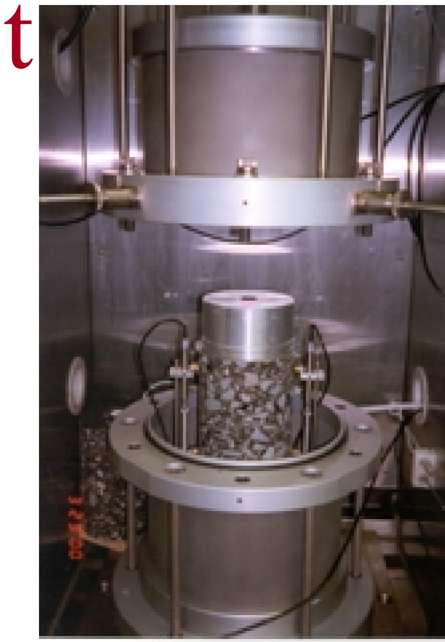


MnR: Unconfined Static Creep Test - Flow Time @ 130 °F (54.4 °C)



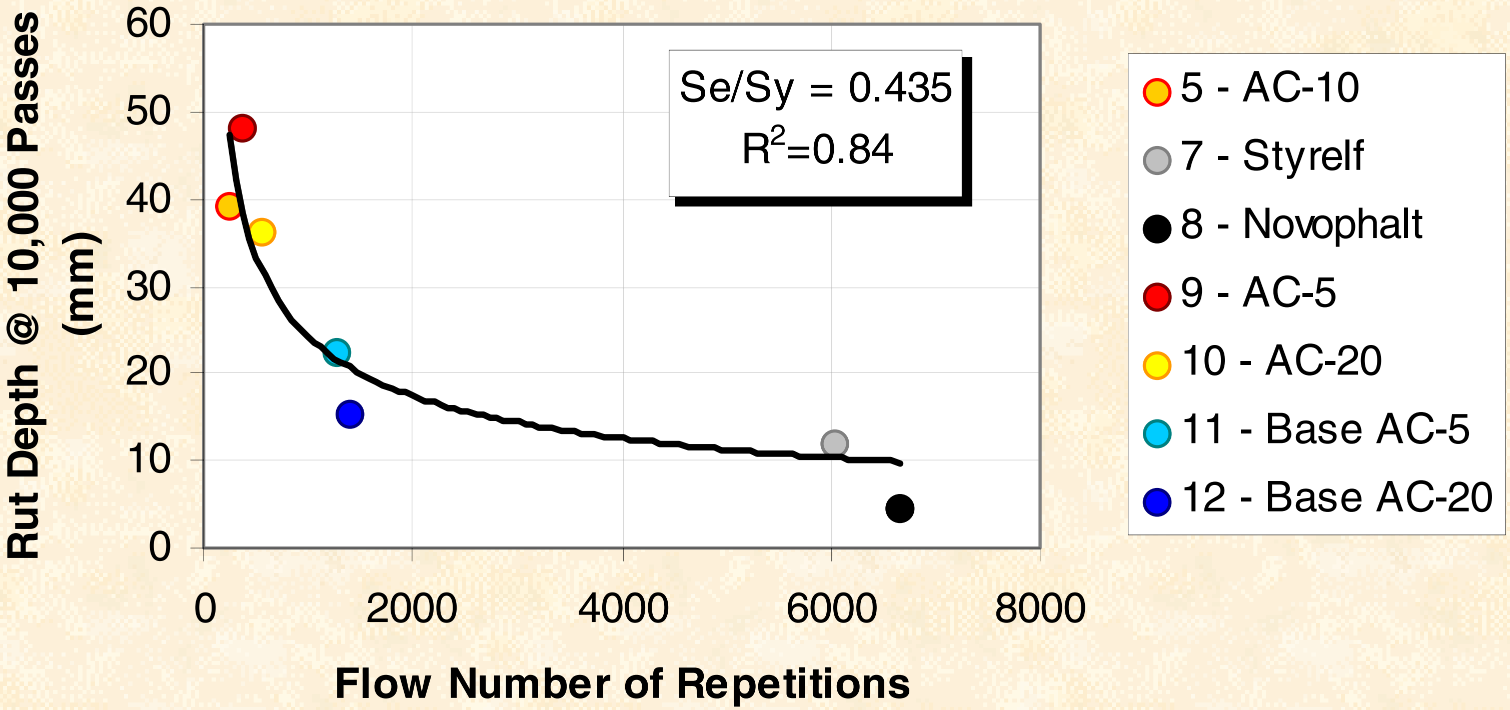
Repeated Load Permanent Deformation Test





Loading Cycles

ALF: Unconfined Repeated Load Test - Flow Number @ 130 °F (54.4 °C) (20 psi)



Further Work

- Field Verification
  - Underway as part of NCHRP 9-19
  - Establish and Validate Acceptance Limits
  - Introduce Equipment to Users
- First Article Equipment
  - New NCHRP Study NCHRP 9-29
  - Procure and Evaluate Two First Articles

NCHRP 9-18 Field Shear Test

- Penn State
  - Don Christensen PI
  - AAT
  - EnduraTec Systems