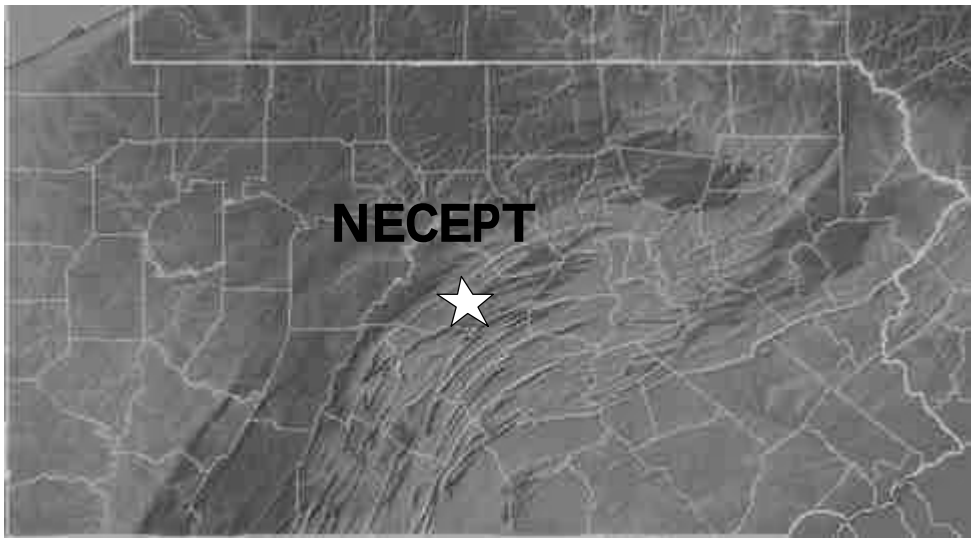
N E C E P T

Development of New Moisture Sensitivity Test for HMA Pavements

Northeast Asphalt User/Producer Meeting
October 30, 2002 . Newport, Rhode Island



Northeast Center of Excellence for Pavement Technology
Pennsylvania Transportation Institute

NCHRP Research Project 9-34

Improved Conditioning Procedure for Predicting the Moisture Susceptibility of HMA Pavements

Project Manager: Dr. Edward Harrigan

Principal Investigator: Dr. Mansour Solaimanian

Period: April 2002 – March 2004

Research Team

- Pennsylvania State University
- University of Texas at El Paso
- Advanced Asphalt Technology
- PaveTex Engineering & Testing

Main Objective

ECS/SPT System:

Simple Performance Tests (SPT)

+

Environmental Conditioning System (ECS)

Project Objectives

- **Sensitivity of SPT conditioned with ECS – Phase I**
- **Modifications to the ECS conditioning procedure – Phase II**
- **The most reliable ECS/SPT procedure**
- **Compare the ECS/SPT method with**
  - **ASTM D4867 – Conditioning & indirect tensile strength**
  - **Hamburg wheel tracking test**
  - **ECS/split tensile test as a potential surrogate**
- **Preliminary ECS/SPT test method in AASHTO standard format**

What Is Important?

- **Chemistry Extremely Important!**

  Adhesion, Surface Energy, …

- **Practitioner's Guide**
  - **What Properties to Look for?**
  - **System Compatibility?**
  - **What Adhesion Promoter and How Much?**

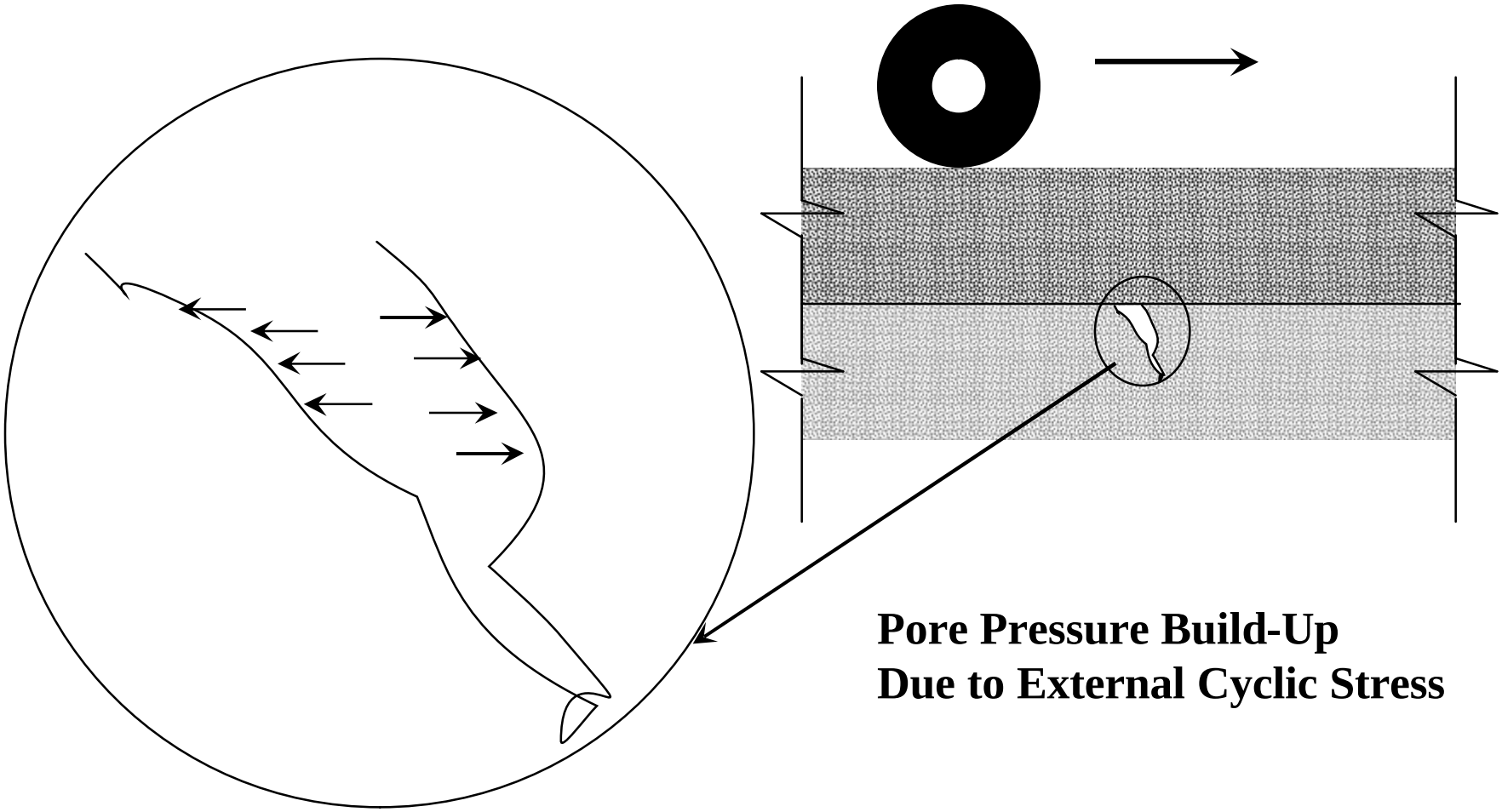
What Is Important?

- **Pay attention to**

mix, traffic, and environment

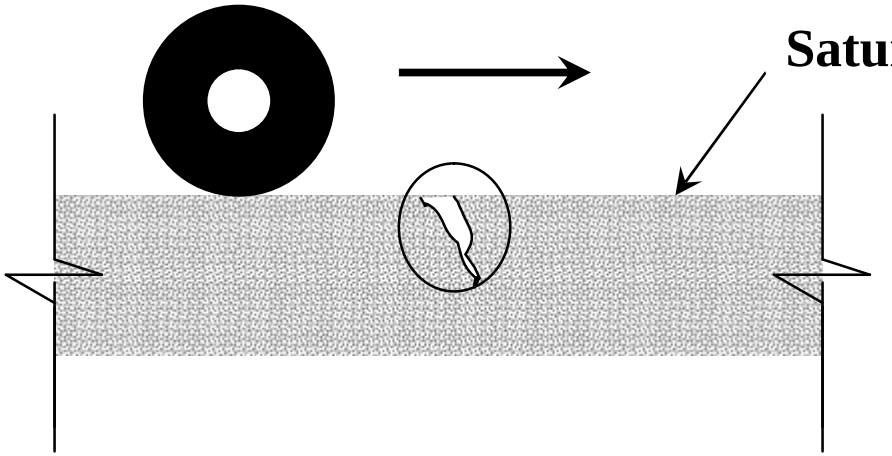
  - **Binder Content**
  - **Binder Stiffness**
  - **Air Void Level and Size**
  - **Connectivity of Voids**
  - **Traffic Effect: Pumping & Hydrostatic Pressures**

Pore Pressure Effect



Pore Pressure Build-Up
Due to External Cyclic Stress

Hydraulic Scouring



Compression/Tension Cycle

Stripping Starts at the Surface Progressing Downward

N E C E P T

- **Need a Mechanical Mixture Test**
- ***Minimize*** **Moisture Damage**

New Mixture Tests

- There are shortcomings with existing tests
- NCHRP 9-34:
  - Trying to have one reliable testing system for both rutting & moisture damage
  - Conduct at two phases

Phase-I Tests

Testing Matrix for SPT Sensitivity

	SPT Tests								
Agg.	Dynamic Modulus		Axial Creep		Axial Repeated		ASTM D4867		HWTD
	Dry	Cond	Dry	Cond	Dry	Cond	Dry	Cond	
A	4	4	4	4	4	4	4	4	4 4
B	4	4	4	4	4	4	4	4 4	4
C	4	4	4	4	4	4	4	4 4	4 4

Phase II

- **Identify A Practical, Reliable ECS/SPT Method**
  - **Conditioning Temperature**
  - **Confining Pressure**
  - **Conditioning Time**
  - **Conditioning Load**
  - **Conditioning Load Duration**

Phase II

- **HMA Variables Considered**
  - **Gradation**
  - **Binder Content**
  - **Binder Type**
  - **Air Voids**
  - **Adhesion Promoter Agent**

Where Are We?

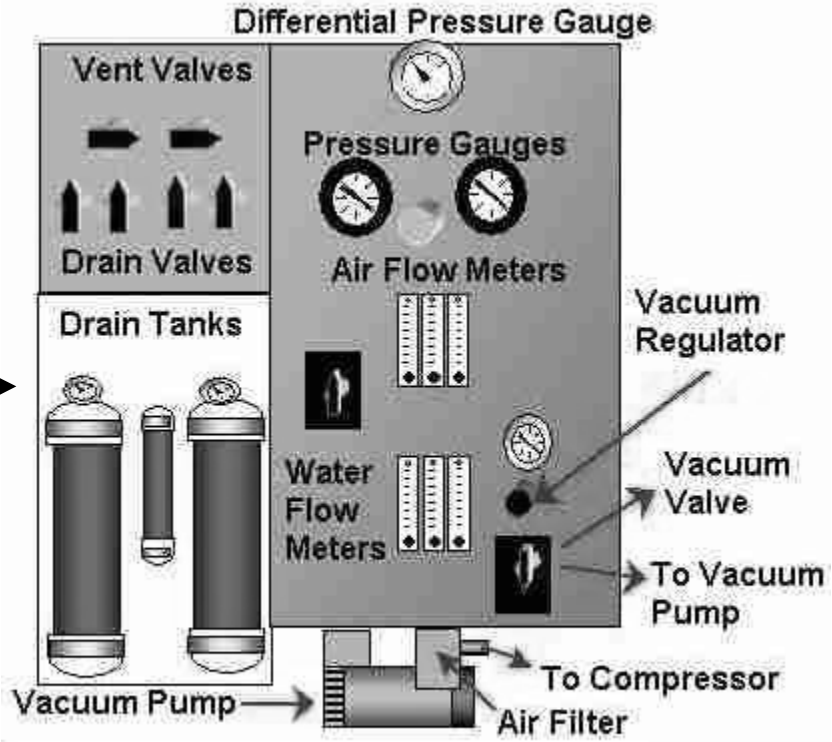
- **Phase-I**
  - **Materials Selected & Procured**
  - **TSR and HWTD Completed**
  - **ECS/SPT Testing in Progress**

Materials

- Limestone from Colorado Materials, Hunter, TX.
- Sandstone from Martin Marietta Materials, Sawyer, OK
- Granite from Vulcan Materials, Richmond, VA
- Unmodified PG 70-22

ECS/SPT

SPT

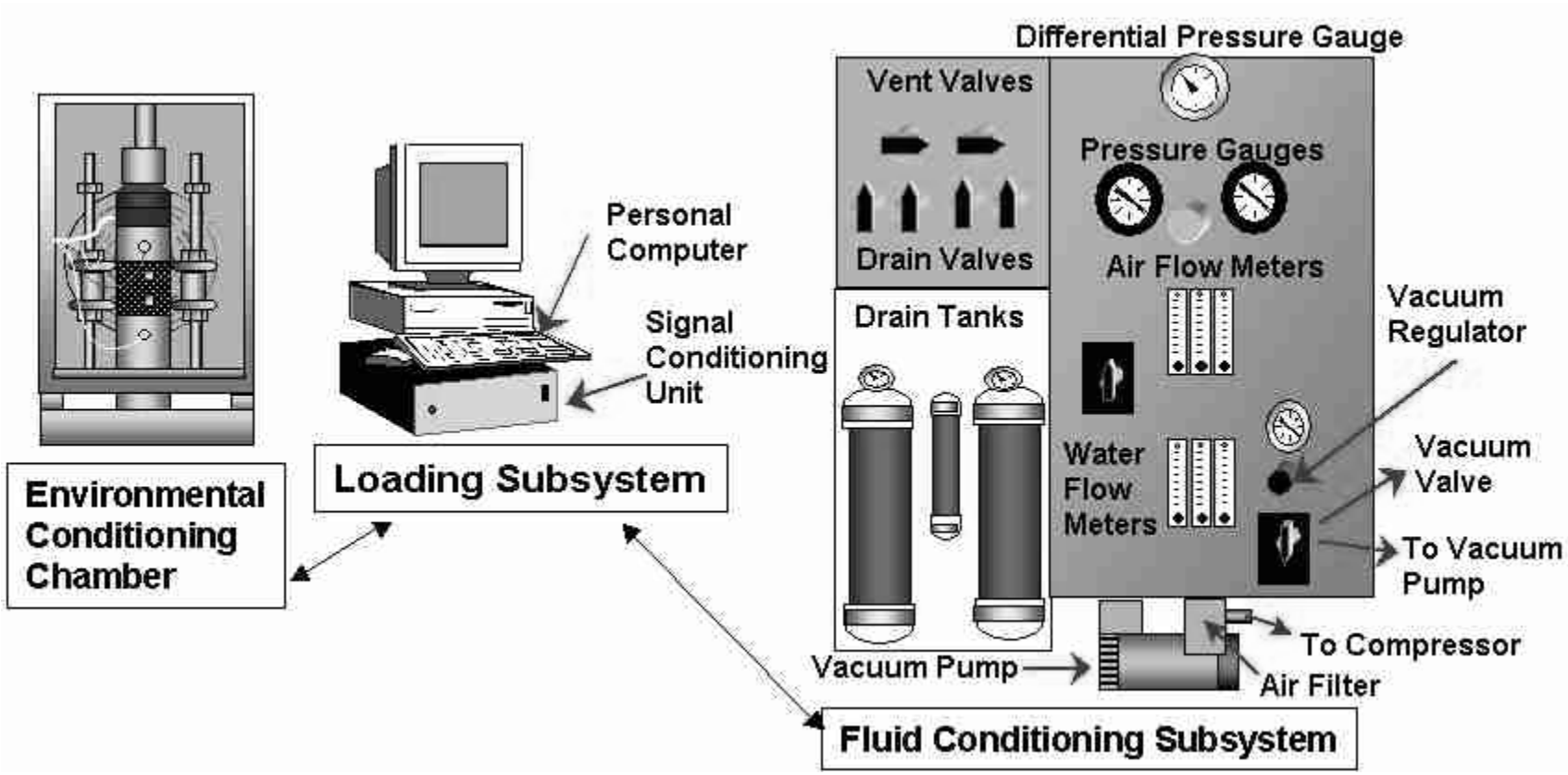


ECS - Subsystem

Environmental Conditioning System

- Developed at OSU as part of SHRP A-003A
- SHRP Period 1987-1993
- Improved at UTEP under TxDOT Project
  - Repeatability
  - Rigidity
  - Strain Measuring System
  - Controlling Water Temperature
  - Confining Pressure

Environmental Conditioning System



Current ECS Testing

Measure Resilient Modulus before and after Conditioning

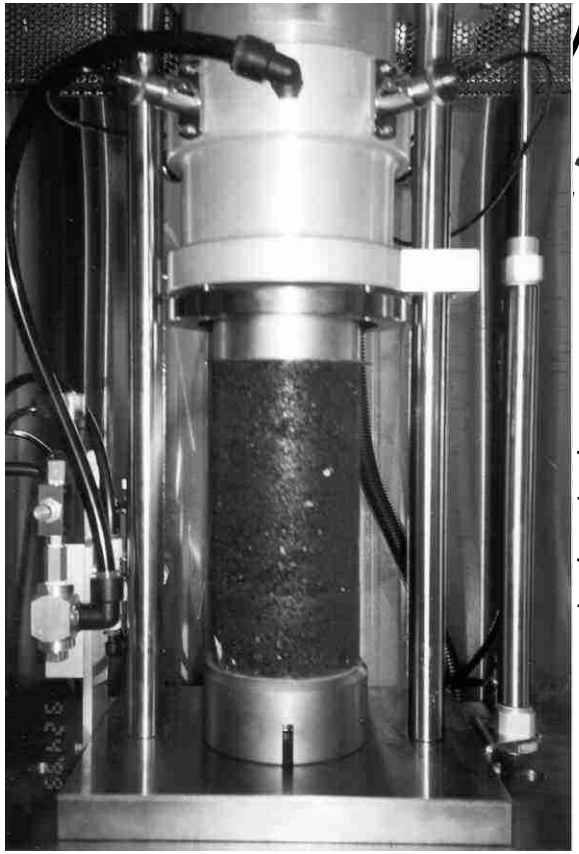
- **Specimen Size: Dia: 100 mm, H: 100 mm**
- **Conditioning Temperature** 60 ?C
- **Confining Pressure** 2.5 inches of mercury
- **Conditioning Time** 6-18 hours
- **Conditioning Load** 200 lbs
- **Haversine Load**
  - 50 to 100 Microstrain
  - 0.1 sec loading period – 0.9 sec rest period

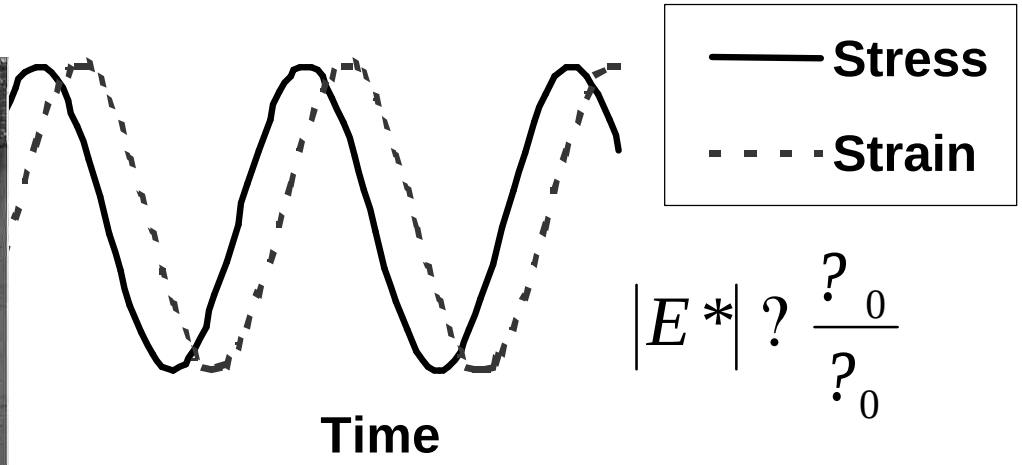
Simple Performance Tests

Candidate Tests

- Dynamic Modulus
- Creep Test (Flow Time Test)
- Repeated Load Test (Flow Number Test)

Dynamic Modulus Test



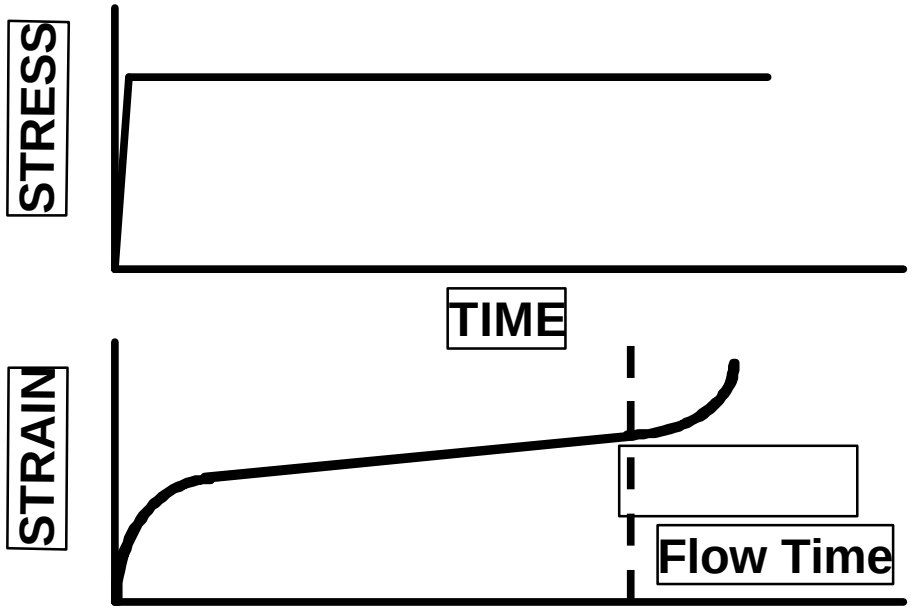


$$|E^*| = \frac{\sigma_0}{\varepsilon_0}$$

Rutting

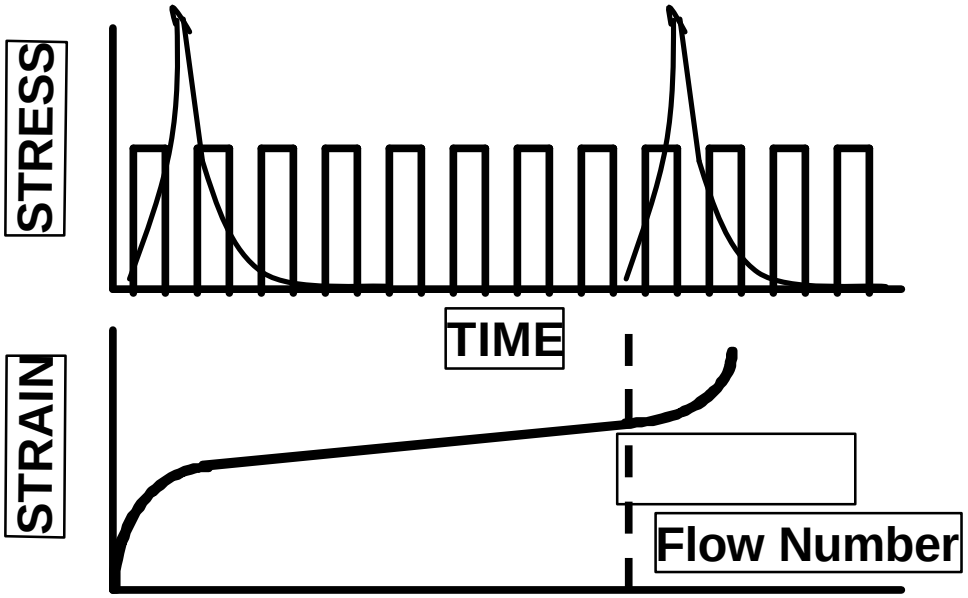
Fatigue Cracking

Creep Flow Time Test



- **Rutting**

Repeated Load Perm. Deformation Test



- **Rutting**

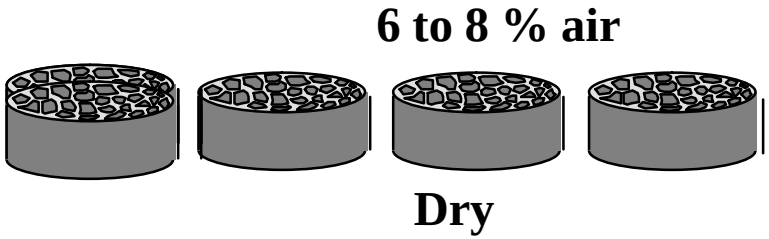
Comparisons

- Compare the ECS/SPT method with
  - ASTM D4867 – Conditioning & indirect tensile strength
  - Hamburg wheel tracking test
  - ECS/Split Tensile test as a potential surrogate

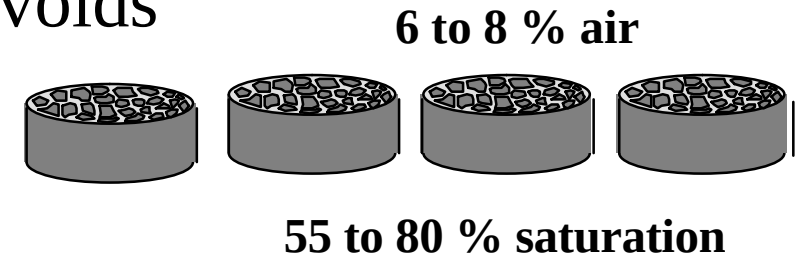
Tensile Strength Ratio

Moisture Sensitivity – ASTM D 4867

- Compaction:
  - Superpave Gyratory Compactor
  - Eight specimens



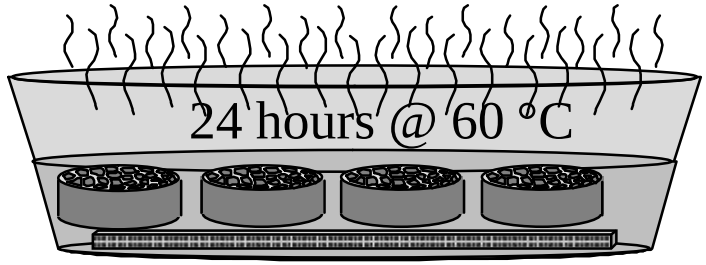
- Two subsets with equal voids
  - one - “dry”
  - one – “conditioned”



Moisture Sensitivity – ASTM D 4867

- **Conditioning**
  - **freeze cycle**

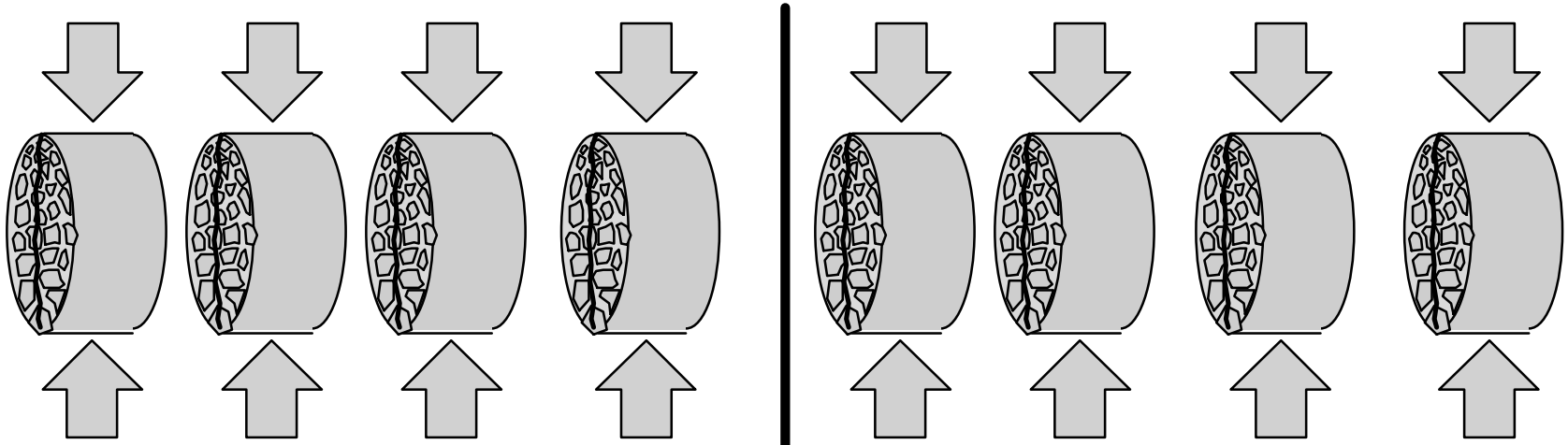
  - **hot water soak**



Moisture Sensitivity – ASTM D 4867

✍ Determine Tensile Strength Ratio (TSR)

51 mm / min @ 25 °C



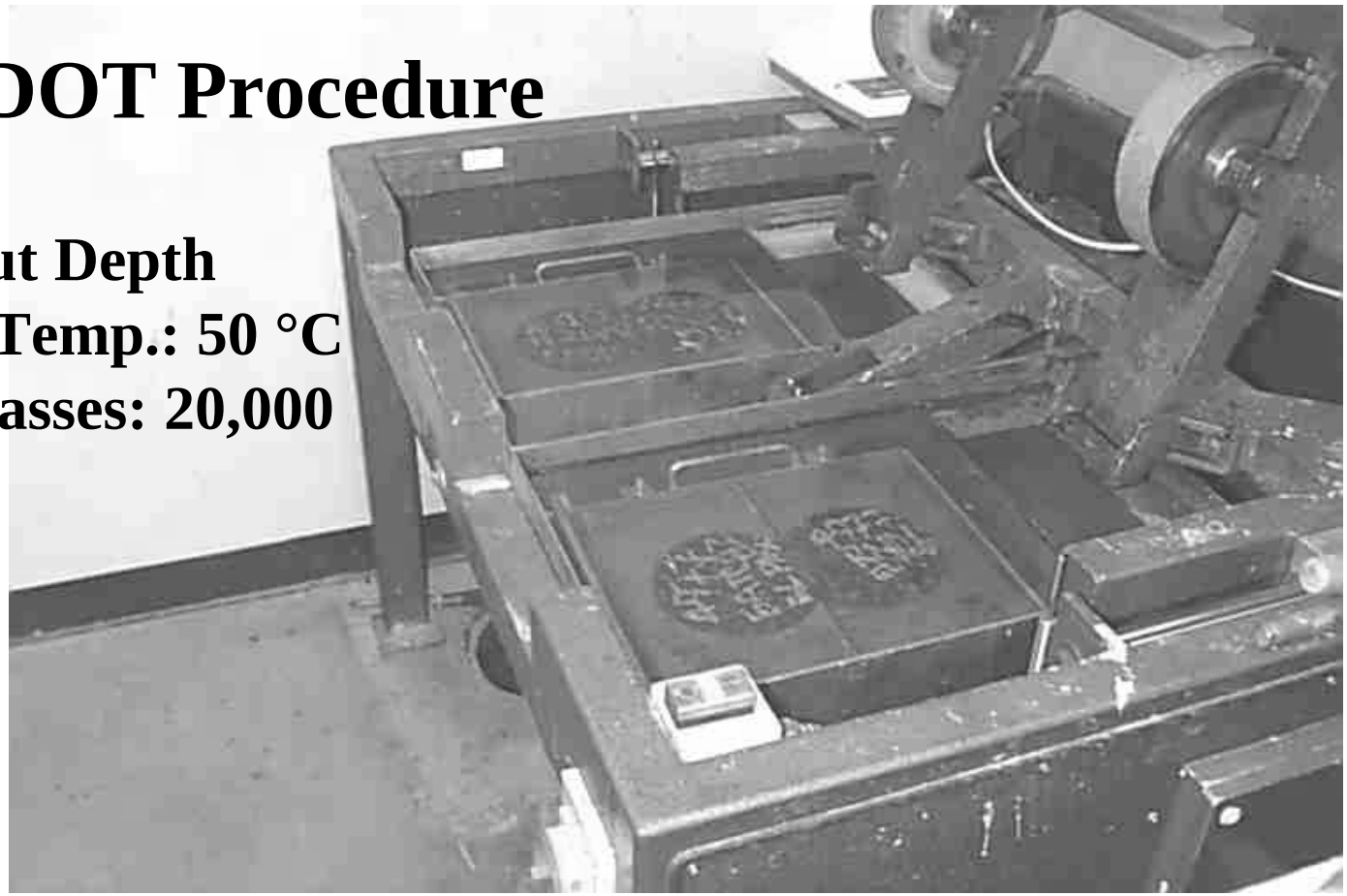
Avg Dry Tensile Strength | **Avg Wet Tensile Strength**

$$TSR = \frac{\text{Wet}}{\text{Dry}} \geq 80\ \%$$

Hamburg Wheel Tracking

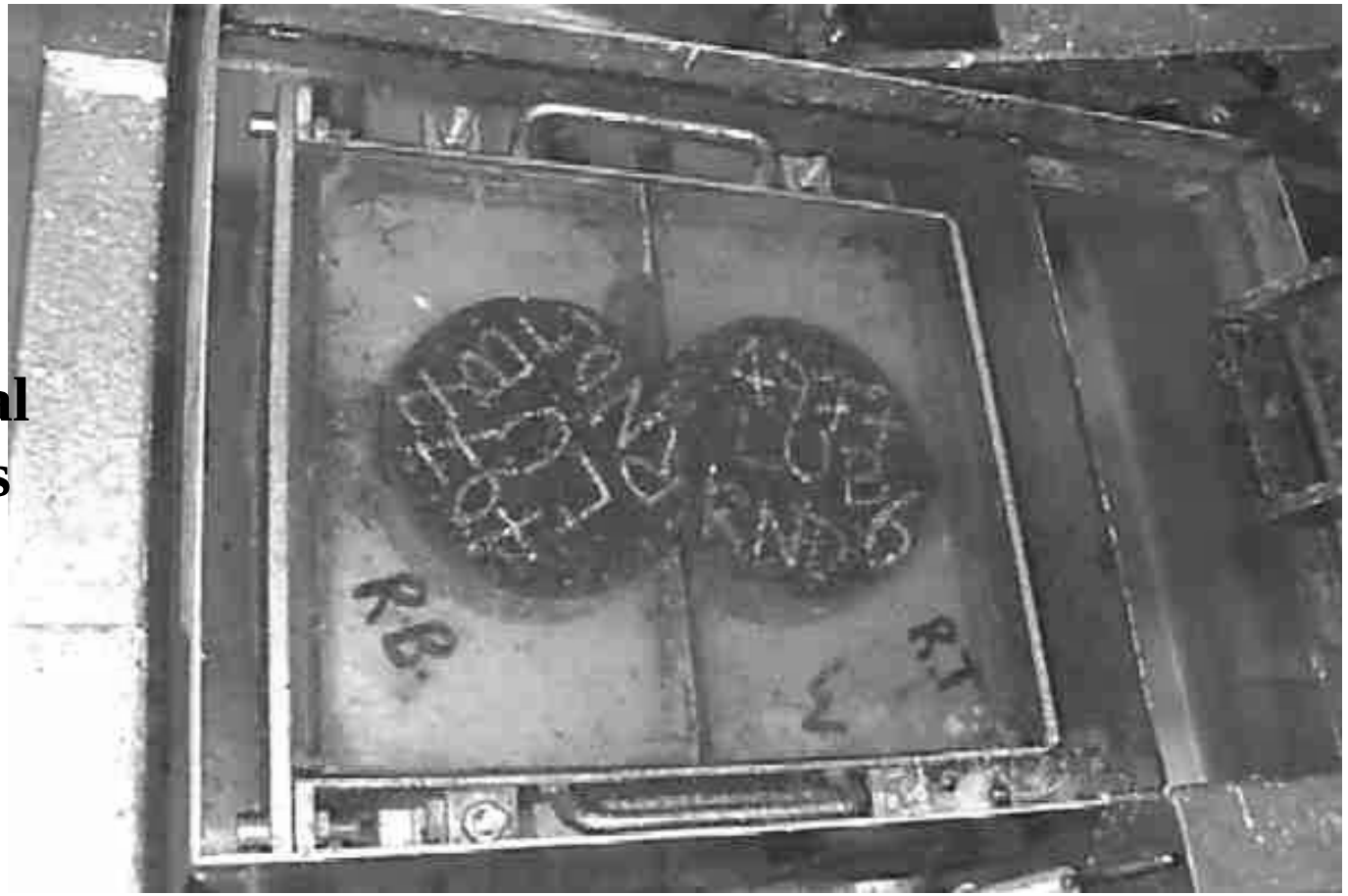
Hamburg Wheel Tracking Device (HWTD)

- **TxDOT Procedure**
  - **½" Rut Depth**
  - **Test Temp.: 50 °C**
  - **# of Passes: 20,000**



Hamburg Wheel Tracking - Specimens

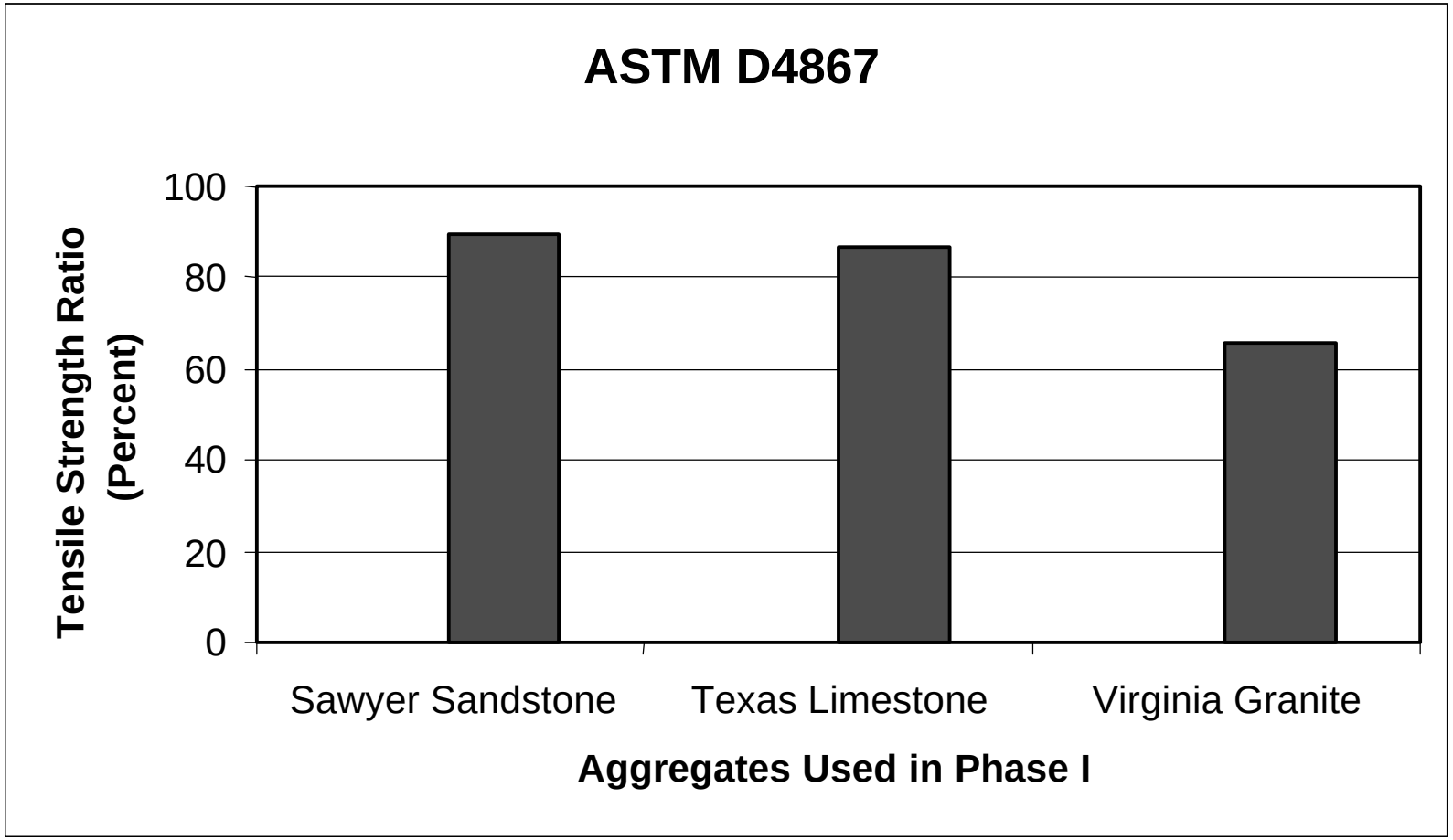
Two Cylindrical Specimens



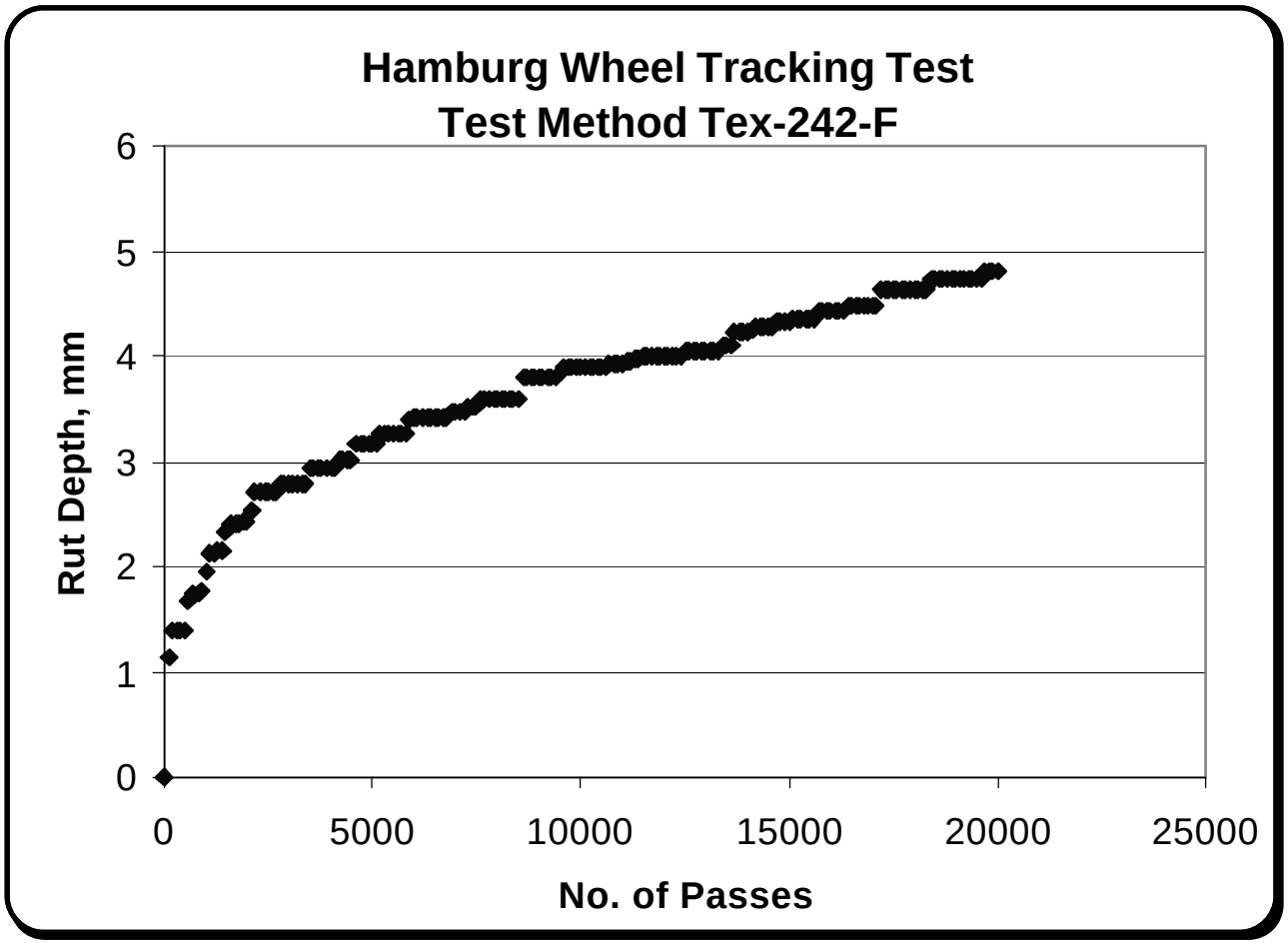
Hamburg Wheel Tracking - Specimens

Results

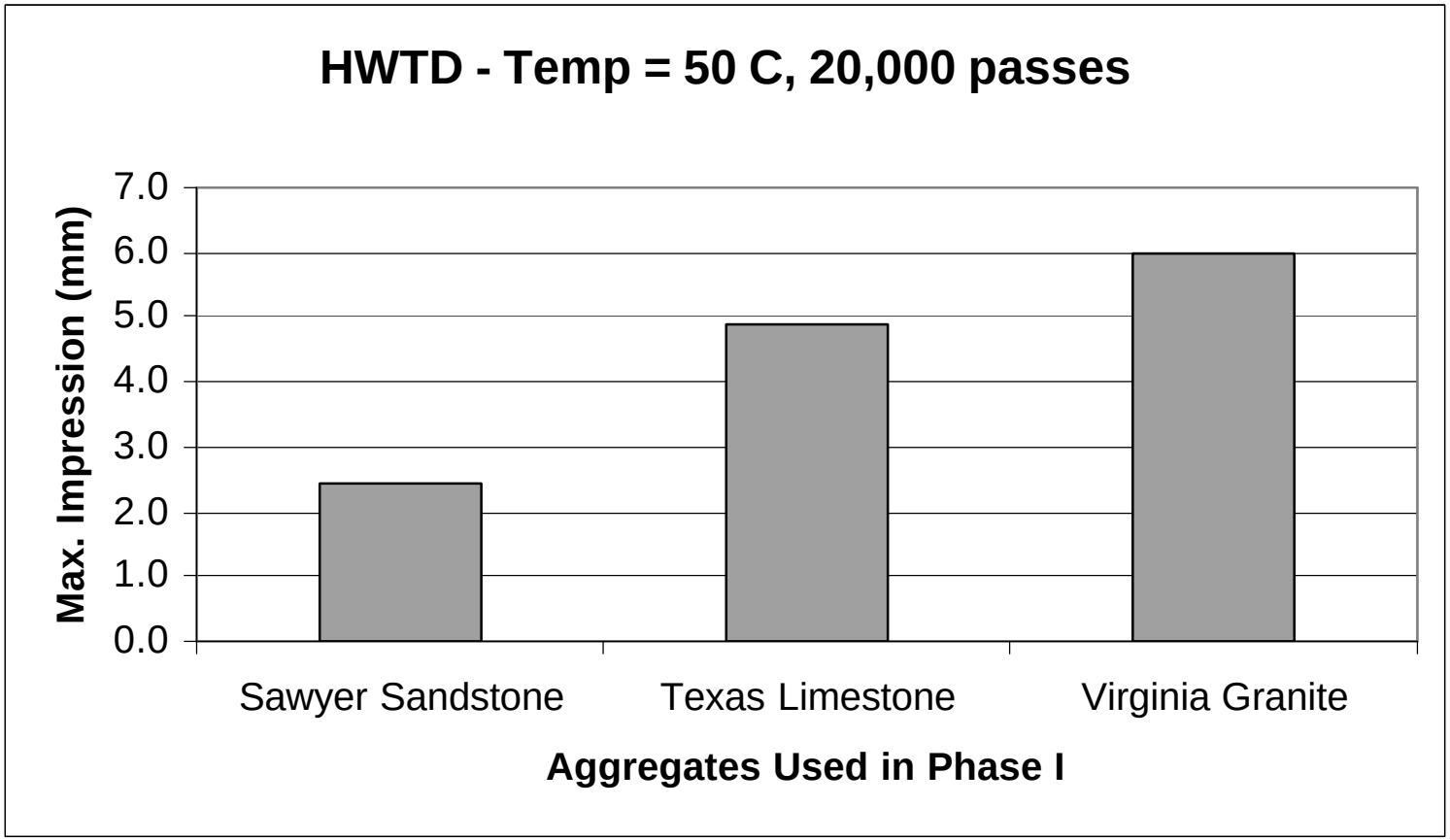
TSR Results


ASTM D4867
Tensile Strength Ratio (Percent)
100
80
60
40
20
0
Sawyer Sandstone
Texas Limestone
Virginia Granite
Aggregates Used in Phase I

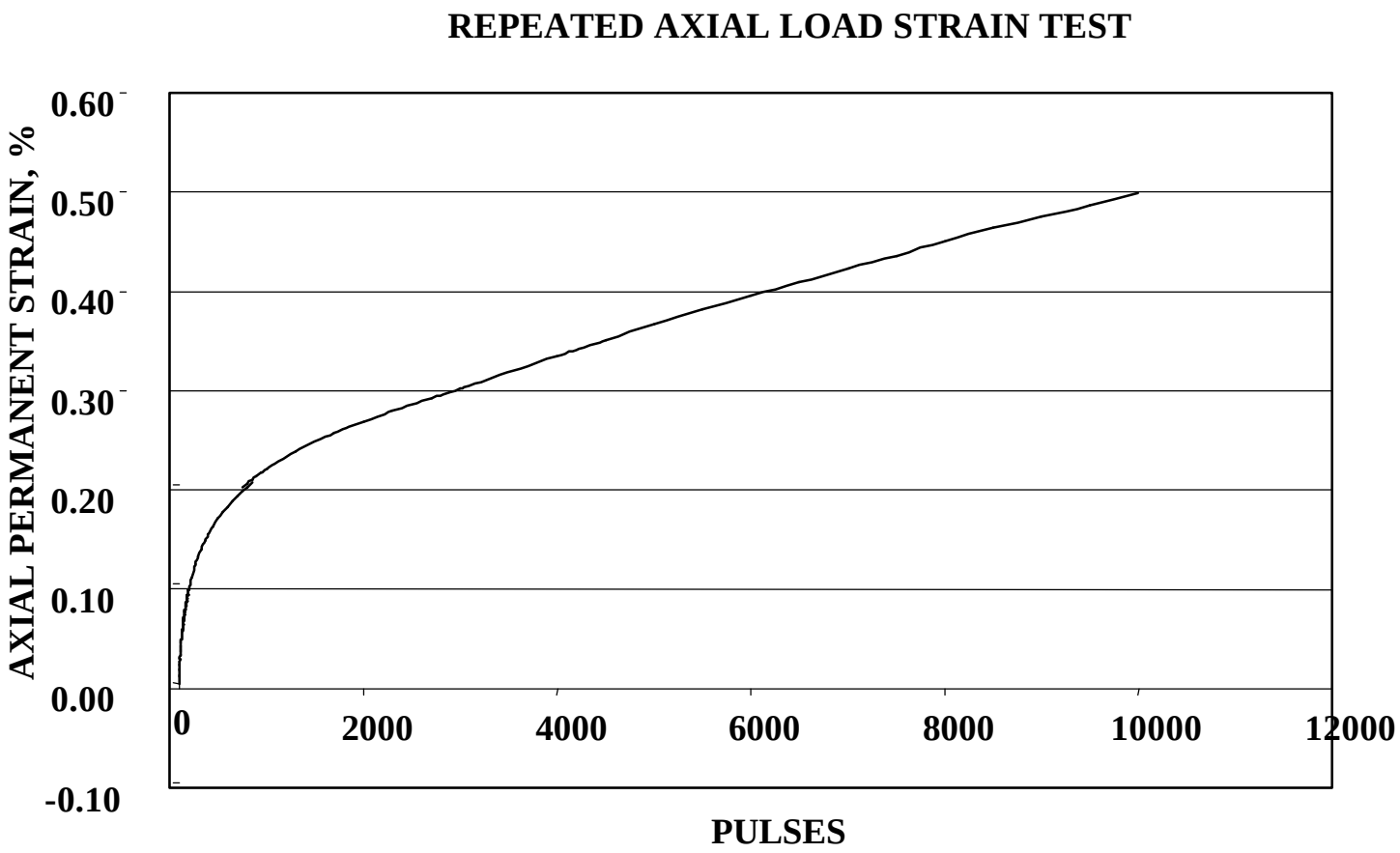
HWTD Results



HWTD Results



ECS/SPT Results



SUMMARY

- **Can SPT be Used with ECS System to Identify Moisture Damage?**
- **If So, What Modifications Are Required?**
- **What Would be the Most Reliable ECS/SPT Procedure?**
- **How Does It Compare with the Following?**
  - **ASTM D4867 – Conditioning & indirect tensile strength**
  - **Hamburg wheel tracking test**
  - **ECS/split tensile test as a potential surrogate**

Thank You!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