



*Effect of Mixture Design on
Densification*

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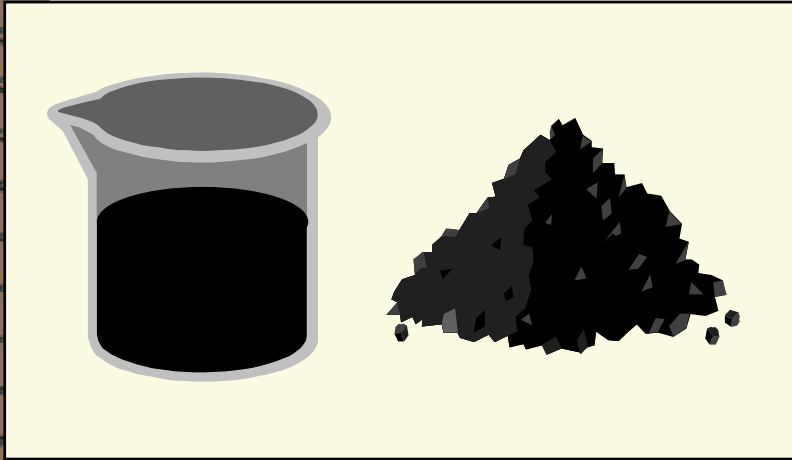
Outline

- Background
- Objective
- Scope
- Mixtures Evaluation
- Results
- Concluding Remarks

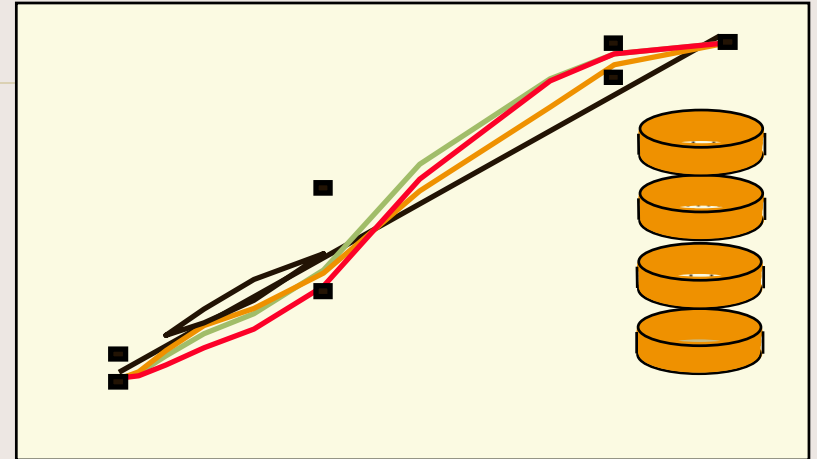
Objectives of Mix Design

- **Resist**
 - permanent deformation.
 - fatigue cracking – repeated load
 - low temperature cracking
 - moisture induced damage
- **Resist skid**
- **Workability**

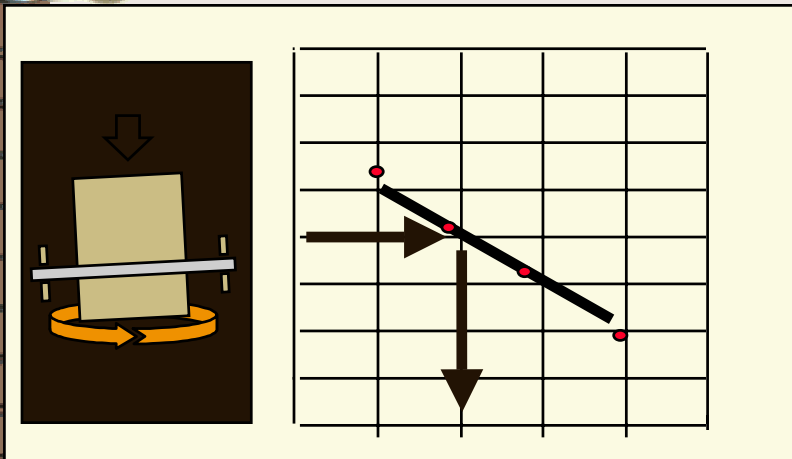
Steps Involved in the Mixture Design



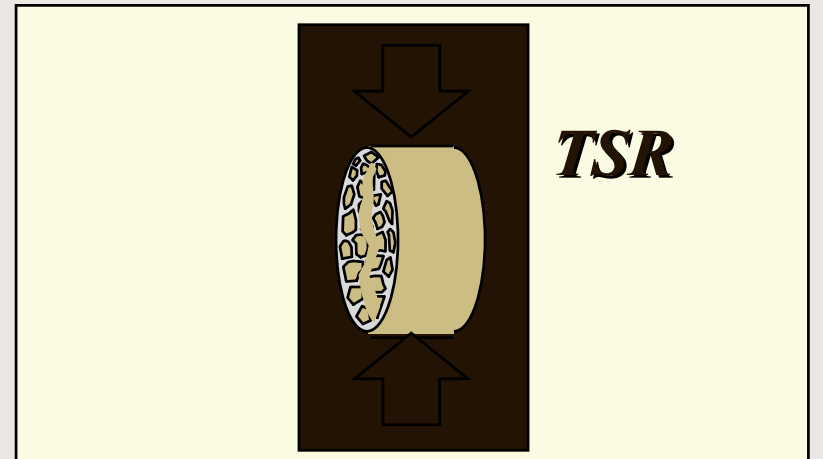
1. Materials Selection



2. Design Aggregate Structure



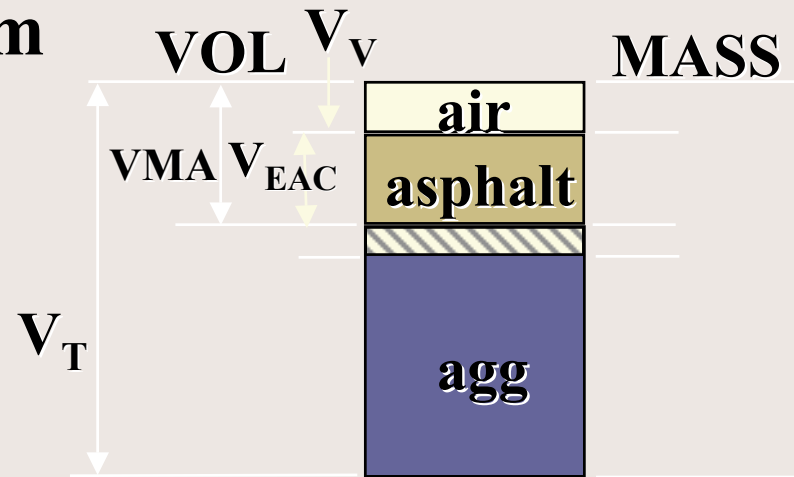
3. Design Binder Content



4. Moisture Sensitivity

Superpave Mixture Design Concerns:

- Minimum VMA Criteria
- Difficulties
- Differentiate sound from unsound mixtures
- higher VMA mixtures
 - Cannot guarantee
 - Durable
 - rut resistant



Superpave Mixture Design Concerns:

- **Aggregate Properties/Gradation selection**
- **95 percent**
- **Aggregate Specification**
 - **Consensus – ETG**
 - **Little research**
 - **Aggregate Structure/Mixture Design and Performance**

Superpave Mixture Design Improvement:

- **Design Aggregate Structure**
 - **Mixture stability**
- **Rational approach to design aggregate structure**
 - **based on principles of aggregate packing concepts**

Objective

- **Critically examine Superpave mixture design criterion**
- **Effect of**
 - **NMS**
 - **Aggregate Gradation and type**

Scope

- **Aggregate Types**
 - Two
 - Sandstone, Limestone
- **Aggregate Structure**
 - 12.5 mm NMS
 - 25 mm NMS
- **Aggregate gradation**
 - Coarse, Medium, Fine
 - Bailey Method
 - analytical method that enables blending aggregates using engineering principles and packing theory concepts

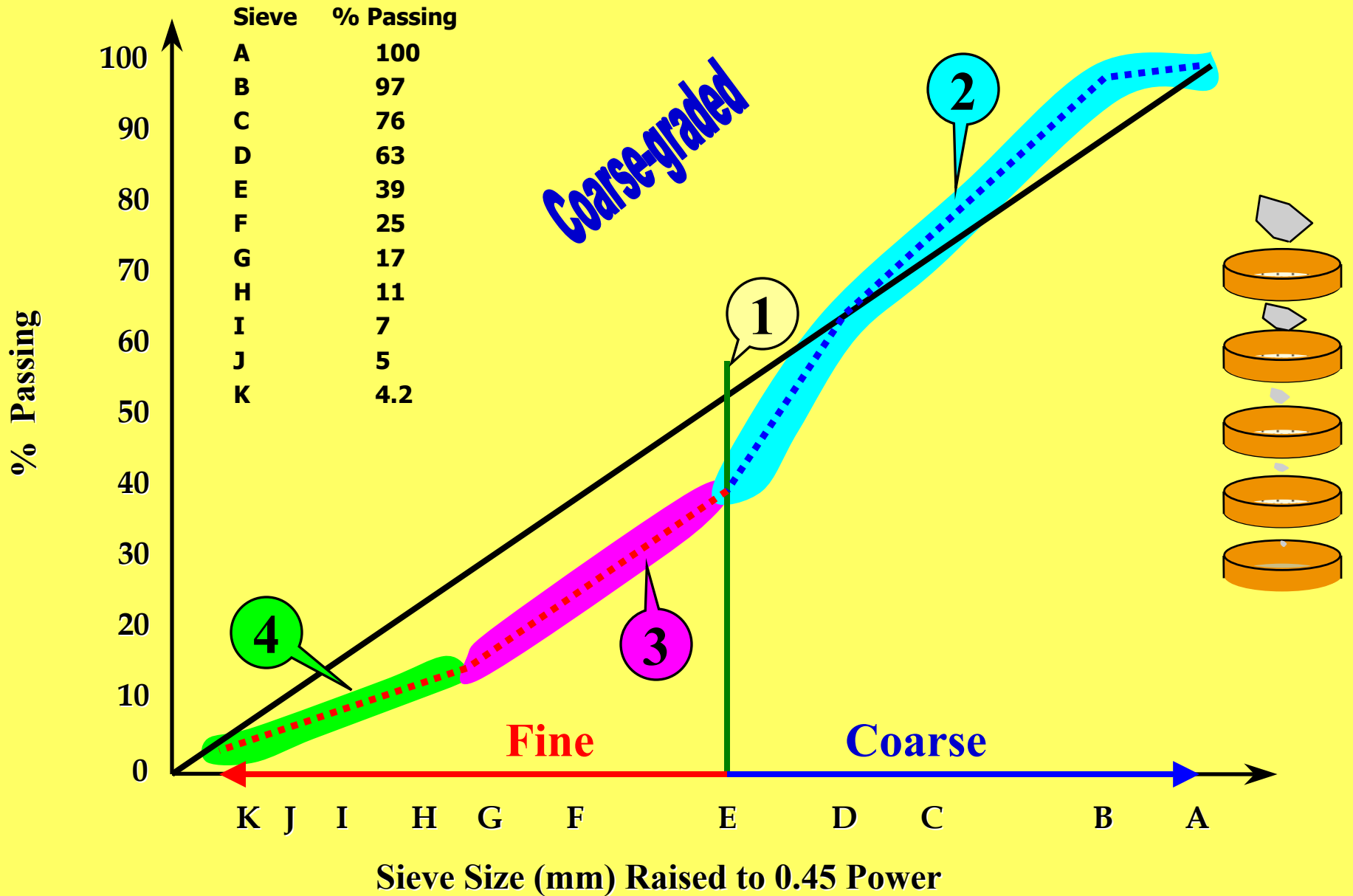
Scope

- **Compaction Level**
 - 125 gyrations
- **Binder Type**
 - PG 76 – 22M

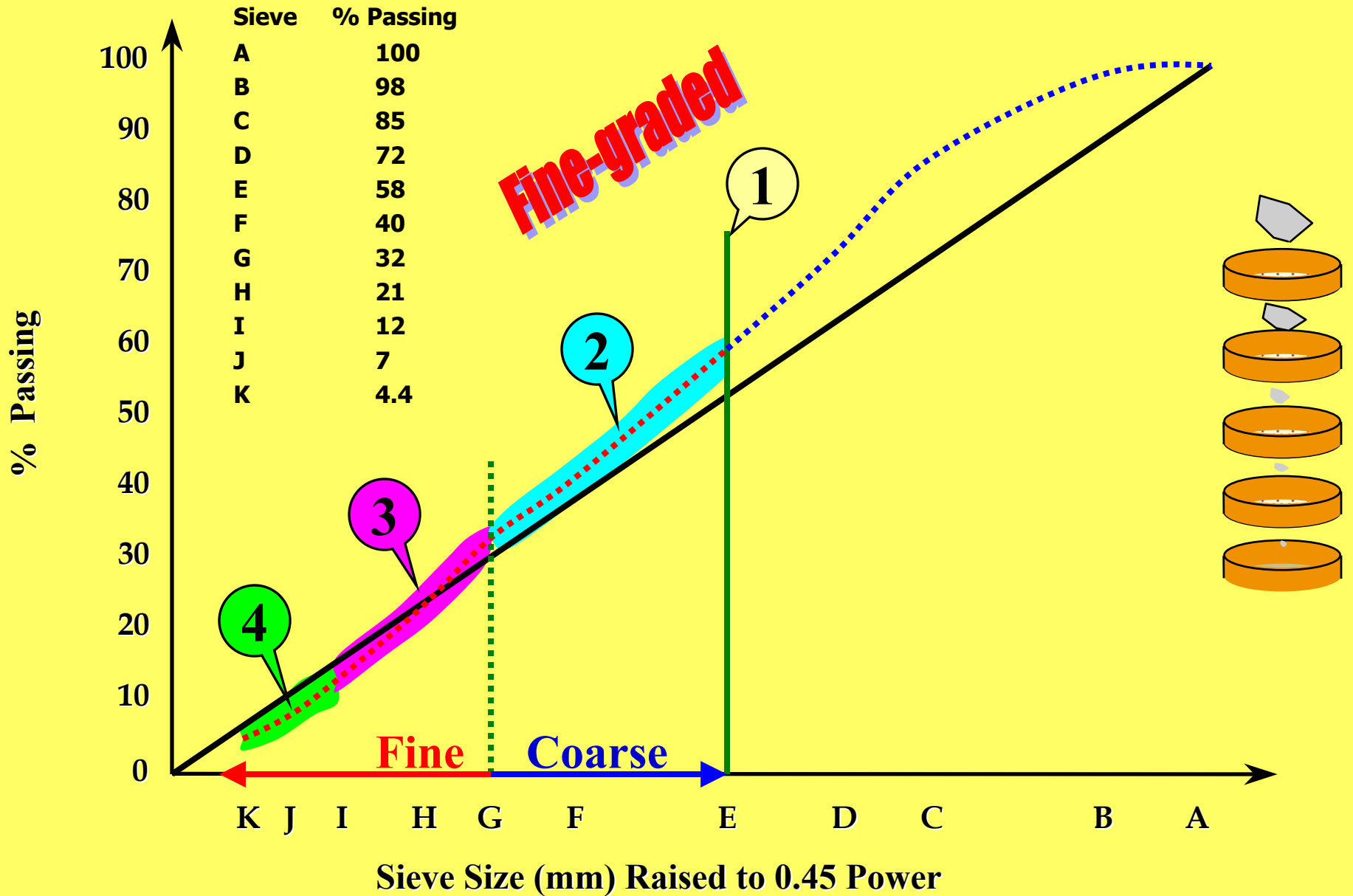
Methodology

- **Superpave Gyrotory Compactor**
 - **Densification Indices, Slope**
 - **Locking Point**
- **Pressure Distribution Analyzer**
 - **Frictional Indices, Locking**
- **Loaded Wheel Tester**
 - **PMW**

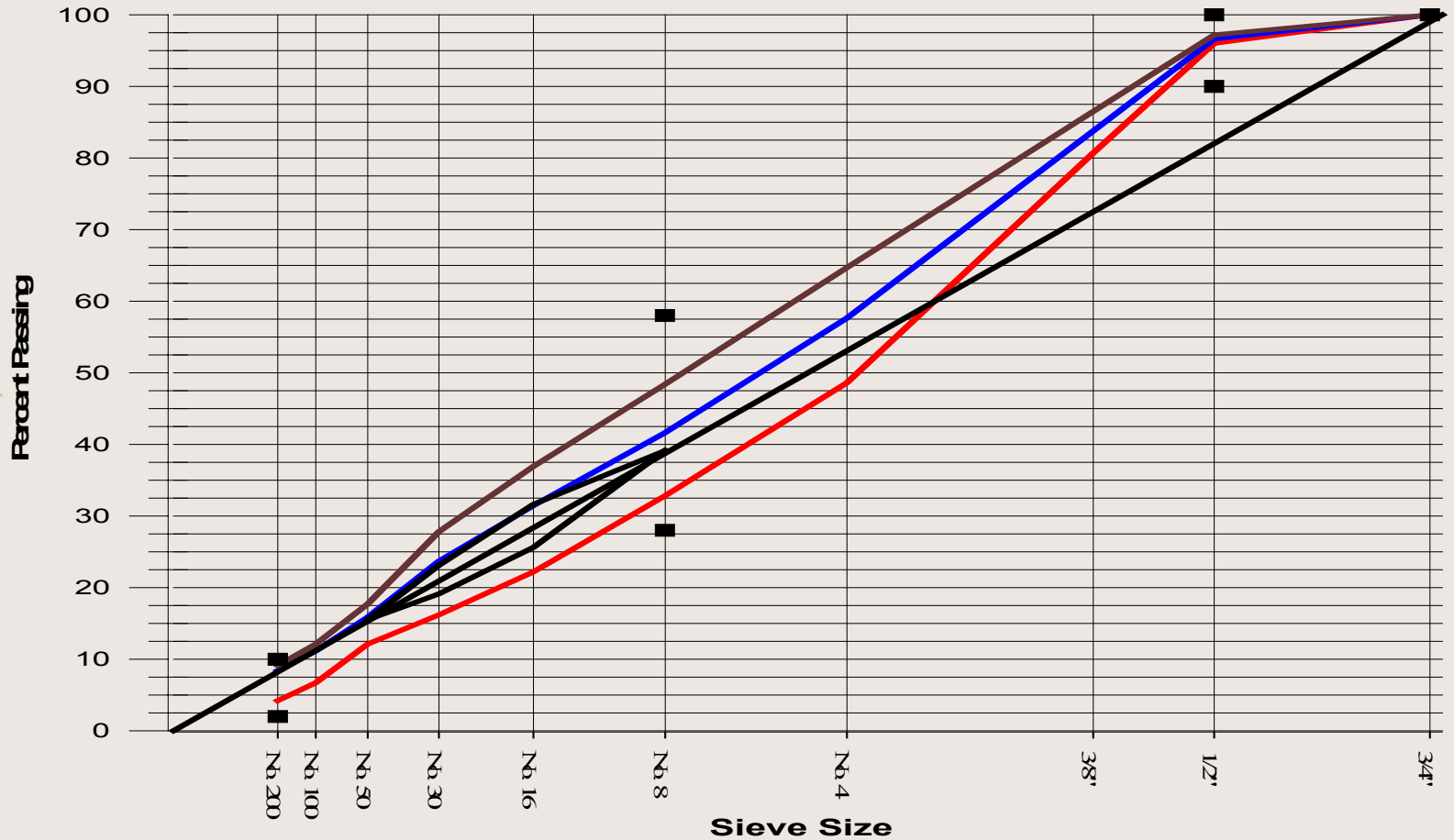
Combined Blend Gradation



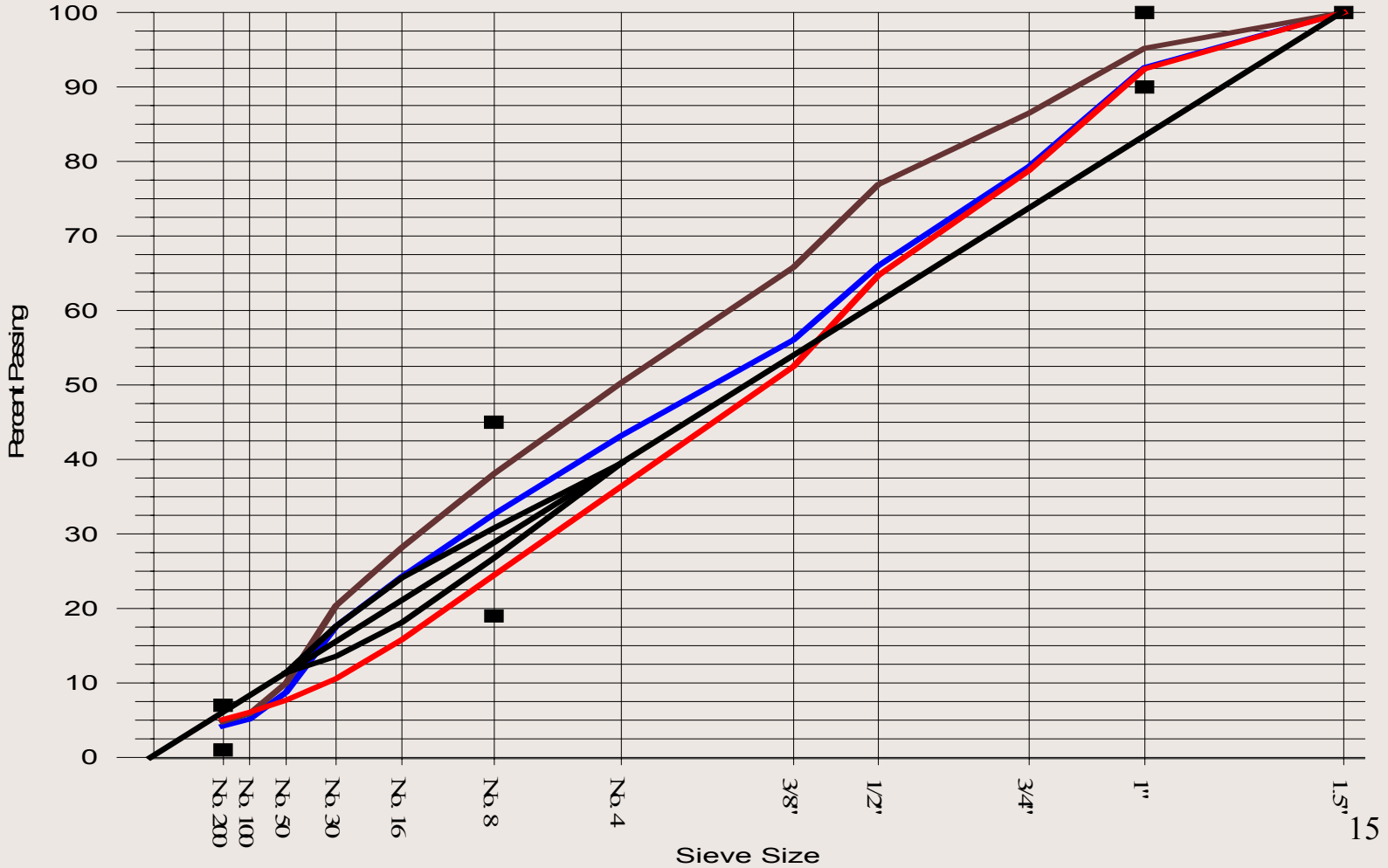
Combined Blend Gradation



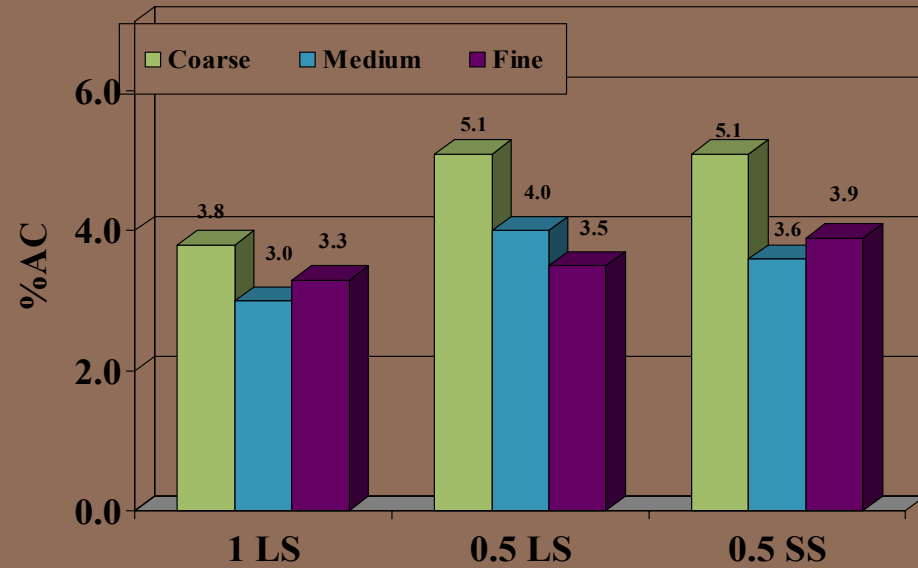
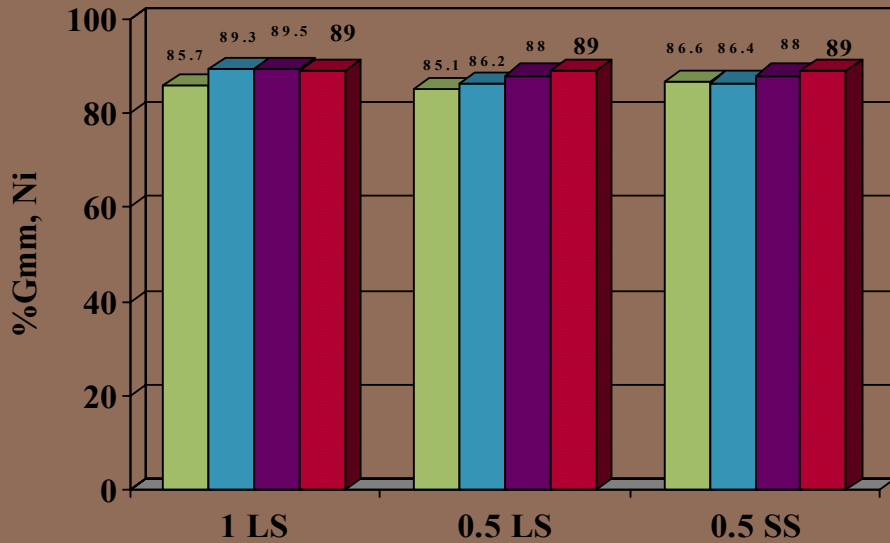
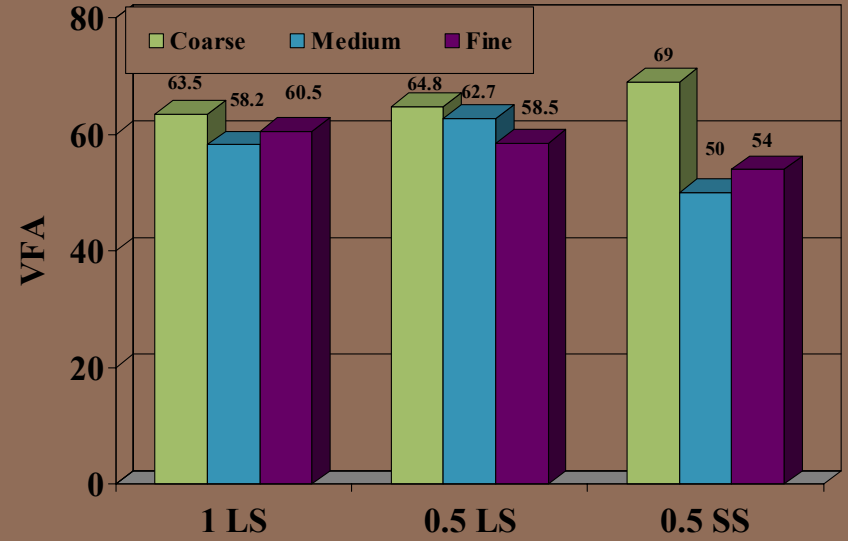
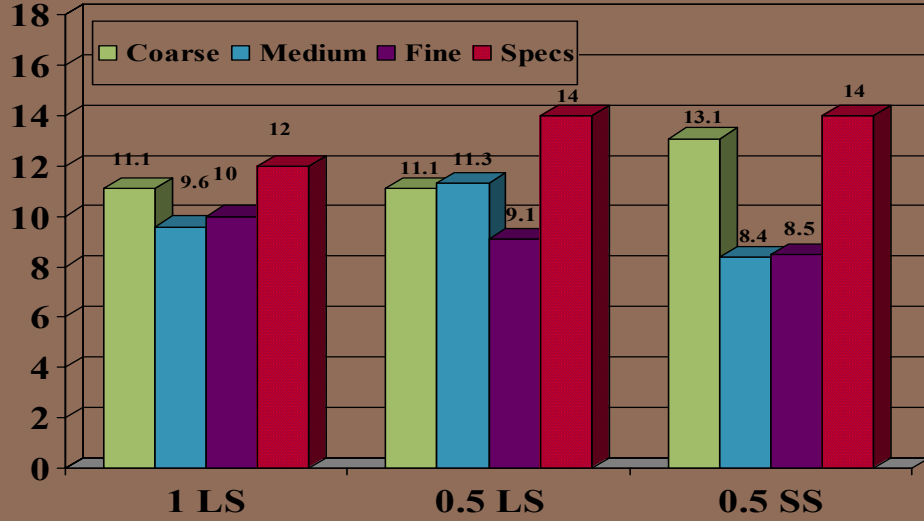
Aggregate Gradation 1/2 SS



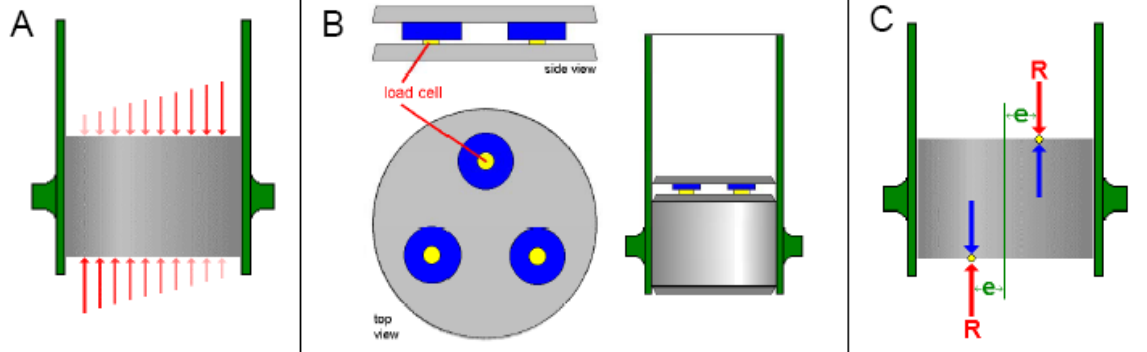
Aggregate Gradation 1" LS



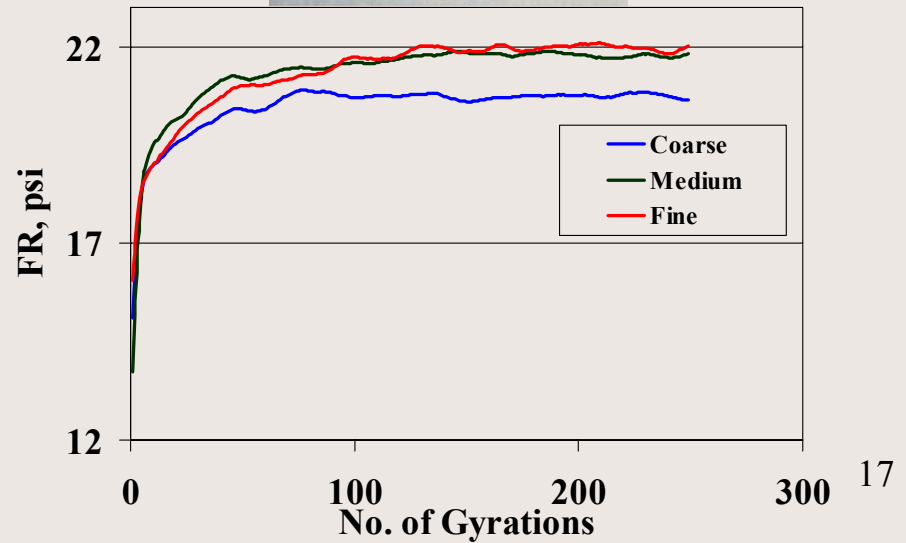
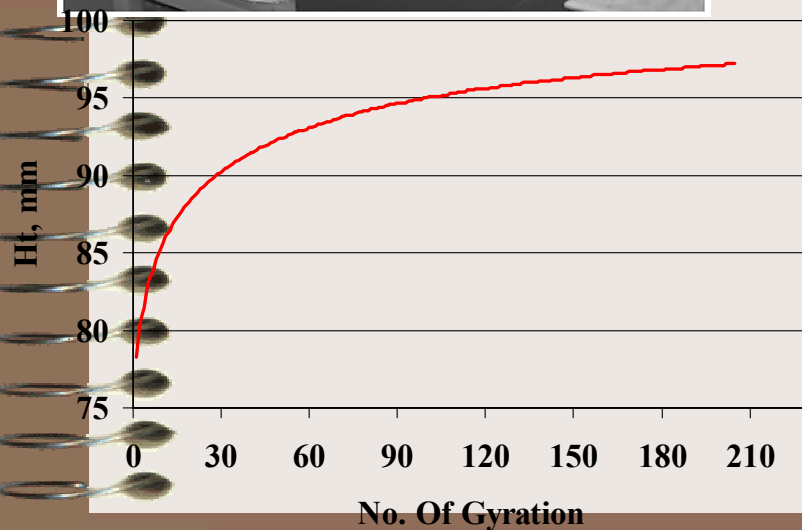
Mixture Design



SGC



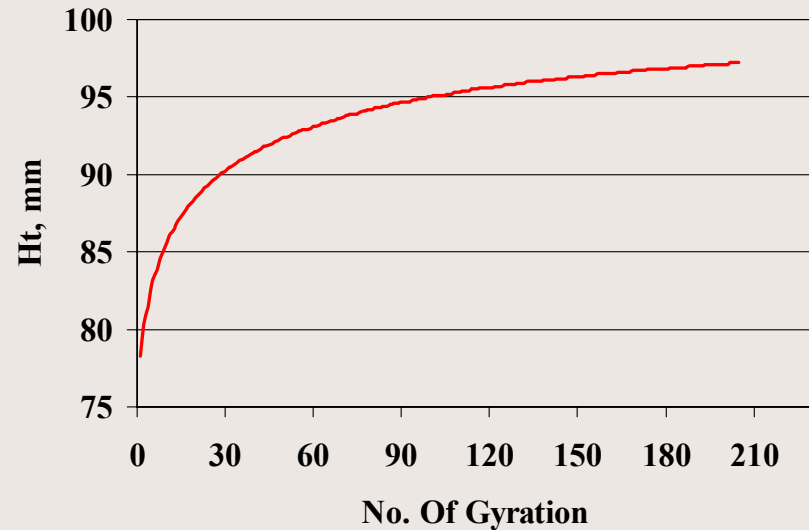
Pressure Distribution Analyzer



Superpave Gyrotory Compactor Locking Point

– Number of gyration

- Ht specimen remains constant for three consecutive gyrations



N0. Gyrations	69	70	71	72	73	74	75	76	77
Height, mm	115.7	115.7	115.6	115.6	115.5	115.5	115.4	115.4	115.4

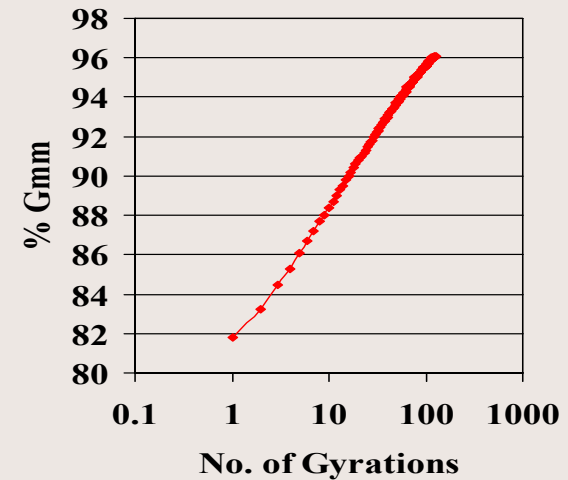
Superpave Gyrotory Compactor Locking Point

↓ Locking
Point

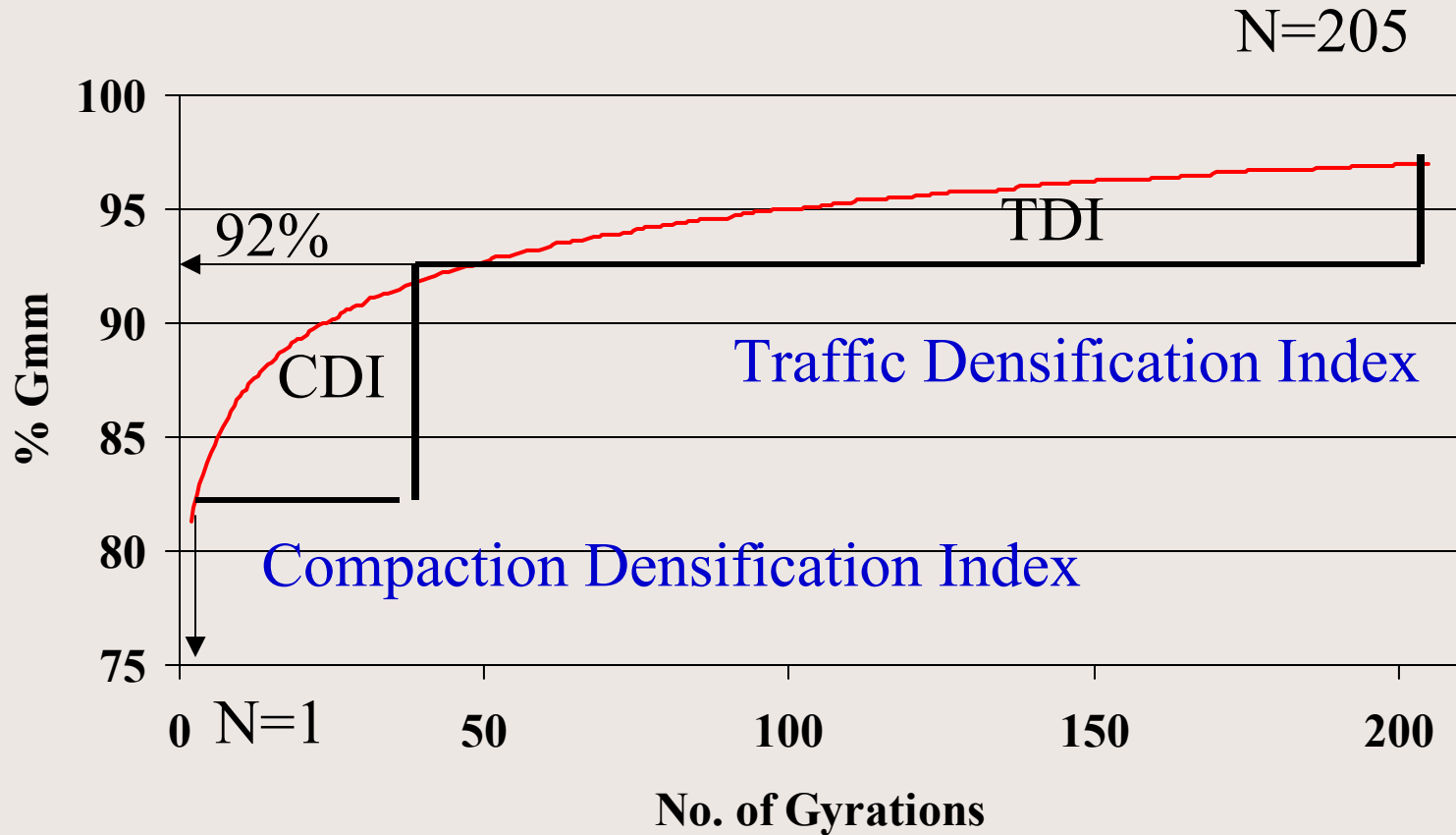
N0. Gyrations	69	70	71	72	73	74	75	76	77
Height, mm	115.7	115.7	115.6	115.6	115.5	115.5	115.4	115.4	115.4

Superpave Gyrotory Compactor Slope

$$\frac{\%Gmm@Ndes - \%Gmm@Nini}{\text{Log}(Ndes) - \text{Log}(Nini)}$$

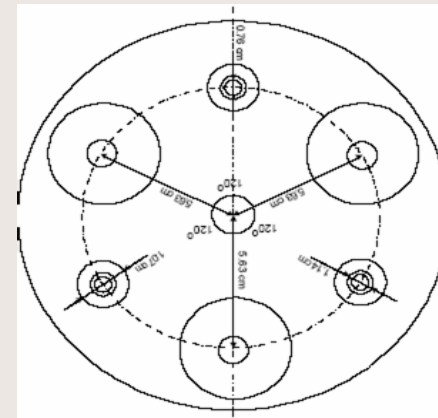


Superpave Gyratory Compactor Compaction Indices

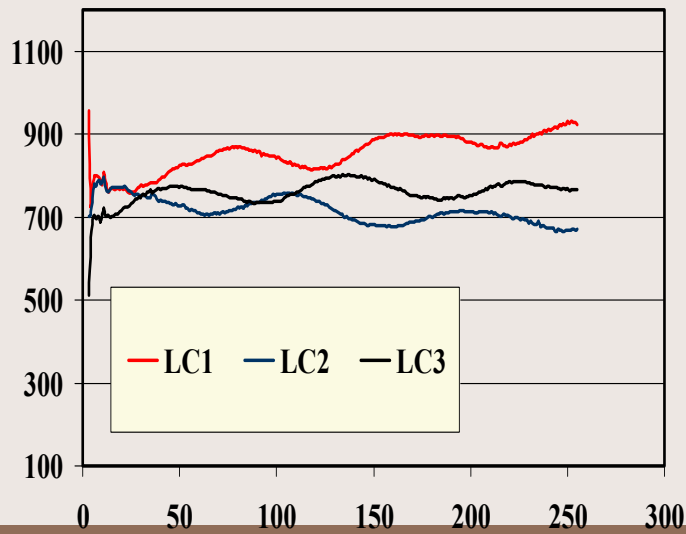


Pressure Distribution Analyzer

- Measures the frictional resistance of mixtures during compaction
- Double plate assembly with 3 load cells equally spaced on the perimeter

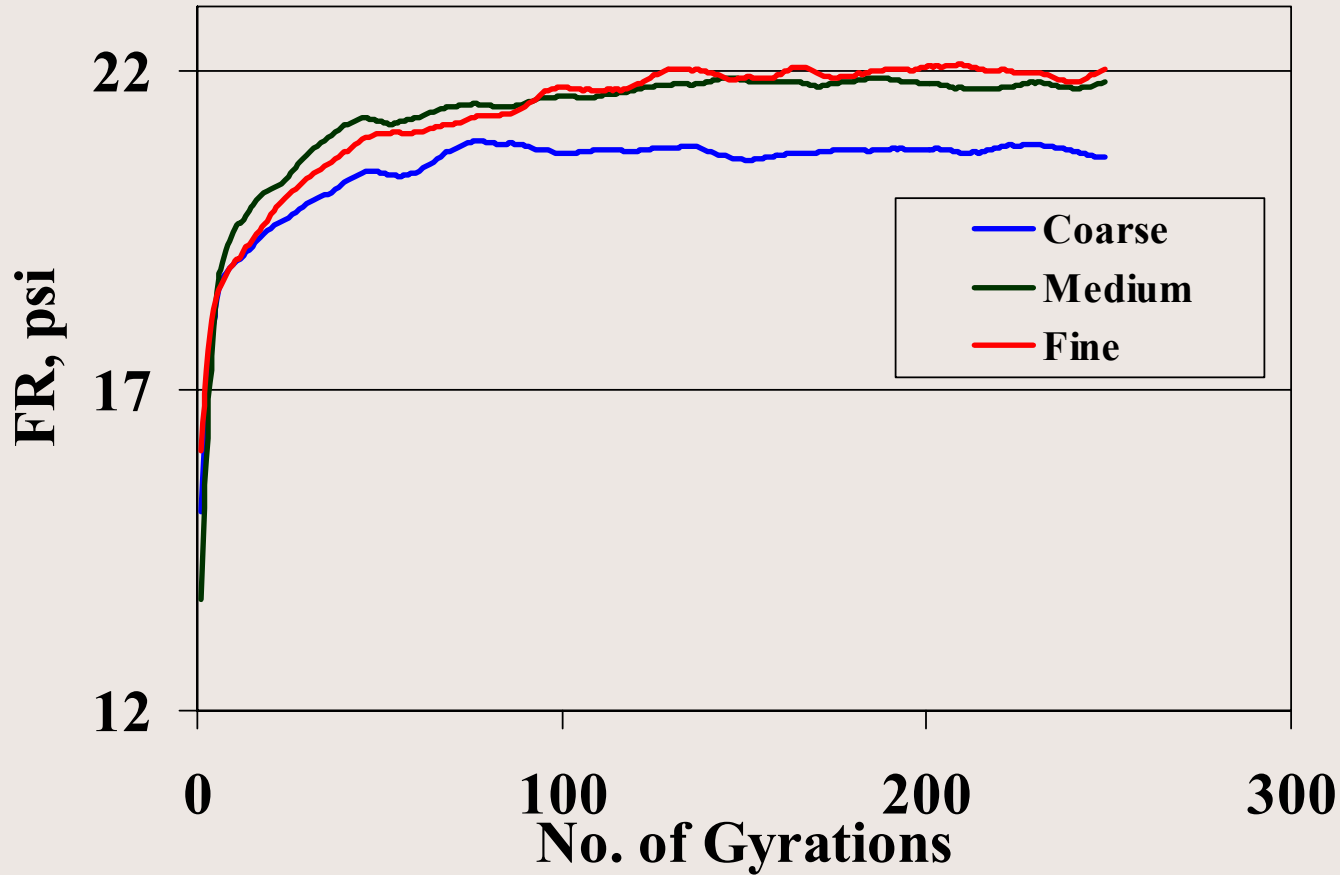


Pressure Distribution Analyzer



Pressure Distribution Analyzer

Frictional Resistance

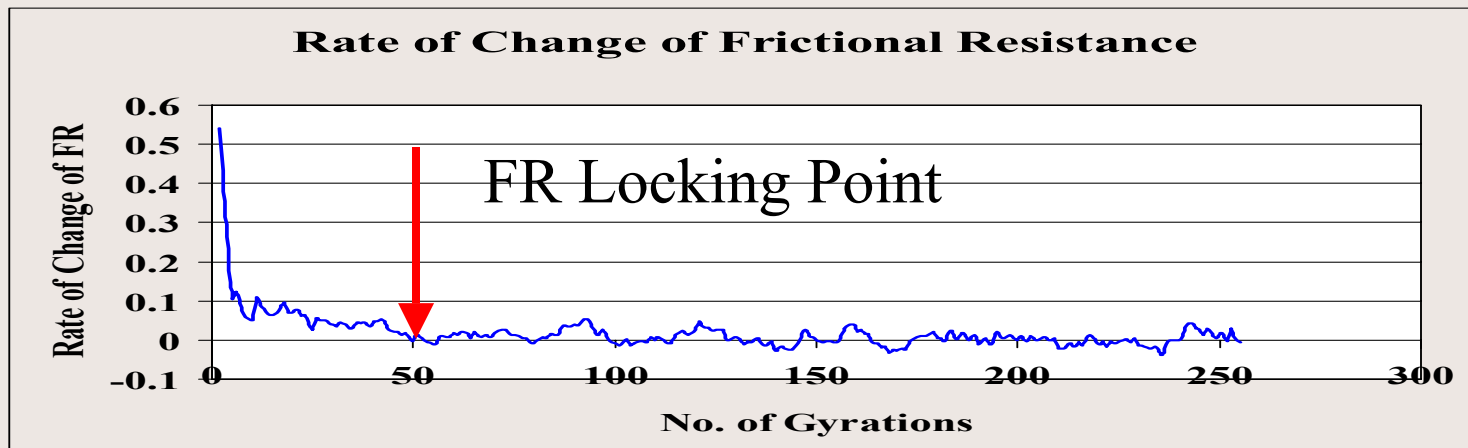
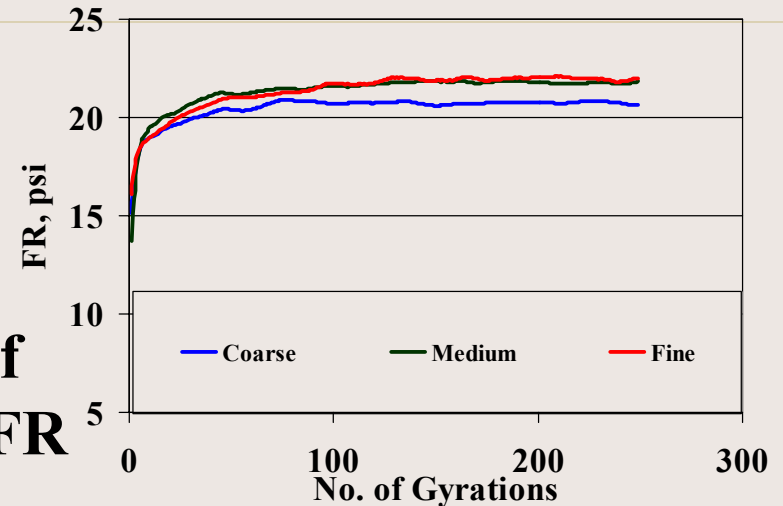


Pressure Distribution Analyzer

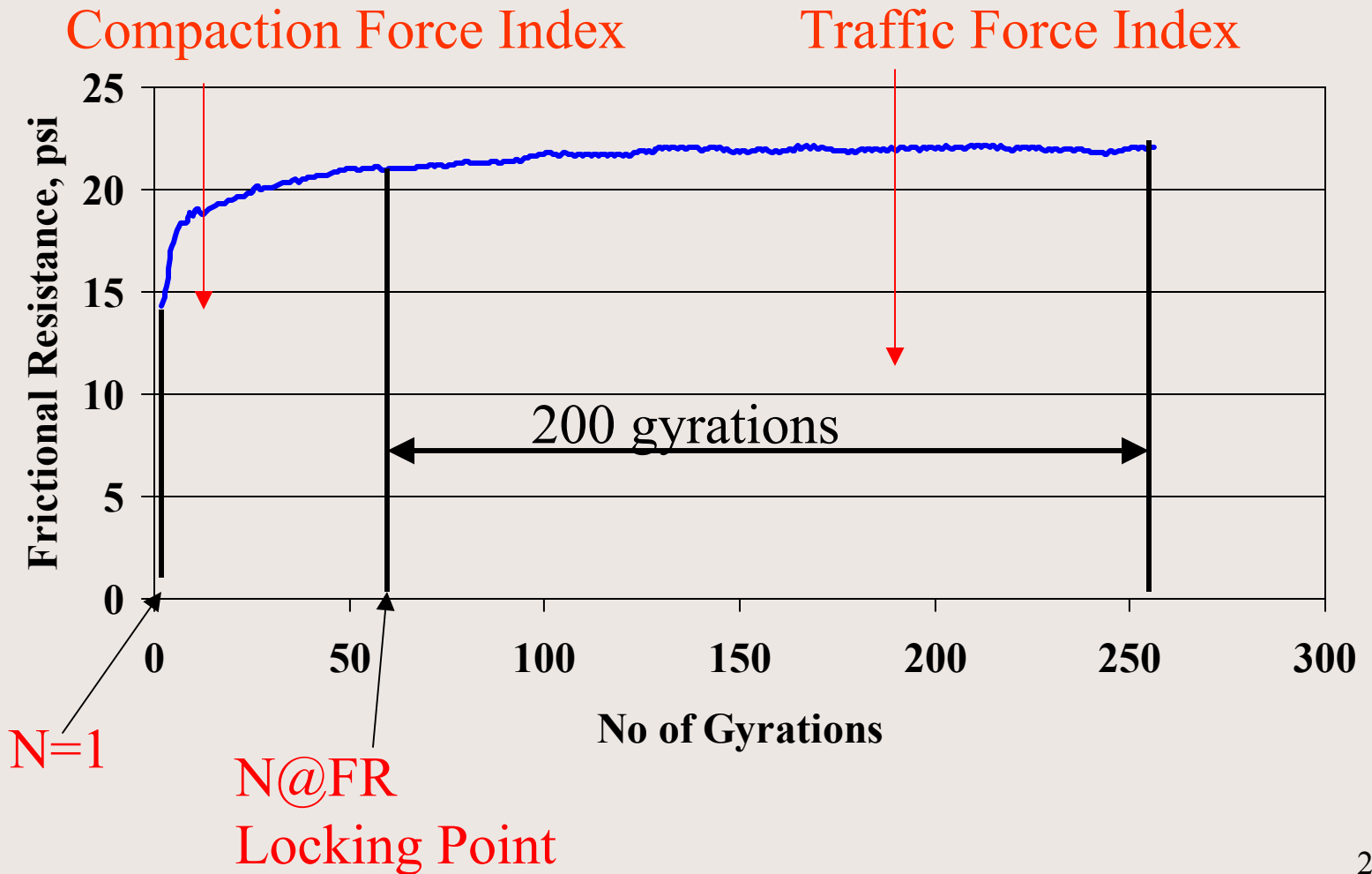
Locking Point

-Maximum interlock in the aggregate structure

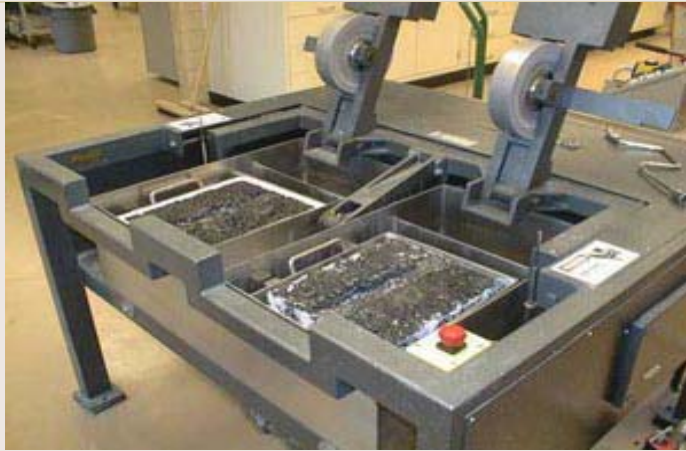
Number of gyrations corresponding to the point of minimum rate of change in FR



Pressure Distribution Analyzer Indices



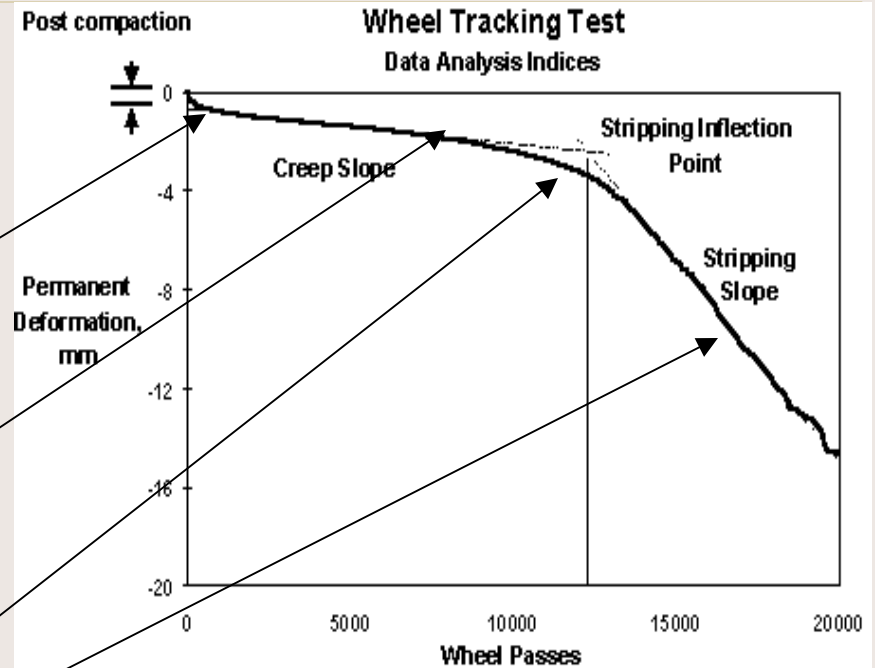
Loaded Wheel Tracking Test



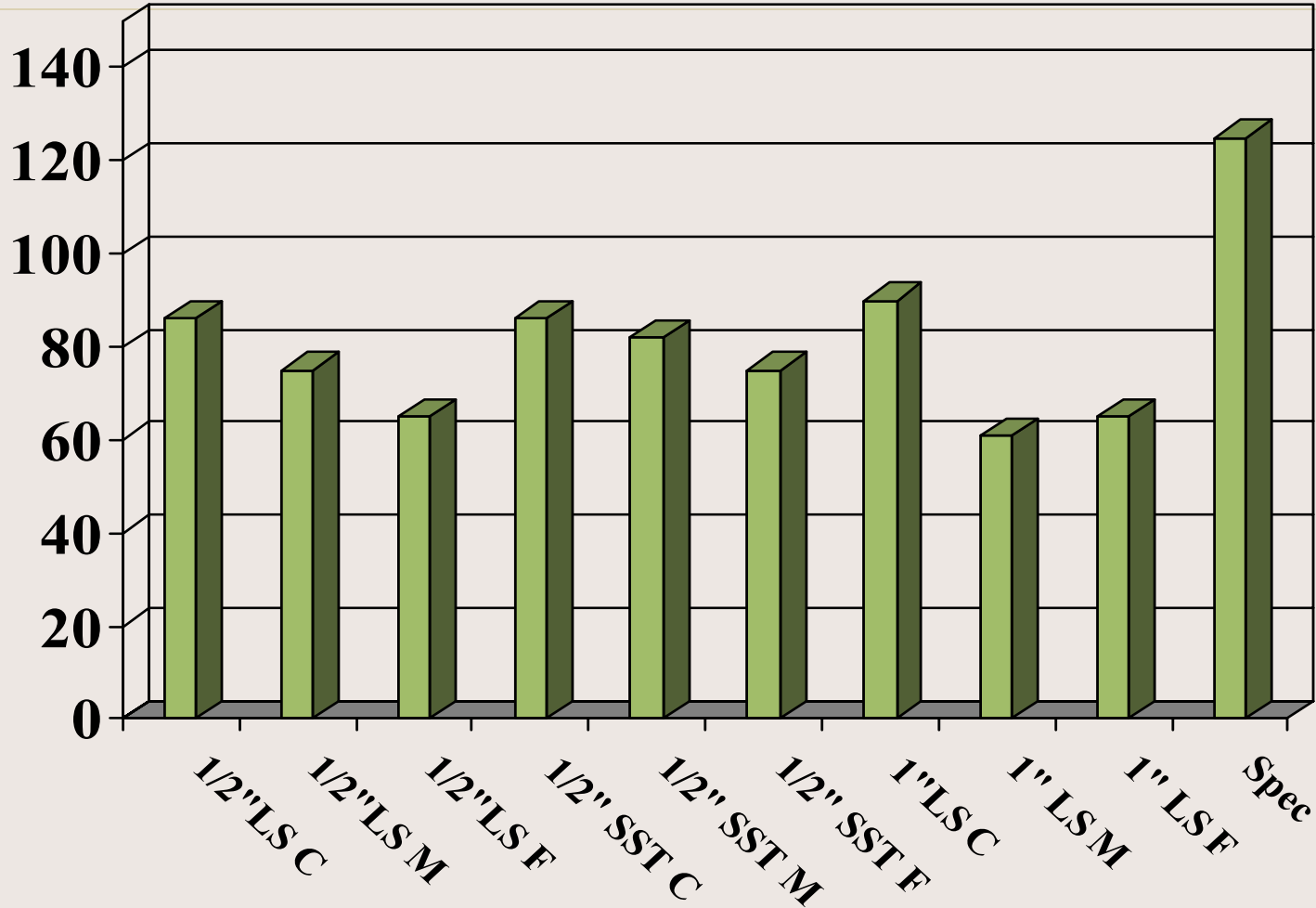
Loaded Wheel Tracking Test

Four parameters (indices) are measured from the data collected in the HWT test

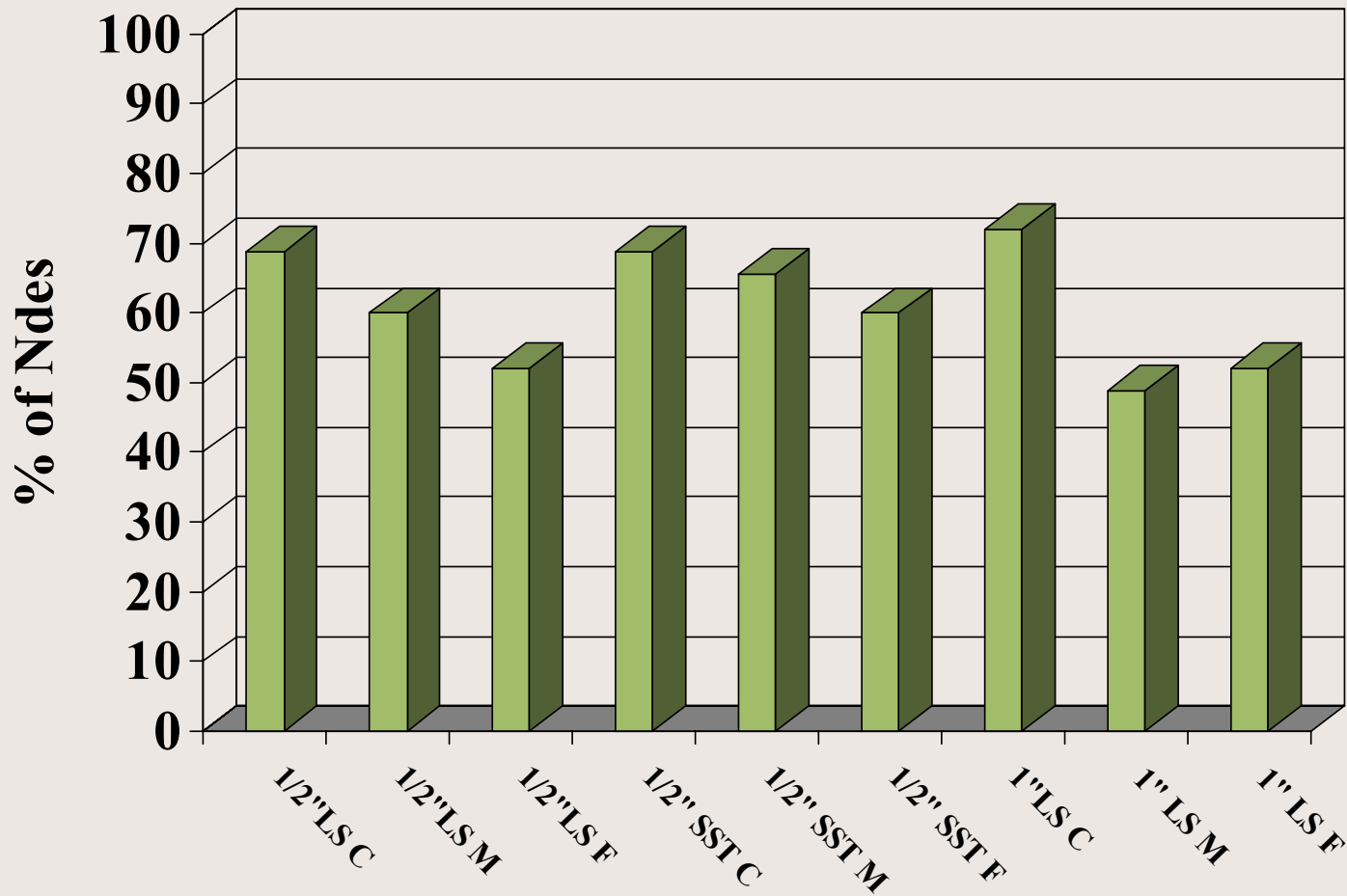
- Post Compaction Consolidation
- Inverse Creep Slope
- Stripping Inflection Point
- Stripping Slope



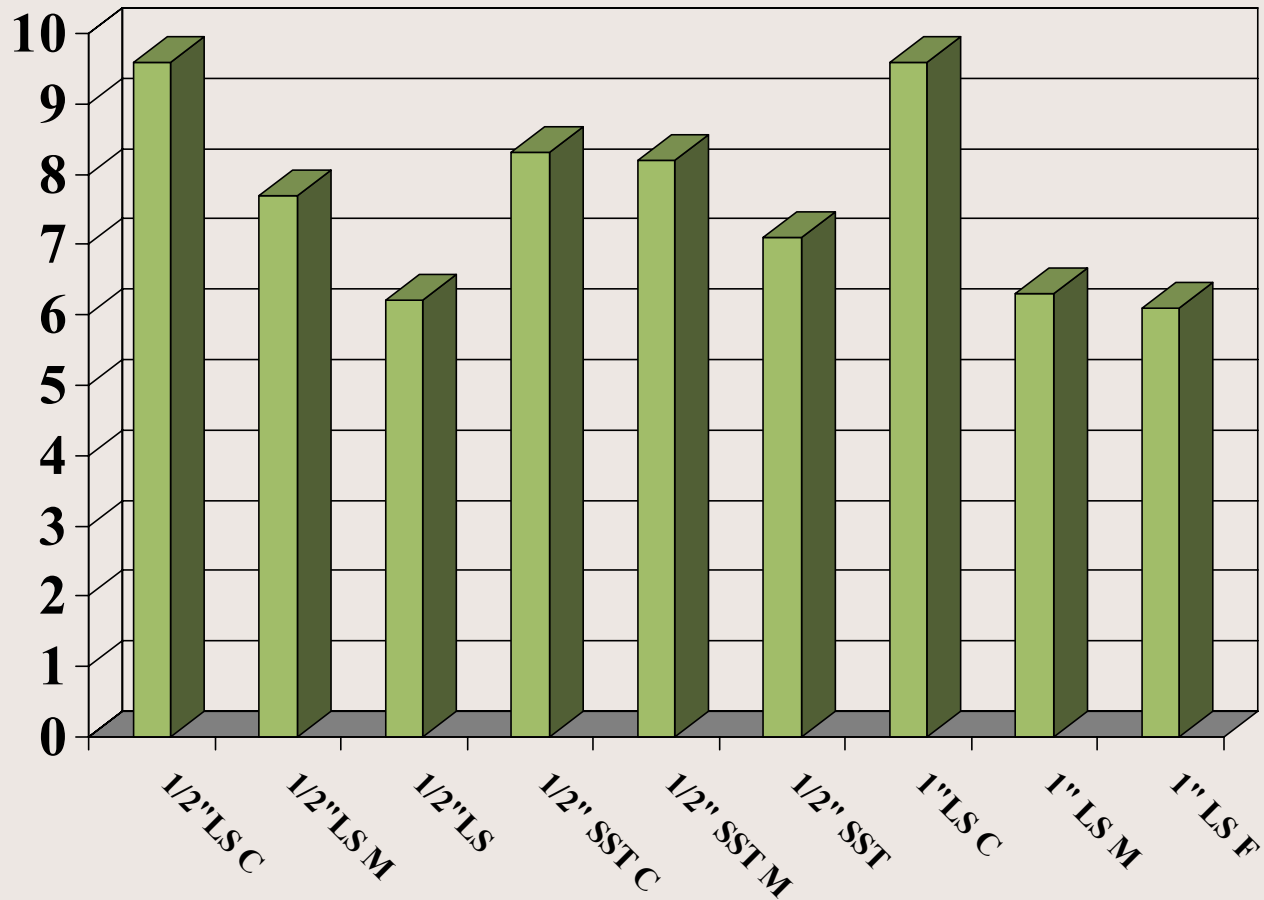
Superpave Gyratory Compactor Locking Point



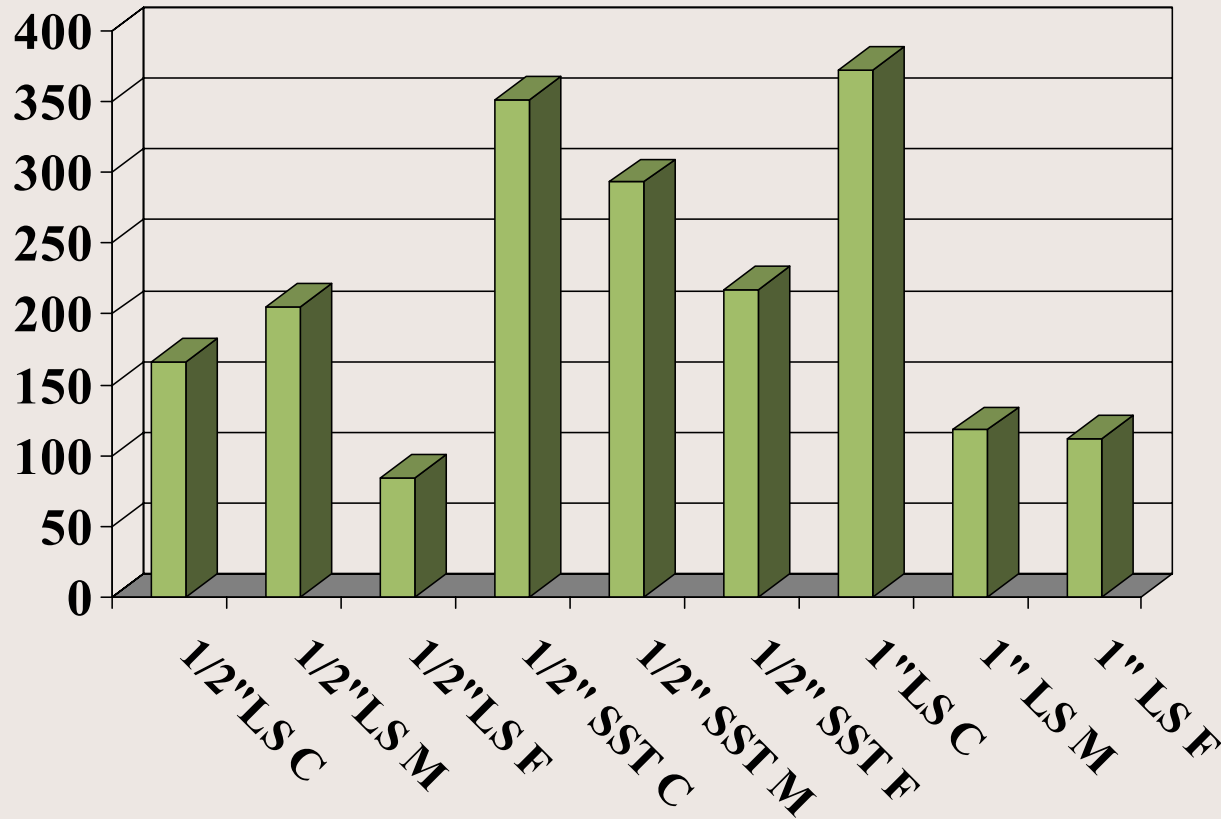
Superpave Gyrotory Compactor Locking Point



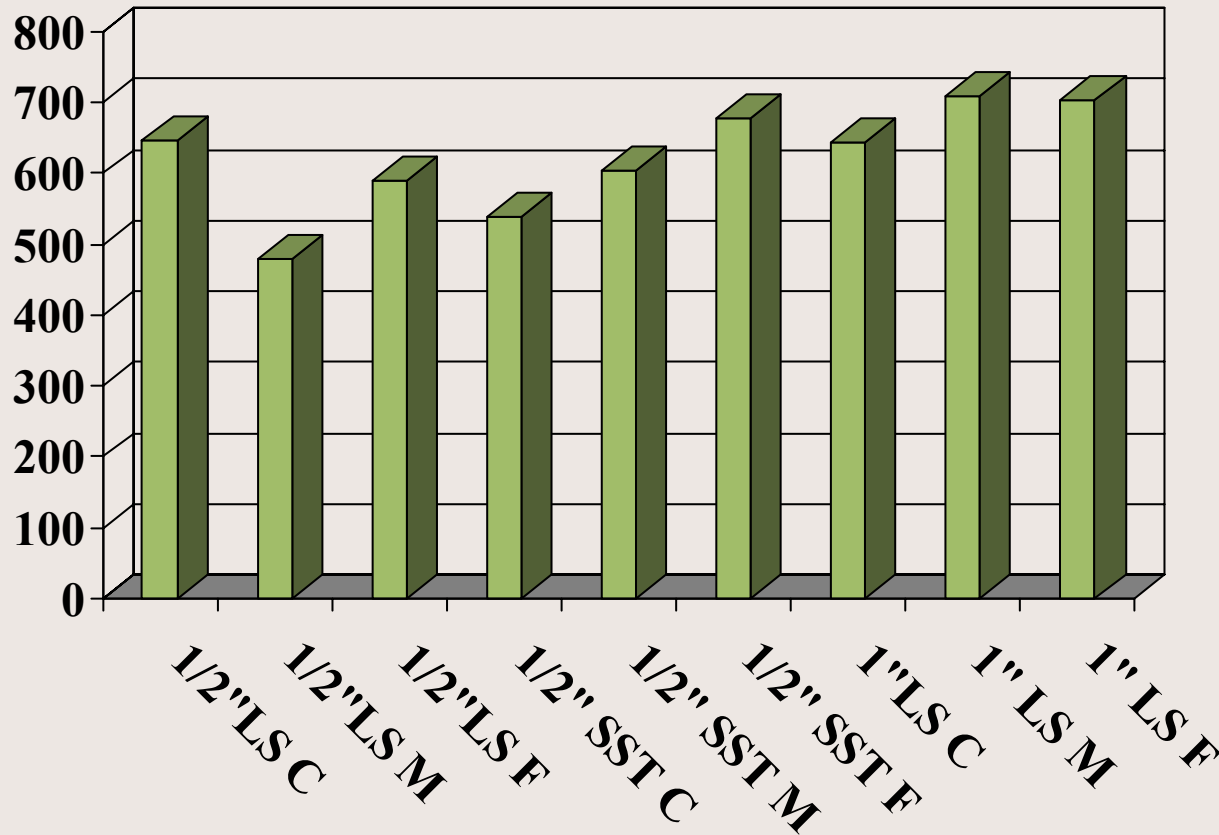
Superpave Gyrotory Compactor Compaction Slope



Superpave Gyratory Compactor Compaction Indices -- CDI

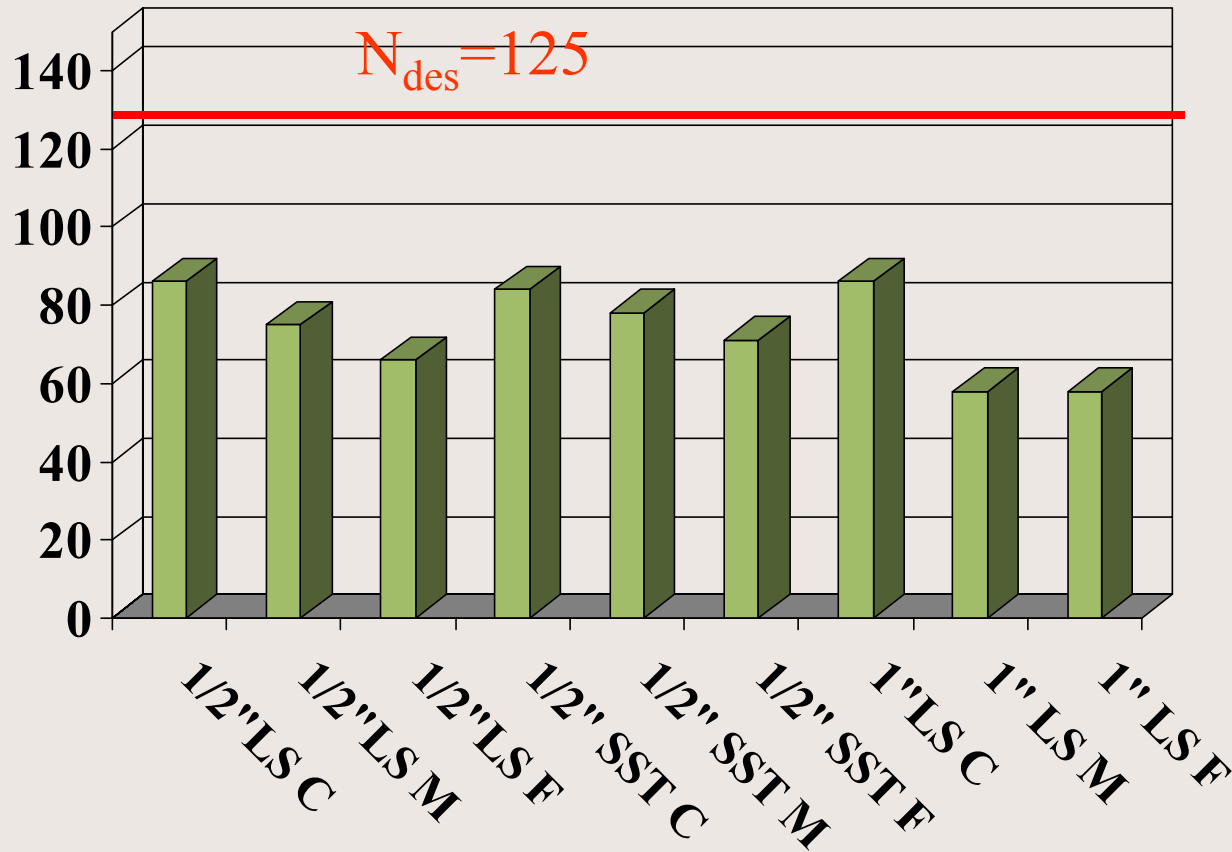


Superpave Gyrotory Compactor Compaction Indices -- TDI



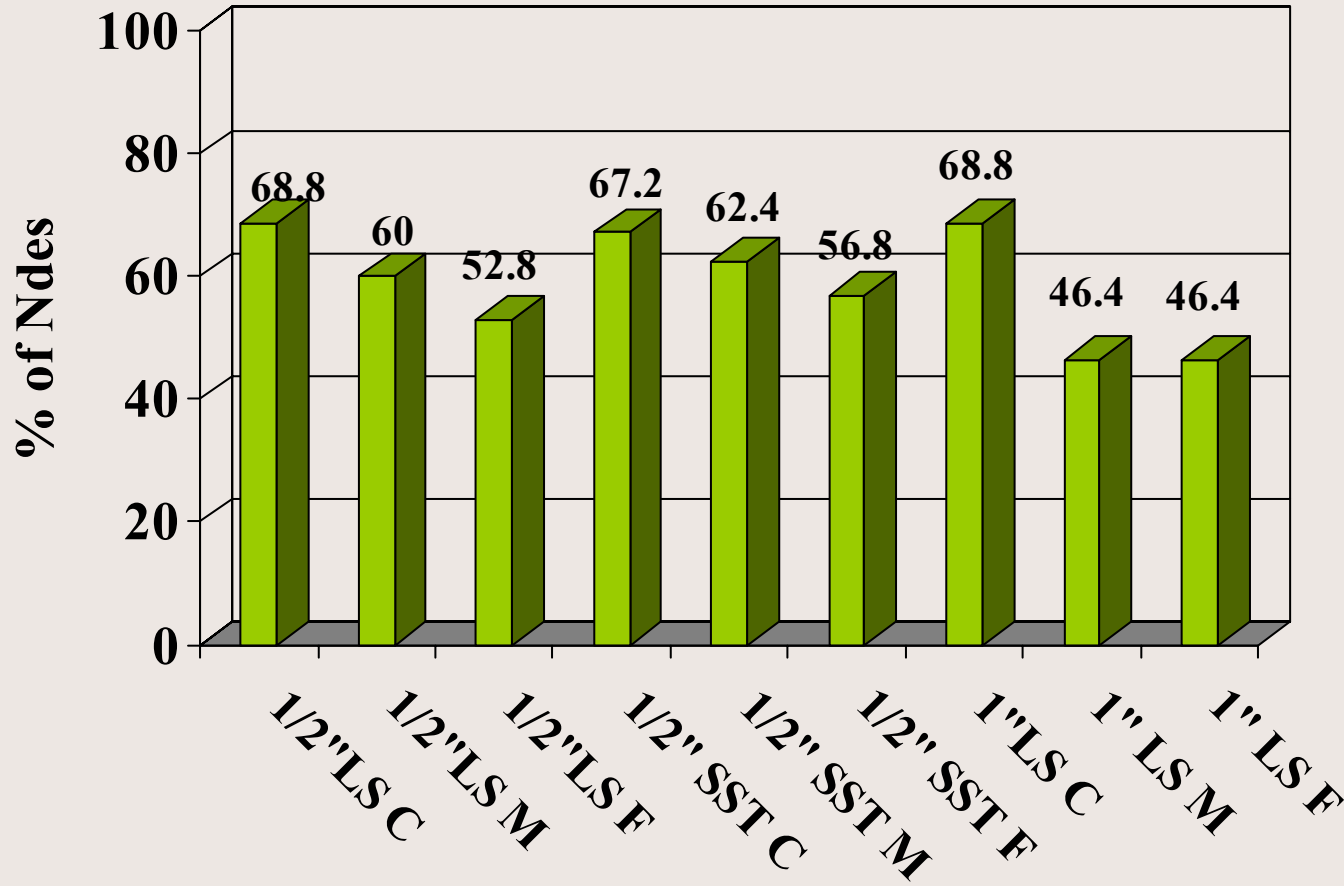
Pressure Distribution Analyzer

FR Locking Point

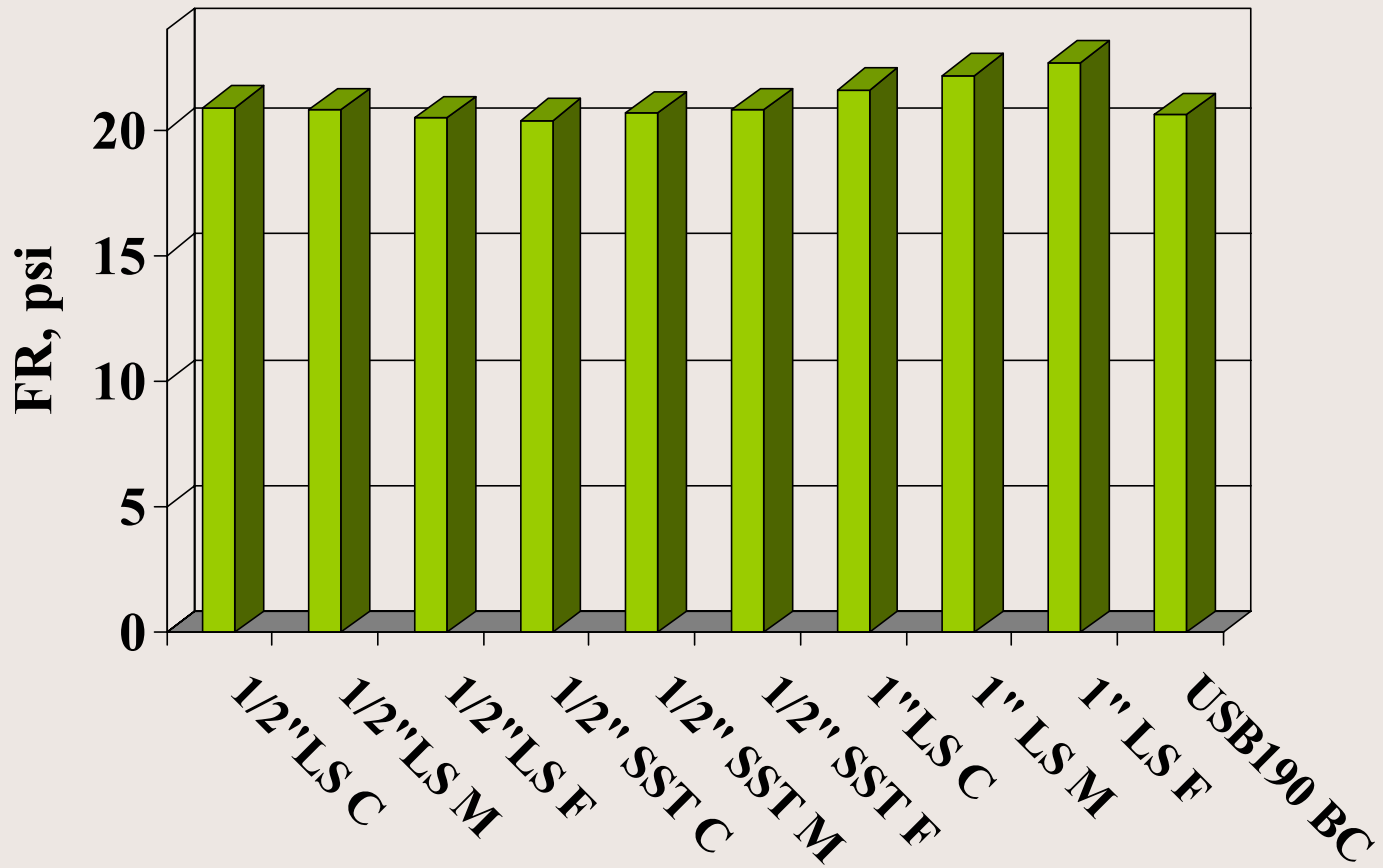


Pressure Distribution Analyzer

FR Locking Point

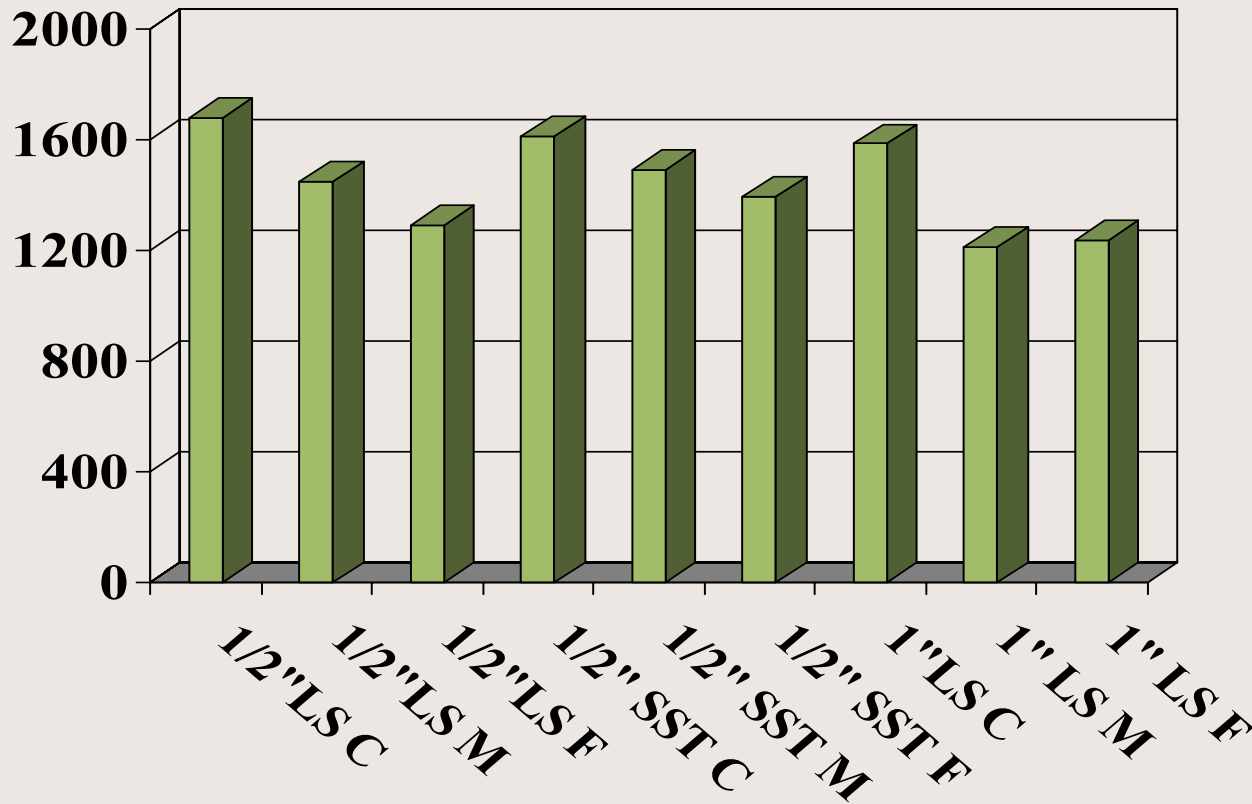


Frictional Resistance – Locking Point



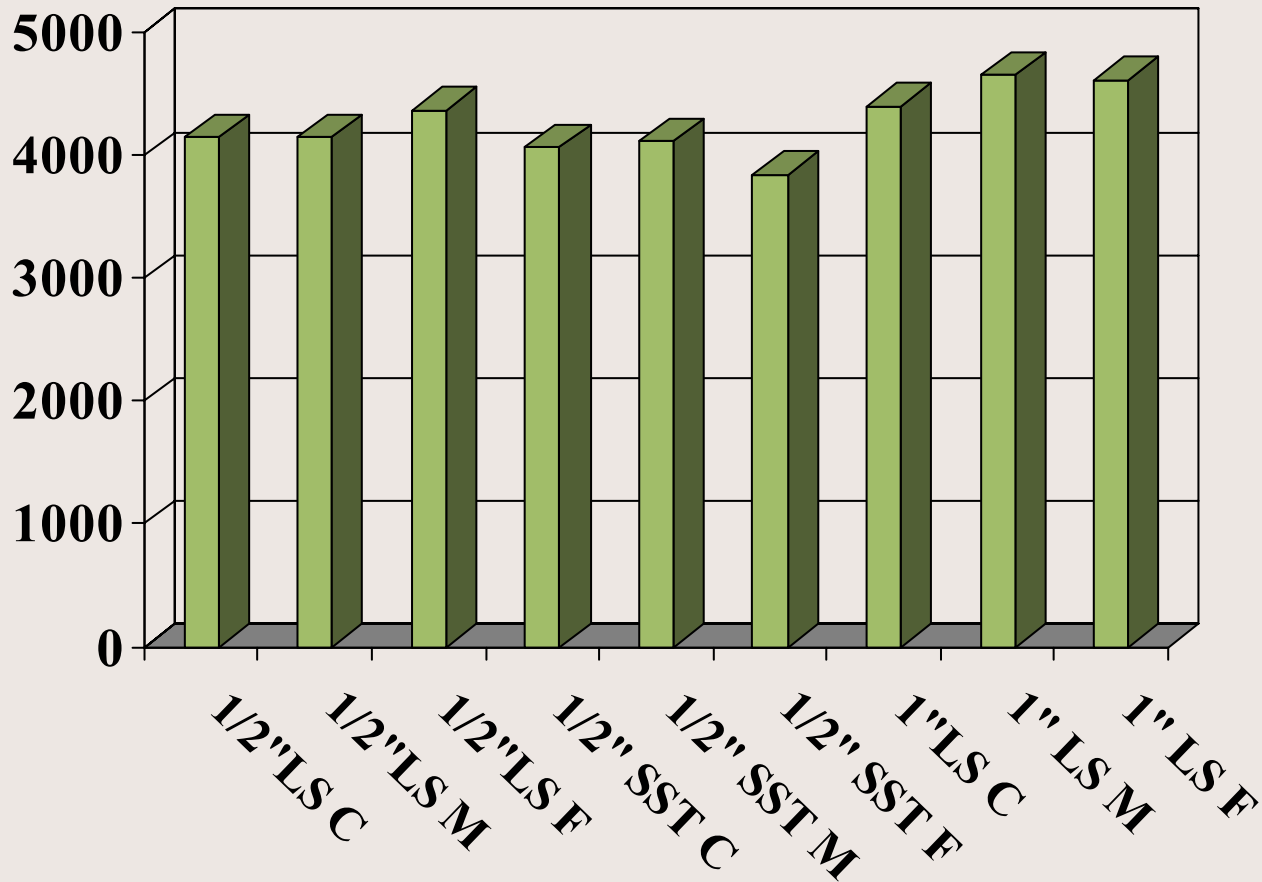
Pressure Distribution Analyzer

FR -- CFI

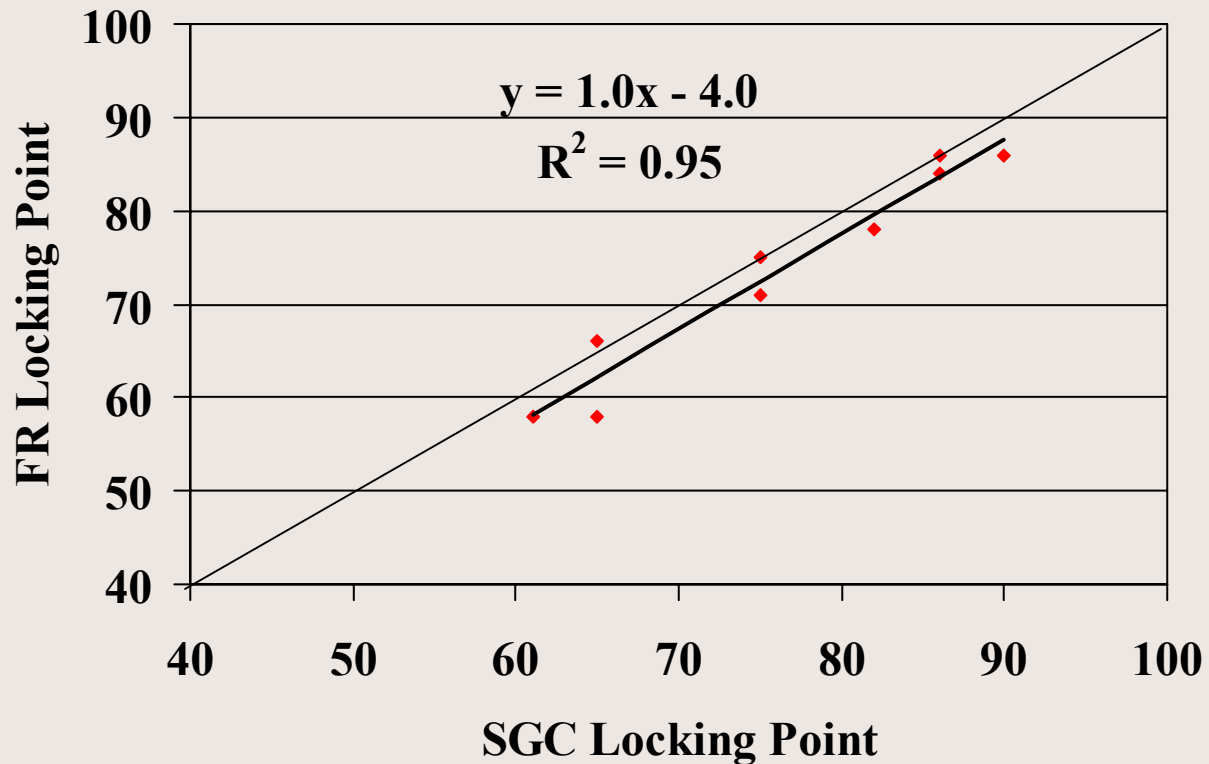


Pressure Distribution Analyzer

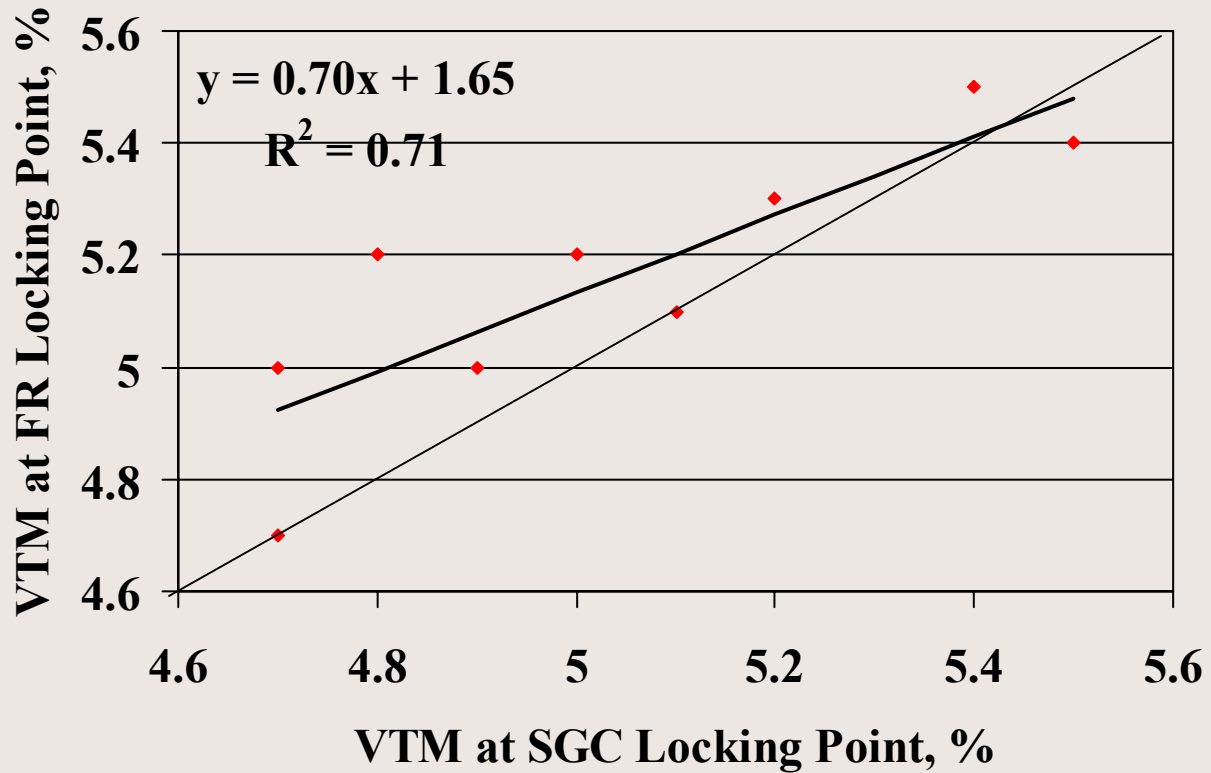
FR -- DFI



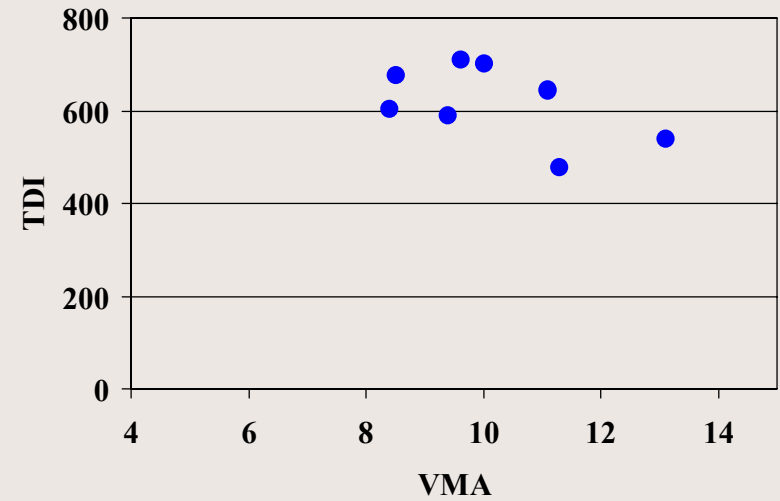
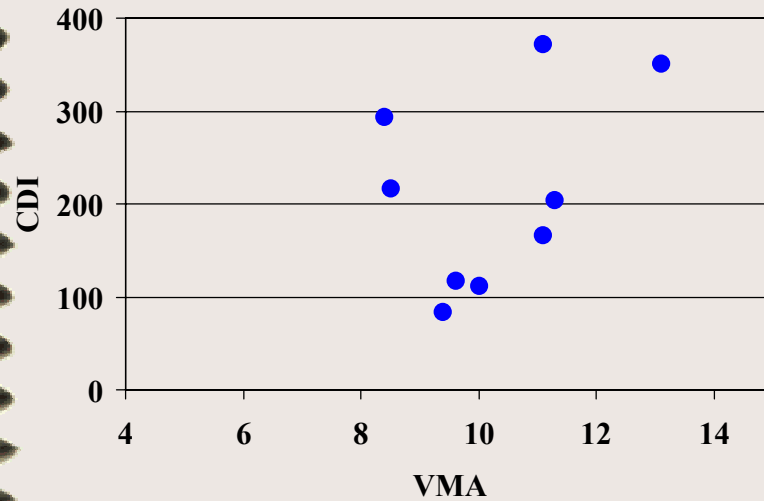
Relationship: No. of Gyration SGC LP vs. PDA LP



Relationship: VTM SGC LP vs. PDA LP



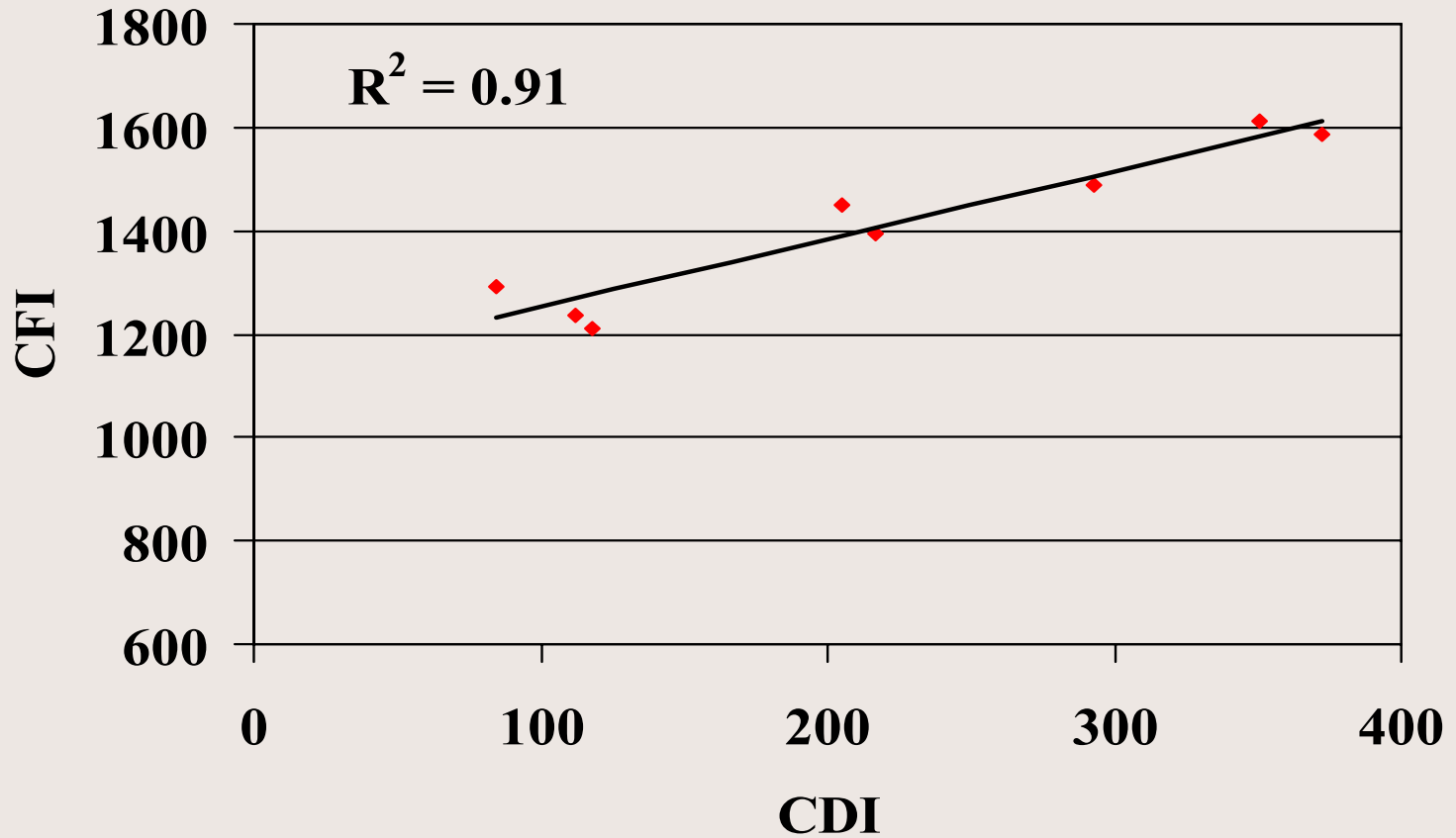
Relationship: VMA vs SGC CDI & TDI



- Trends
- Increase VMA
 - Higher CDI
 - Lower TDI
- Is there a Min. VMA?

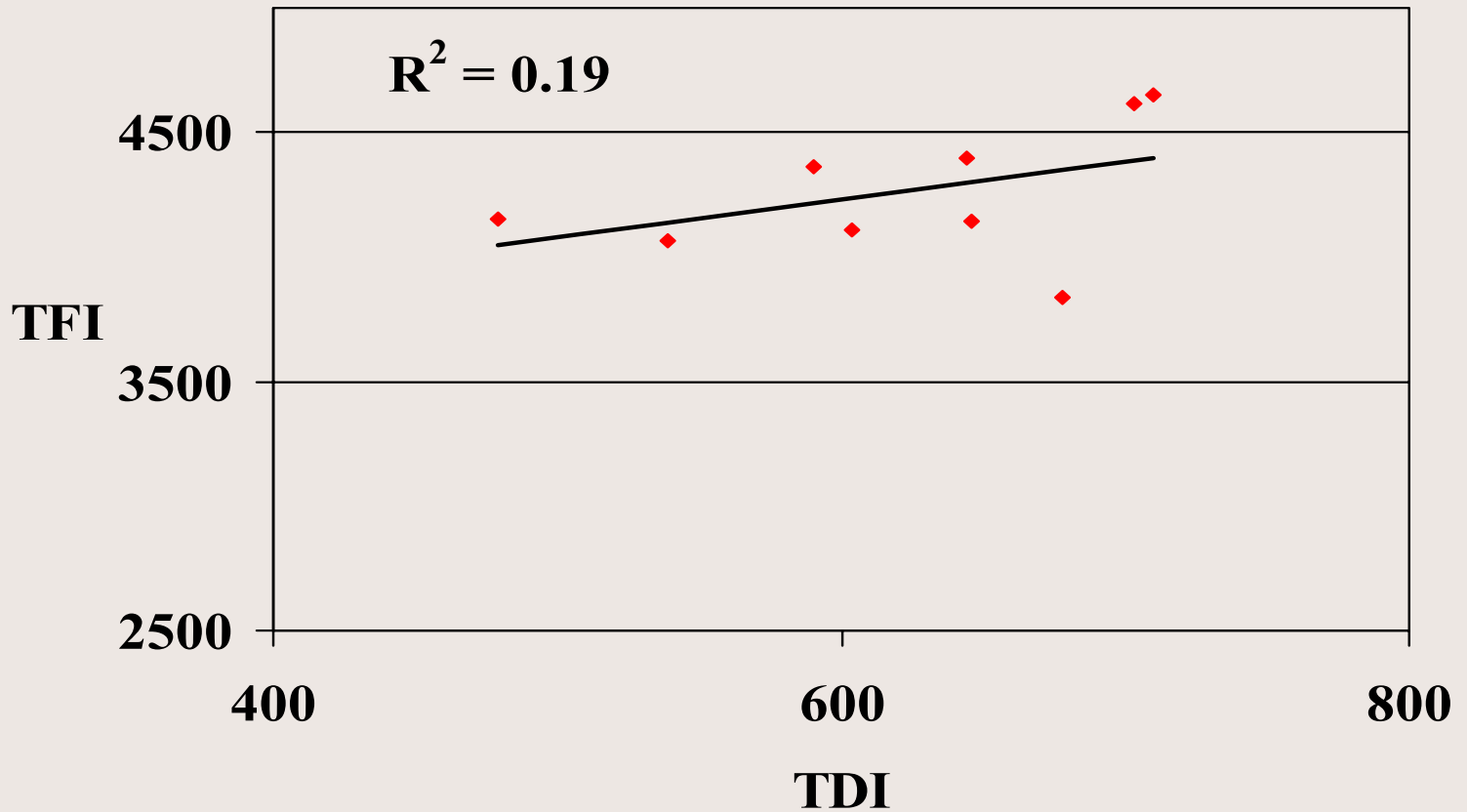
Relationship: Compaction Indices

SGC CDI vs PDA CFI

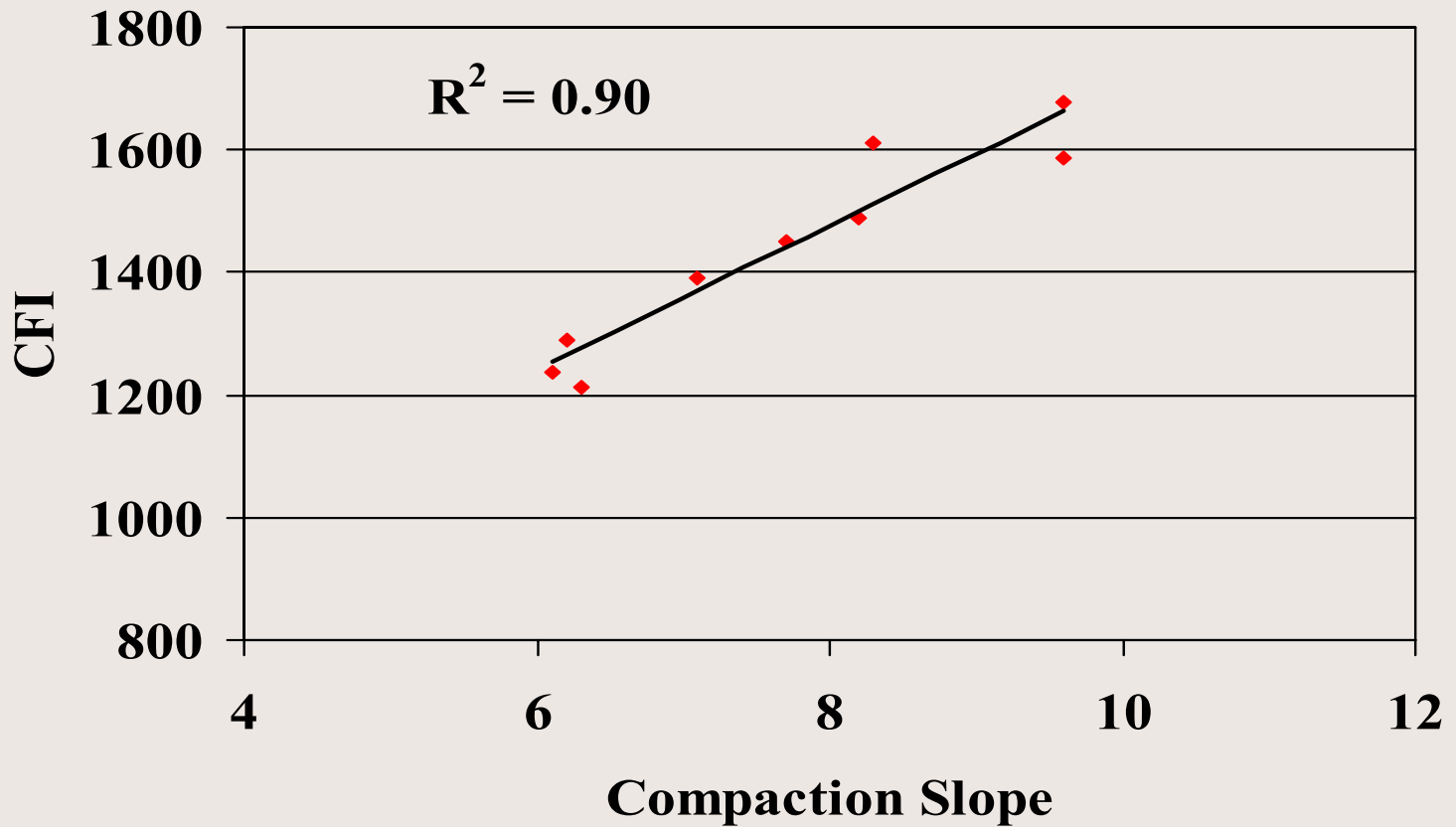


Relationship: Compaction Indices

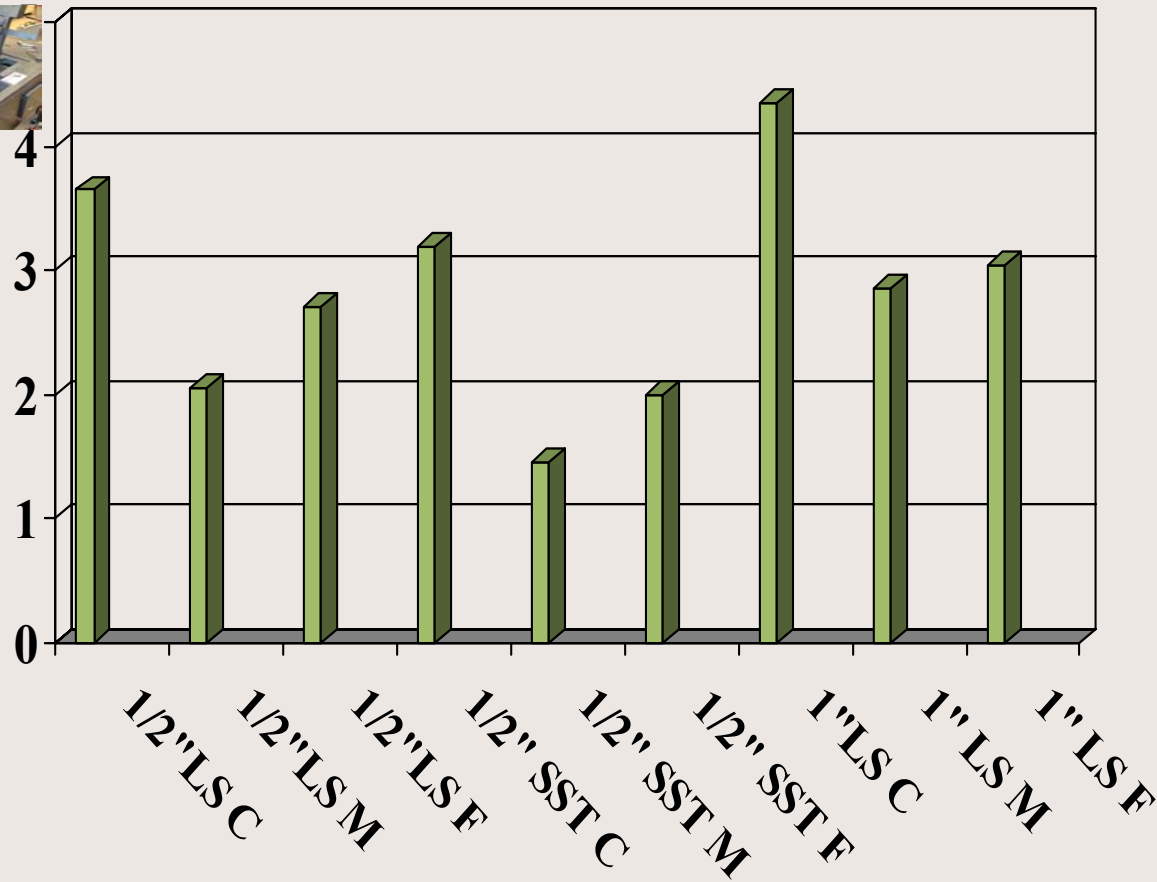
SGC TDI vs PDA TFI



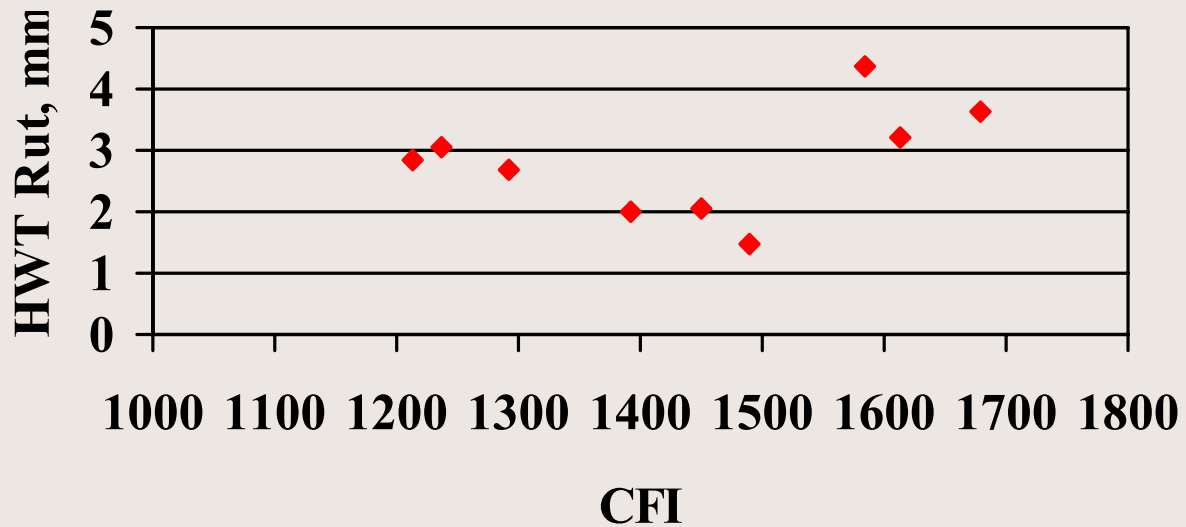
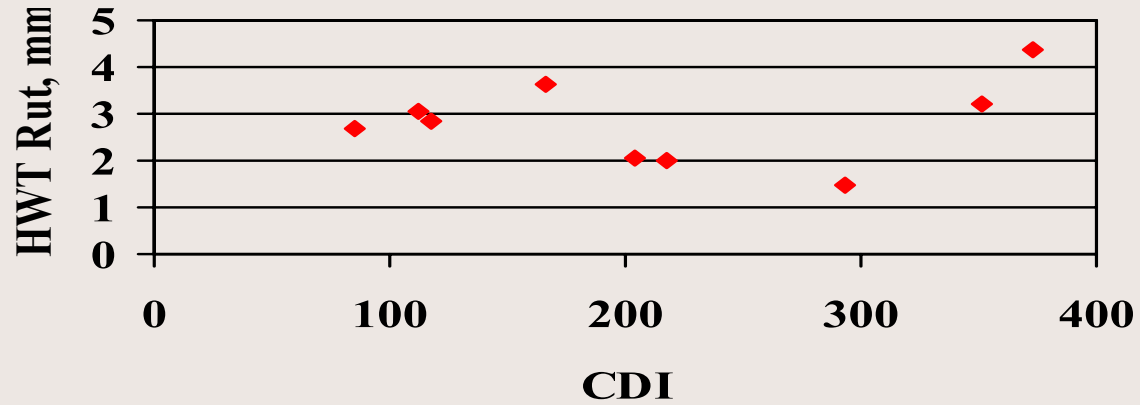
Relationship: SCG Compaction Slope vs. CFI



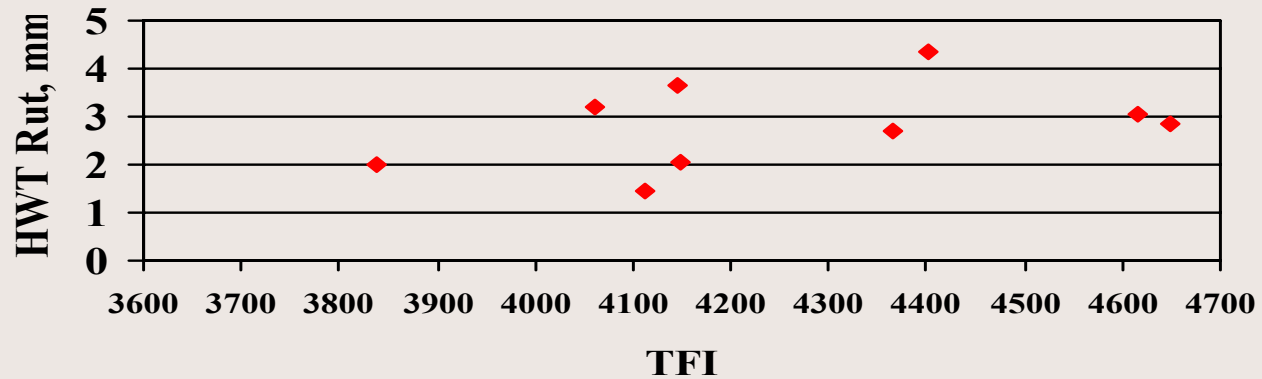
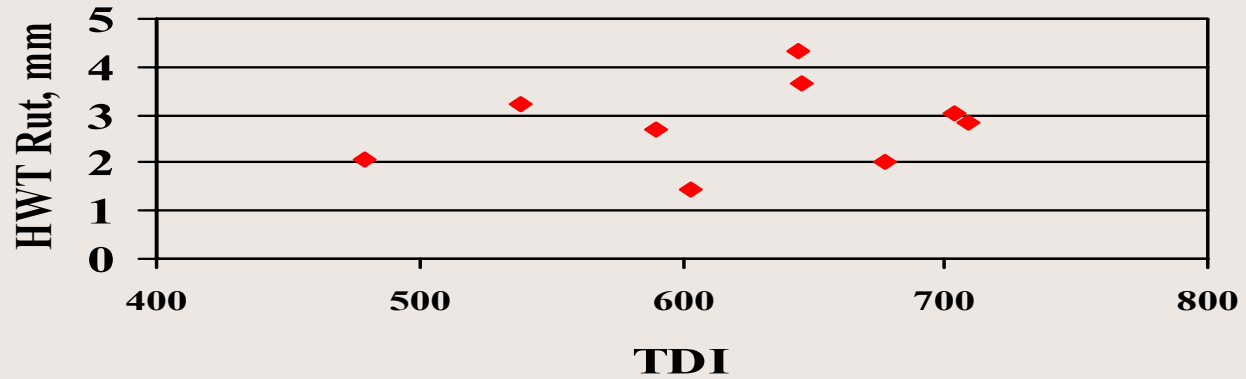
LWT Test Results



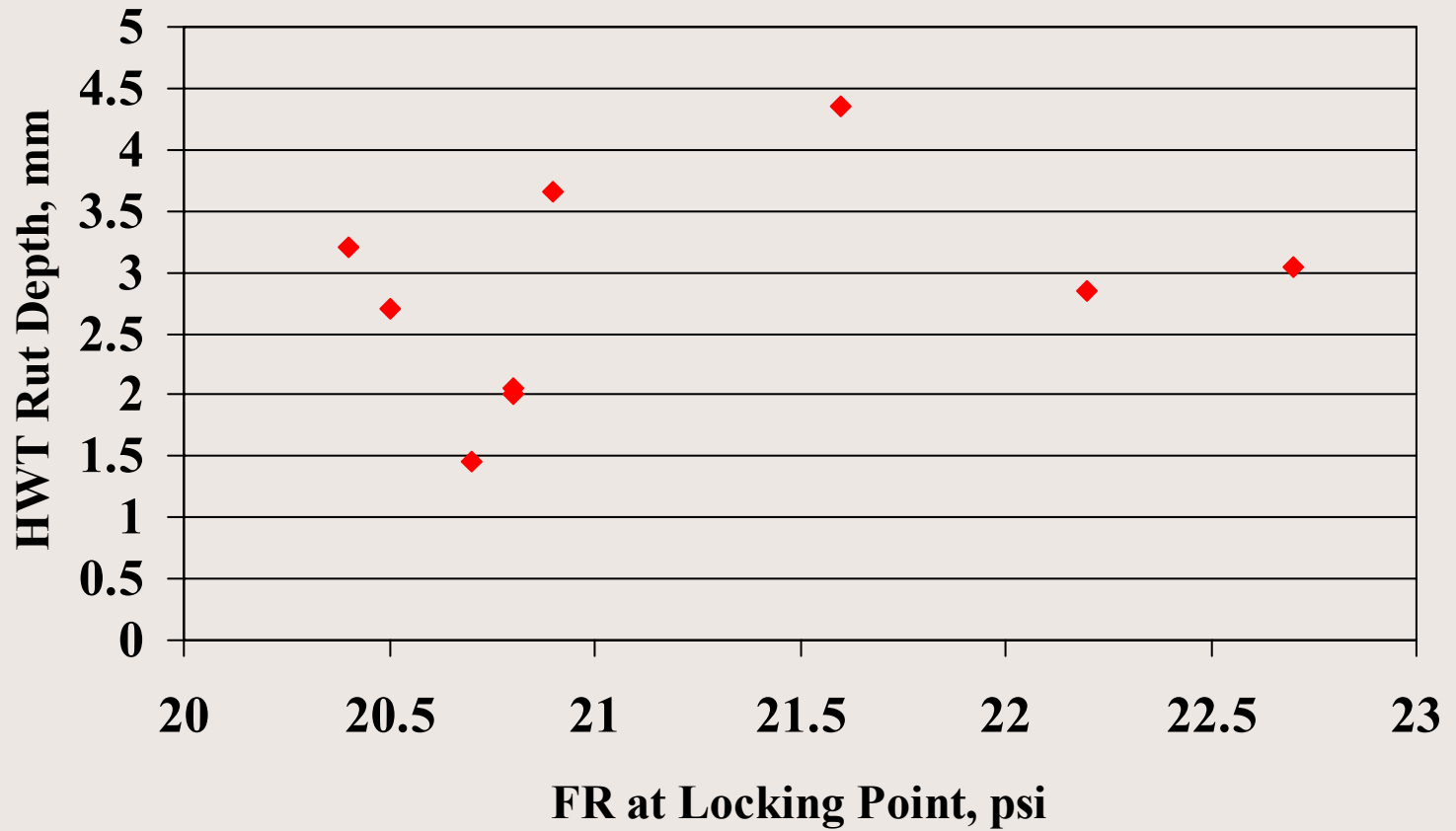
Relationship: Rut Dept vs. CDI & CFI



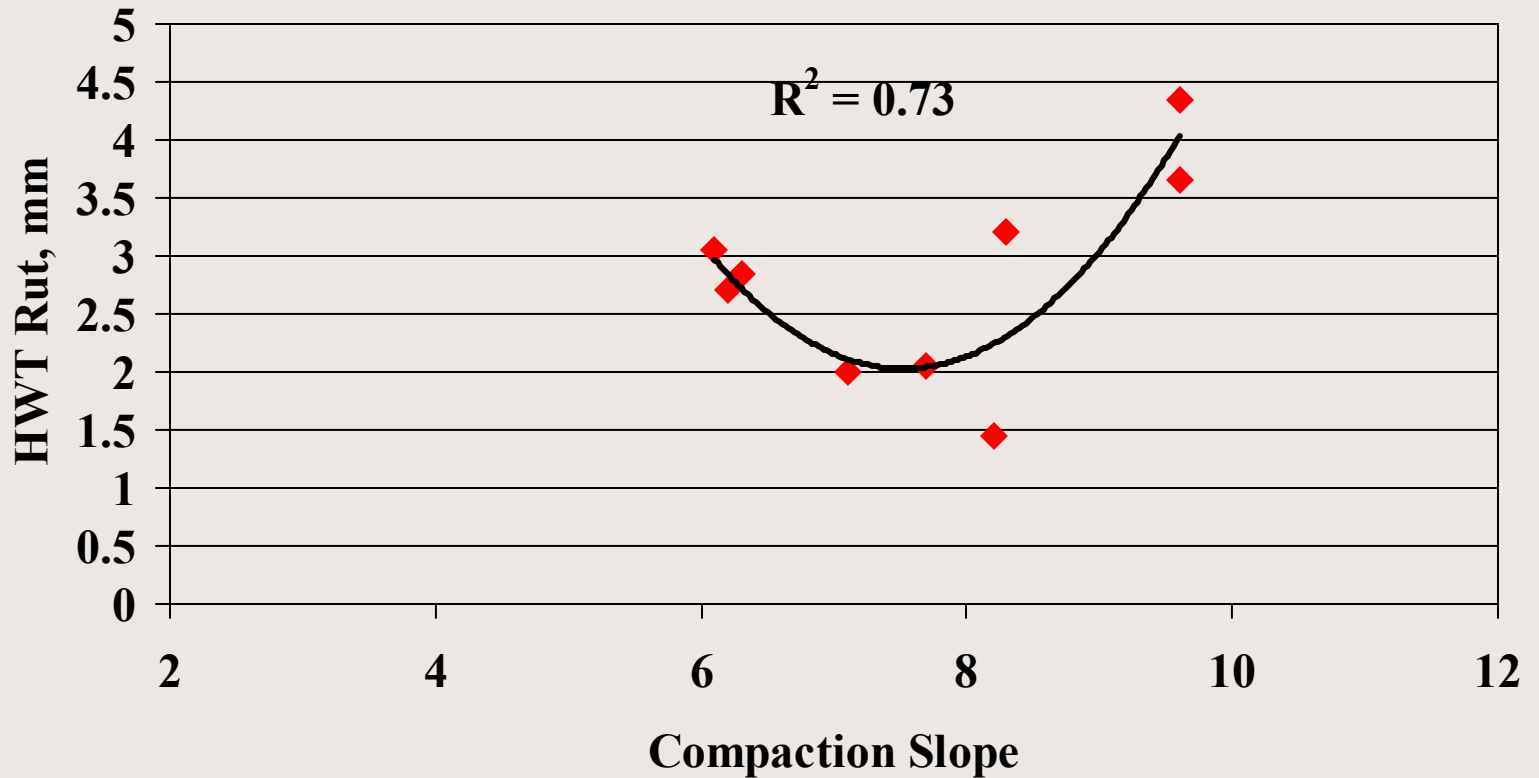
Relationship: Rut Dept vs. TDI & TFI



Relationship: Rut Depth vs. FR



Relationship: LWT Rut Depth & Compaction Slope



Conclusions

- **SGC densification curves can provide valuable information about mixtures behavior during compaction**
 - **CDI, Slope**
- **Coarse-grades mixtures had higher SGC LP**
 - **50% - 70% of N_{design}**
- **Coarse-grades mixtures had higher Compaction Slope:**
 - **6-10**
- **SGC CDI and PDA CFI indices were higher for Coarse-grades mixtures**
- **PDA measured LP showed similar ranking as SGC LP**
 - **Lower**
- **FR increased with an increased in the NMS**

Conclusions

- **Good correlation was observed B/W**
 - SGC LP and PDA LP
 - SGC CDI and PDA CFI
 - SGC Slope and CDI
 - SGC Slope and LWT rut depth
- **Poor correlation was observed B/W**
 - SGC TDI and PDA TFI
- **Mixtures evaluated performed well in the LWT**

A silver metal spiral binding is visible on the left side of the page, winding through a series of holes in the paper.

Thank You