



How to Use Recycled Foundry Sand in *Hot Mix Asphalt (HMA)*

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Foundry Sand Recycling Forum
“Foundry Sand in Infrastructure Applications”

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Overview of Talk

- Introduction: Why use these sands?
- What are the Important properties of Sands ?
 - Foundry sands can vary by metals and molding binder systems
 - Gradations, Angularity, Clay and Organic Contents
 - Range in Properties measured
- Can sands result in acceptable Asphalt Mixtures?
 - Studies completed
 - Effects on durability , constructibility, traffic resistance
 - Moisture effects
 - Guidelines for use
- Questions





Introduction

Why use these sands?

- For Asphalt **contractors**:
 - Natural aggregates are becoming more scarce.
 - More energy/money needed to extract natural aggregates.
 - In some areas fine aggregates are not available.





Sands can be Variable based on Source (Metal + Binder)

- Properties of sands can vary by
 - Metal type
 - Binder system used
- DOE project- Most **comprehensive study**:
 - Metal Poured (8 Metals)
 - Binder System (10 Systems)
 - Data base can be used as a guide





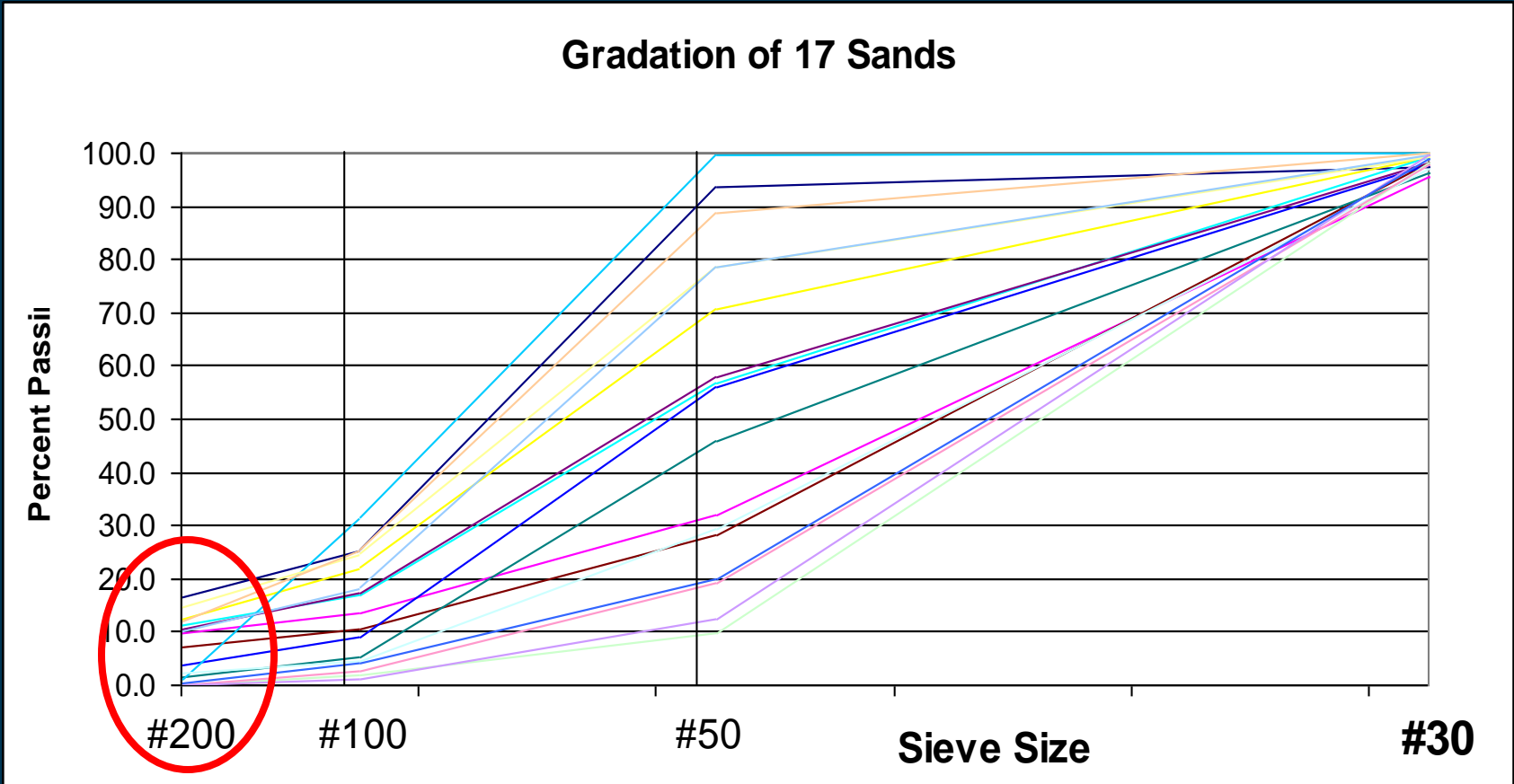
What are the Important Properties of Sands for Hot Mix Asphalt Application

- **Important properties** are:
 - Gradation
 - Densities: Maximum, Effective and Bulk
 - Angularity
 - Organic Content
 - Clay Content





Gradation- Size Distribution

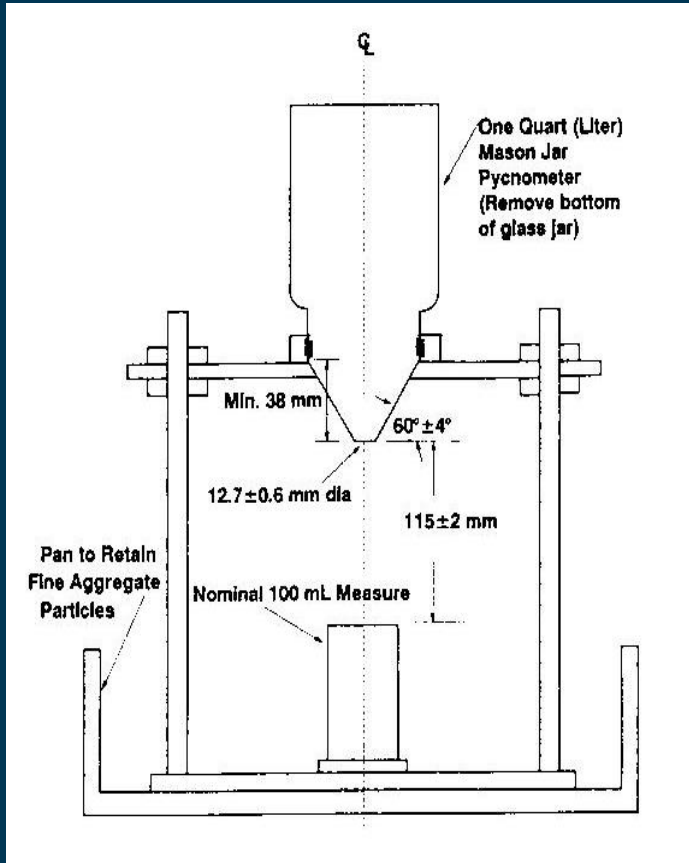


It can be seen that the gradation varies widely, so it can't be assumed that foundry sands have the same gradation.





Angularity

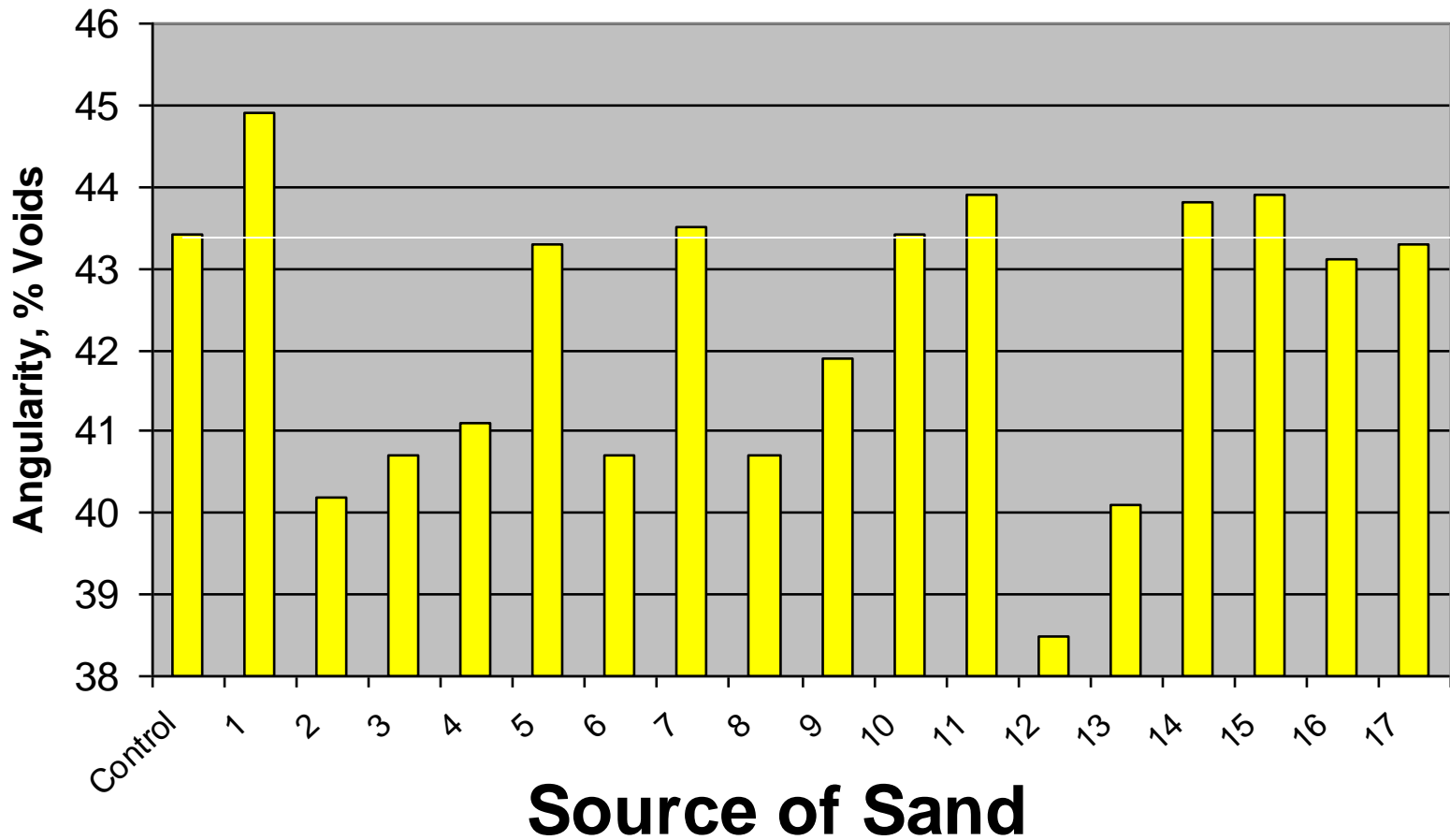


ASTM C1252 “Un-compacted Void Content of Fine Aggregates”
Used to determine the surface characteristics.
The more angular, the higher resistance to rutting.





Variation in Angularity of Sands As measured by voids





Organic Content

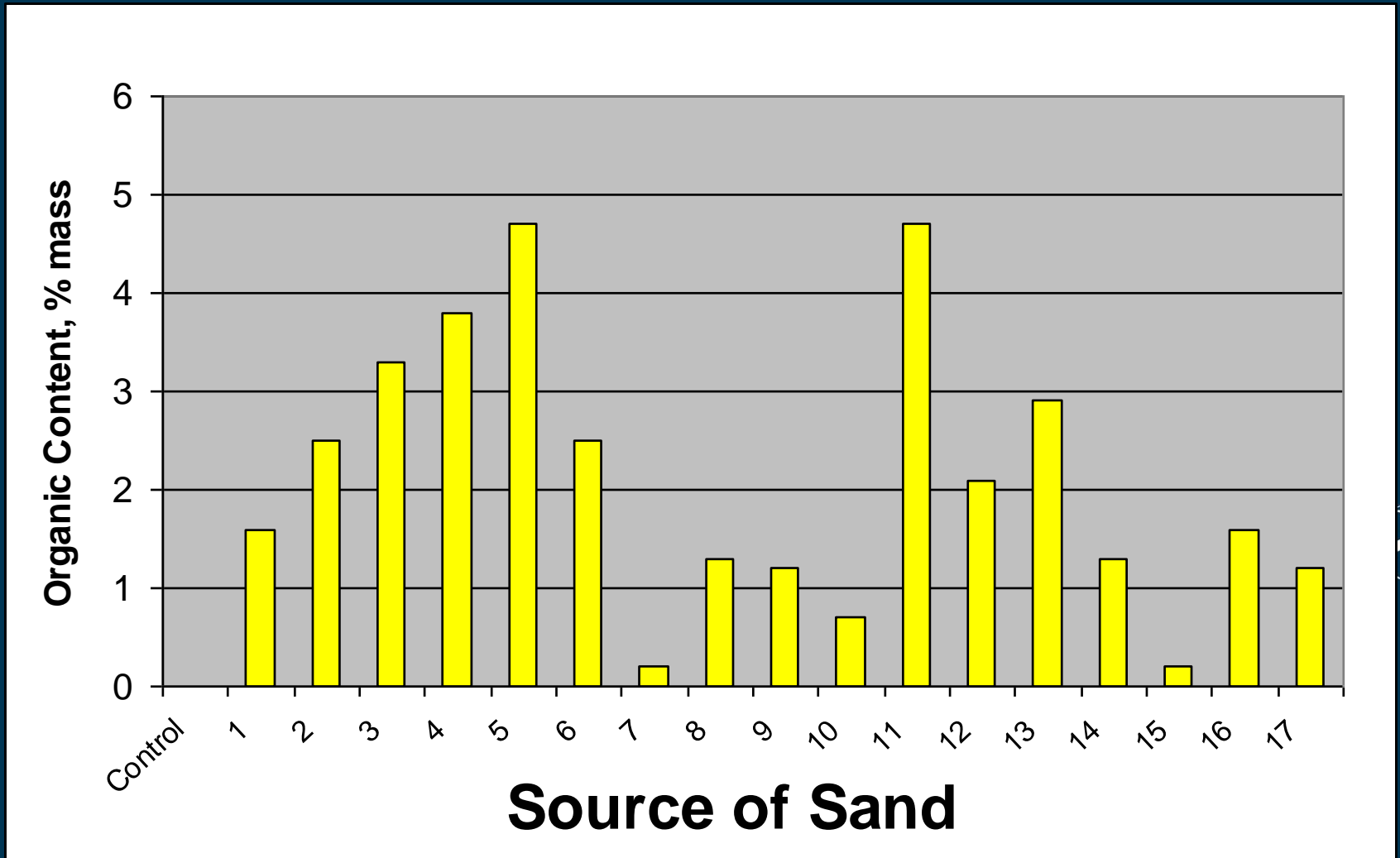


*Determined by AASHTO T267-86 “Determination Of Organic Content (OC) in Soils by Loss on Ignition” Expressed as percent loss.
Less OC is better.*





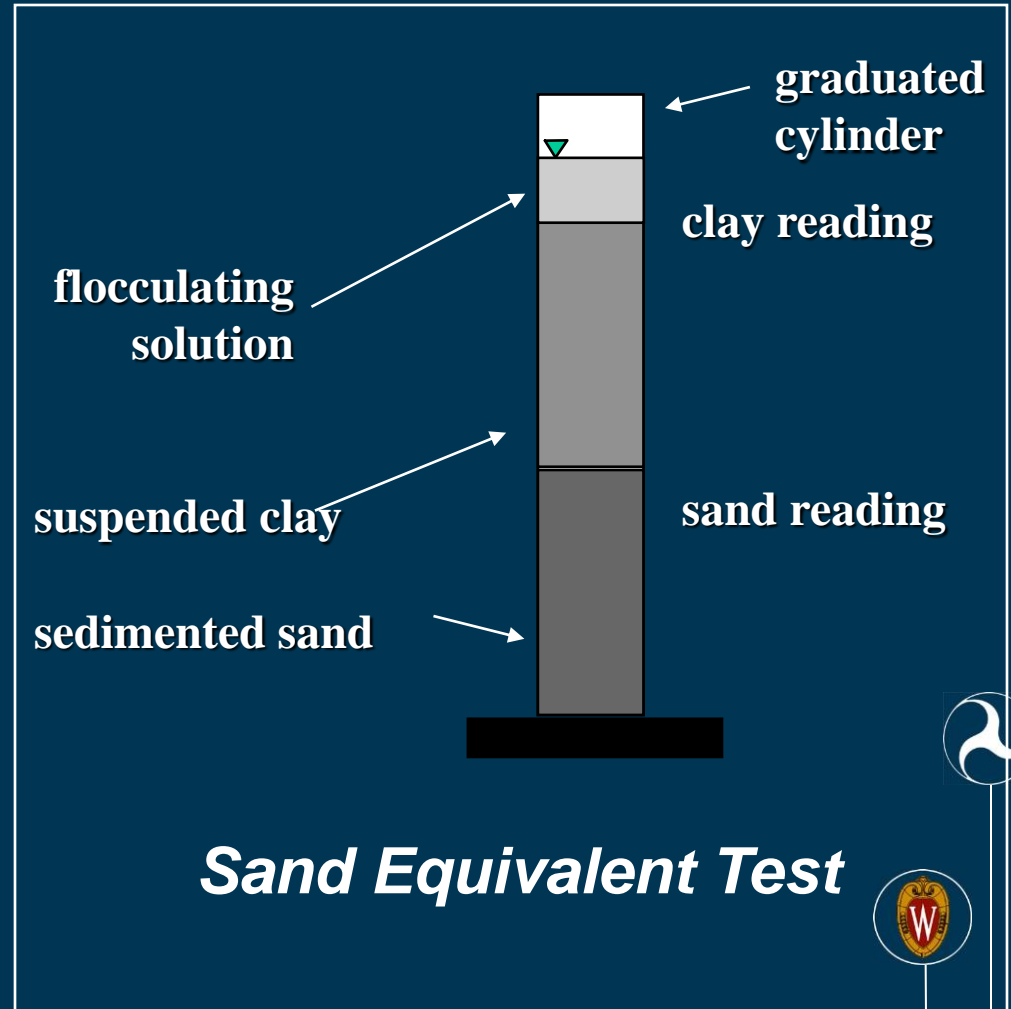
Variation in Organic Content of Sands





Clay Content

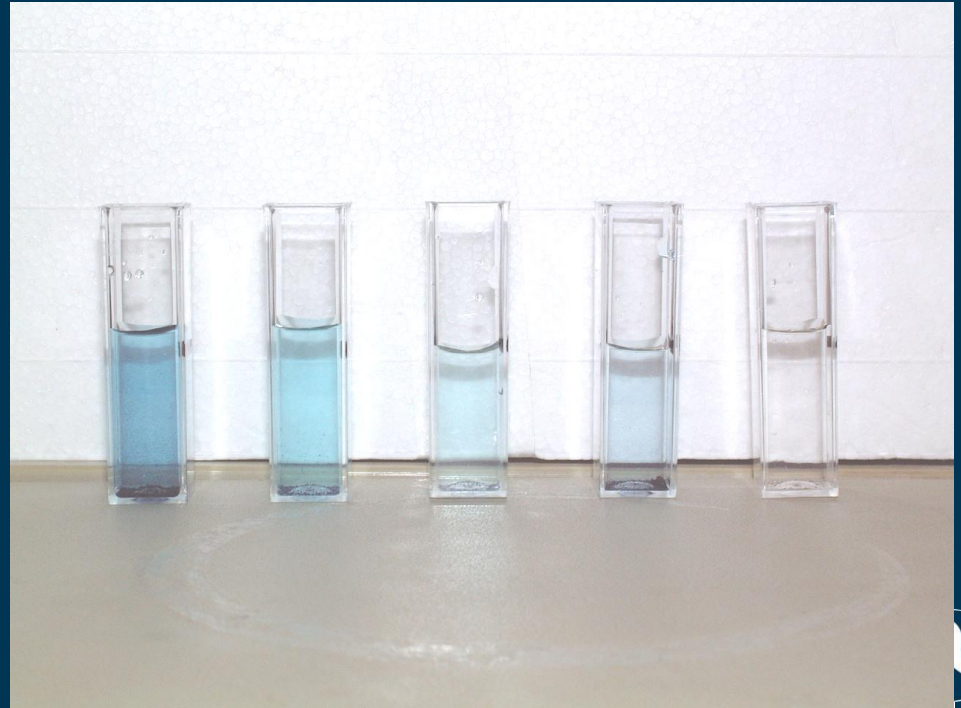
- Traditionally used Sand Equivalent Test
- Due to carbon content, **this could not be used**
- Modified AFS 2210-00-S “Methylene Blue Clay Test, Ultrasonic Method”





Clay Content Modified Method

- Used a spectrophotometer instead of filter paper to determine “how blue is blue”.
- Methylene blue index (milligrams of methylene per gram of sand- mg/g) tested at a wavelength of 670 nm.

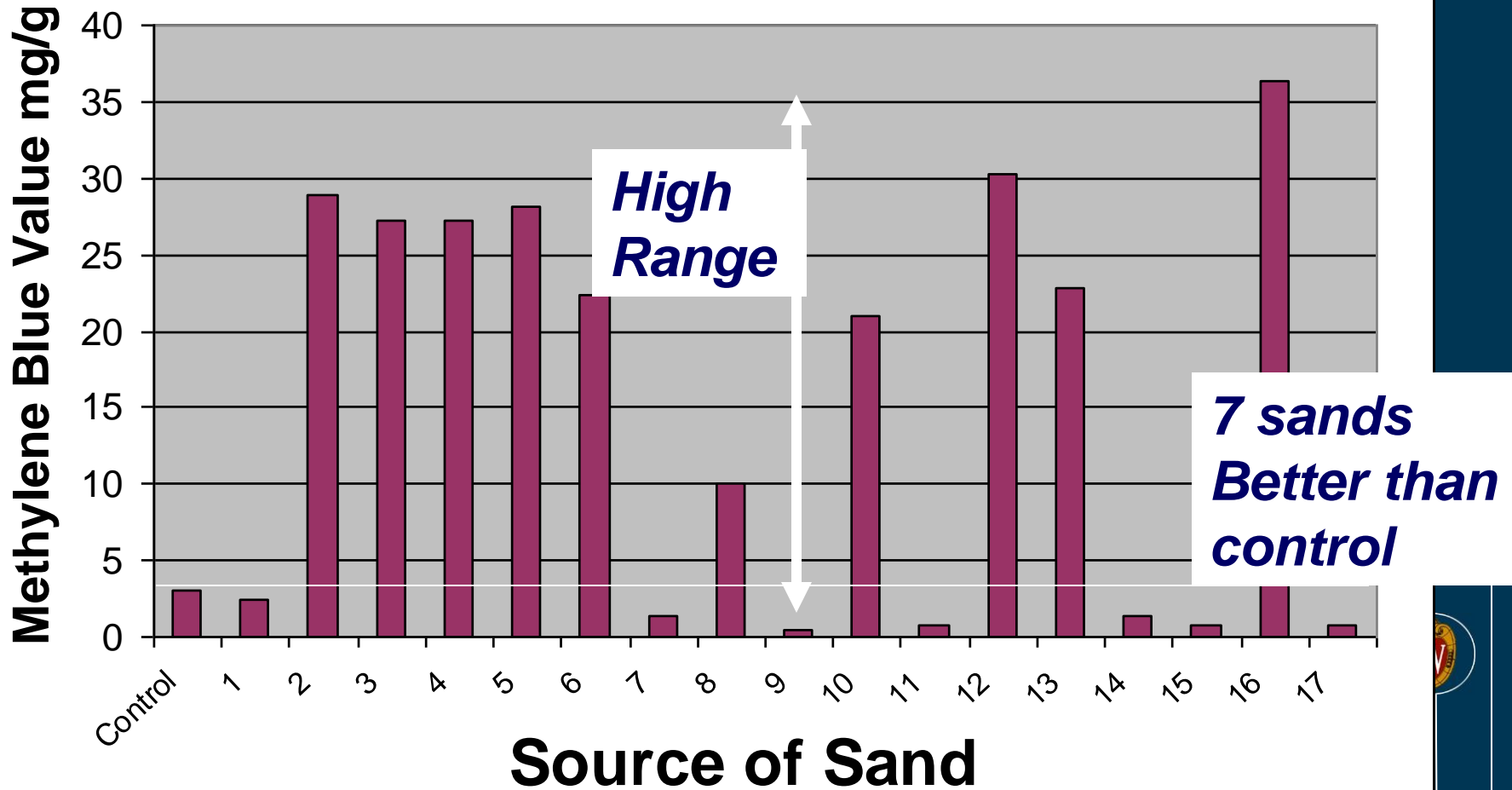


A typical bentonite has a MBV of about 387 mg/g, so a foundry sand with a MBV of 20 contains about 5% active clay.





Variation in Clay Content As measured by Methylene Blue





Can Sands be used for production of Acceptable Asphalt Mixtures ?

- Studies at UW-Madison
 - First study (2000) by E. Miller
 - Second Study (2001) by K. Delage
 - Third Study (2002) by A. Braham
 - **Fourth study (2004) by T. Snyder**
 - **With Penn State and First**
 - **17 sands from 11 different states.**
 - **Developed Guidelines**





Asphalt Mixture Performance Indicators

- **Durability:**
 - Asphalt Content
 - Voids Filled with Asphalt (VFA)
- **Mixture Stability / Volumetrics:**
 - % Maximum Density @ N_{ini} , N_{des} , N_{max}
- **Constructability**
 - Paver Energy Index: PEI
 - Rolling Energy Index: REI
- **Resistance to traffic action**
 - Traffic Densification Index: TDI
- **Resistance to fatigue and moisture damage**
 - Indirect Tension Strength

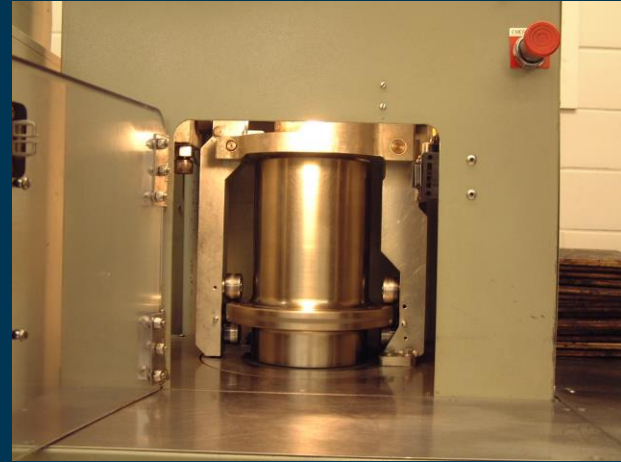




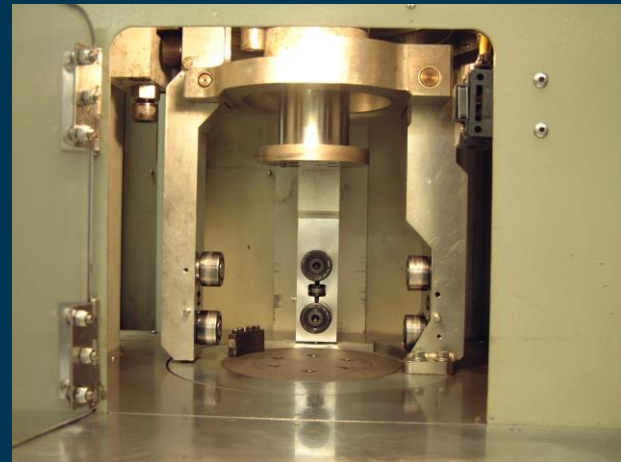
Mix Designs – Superpave Technology



Loose mix is placed into compaction mold



Superpave Gyratory Compactor compacts the sample



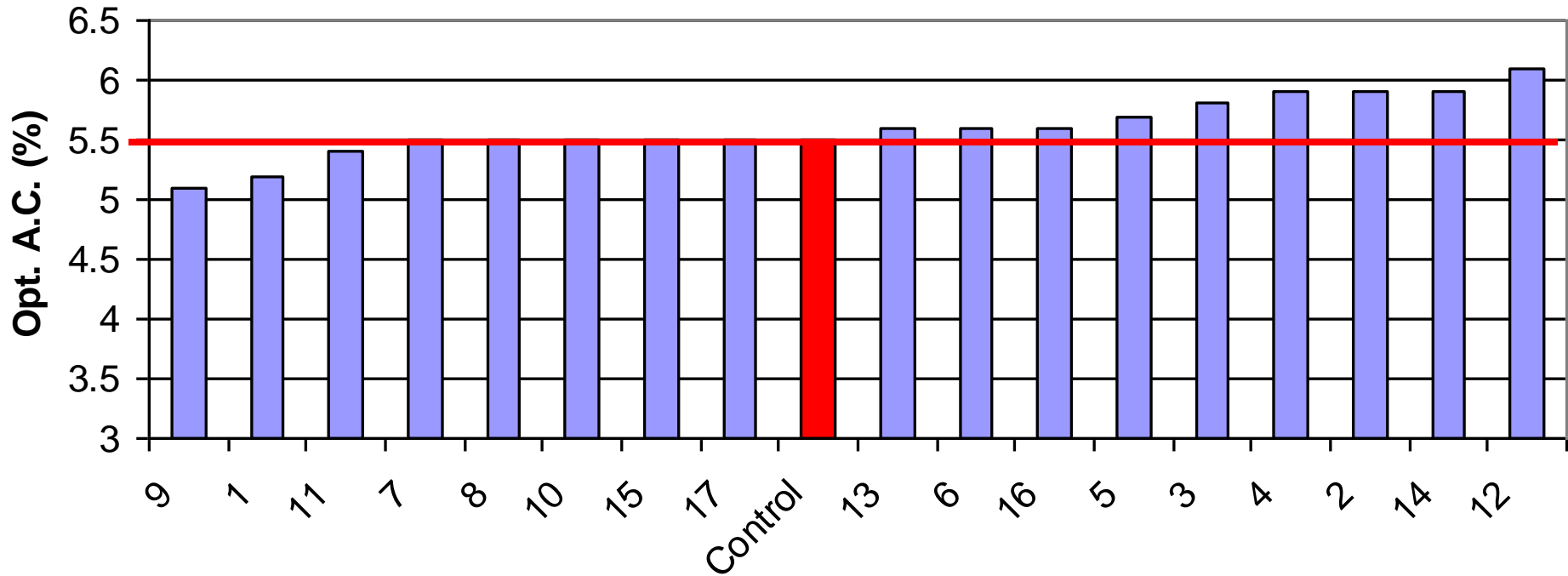
Ram used to compact sample.
Aluminum arm gyrates around sample





Durability and Economics

Optimum A.C.



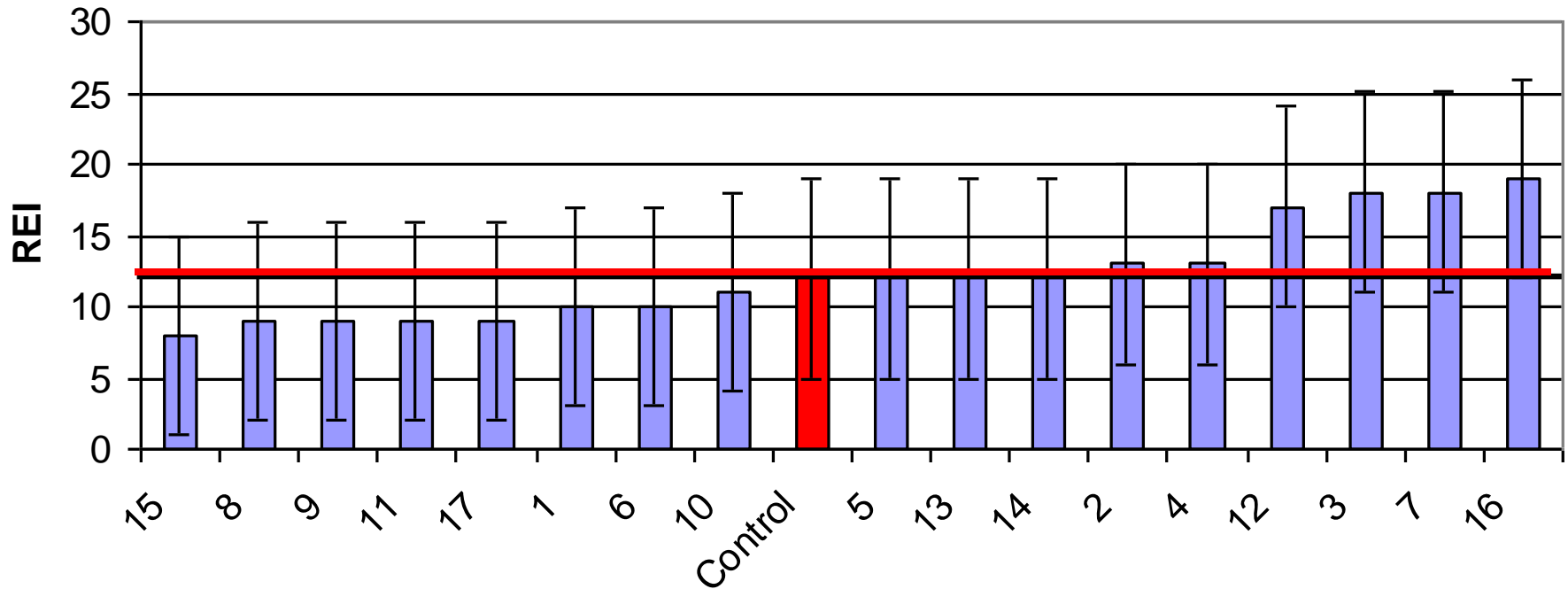
Asphalt Content is not affected significantly





Constructability

Roller Energy Index



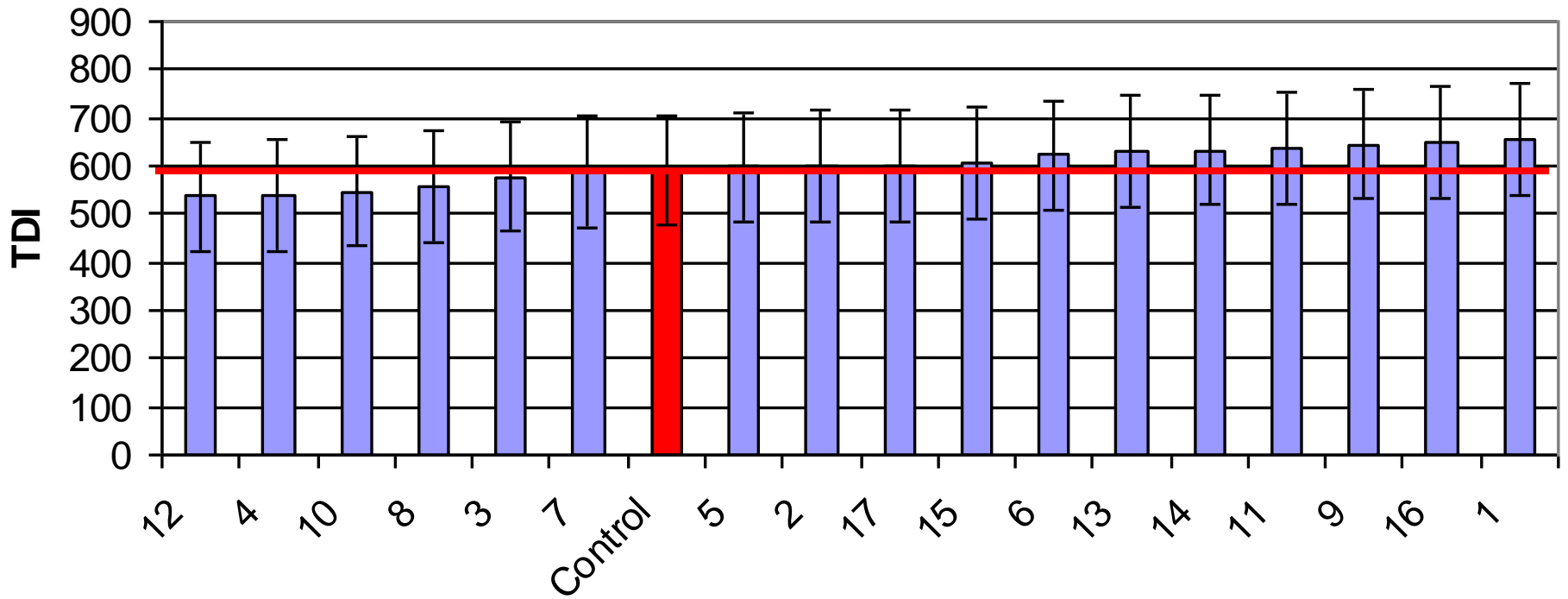
Constructability is not affected significantly





Resistance to Traffic Action

Traffic Densification Index

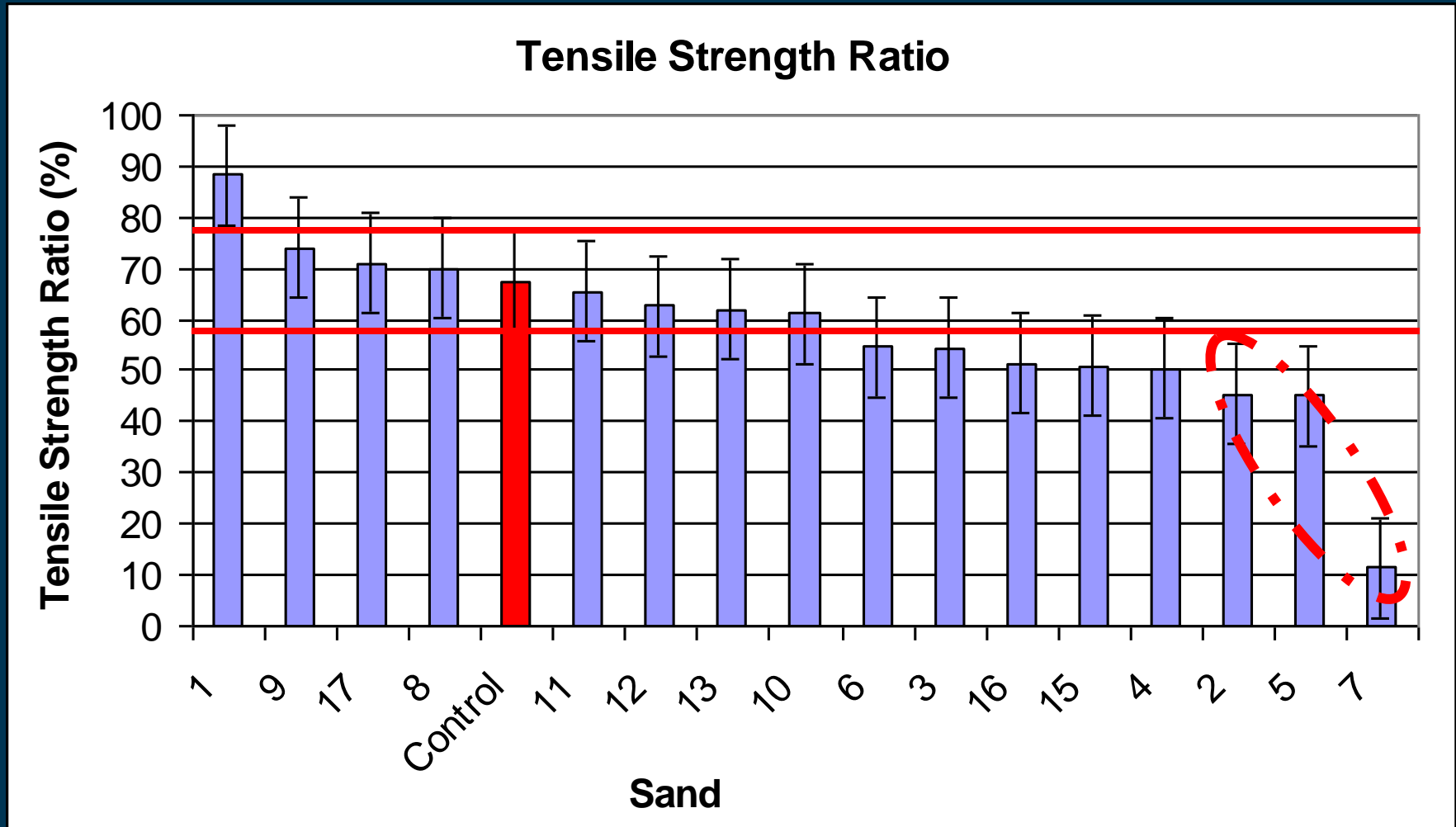


Traffic Resistance is not affected significantly





Resistance to Moisture Damage



For Some Sands, there is important Reduction





Current Knowledge

- Change in economics of HMA is minimal:
 - Some sands showed an increase in asphalt content, while others did not.
 - Asphalt contents ranged from 5.1 to 6.1% with the control at 5.5%
- Effect of sand on moisture sensitivity varies:
 - 9 of the 17 foundry sands either caused an increase or no change in Tensile Strength Ratio values.
 - Based on this, over half the sands can be used safely in HMA.
- Sodium Silicate binder system is detrimental to HMA.





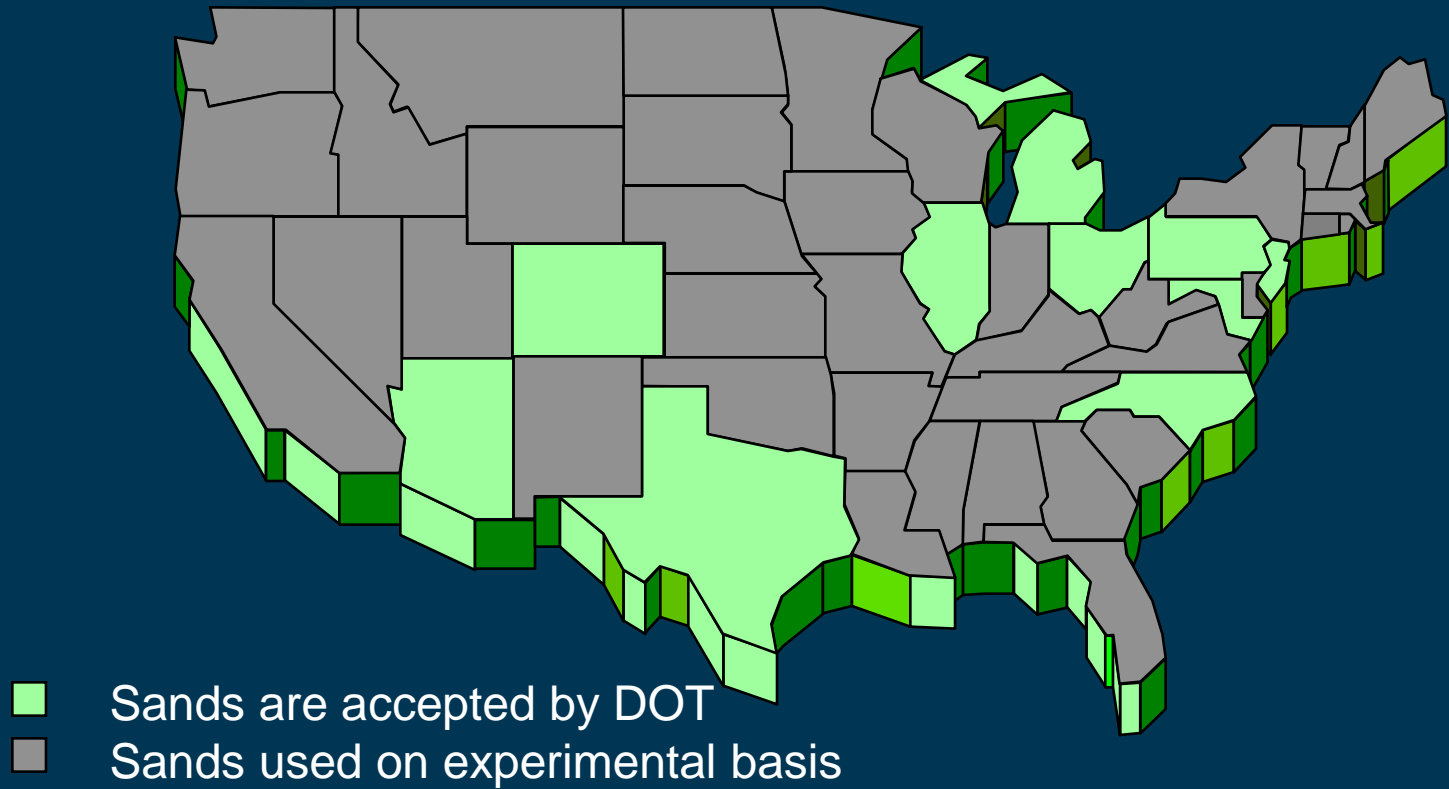
Case Studies

- Departments of Transportation allows it:
 - Pennsylvania: DOT allows 8-10% in all mixes
 - Michigan: HMA producer use 10-20%
 - Tennessee: HMA producer uses 10 %
 - Ontario, Canada: HMA producer has used it for more than 10 years
- Concerns of UMA suppliers
 - Consistency required
 - Environmental classification
 - Clay content
 - Total amount





Where are Sands Used for HMA?





Guidelines for Using Sands in Asphalt Mixtures

- **Foundry Quality Check**
 - Required: Report Binder system used
 - Required: Report if sand contains any Sodium Silicate
 - Required: Measure Methylene Blue value
 - Optional: Size Distribution
 - Optional: Anuglarity





Guidelines for Using Sands in Asphalt Mixtures

- Asphalt Contractors:
 - Try first at a minimum of 10 %
 - In general, do not cause an increase in asphalt content. Depends on specific foundry sand.
 - Test for moisture damage is necessary.
 - If $MB < 10$, no additive is needed.
 - If $MB > 10$, moisture damage needs treatment
 - If moisture damage is evident:
 - Anti-stripping additives may not solve problem.
 - Washing should be tried.





Step by Step Procedure

- Similar to other fine sands
 - Measure gradation
 - Measure angularity
 - Measure clay content
- If passes all HMA limits by DOT, use as much as needed.
- If not (too much fines, low angularity or high clay content)
 - Add as much as possible to meet limits
- Always test moisture damage of HMA after compaction





Questions



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