P 9-35: A Critical w of Superpave Aggregate Properties and New Advances in Aggregate Testing

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Superpave Aggregate Properties

- Consensus
  - Fine Aggregate Angularity
  - Sand Equivalent
  - Coarse Aggregate Angularity
  - Flat and Elongated Particles
- Source
  - LA Abrasion
  - Soundness
  - Deleterious Materials

Delphi process. Research was not performed during SHRP to validate the properties.

Research Conducted Since SHRP

- NCHRP 4-19 – Aggregate Tests Related to the Performance of Asphalt Concrete
- NCHRP 9-14 – Investigation of the Restricted Zone
- Pooled Fund Study 176
- NCHRP 4-19 II – Validation of NCHRP 4-19 Through Accelerated Testing (On-going)
- NCHRP 4-30 – Test Methods for Characterizing Aggregate Shape, Angularity and Texture (On-Going)
- Numerous other efforts by ICAR, State Agencies and Other Universities

NCHRP 4-19

Recommend a set of tests related to the performance of HMA with respect to:

- **Permanent deformation**
- **Fatigue cracking**
- **Raveling, popouts, or potholing**
- Frictional resistance

Fine Aggregate Angularity

- Recommended by NCHRP 4-19
- Concerns by Aggregate Industry ar Some Agencies:
  - Some 100% crushed materials, mainly limestone, do not meet high traffic specification (>45)
  - Material passing 4.75 mm and retained on 2.36 mm sieve not evaluated
  - FAA may not be related to rutting propensity of HMA

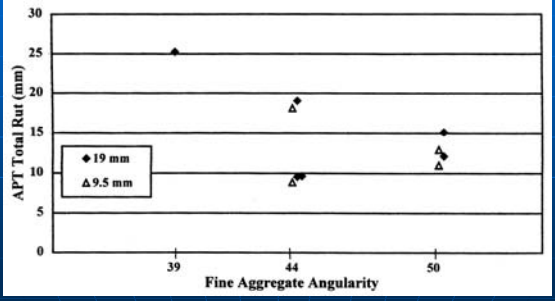
Where did 45% come from?

- Brown and Cross (1992) developed a relationship between field rutting and FAA. Also stated a rutting rate less than 0.005842 mm / (ESALs)^0.5 indicated good performance
- Kandhal et al (1992) used this relationship to recommend a limit of 43.3%
- Stuart and Mogawer (1992) recommended 44.7% "would divide good and poor performing sands for high traffic levels."

Current Usage of FAA

- 85 percent of states use AASHTO T304
- Other states visually assess fractured faces or limit the percentage of natural sand
- Some states have modified specifications
  - > 45 for all traffic levels
  - > 42, 43 or 44 for medium to high traffic levels in lieu of >45

Relationship of T304 to Performance

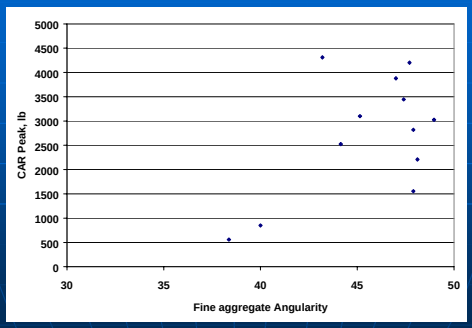


Stiady et al, 2000

Alternative Tests for Measuring Fine Aggregate Angularity

- ASTM D3398 Aggregate Particle Index
- ASTM D3080 Aggregate Direct Shear
- Compacted Aggregate Resistance Test (CAR)
- Imaging Methods

Comparison of FAA and CAR Data



Data from Jahn

Summary of Findings on FAA

- AASHTO T304 Methods A and B are highly correlated
- Results of studies to relate FAA to rutting mixed. Generally a trend of decreased rutting with increasing FAA.
  - Unclear between 43 and 45
  - Some aggregate with very high FAA (>50) can lead to high AC%
- Higher FAA generally results in increased VMA and decreased density at
- Variability higher than reported, probably due to Gsb

Sand Equivalent Test for Evaluation of Clay-Like Fines

- AASHTO T176 currently used by 91% of states
- Concerns that some crusher fines identified as clay-like particles
- NCHRP 4-19 recommended Methylene Blue Test
- Some states report MB good tool, but not good for specification

- **NCHRP 4-19 Recommend using methylene blue test to evaluate plastic fines in the fine aggregate**

Coarse Aggregate Particle Shape and Surface Texture

NCHRP 4-19 Recommended Tests

- **Uncompacted voids**
- **Flat or elongated 2:1 ratio**

Uncompacted Voids in Coarse Aggregate

New Methods for Measuring Coarse Aggregate Shape and Texture

Multiple Ratio Analysis

	<2:1	2:1-3:1	3:1-4:1	4:1-5:1	>5:1
1x3/4	28	53	17	2	
3/4x1/2	33	43	13	6	5
1/2x3/8	16	42	22	14	6
3/8x#4	10	43	29	9	9

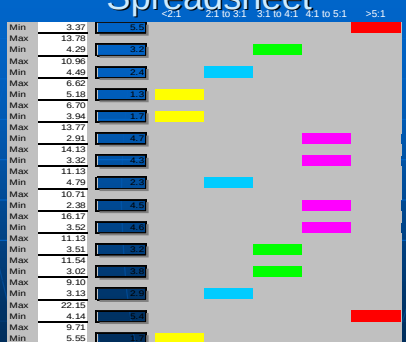
Multiple Ratio Analysis provides significantly more detailed information about the different particle *shapes*.

Courtesy of Jahn

Martin Marietta has developed a low cost device to sort particles into five different flat and elongated ratios, that combines the ruggedness of a 1/2 ton press with the sensitivity of a digital caliper.

Spreadsheet

Courtesy of Jahn



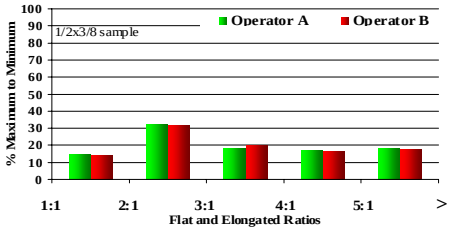
The spreadsheet calculates the flat and elongated ratio for the operator, and then uses a color coding system to indicate to the operator which flat and elongated category the particle should be placed in. After sorting all the particles, simply determine the mass of each flat and elongated category to calculate the percent.

AMRL F&E Proficiency Sample

ASTM D4791 D2S%

Size	Avg. F&E	Multi-laboratory		Single Operator	
		Samp. 117	Samp. 118	Samp. 117	Samp. 118
+ 12.5	13.8	144.3	151.0	75.3	82.2
+9.5	17.5	65.2	119.2	64.2	65.2
+4.75	23.9	129.3	131.2	51.8	55.4

Different Operators For Same Sample (Approximately 400 pieces)

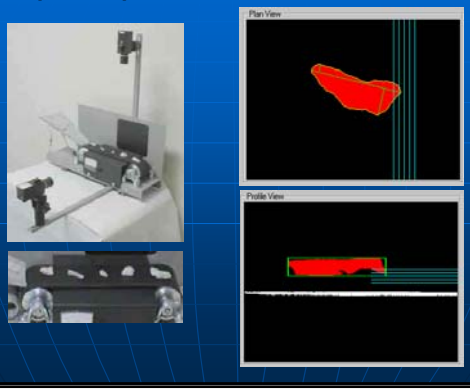


Accuracy with the new MRA device. Operator A was experienced, while Operator B had no experience.

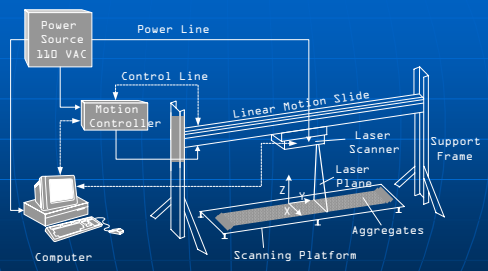
Imaging Systems

- VDG-40 – LCPC
- Whipshape – University of Missouri
- Three Camera System – University of Illinois
- Laser Based Aggregate Scanning System (LASS) – U Texas Austin
- Aggregate Imaging System – Washington State/ Texas A&M

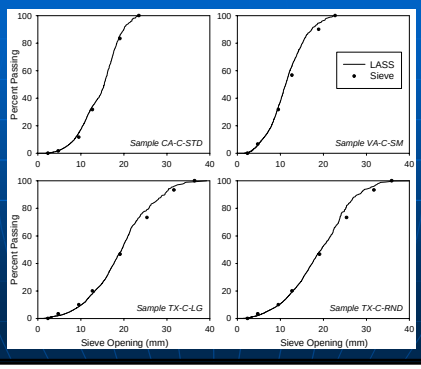
WipShape – 3 Dimensional



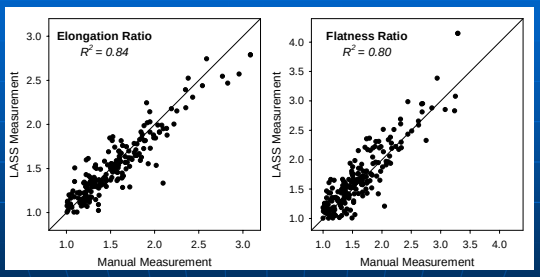
Laser-Based Aggregate Scanning System –3D



LASS – Gradation Data



LASS – Shape



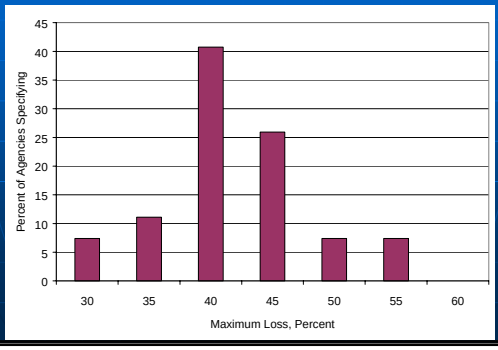
Aggregate Toughness / Abrasion Resistance

Aggregate Durability / Soundness

Toughness / Abrasion Resistance

- Needed to resist crushing, degradation, and disintegration during stockpiling, mix production, construction, and traffic
- Los Angeles abrasion test used by 96 % of State Agencies (no significant validation data)

LA Abrasion Specifications



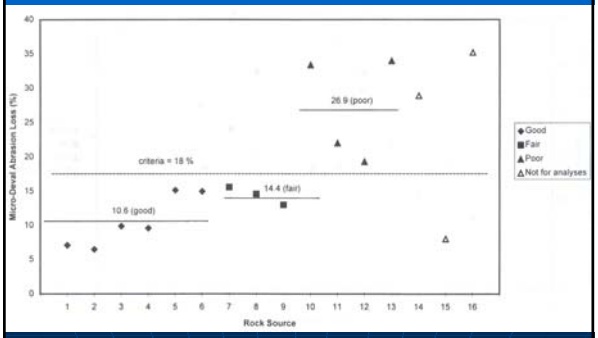
Durability / Soundness

- Needed to resist breakdown or disintegration when subjected to wetting / drying and / or freezing / thawing
- Sulfate soundness commonly used

Micro-Deval Test

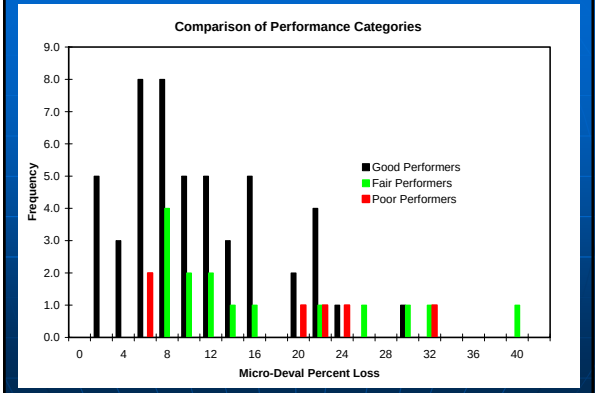
- Developed in France During 1960's
- Abrasion in Presence of Water
- AASHTO TP58-00

NCHRP 4-19

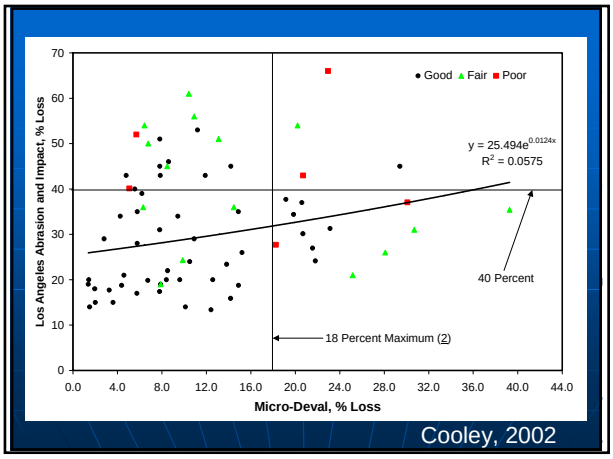


NCHRP 4-19 Conclusions

- Micro-Deval and Magnesium sulfate loss are the two best indicators of potential pavement performance
- Losses of 18% maximum for both appear to separate good and fair from poor performers



Cooley, 2002



Cooley, 2002

Conclusions of SE Superpave Center Study

- There was no relationship between the Los Angeles Abrasion and Impact and the Micro-Deval test results when the data was evaluated as a whole
- Specifications developed for the Micro-Deval test method may need to be based upon the parent aggregate type.

Cooley, 2002

Summary

- Difficult to develop strong relationships between aggregate properties and performance
- Pavements using Superpave aggregate properties perform well in rutting
- Imaging offers bright future for shape and angularity
- Durability tests need more investigation