Particles On the Road

Particle analysis of glass traffic beads
at the Texas Department of Transportation

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Arturo Perez aperez1@dot.state.tx.us

Who are we?

- **Tom Schwerdt is the lead paint chemist at the Texas Department of Transportation after a decade in private industry as a paint chemist. He is a graduate of the University of Delaware with a Bachelor's degree in Chemistry prior to pursuing graduate studies in Chemistry at Texas A&M. Tom is a longstanding active member of ASTM D01 and also a NACE Level III Certified Paint Inspector. Tom has also been the Operations Director of KEOS Community Radio and interned at the Naval Surface Warfare Center.**

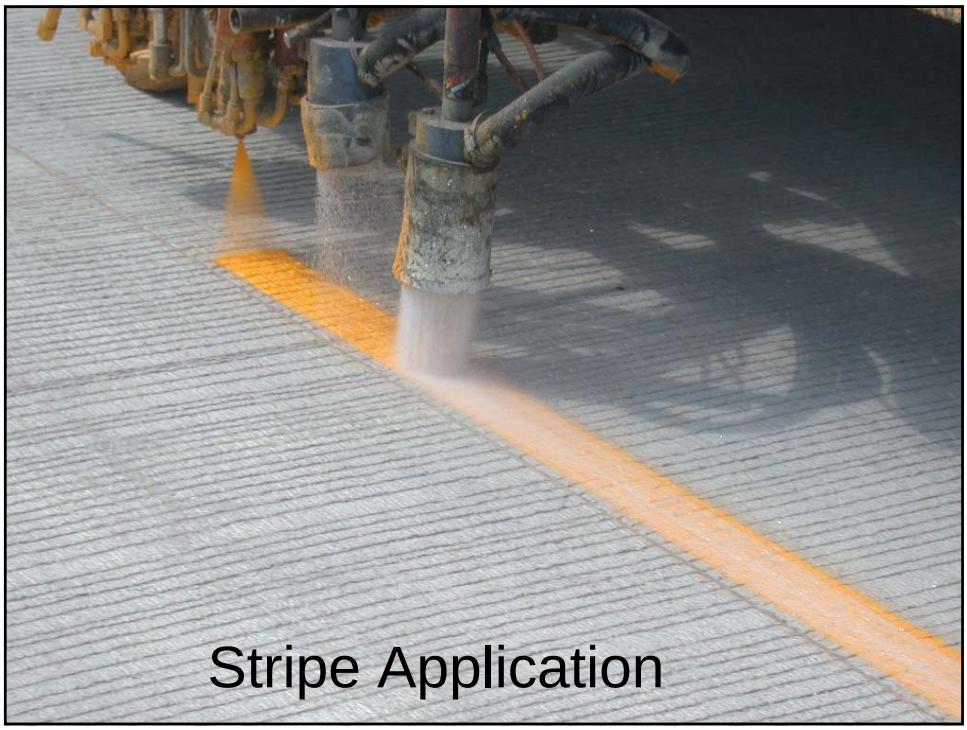
- **Arturo is a Physicist for the Coatings and Traffic Materials Branch at the Texas Department of Transportation in Austin, TX. Arturo designs, builds, implements, and maintains instrumentation for the testing of road materials to help ensure the safety of the motoring public. Arturo has obtain an EIT certification and is currently pursuing a PE in Electrical Engineering. Arturo earned his BS in Physics from the University of Texas at Austin.**

Why does TxDOT care?

(about particles)

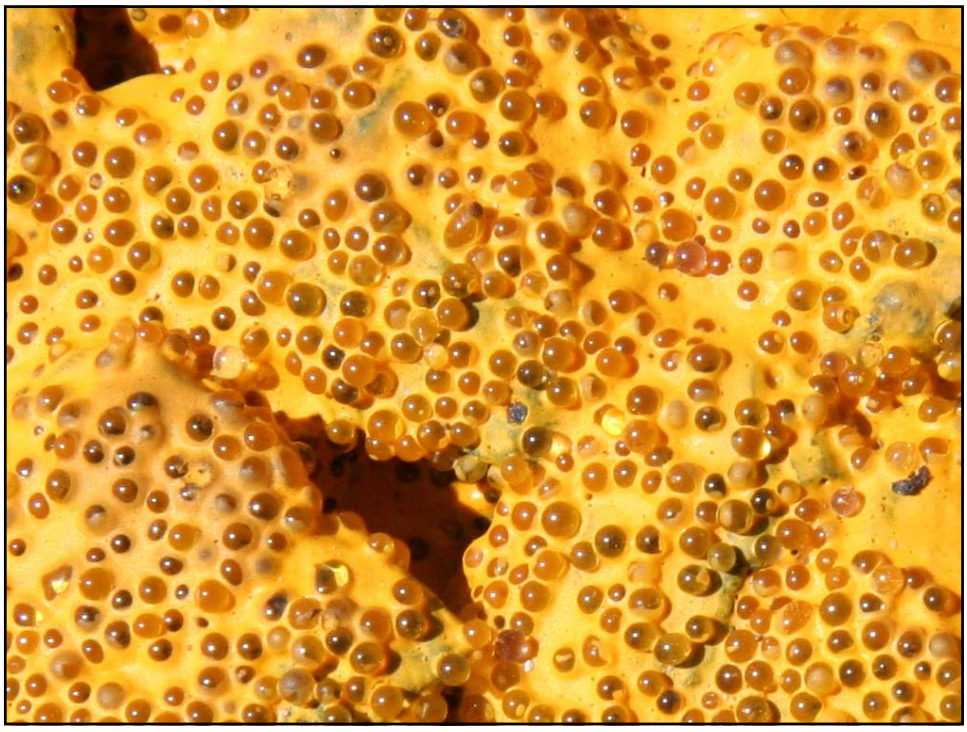
- Retroreflective striping is needed for night-time visibility on roads
- Round, clear, refractive glass beads needed for retroreflectivity
- ~200,000,000 lbs of glass beads purchased per year
- 80,000 centerline miles of road maintained

Measuring retroreflectivity

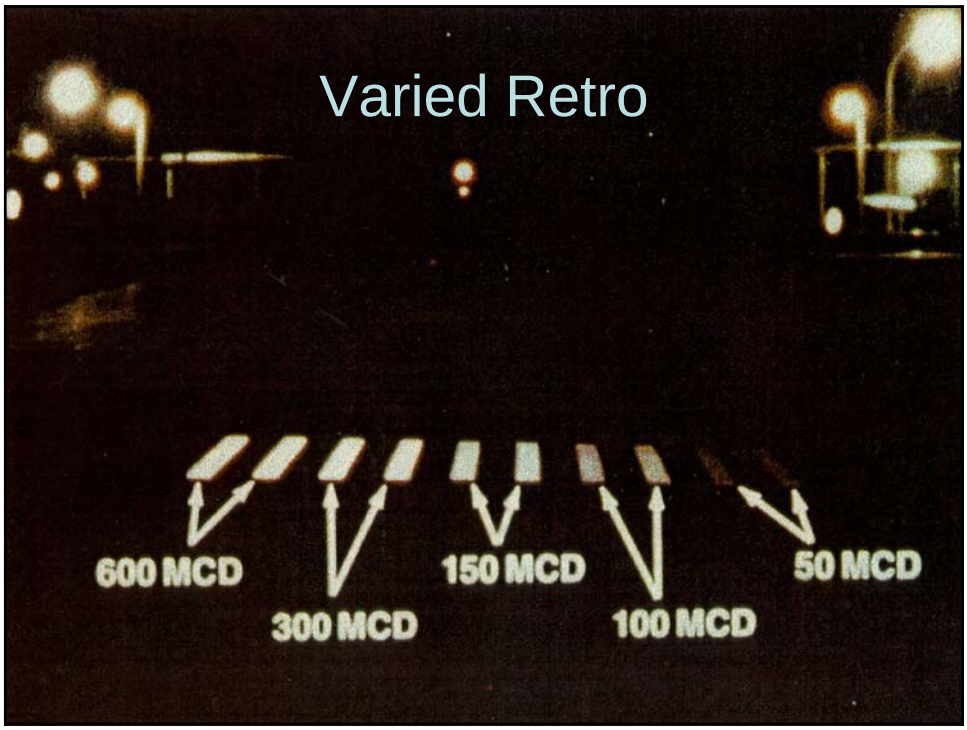


Stripe Application

Embedded Beads



Embedded Beads
(double drop)

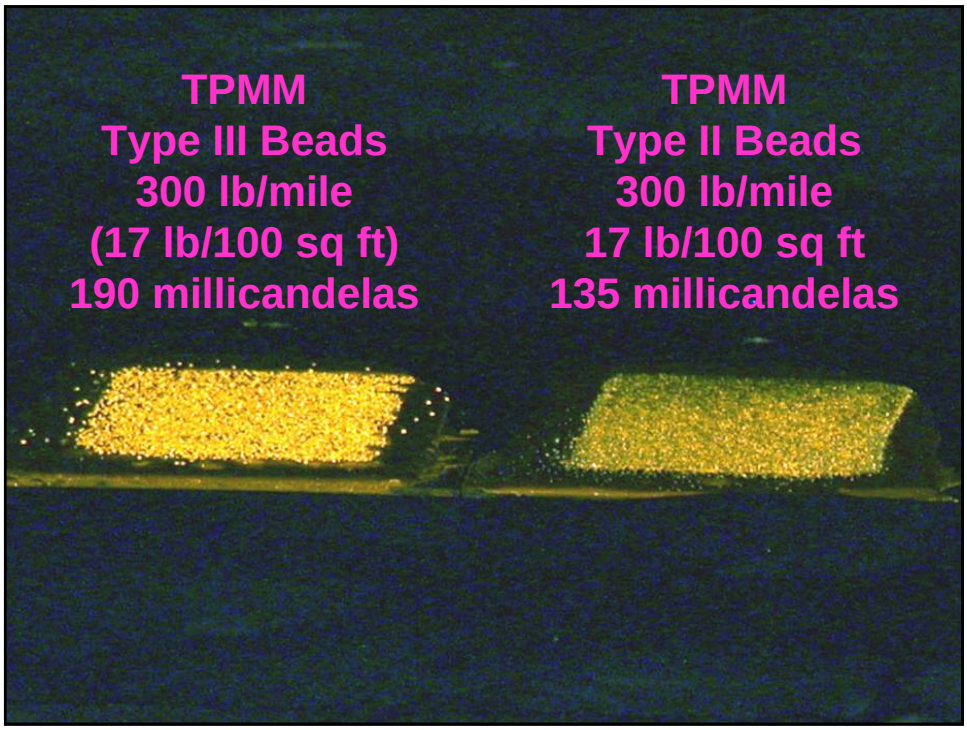

Varied Retro
600 MCD
300 MCD
150 MCD
100 MCD
50 MCD

Important particle properties

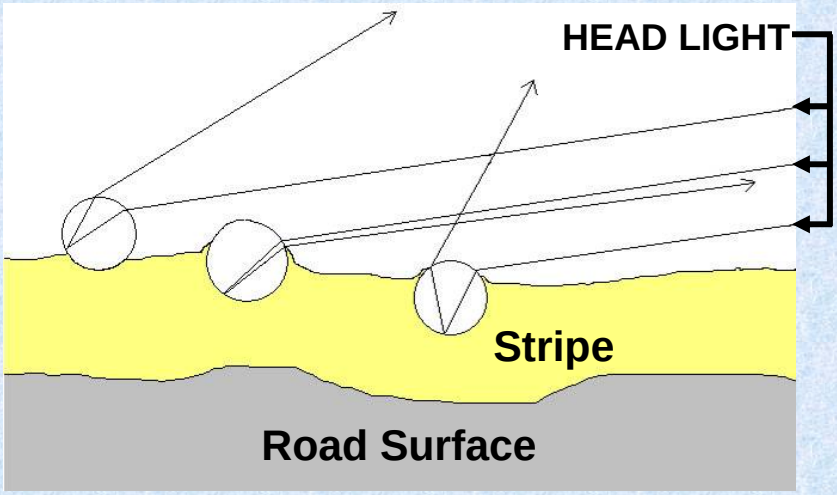
- Roundness*
- Size/size distribution (sieve)*
- Refractive index**
- Coating

* Measured with Current TxDOT Camsizer

** Next-generation light source



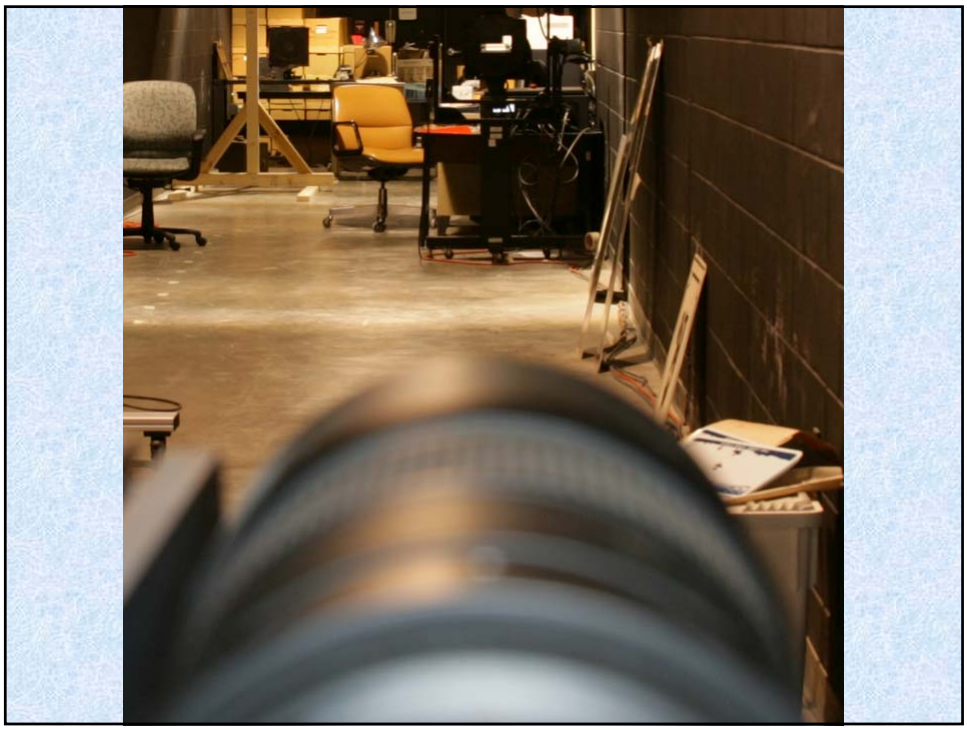
Bead Embedment

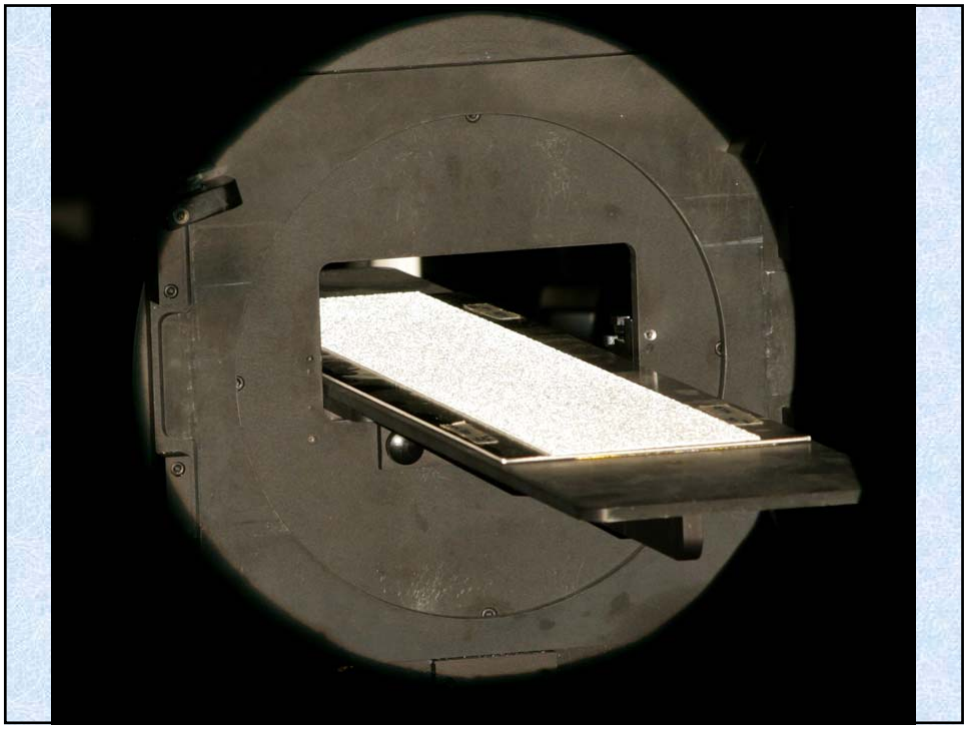


Retro-Reflectivity

- A Measure of how much light is reflected back to the source
- Utilize instruments that mimic real world driving situations and geometries
- Dependant on bead properties such as roundness, index of refraction, clarity and abrasion resistance

Goniometer
or
Reflective Sample Holder
Vehicle Setup
with
Camera & Source
Stripe
with
Beads
Reflected Light
Source Light





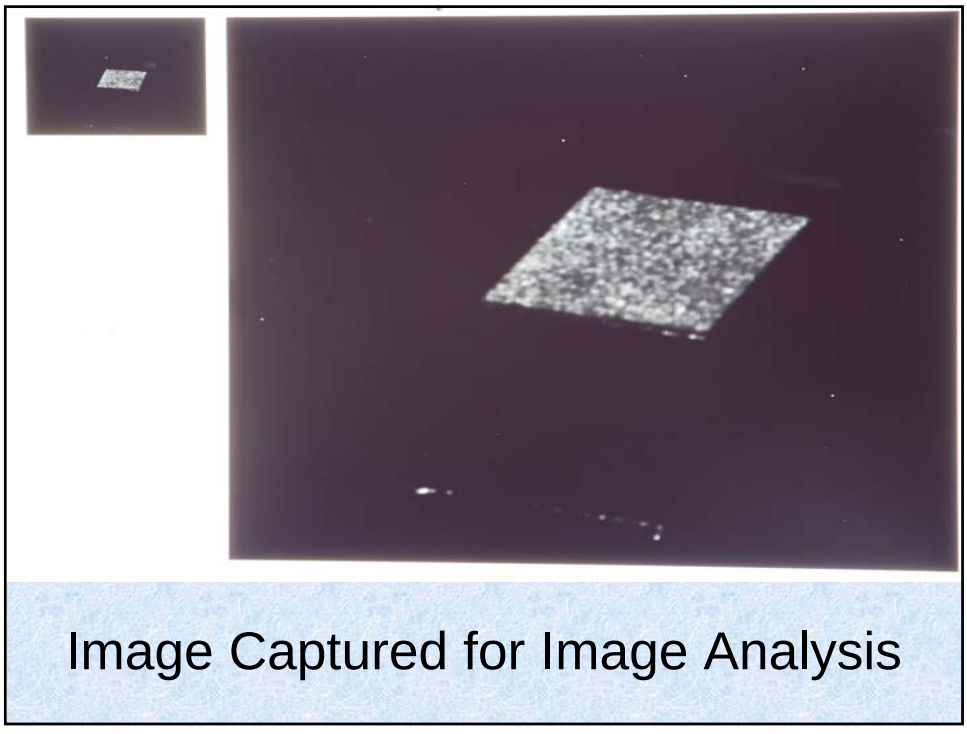
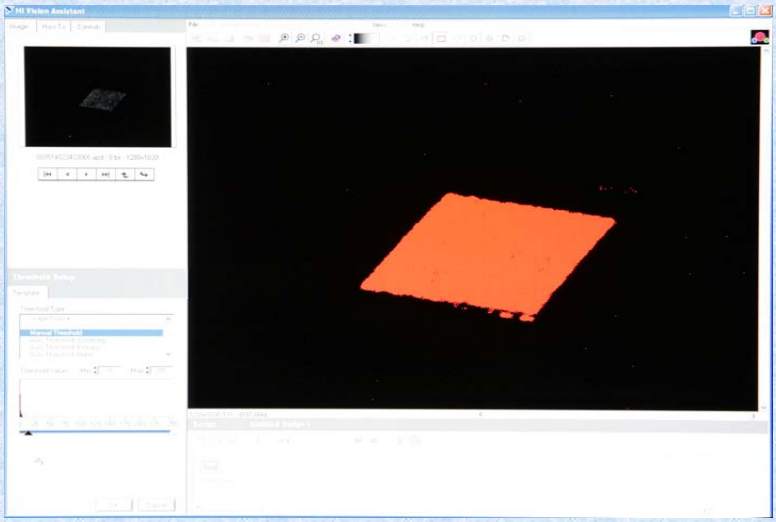


Image Captured for Image Analysis

Region of Interest Defined

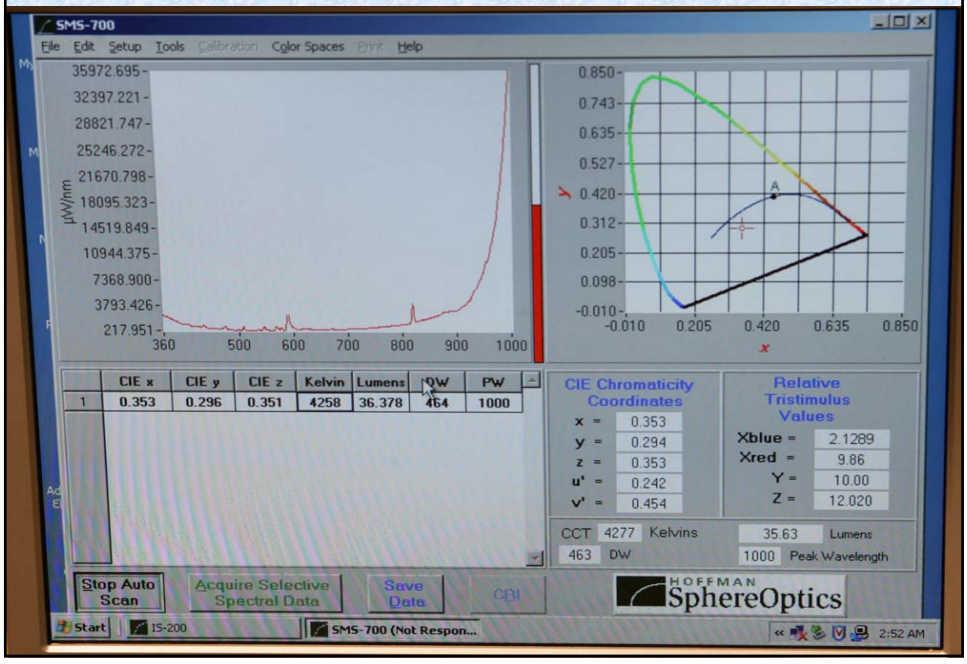


Calculate Average Pixel Value in ROI

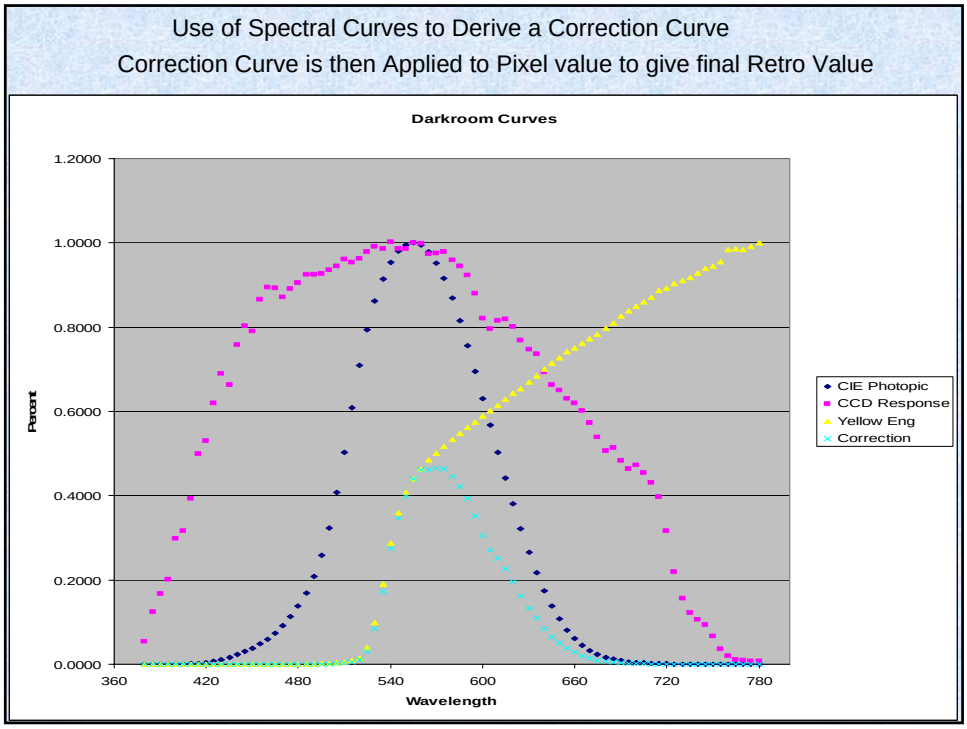
Integrating Sphere

Used to convert average pixel values to Retro-Reflectivity values

Spectral Distribution, Color Corrected Temperature, and Chromaticity are Characterized



Use of Spectral Curves to Derive a Correction Curve
Correction Curve is then Applied to Pixel value to give final Retro Value



Questions?

Old methods for evaluation

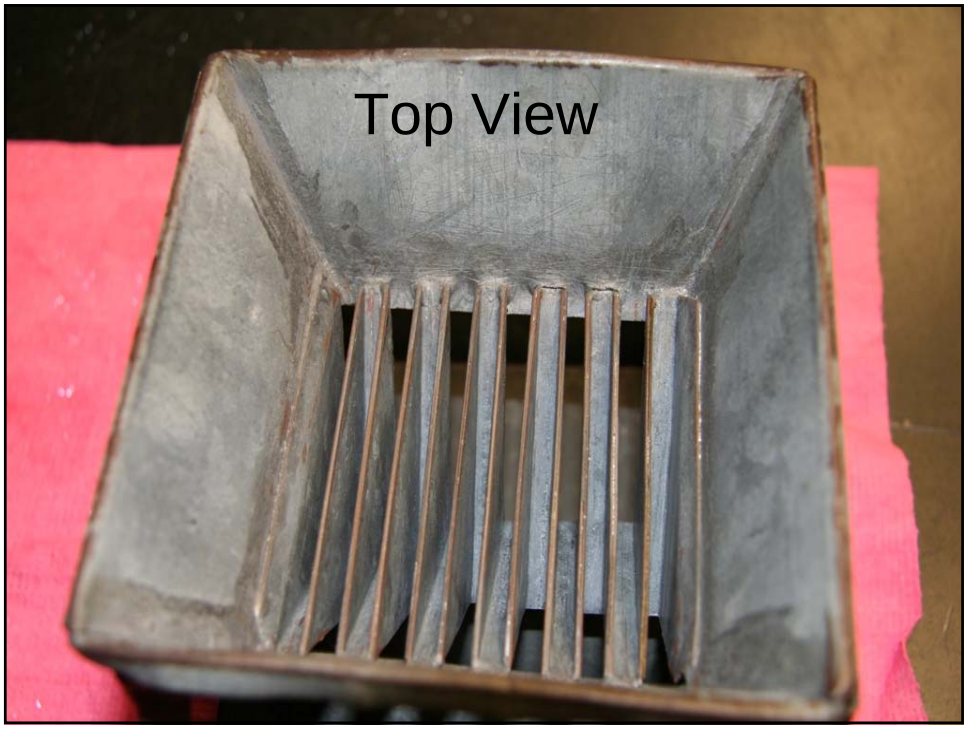
- Split sample down (amount critical)
- Sieve in Ro-Tap
- Evaluate each split in roundometer (2-4g)
  - OR
- Evaluate ~100 beads per split under magnification
- Other evaluation
- Throughput of 1-10 samples/day

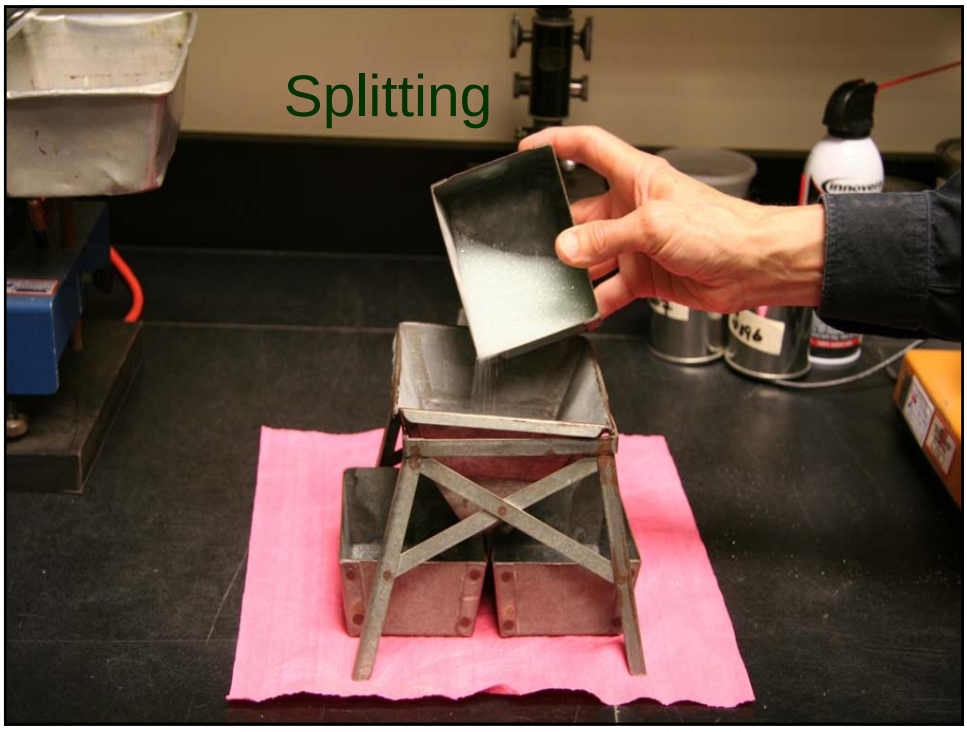
Evaluation with Camsizer

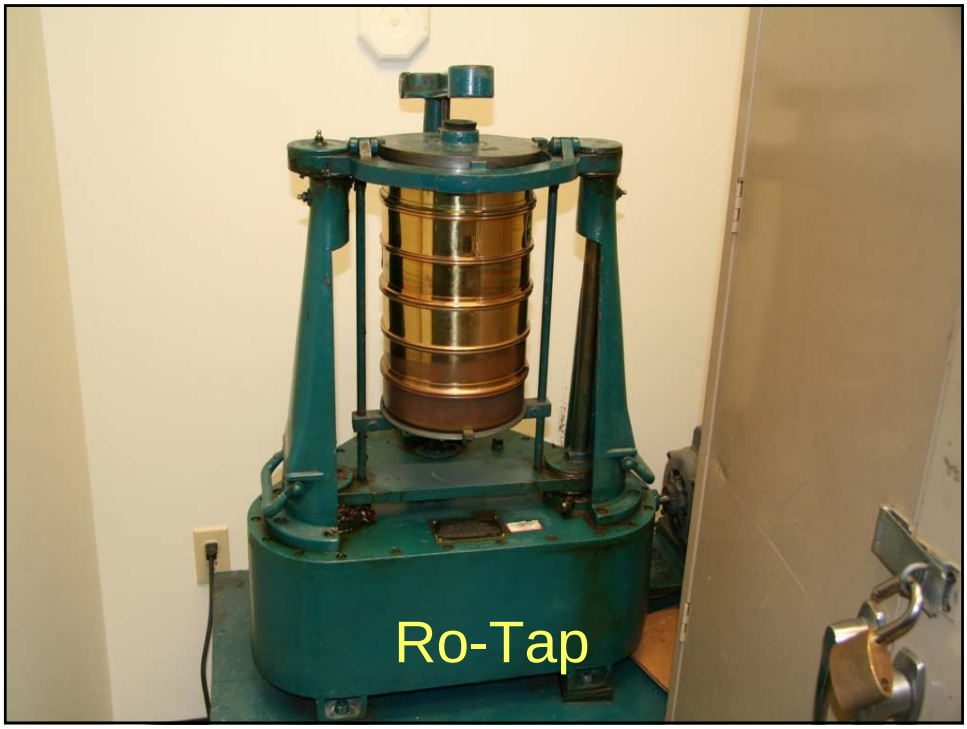
- Split sample down (amount less important)
- Optical analysis for size & roundness
- Other evaluation
- Throughput of 20-50 samples/day

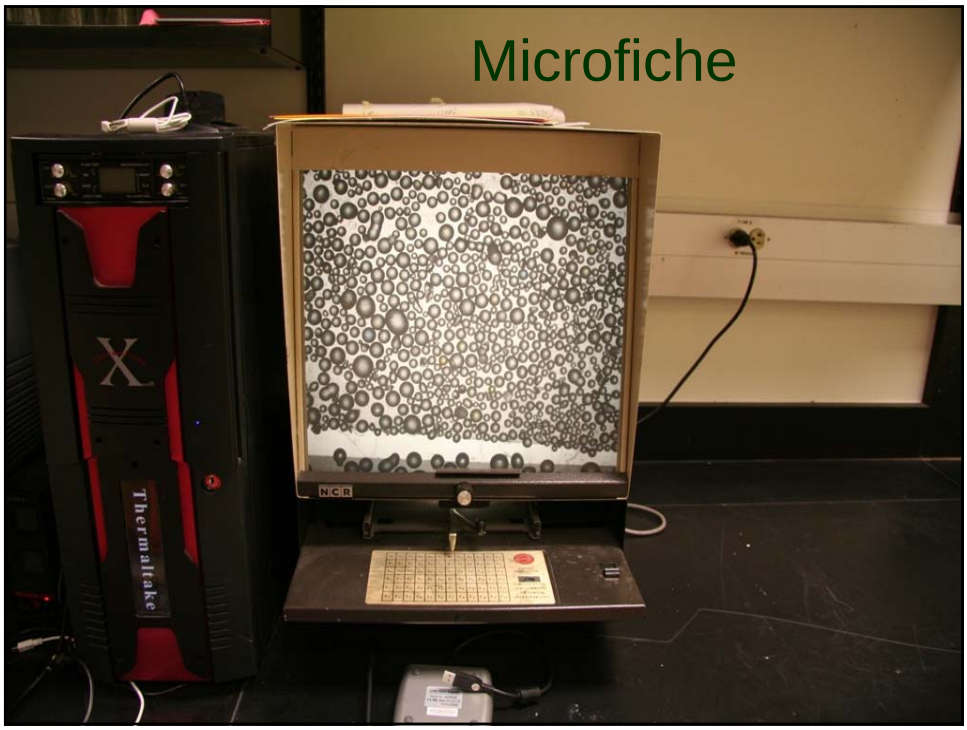
Large Bead Splitter

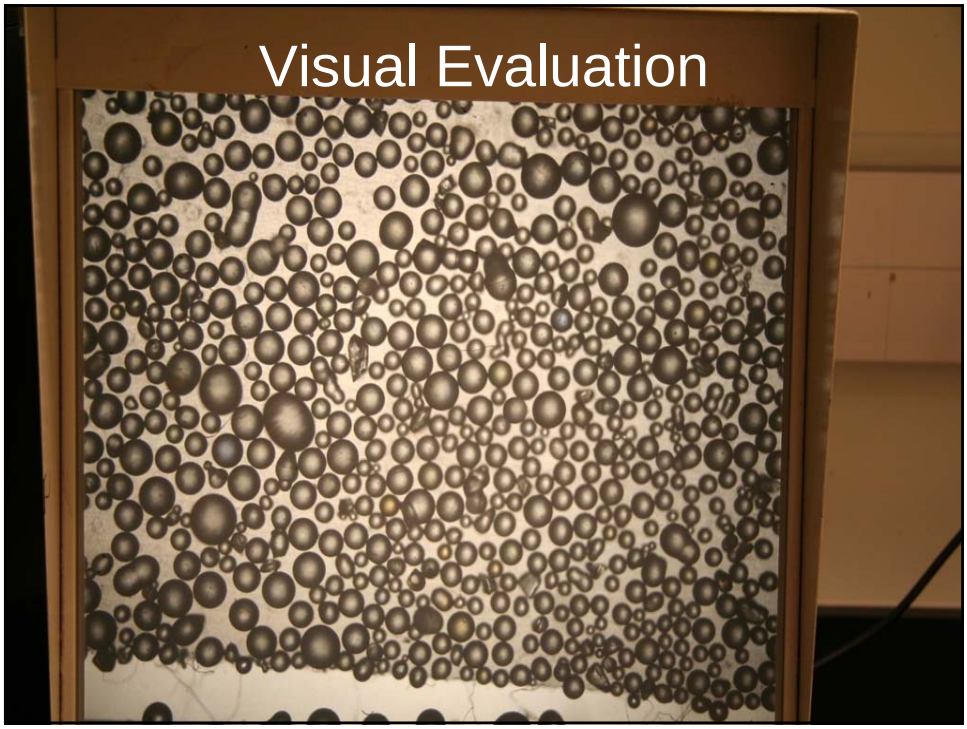
Small Bead Splitter

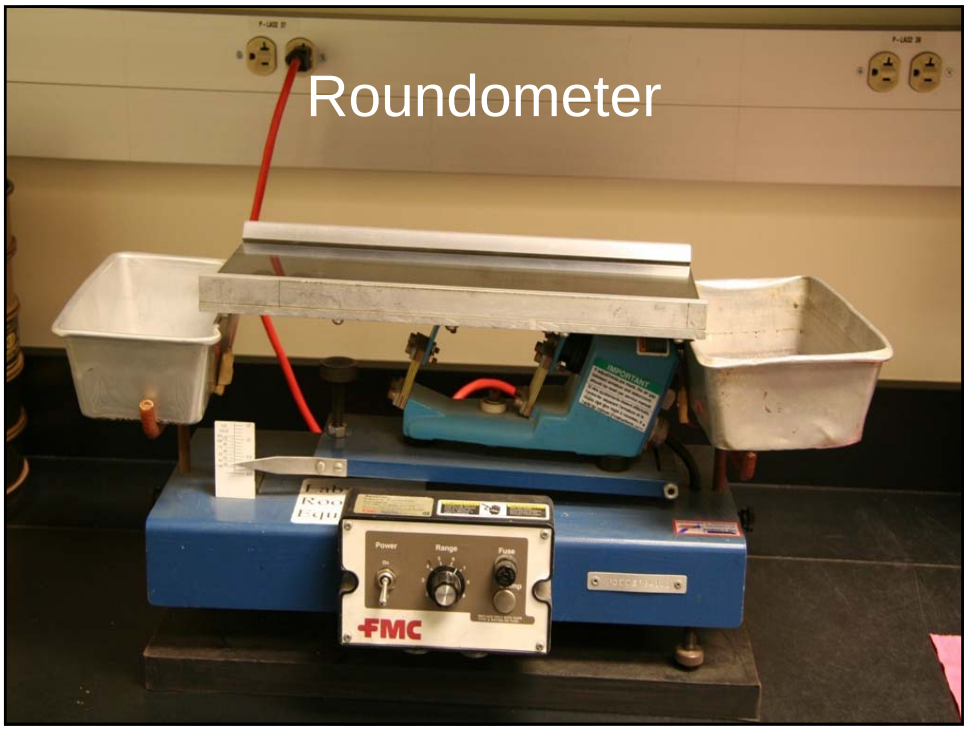

Top View


Splitting


Ro-Tap


Microfiche
Thermaltake
NCR


Visual Evaluation


Roundometer
FMC

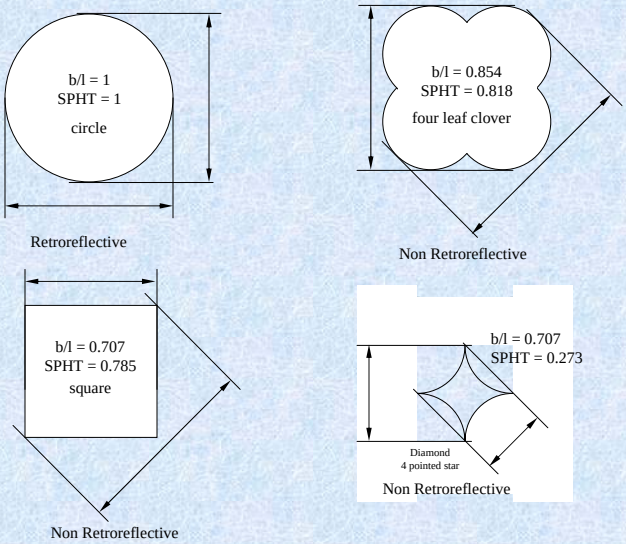
Using the Camsizer to Evaluate Glass Beads

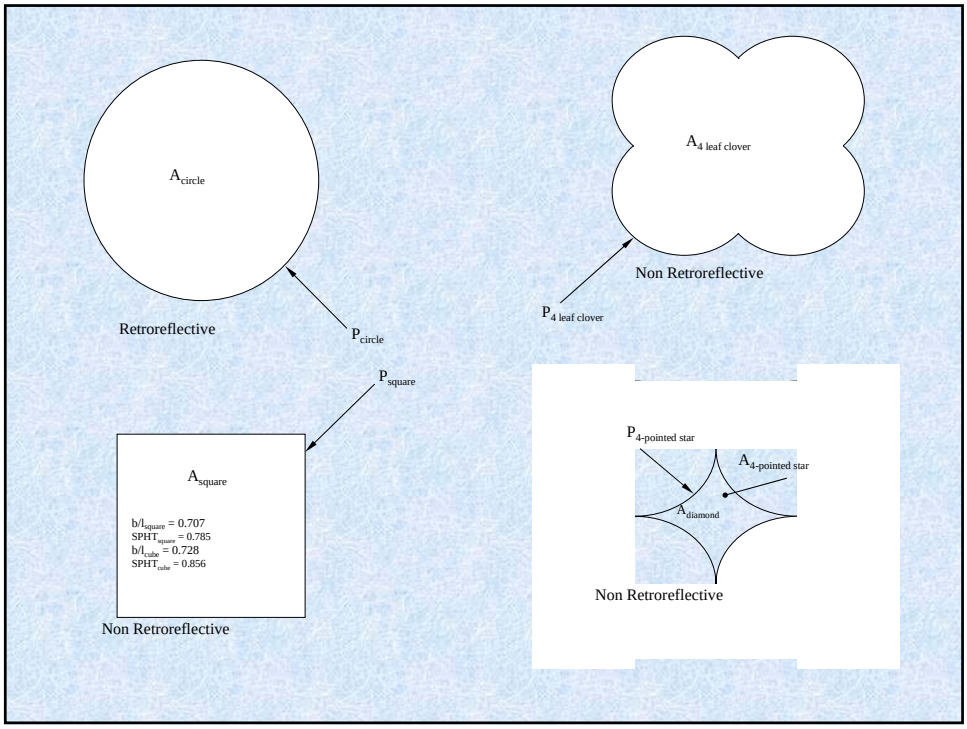
- Defining Roundness
- Applying Camsizer
- Using Results to Save Taxpayer's Money

1. Aspect ratio “b/l” is defined, measured and calculated as the smallest of all maximum chords (xc min) against the longest Feret diameter (xFe max).
2. Roundness (Sphericity/Circularity) is calculated as a ratio between projection area of the particle and the perimeter of its projection.

Only the circle’s Aspect Ratio is measured with b/l = 1 and only the projection of the circle comes from a spherical particle.

All other models like four-leaf-clover, square and four-pointed-star have an aspect ratio < 1





Comparison Aspect Ratio <=> Sphericity					Aspect-	Round-
calculated with CAMSIZER formulas					Ratio	ness
	Perimeter	**Area**	diameter 1	diameter 2	**b/l**	**SPHT**
			(smaller)	(larger)		
Circle	3,1416	0,785	1	1	**1**	**1**
4 leaf clover	3,1416	0,6427	0,854	1	**0,854**	**0,818**
Square	4	1	0,707	1	**0,707**	**0,785**
4 pointed star	3,1416	0,215	0,707	1	**0,707**	**0,273**
(diamond)						

To get data from 3-dimensional particles one can use different models in the CAMSIZER software and one will see how particles fall and get their results (see image of a cube). This tool is available in the new CAMSIZER software.

Texas Department of Transportation

CAMSIZER®

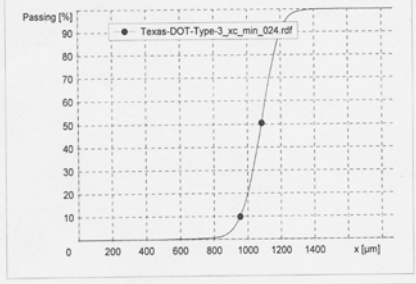
Retsch® TECHNOLOGY

TXDOT Quality Report

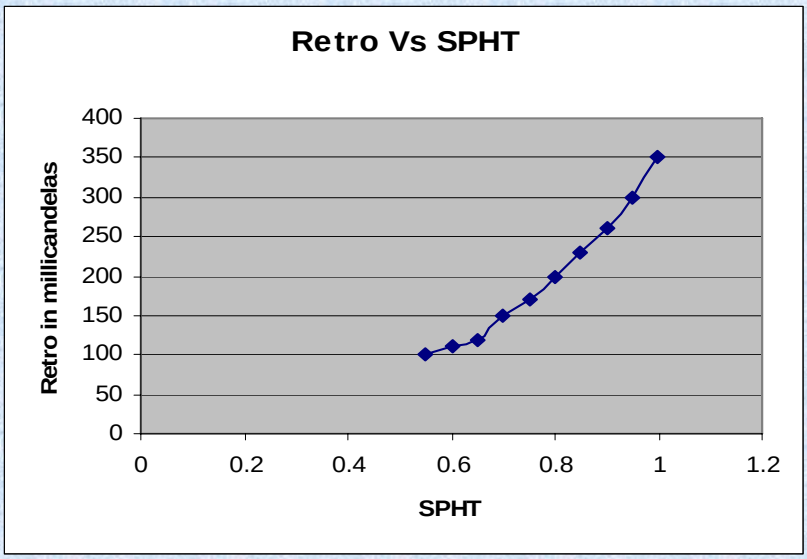
Company:	post
User:	worden
Result file:	C:\Program Files\CAMSIZER-331t\CAMDAT\Demo\Texas-DOT-Type-3_xc_min_024.rdf
Task file:	C:\Program Files\CAMSIZER-331t\CAMSYS\Type3.afg
Time:	8.5.2008 , 10:47 , duration 8 min 56 s at 0.5 % covered area, image rate 1:1 and 40 mm feeder
Particle model:	min(xc)
No. of particles:	CCD-B = 126069 , CCD-Z = 13742
Fitting:	no
Material:	Type III
Comment:	Lot 1483 B08440161 S04AL 29-8-32540
Refractive Index:	Color: Coating:

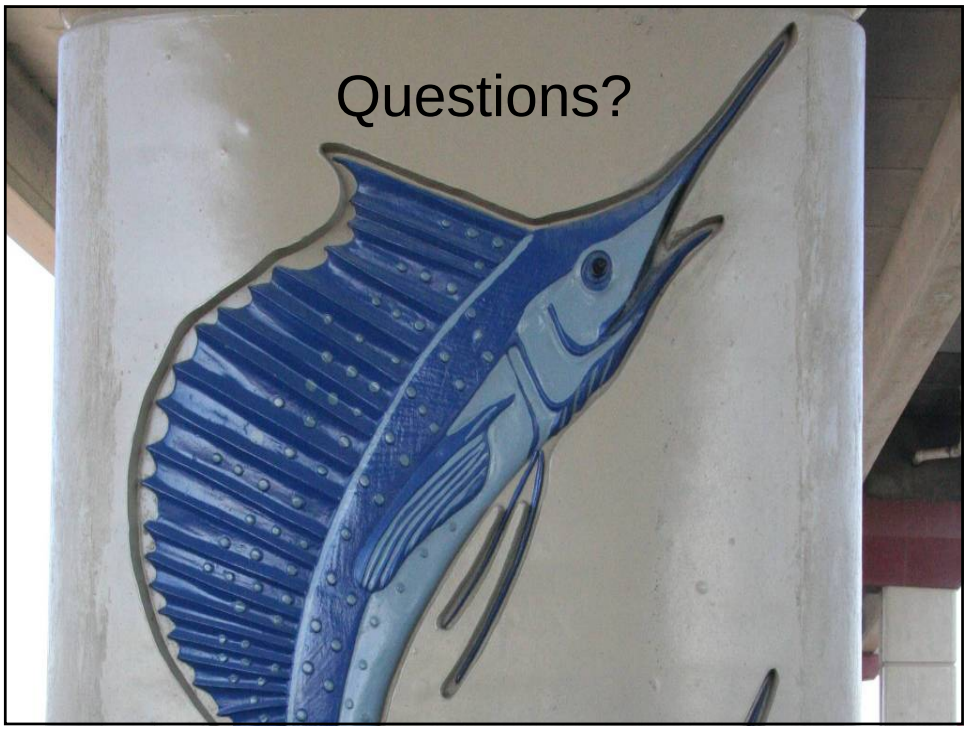
ASTM(+)	No(-)	retained [%]	Average Sphericity	Particle Count	1-Q3(b/l) 0.8300
#12	#10	0.0	0.530	1	0.0
#14	#12	0.2	0.840	33	42.0
#16	#14	14.1	0.978	10308	93.6
#18	#16	66.2	0.982	77755	97.0
#20	#18	18.2	0.982	36343	97.1
#25	#20	1.0	0.942	2672	85.3
PAN	#25	0.3	0.949	3214	92.8

Characteristics



By comparing Retro vs SPHT TXDOT can redefine it's roundness spec toward cost effective roundness





Optical Analysis Advantages

- Much higher throughput
- Much more detailed and flexible analysis
- More representative analysis
- Less operator sensitive
- Less quantity sensitive

Optical Analysis Disadvantages

- $$$ - Initial Cost
- No Consensus Standard

Developing a Consensus Standard

- Work is currently underway in ASTM D01.44: www.astm.org
- Participation from equipment producers, glass bead producers and end users
- Initial round-robin completed
- Working on draft standard

Upcoming Uses

- Direct measurement of refractive index
  - Measure each bead instead of 30-50 beads
  - Displaces microscope & fluid, saves time
  - Precise measurement
  - Allows mixed refractive index beads (“normal” and “high-index”)
  - Currently no reasonable method at TxDOT for measuring mixed index beads

Refractive Index

- Currently ~1.5
  - Low cost
  - Good retroreflectivity
  - Excellent durability
- May incorporate high index ~1.9 beads
  - Expensive
  - Excellent retroreflectivity
  - “Good” durability

- Mixing 1.5 and 1.9 index beads may allow stripers to achieve better retroreflectivity (safety) while still maintaining good durability and reasonable cost.
- Will need better monitoring – need to know actual fraction of each type of bead, not just presence
- May displace mixture of large and small 1.5 index beads

Aggregate (“rocks”)

For durability of concrete structures, and both concrete and asphalt pavements, particles (rocks) need the opposite physical character of glass beads: they need angularity.

Steel Grit

- Steel grit is commonly used for abrasive blasting (formerly “sandblasting”) of old paint from bridges and is recycled onsite
- Both particle size and angularity are important to achieve a clean surface

14 FT 3 IN
Questions?

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