Emerging HMA Technologies

2004 NCAUPG Annual Meeting

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Emerging Technologies

- Warm Asphalt
- SMA Compaction Levels
- Use of RAP with SMA
- Real Time Quality Control

Why Warm Asphalt?

Research by Stroup-Gardiner and Lange at AU
ndicates increased emissions with increased temp.

Why Warm Asphalt?

Blowers to draw fumes away from workers

Why Warm Asphalt?

- Reduce production and laydown temperatures
- Reduce emissions
- Reduce energy costs
- Reduce aging of binder
- Cool weather paving?

Lower the Temperatures

C/O Dr. Els

What are Warm Asphalt Mixes?

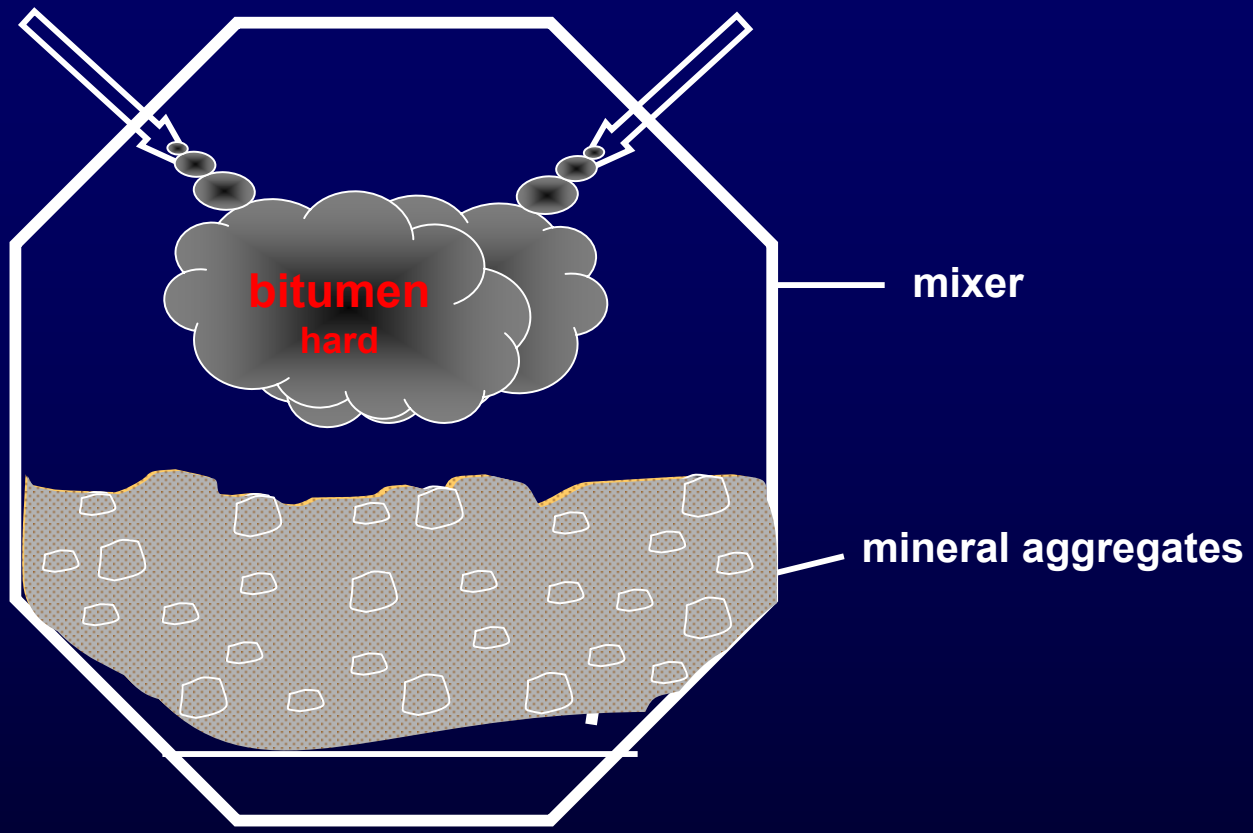
Several process have been developed to improve mixture workability allowing lower production and laydown temperatures

- WAM Foam – Shell/Kolo Veidekke
- Zeolite – Eurovia/Hubbard Construction
- Sasobit – Sasol Int./Moore and Munger

WAM-Foam

- Two Phase addition of asphalt
  - Aggregate coated with “soft” asphalt
  - Hard asphalt foamed to mix with pre-coated aggregate
  - Soft asphalt controls minimum placement temperature
  - Material placed as low as 80 C (176 F), 50 – 60 C (90 – 108 F) reduction
  - Requires plant modification for foaming, estimated at $70,000
  - Special asphalt feeds may be required

Two phase bitumen mixing method

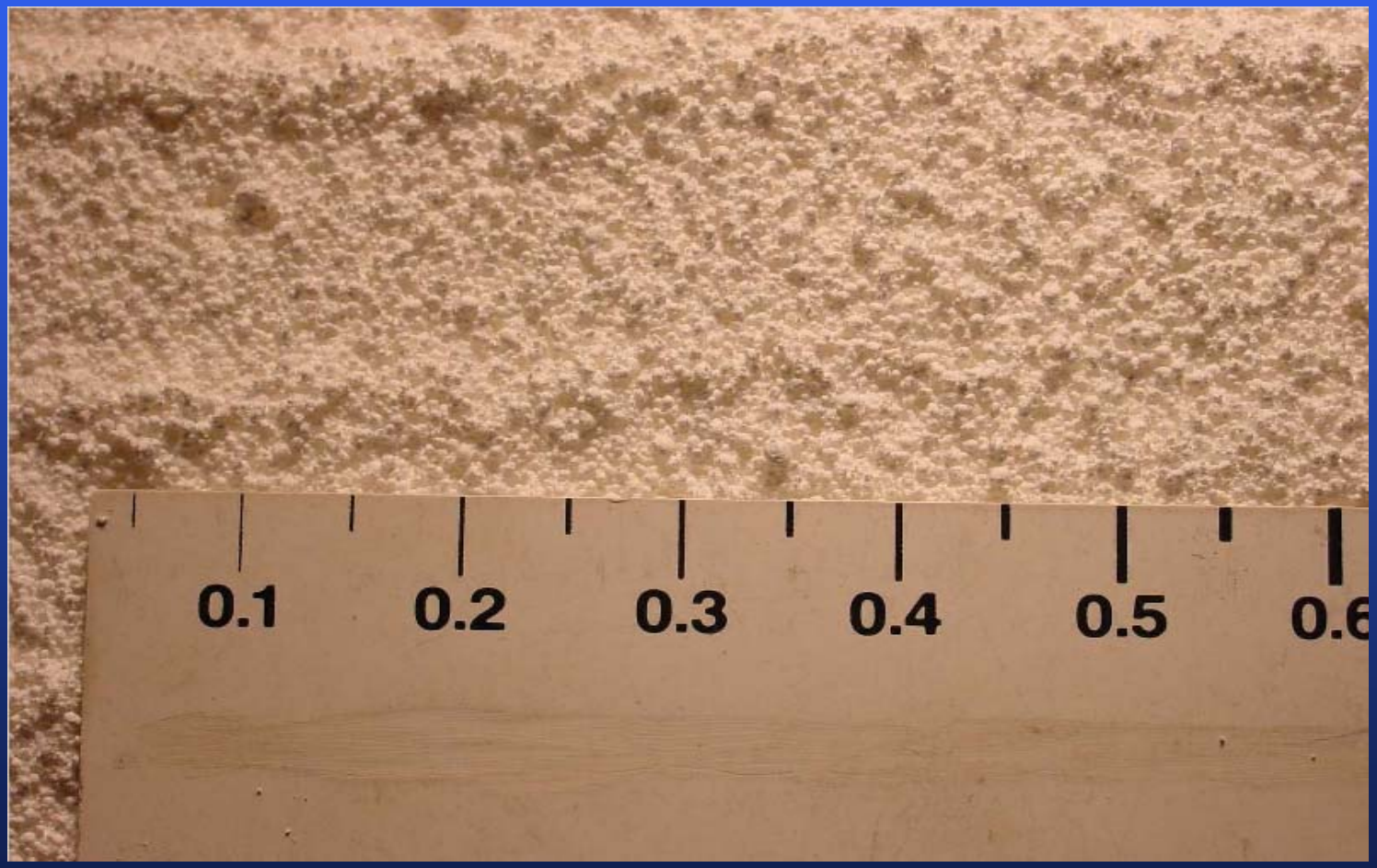


Courtesy IFTA GmbH

Zeolite

- Zeolites are crystalline hydrated aluminium silicates
- aspha-min®, is a special Zeolite added to the hot mix asphalt in the temperature range of 100 to 200 °C (212 to 392 °F)
- When the Zeolite is heated, it gives up its internal moisture, approximately 21% by weight, foaming the asphalt

Granulated aspha-min®



Addition of aspha-min®

- Aspha-min is typically added at an addition rate of 0.3% by weight of mix
- Expected to increase mix cost by $1.50 per ton
- Can be added to the mineral filler or fed separately
- Batch plants are more commonly used than drum plants in Europe
- Aspha-min has been added through the RAP collar into a drum plant in France

Proposed Addition Method for U.S. Market

Manual Addition

Weigh Bucket for aspha-min

Laydown of Polymer Modified Warm Asphalt with Zeolite at 250 F

94% Gmm
55 F Air Temp.

4 passes of Rubber Tire

Followed by 4 vibratory Passes with static finish roller

Organic Additives

- Synthetic Fischer-Tropsch paraffin waxes – Sasobit
  - Added to binder
  - Can incorporate an SBS modifier (Sasoflex)
  - Does not require high-shear blending
  - May negatively impact low temperature properties
- Low molecular weight ester compounds (not included in the study at this time)

Fischer-Tropsch paraffins are

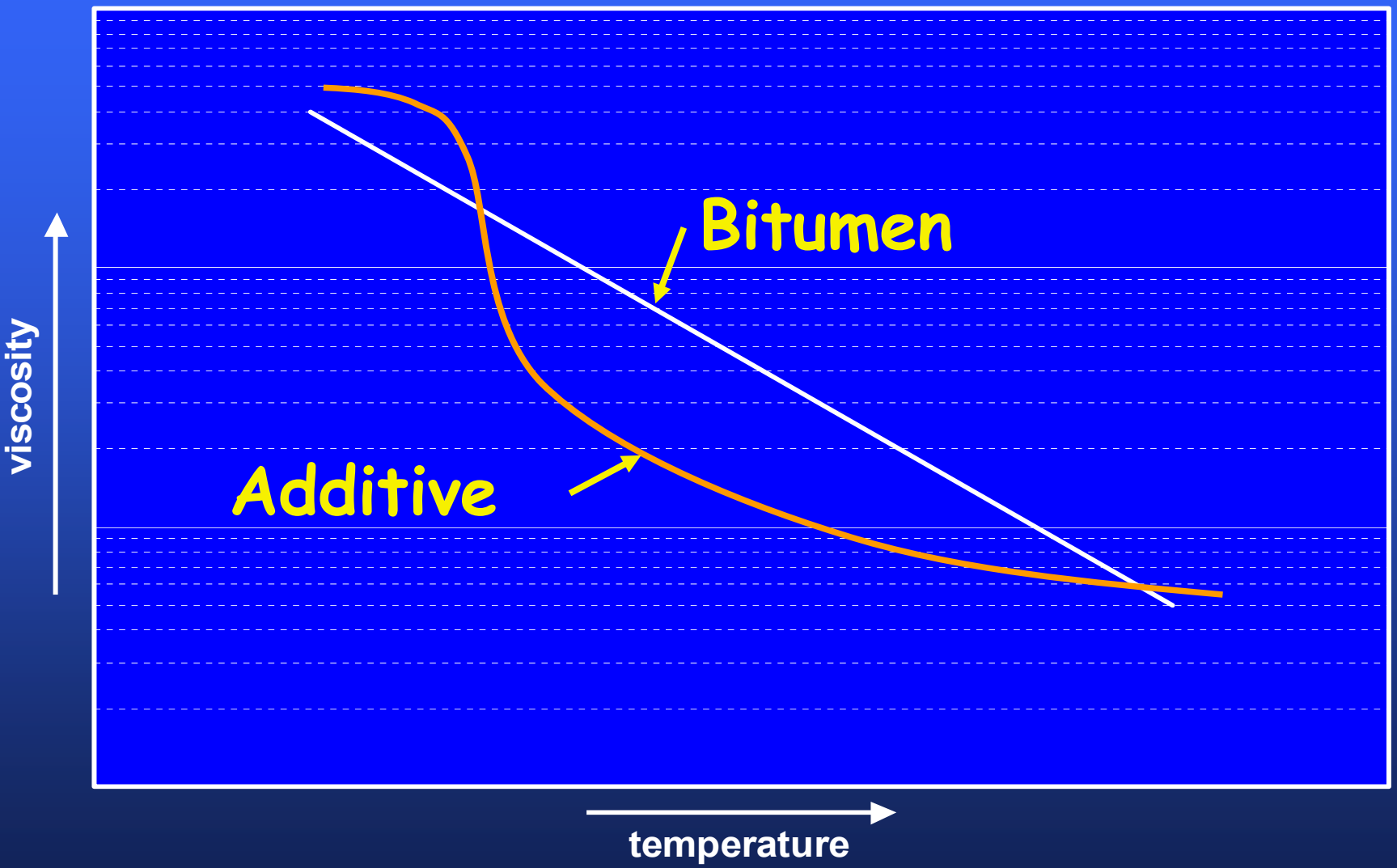
- long-chained aliphatic hydrocarbons
- from coal gasification
- with the Fischer-Tropsch process

Clear differences:

	Bitumen wax	*Synthetic wax*
Melting point, ° C	70	100
Penetration at 25 °C, 0,1 mm	120	< 1
Viscosity at 135 °C mm^2/s	8	15
Average molecular weight, g / mol	800	1600
n-paraffins, %	14	73

C/O Dr. E

How organic additives work



C/O Dr. E


Sasobit

Study Objectives

- Evaluate Warm Asphalt Technologies for U.S. Paving Practices
  - High production
  - Rapid Turn-over to traffic
- Potential Concerns
  - “Curing” Time
  - Increased Potential for Moisture Damage
  - Binder effects

German Autobahn Paving

Cure Time

- Europeans allow pavement to “cure” before allowing traffic on roadway
- Germans specify a minimum of 24 hours for SMA
- When does Warm asphalt’s workability end?
- Will pavements rut if traffic allowed on an hour or so after placement?

German Plants

Production Concerns

- WAM Foam may not use standard PG grades
  - Contractor may need extra tanks
  - Will agency accept blend?
- Predominance of batch plants
- How will silo storage effect workability?
- Lower production rates
  - Will absorptive aggregates dry at lower temperatures?

Summary

- Three warm asphalt processes used in Europe for up to 5 years
- Allows compaction at lower temperatures
- Concerns about U.S. production rates and turn over to traffic
- A Tool for the Tool Box!

SMA Compaction Levels

Stone Mastic Asphalt (SMA)

- Technology transfer from Europe in 1990
- Georgia and Maryland DOT early leaders
  - Initially designed with 50 blow Marshall
  - MD adopted 100 gyrations in 1996
- Research Efforts
  - NCHRP 9-8
  - On-going Research for FHWA

SMA Aggregate Composition

Example

70%	#7
13%	#89
10%	#810
7%	Min. Filler

barse Aggregate

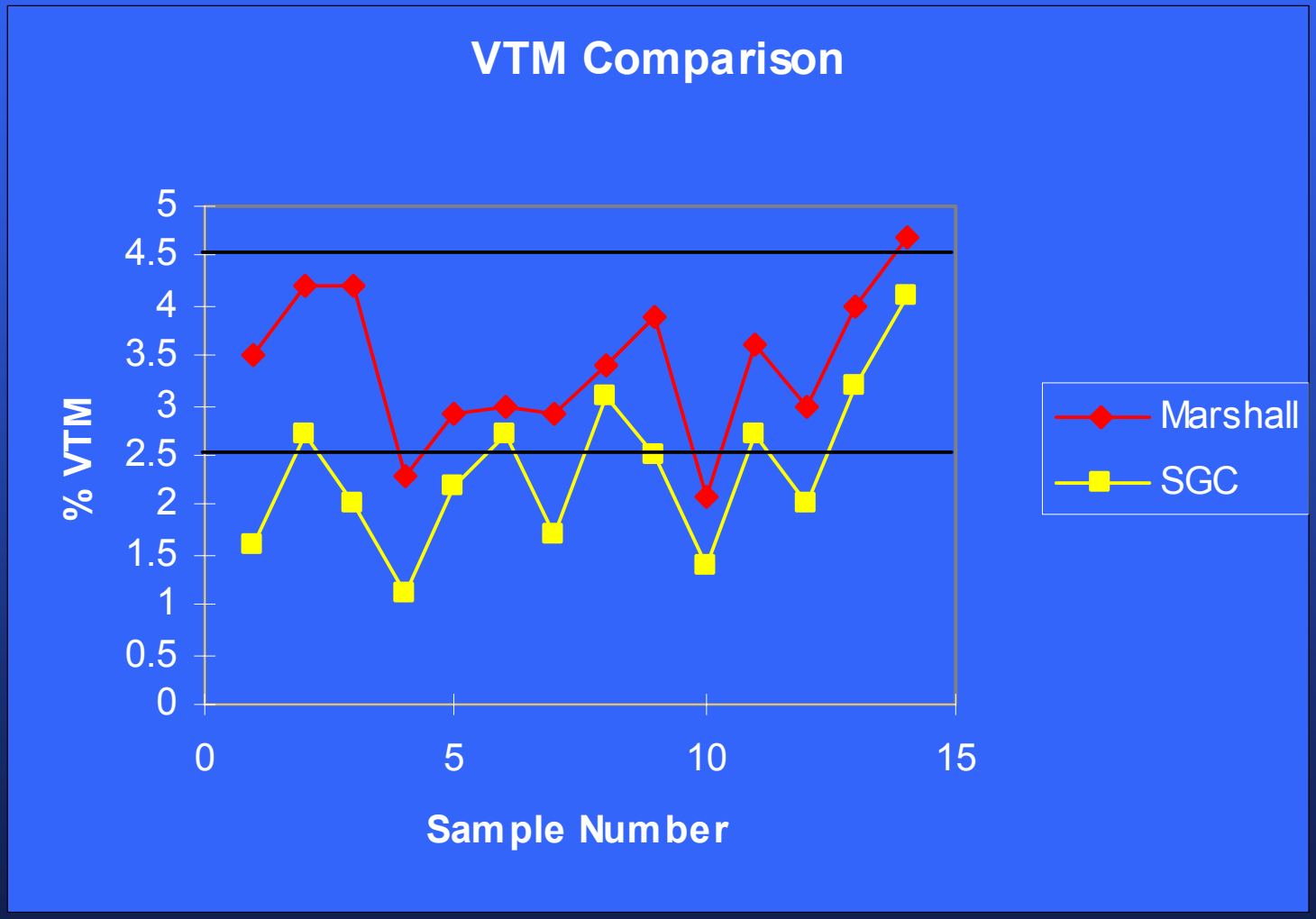
ne Aggregate

ineral Filler + AC + Fiber

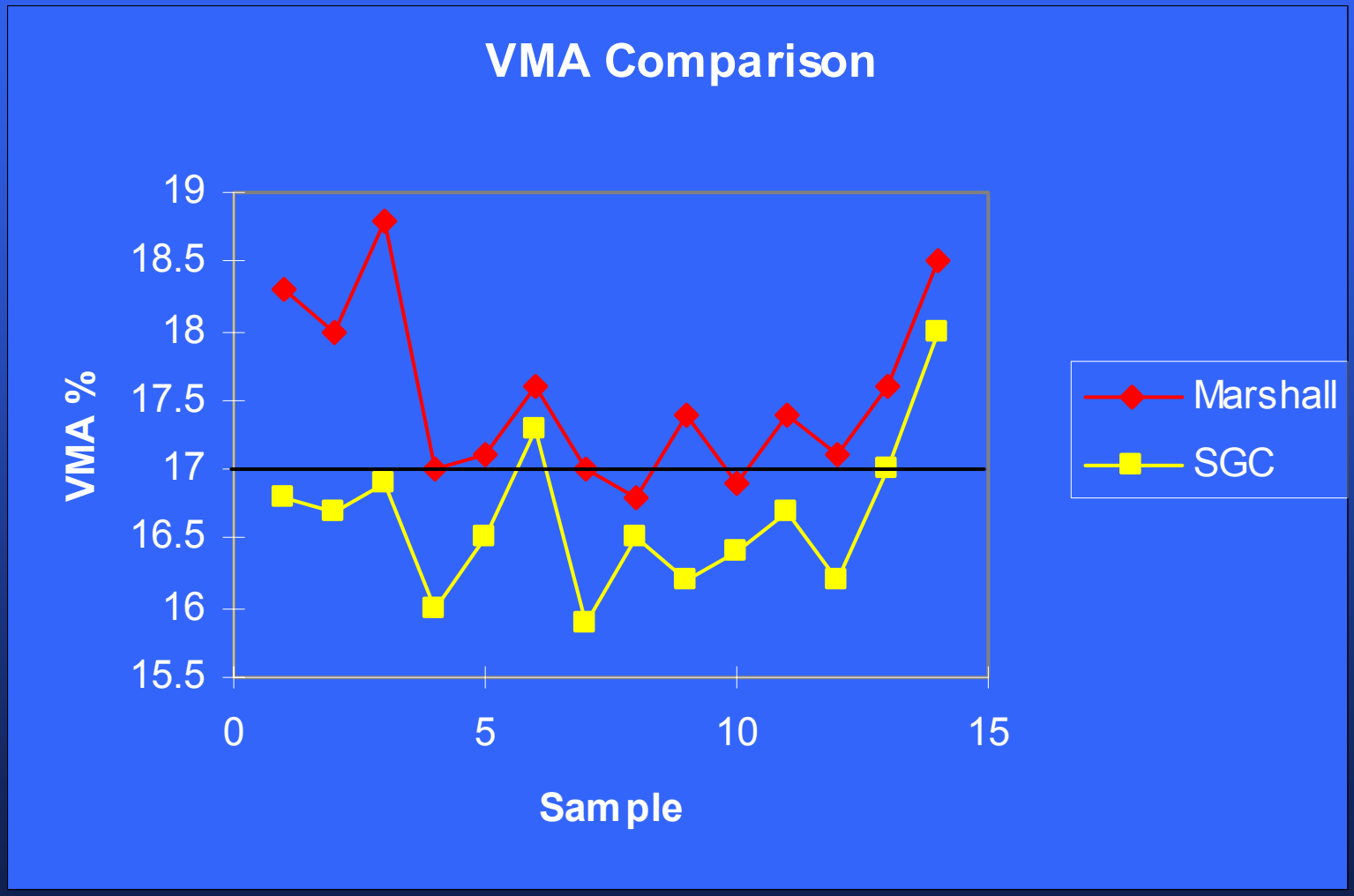
Compaction Methods

- 50 Blows
- 75 or 100 Gyrations

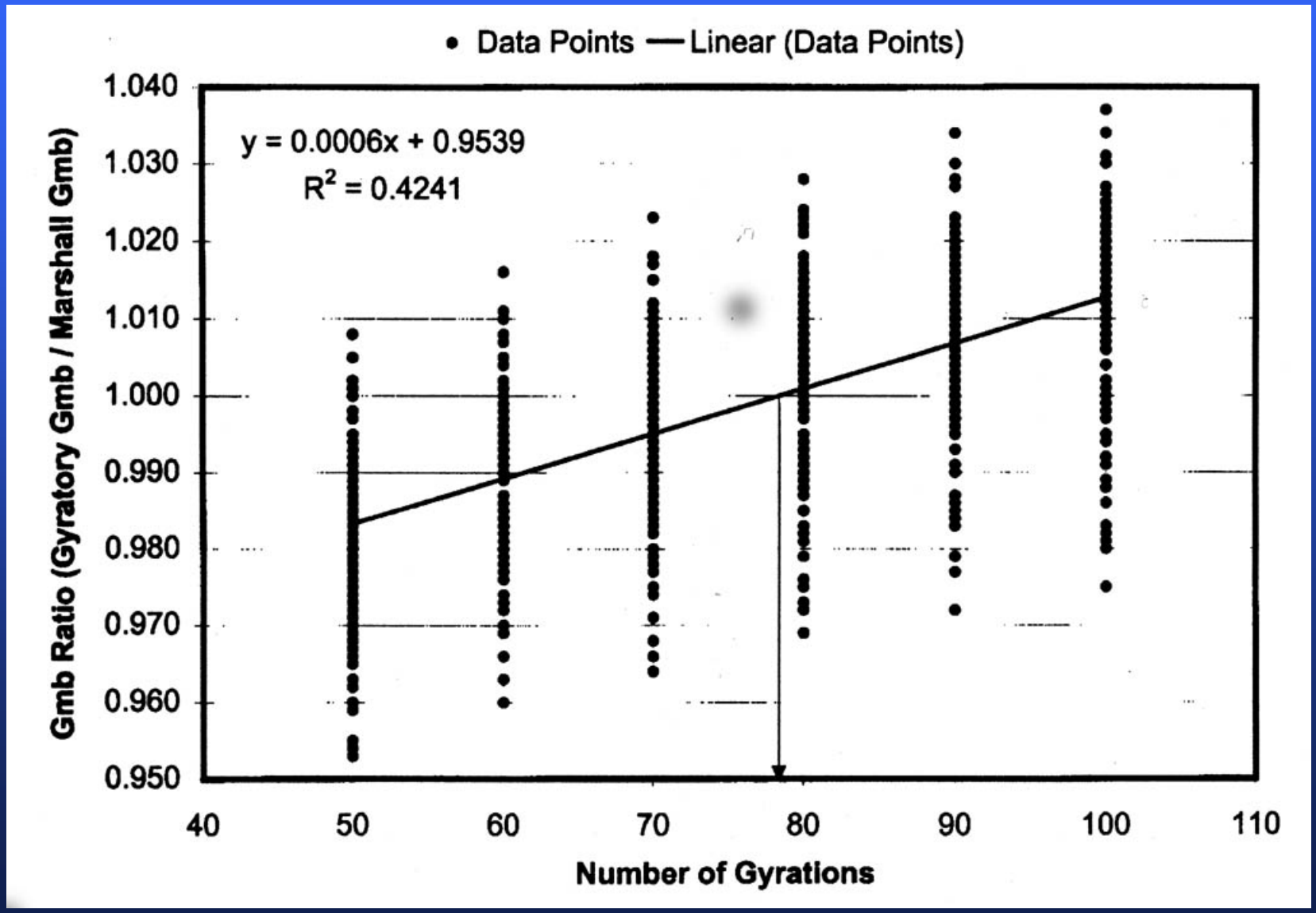
12.5 mm SMA I-64 VA



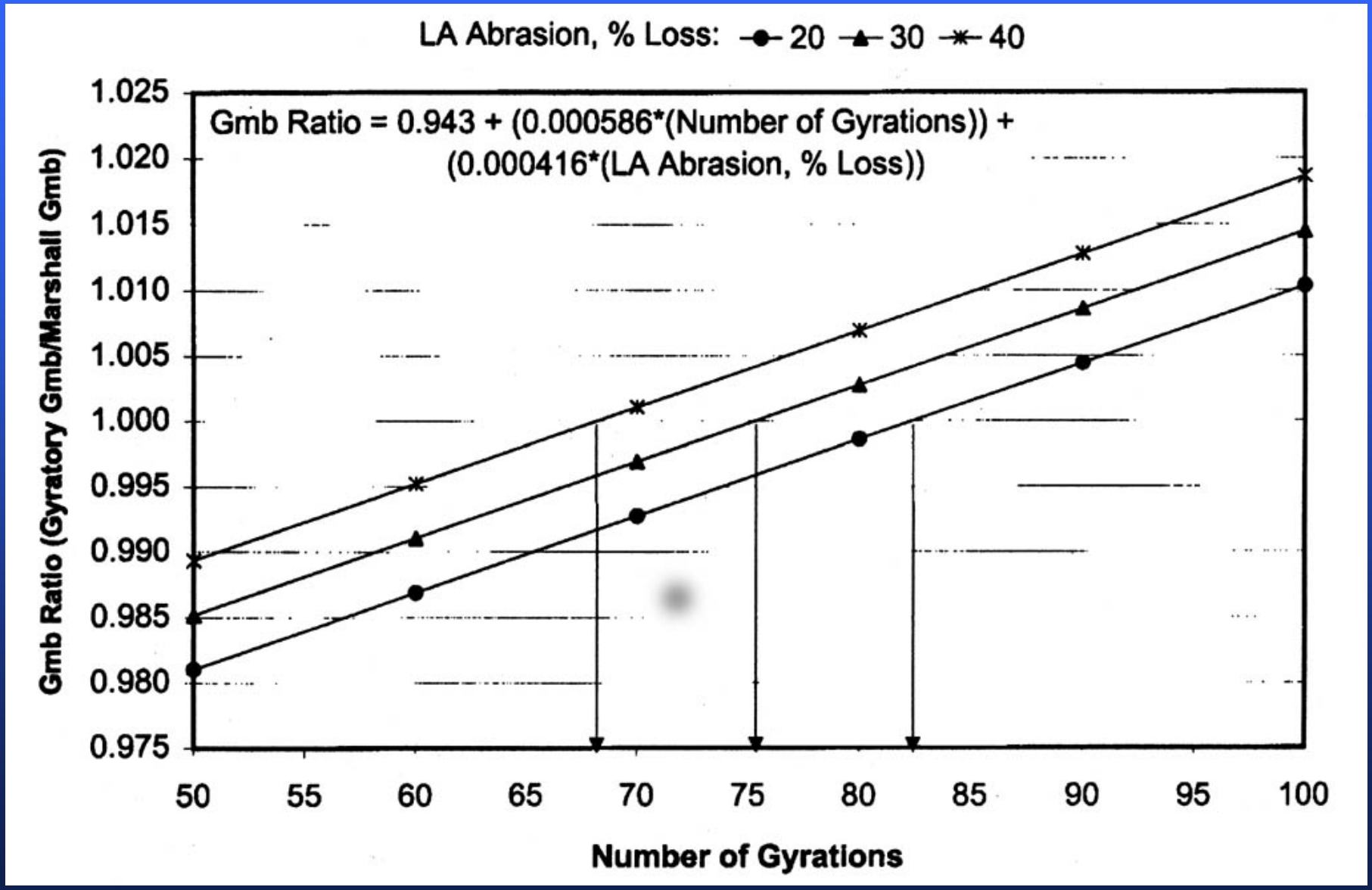
12.5 mm SMA I-64 VA



NCHRP 9-8


Data Points
Linear (Data Points)
y = 0.0006x + 0.9539
R² = 0.4241
Gmb Ratio (Gyratory Gmb / Marshall Gmb)
1.040
1.030
1.020
1.010
1.000
0.990
0.980
0.970
0.960
0.950
40
50
60
70
80
90
100
110
Number of Gyrations

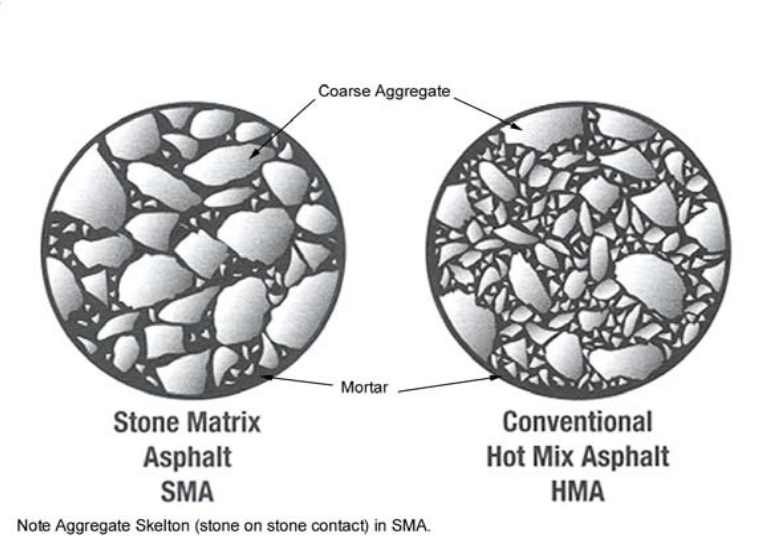
NCHRP 9-8


LA Abrasion, % Loss: 20 30 40
Gmb Ratio = 0.943 + (0.000586*(Number of Gyrations)) +
(0.000416*(LA Abrasion, % Loss))
Gmb Ratio (Gyratory Gmb/Marshall Gmb)
1.025
1.020
1.015
1.010
1.005
1.000
0.995
0.990
0.985
0.980
0.975
50
55
60
65
70
75
80
85
90
95
100
Number of Gyrations

Voids in Coarse Aggregate (VCA)

- VCA is used to ensure stone-on-stone contact
- VCA dry rodded condition (DRC) is obtained by compacting blended coarse aggregate fraction according to AASHTO T19

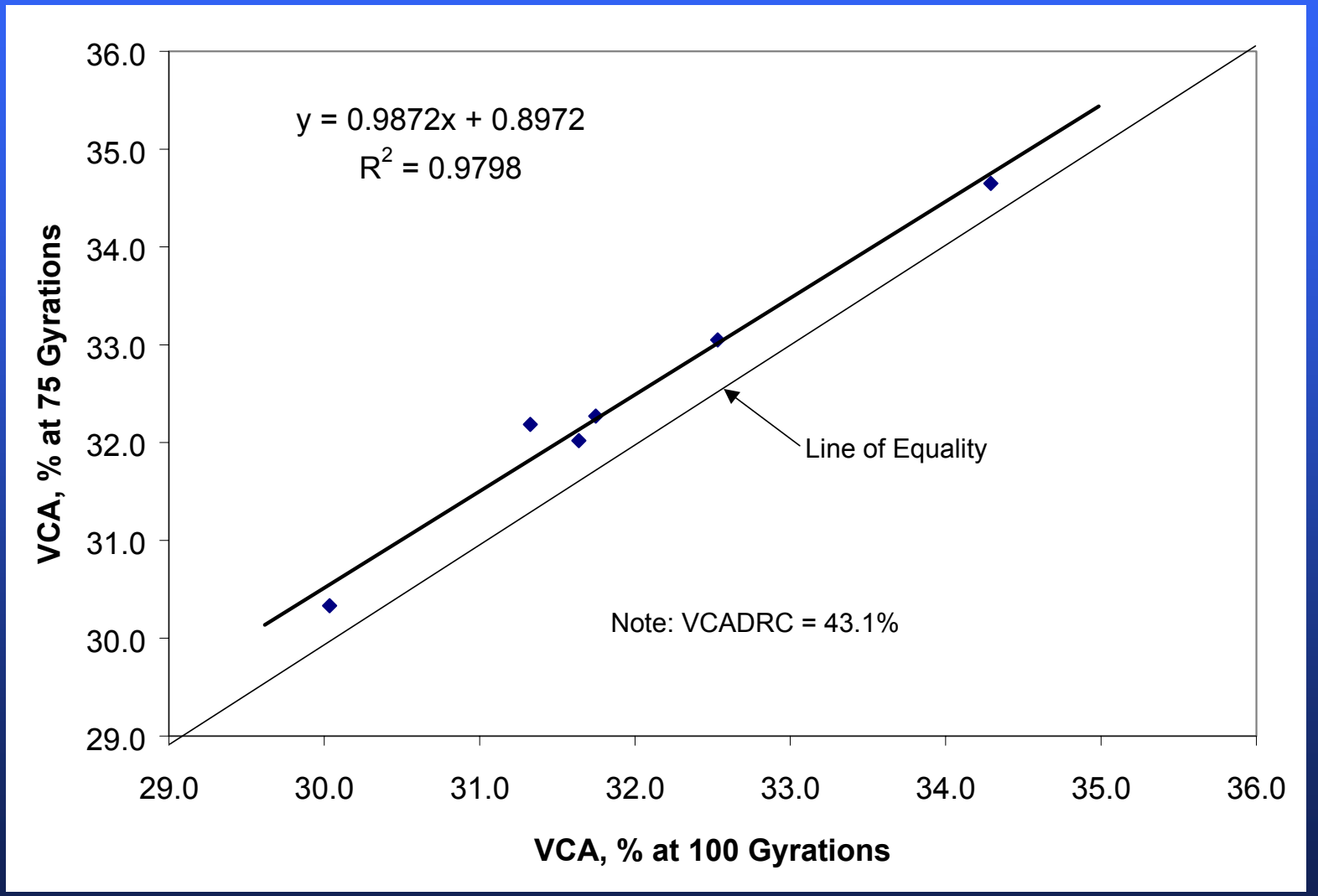
VCA - Continued



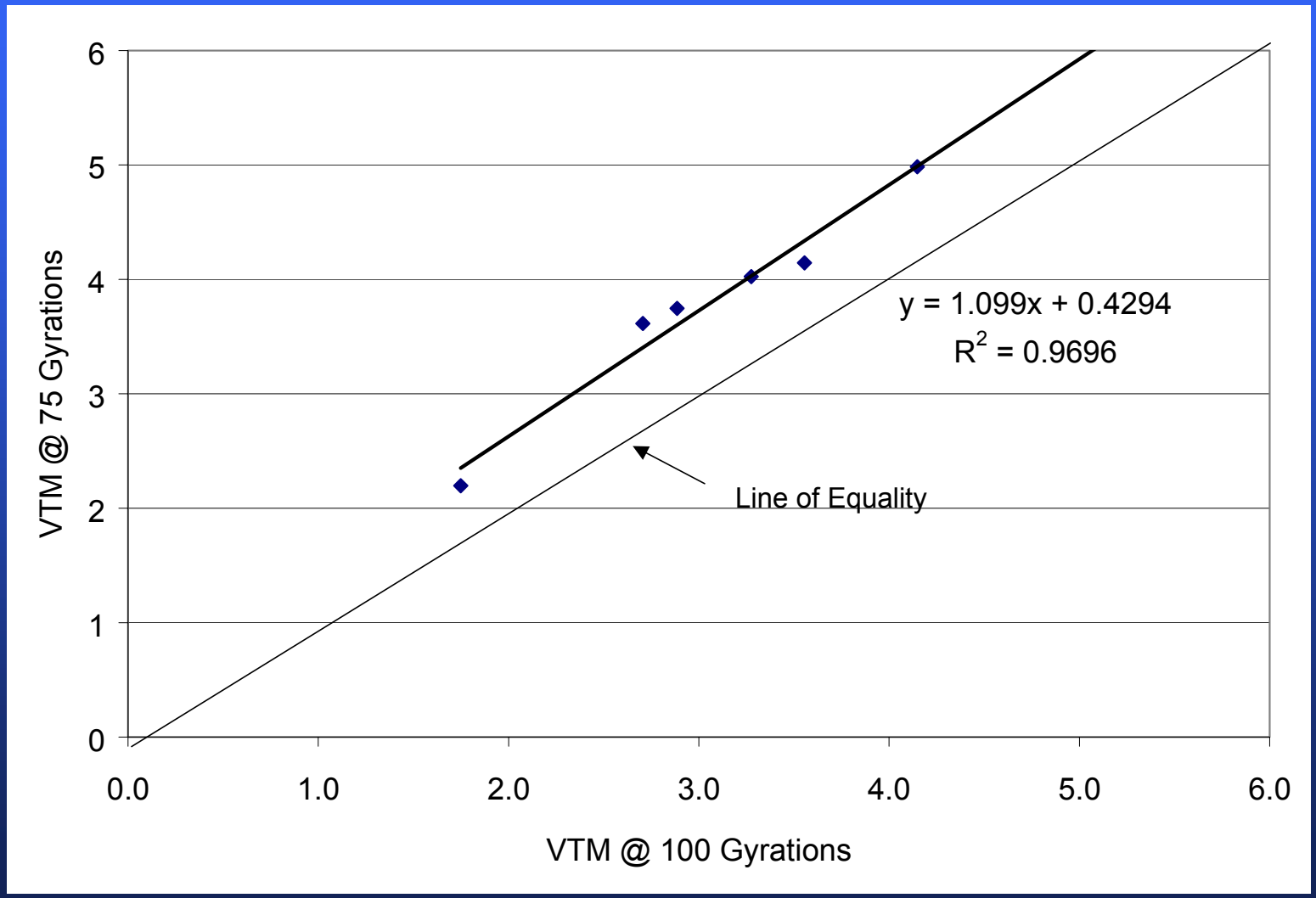
$$VCA_{Mix} = 100 - \left(\frac{G_{mb}}{G_{CA}} \times P_{CA} \right)$$

VCA of compacted SMA sample (VCA_{mix}) must be less than VCA_{DRC} or mastic may be pushing stone skeleton apart, causing mix instability

VCA_{Mix} at 75 and 100 Gyrations



Prowell, Cooley & Schreck, TRR 1813, 2002



Prowell, Cooley & Schreck, TRR 1813, 2002

Evaluation of Compaction Levels for SMA

Sponsored by FHWA

Relationship Between Aggregate Breakdown and Compaction Level

- High coarse aggregate content
- Stone on stone contact
- Higher stress than dense graded mix under compaction or traffic
- Current NCAT study, sponsored by FHWA, to evaluate compaction as it relates to degradation

Aggregate Properties

- Aggregate properties related to degradation
  - LA Abrasion
    - European ≤ 20
    - AASHTO ≤ 30
    - Georgia ≤ 45
  - F&E Content
    - 3:1 ratio ≤ 20%
    - 5:1 ratio ≤ 5%

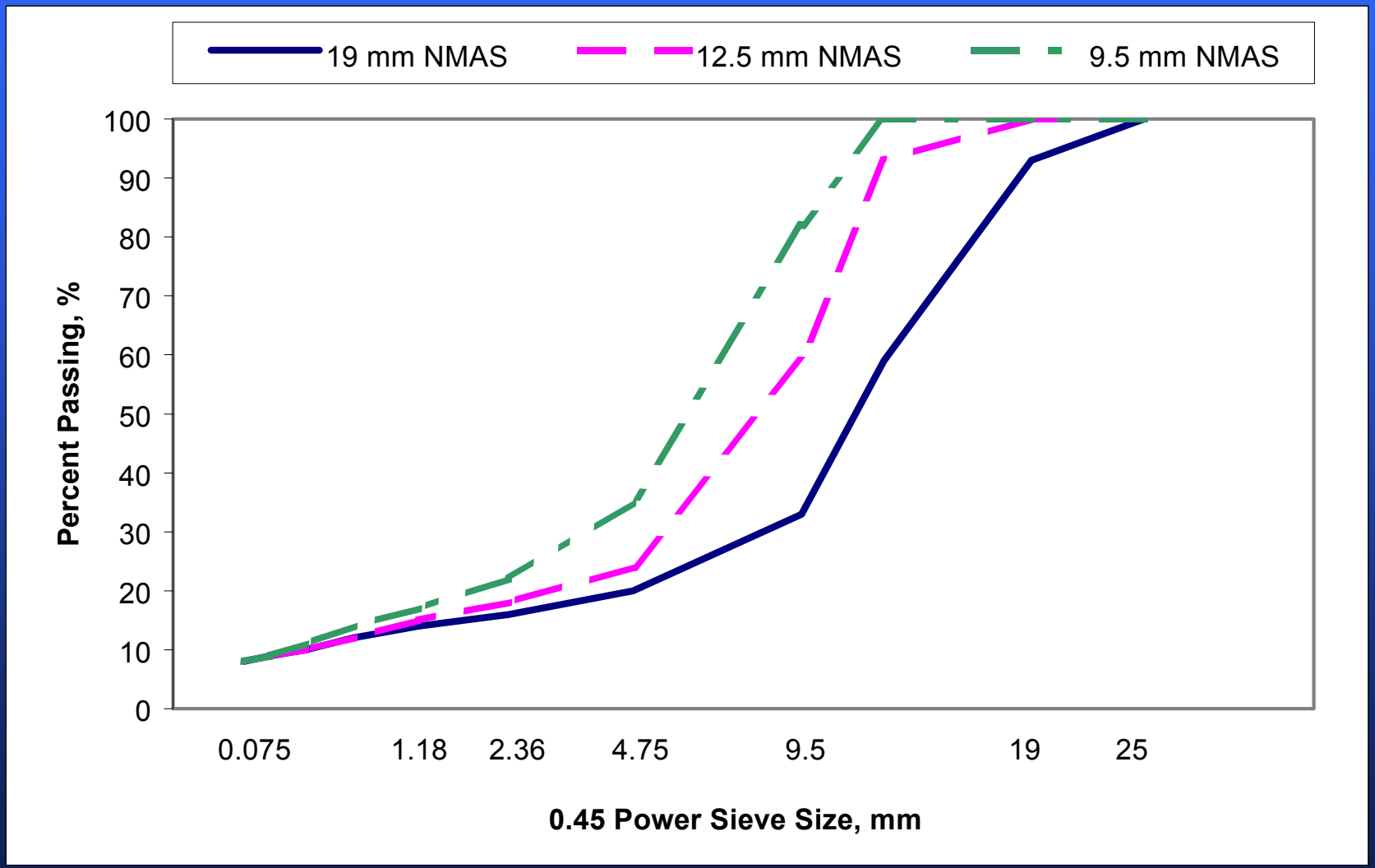
Materials

5 Aggregates

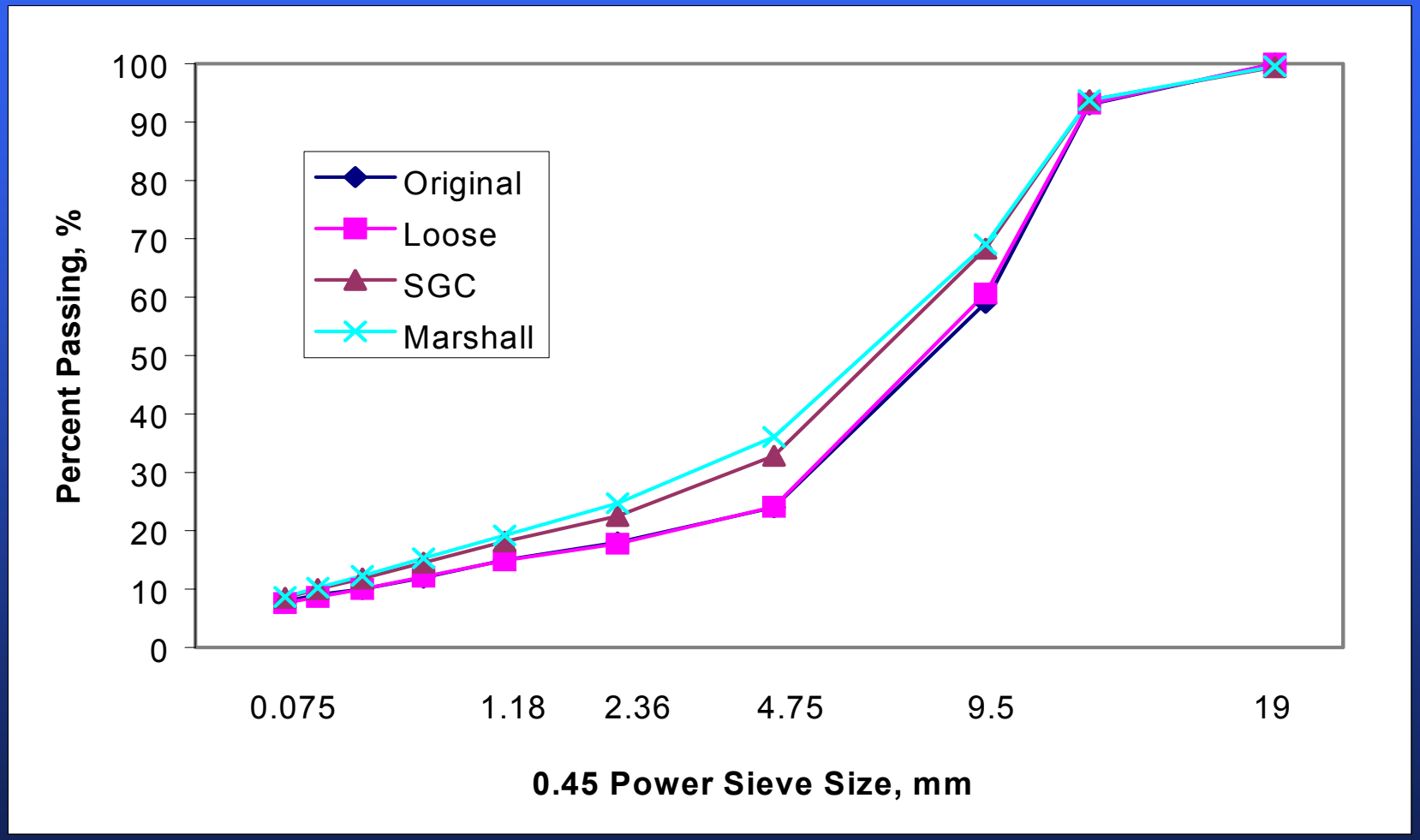
Aggregate Type	*Bulk Specific Gravity*[1]	*LA Abrasion Loss, %*[2]	*F&E Content at 3:1 ratio, %*[1]
Crushed Gravel	2.60	30.7	35.2
L. Granite	2.67	36.4	28.1
Limestone	2.73	26.4	25.5
R. Granite	2.70	20.6	23.4
Traprock	2.93	16.6	17.7

1. The bulk specific gravity and F&E content depends on the combined gradation and NMAS; a 12.5mm NMAS was used to represent it.
2. LA abrasion values are based on B grading.

Gradations


19 mm NMAS
12.5 mm NMAS
9.5 mm NMAS
Percent Passing, %
100
90
80
70
60
50
40
30
20
10
0
0.075
1.18
2.36
4.75
9.5
19
25
0.45 Power Sieve Size, mm

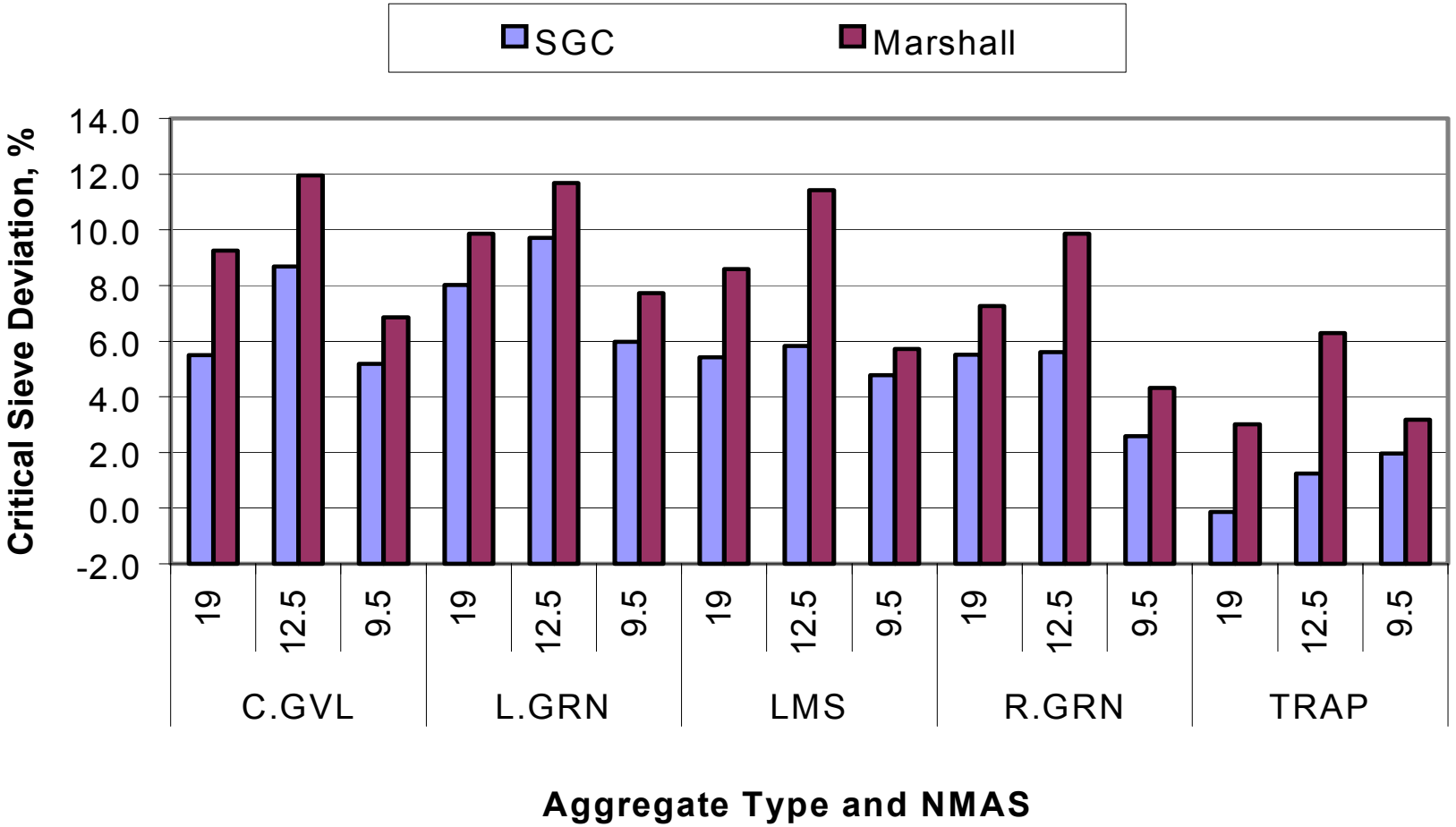
Typical Breakdown



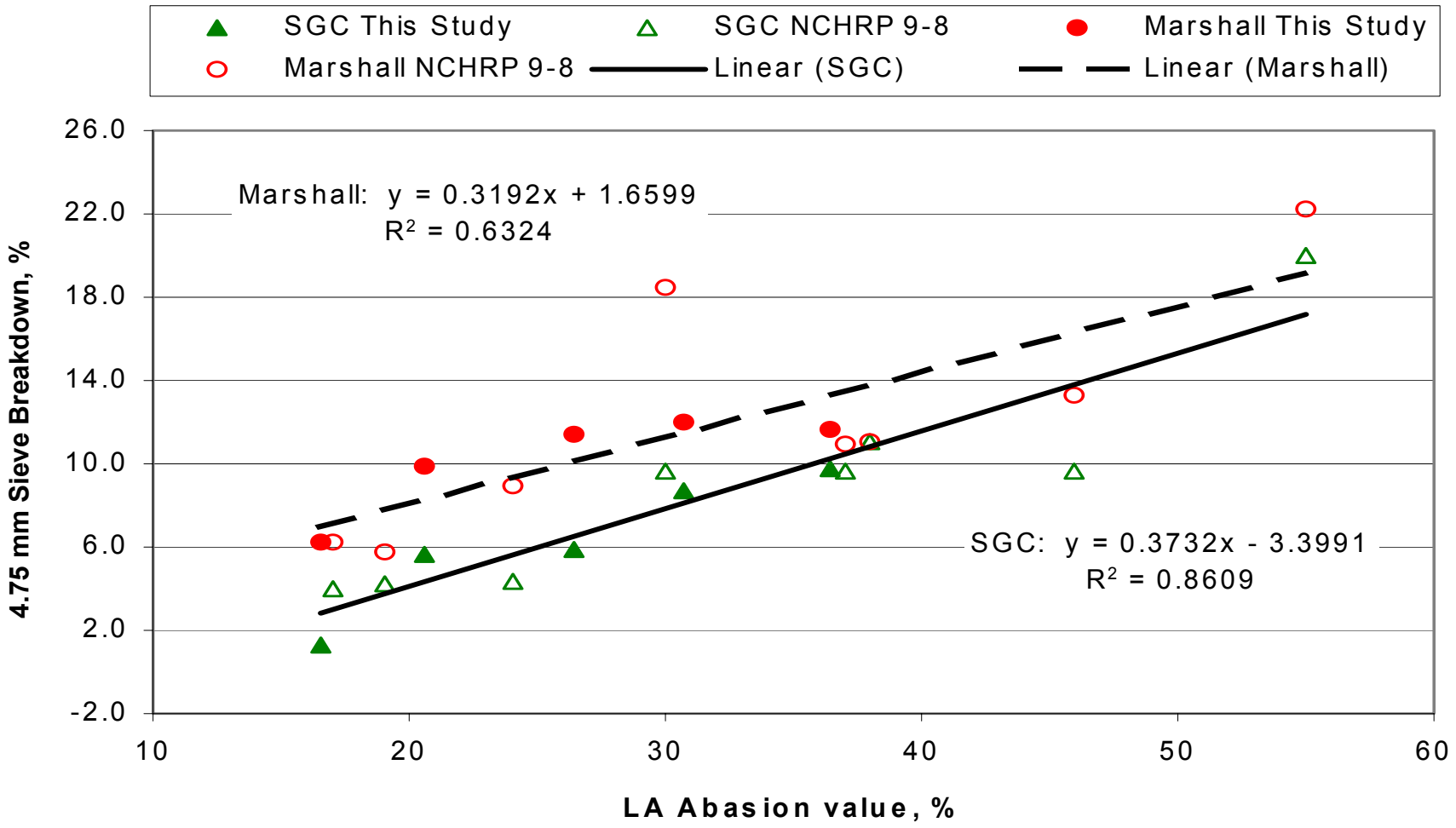
Critical (Breakpoint) Sieve Size

- For 19 mm and 12.5 mm NMAS SMA, No.4 sieve (4.75 mm) was chosen.
- For 9.5 mm NMAS SMA, No.8 sieve (2.36 mm) was chosen.

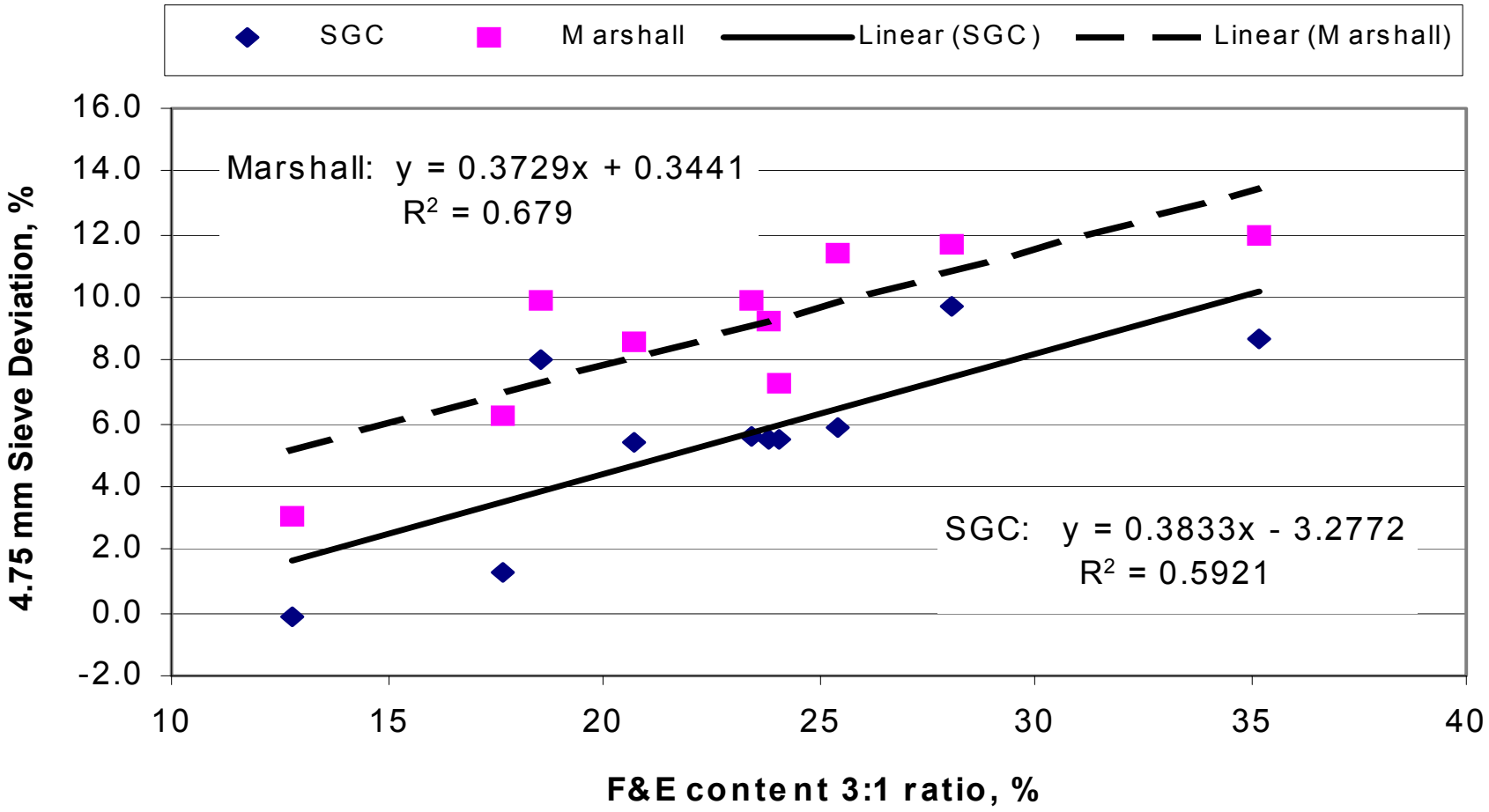
Summary of Breakdown



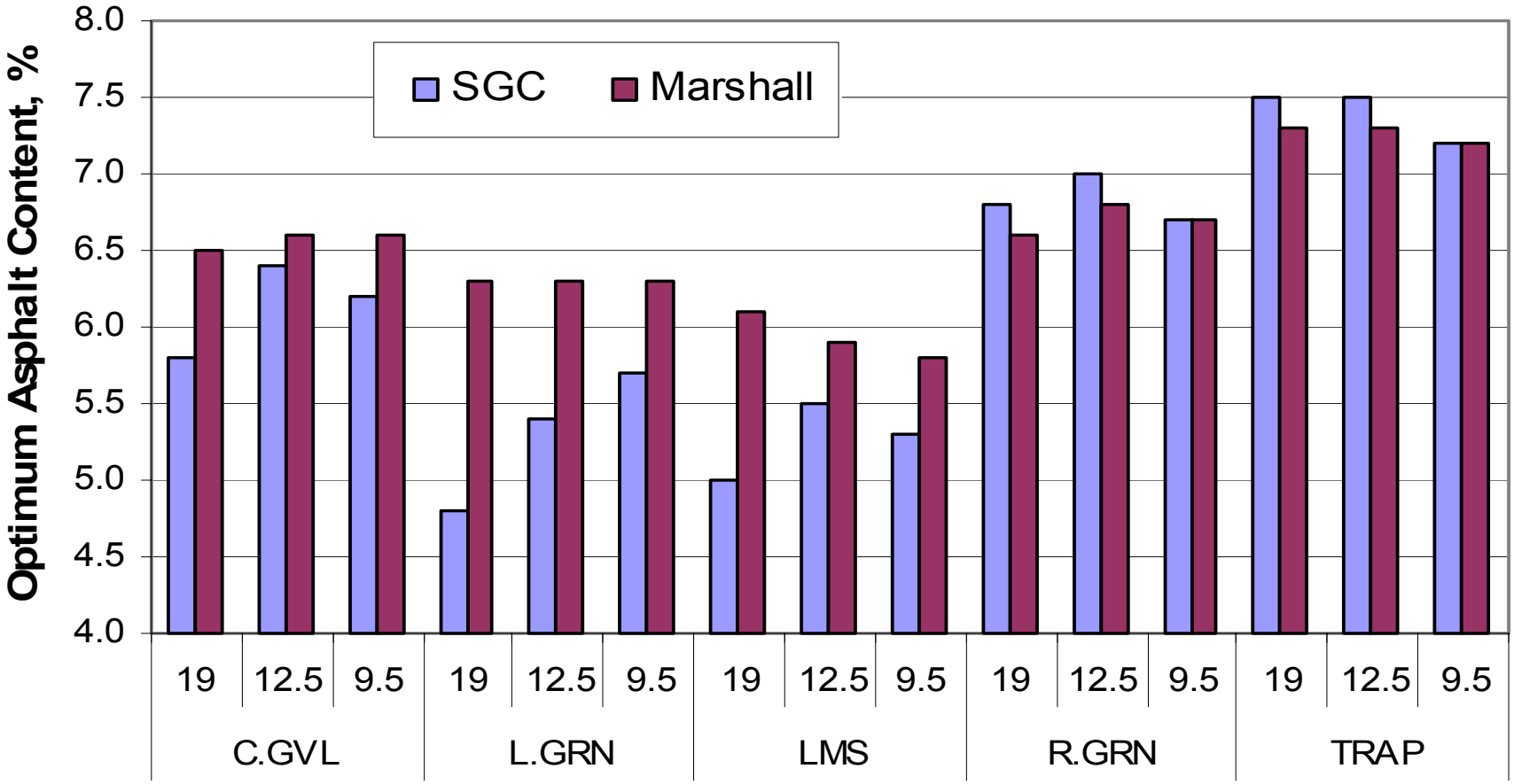
Influence of LA Abrasion on Degradation (Combined data)



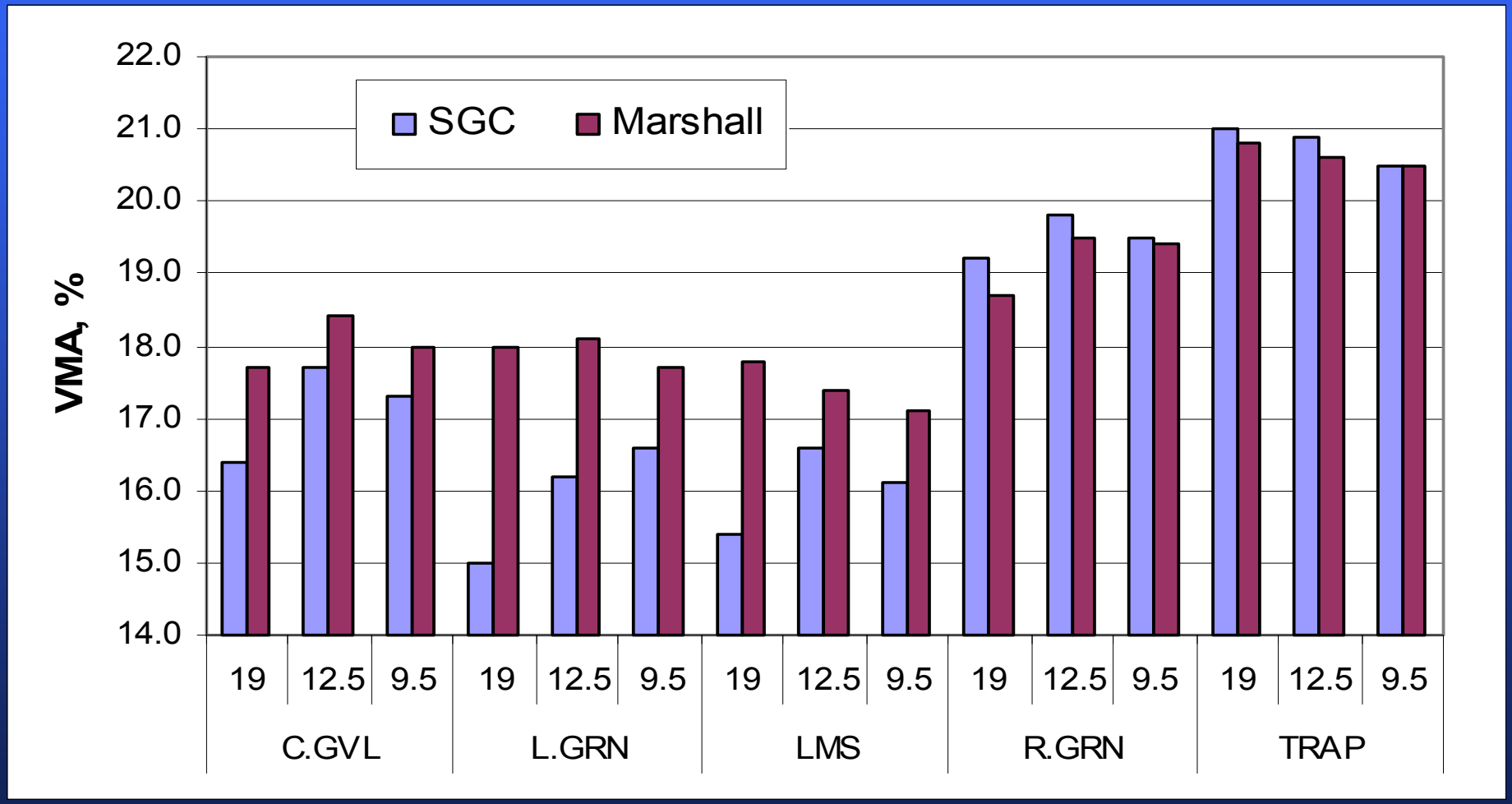
Influence of F&E Content on Degradation



Optimum Asphalt Content Summary



VMA Summary


VMA, %
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
SGC
Marshall
19
12.5
9.5
C.GVL
L.GRN
LMS
R.GRN
TRAP

For More Information on SMA Compaction Levels

Contact:

- Donald E. Watson

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Or

- Hongbin Xie

xiehong@auburn.edu

Complications of Using RAP in SMA

- Most existing asphalt pavements were made with dense graded mixes, therefore, most RAP is dense graded.
- Aggregate quality may not be compatible with SMA or Superpave criteria.
- Mix sensitivity requires high level of materials' quality control, including RAP.

Current industry practice is a crusher run approach to recycling

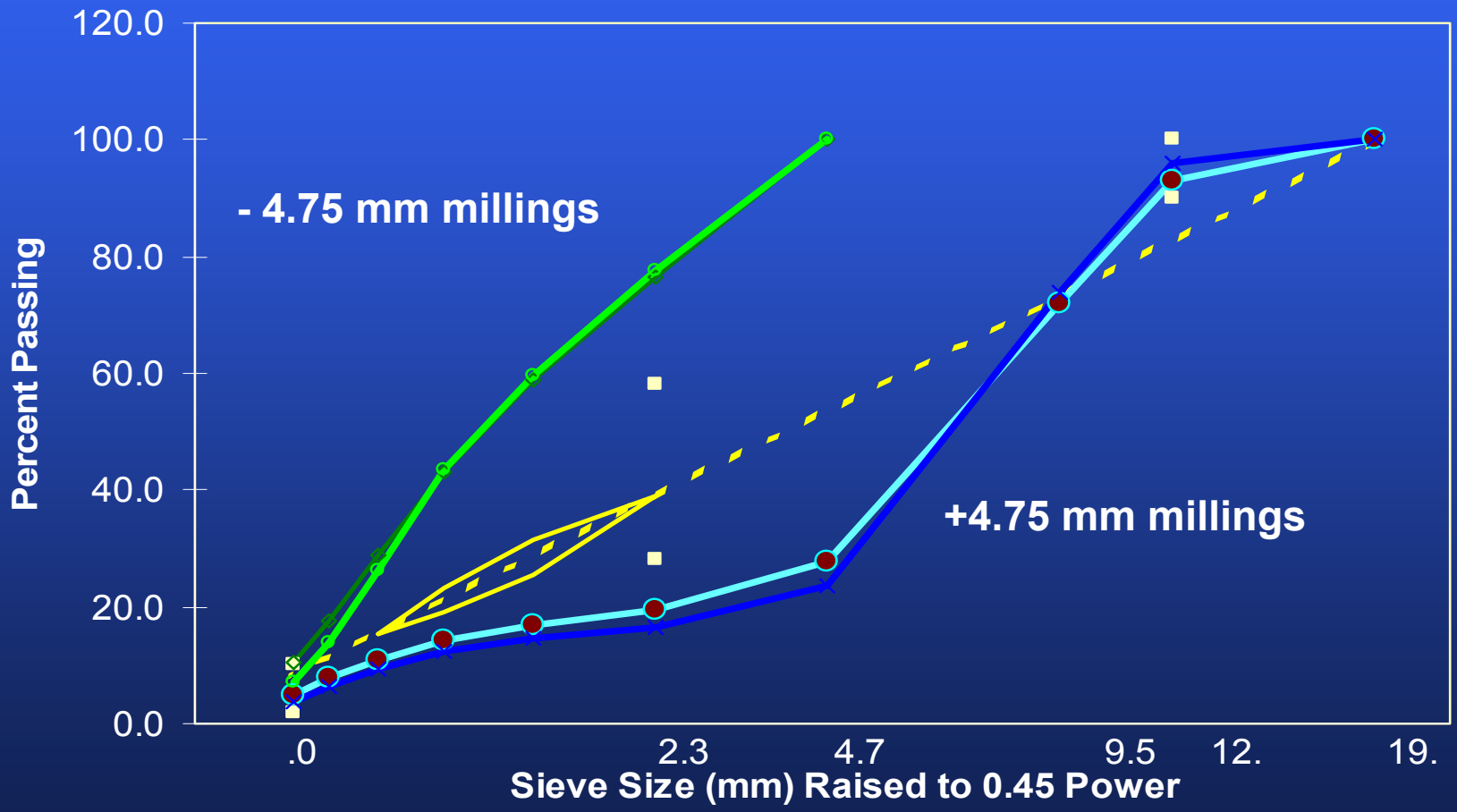
Can RAP be effectively incorporated into gap-graded Superpave and SMA mixes?

Yes, by RAP fractionation or recycling existing SMA Pavements!

RAP fractionation

- Processing and screening (fractionating) RAP into three different materials through the use of high frequency screen decks:
- Resulting Products:
  - 2” (50 mm) to 1/2” (12.5 mm)
  - 1/2” (12.5 mm) to #16 (1.18 mm)
  - #16 (1.18 mm)

Gradations After Ignition for Virginia RAP Millings



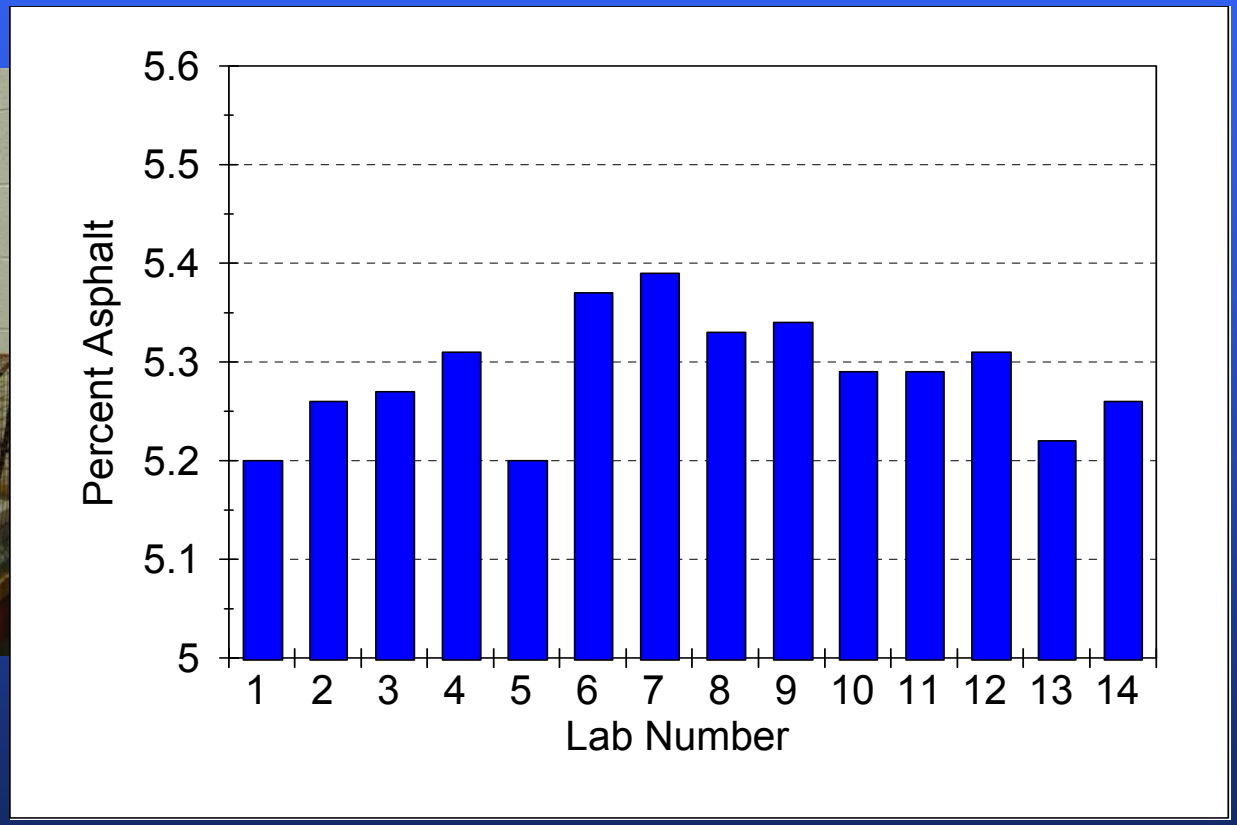
Automated QC & Real-Time Testing

Utilization of Automation and Real-Time Testing to Improve QC/QA Procedures For Hot Mix Asphalt

QC/QC State of Practice

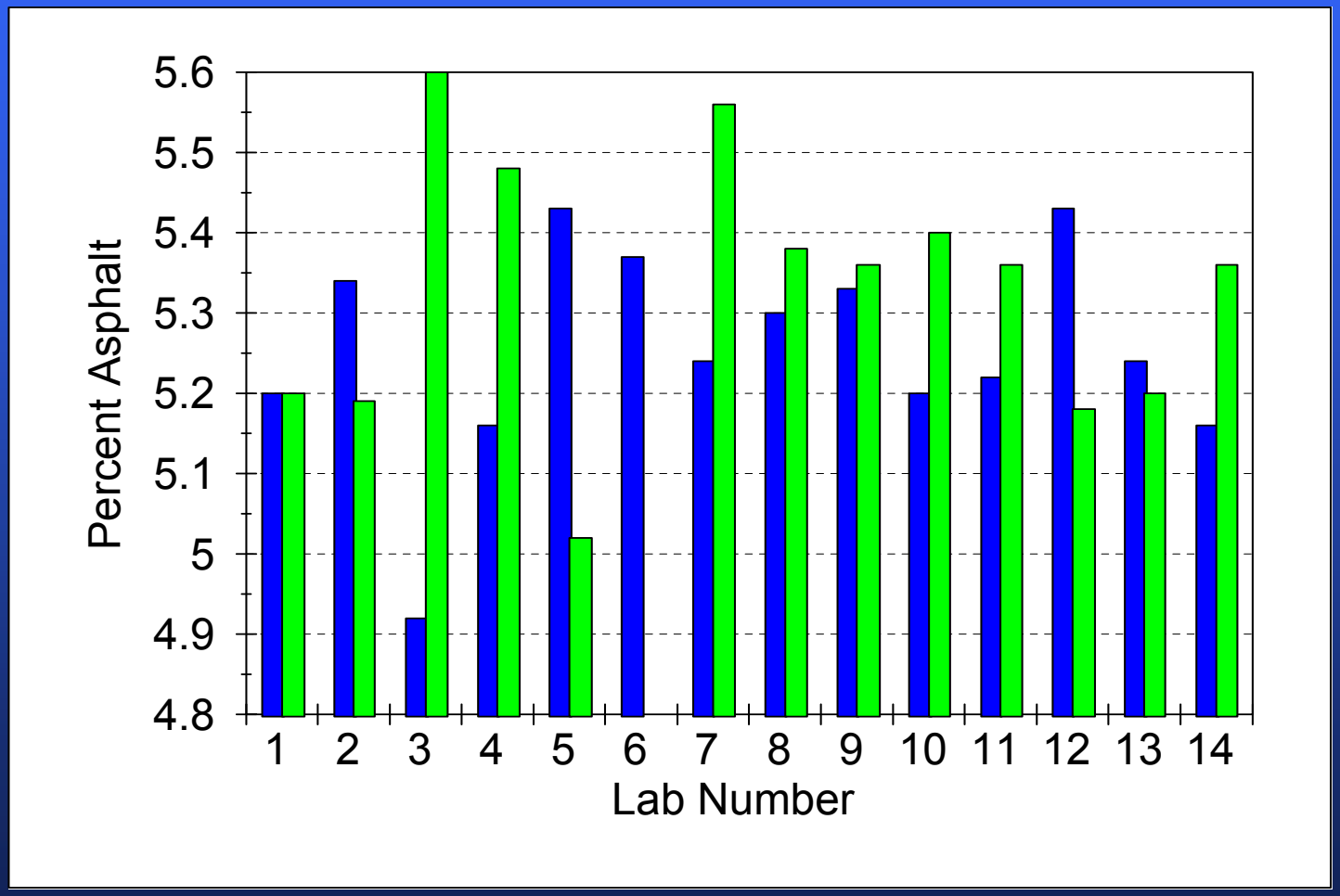
- Most QC/QA specifications for HMA have become quite complex
  - Every sublot of mix- 5 to 6 physical tests used to calculate a dozen or so characteristics for pay factors and other control criteria.
- Technician overload and getting worse
- Management time to address problems

Example AC% - Ignition Furnace Results



Mean = 5.29, Actual 5.30
Standard Deviation = 0.06

The Whole Truth! – Effect of Splitting a Sample



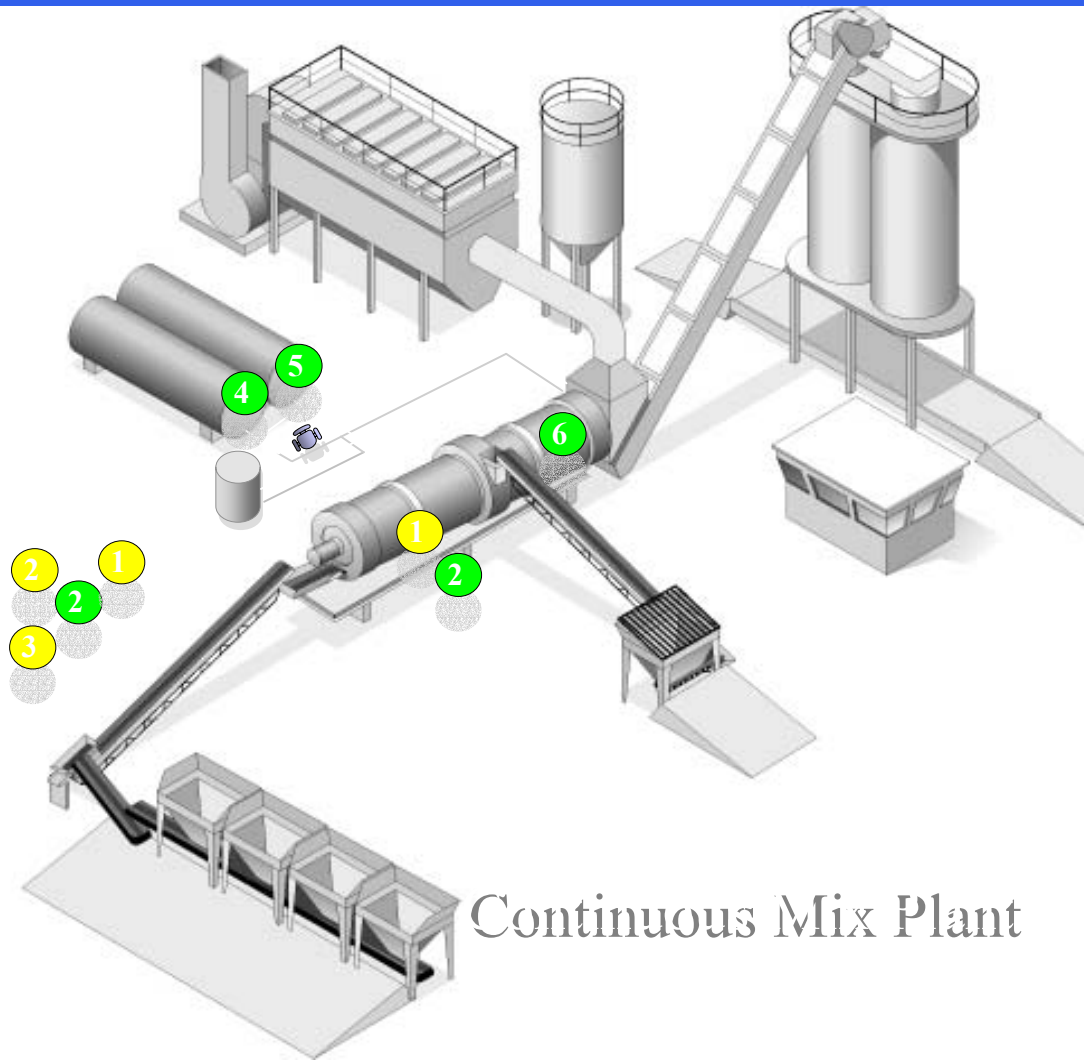
Standard Deviation = 0.15

Alabama DOT Study Asks?

- Can we assure ourselves and the agency's of product quality in a simpler and more efficient manner?
- What do we need to measure?
- Can we automate those measurements (remove the human element)?
  - minimize sampling & testing errors
  - increase frequency of measurements
  - provide rapid feedback (data acquisition and output) of the process

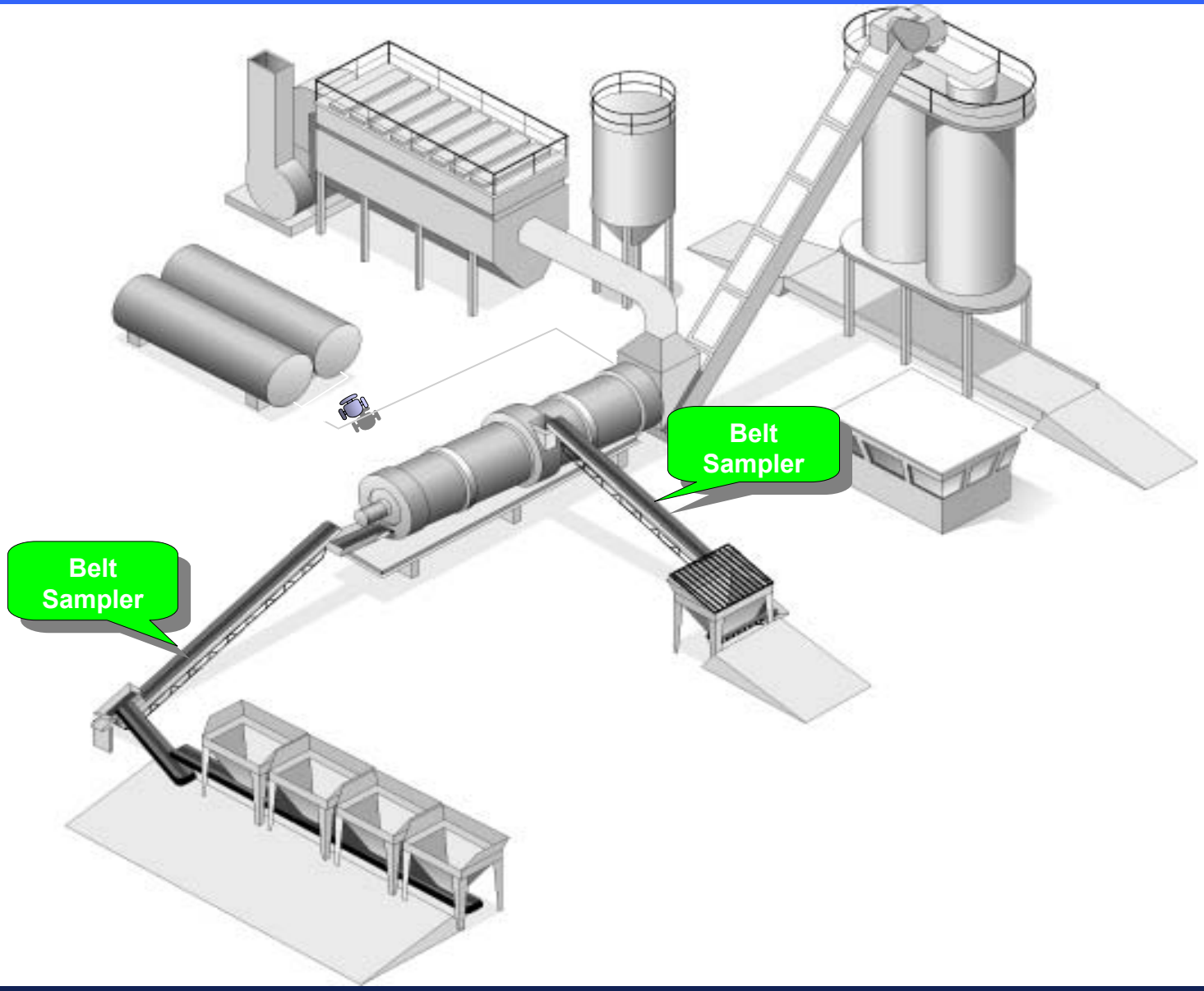
Proposed Automated QC Methods

1. Belt Sampling
2. Moisture Content
3. Gradation
4. Binder Viscosity
5. Binder Flow Meter
6. HMA Temperature



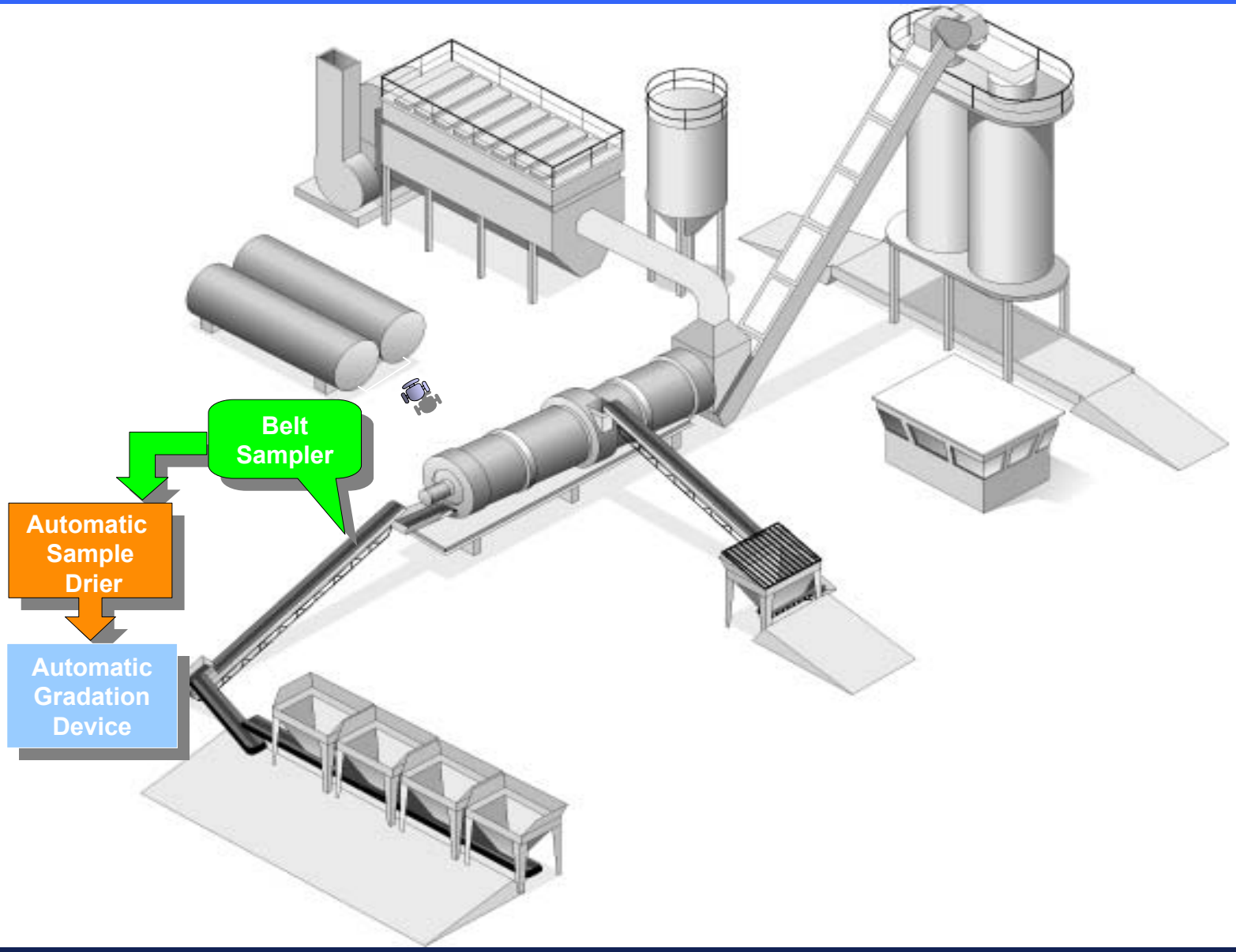
Project Objectives

- Set up and evaluate the equipment and data collection
- Compare data to standard QC sampling & testing
- Evaluate feasibility of systems
- Host Open House / Demo Project


Belt
Sampler
Belt
Sampler

Belt Sampling Device

- a.k.a. – belt sweeper
- Removes a sample of aggregate while the plant is running.
- Plan to have a belt sampler on the aggregate incline conveyor and the RAP conveyor
- ~ $11,000


Belt Sampler
Automatic Sample Drier
Automatic Gradation Device

Aggregate Sample Drier

- Receives aggregate or RAP sample from belt sampler and dries it before the automated gradation device.
- ~ $14,000

Automatic Gradation Unit

- Sieves and weighs aggregate to produce a gradation.
- Currently does not sieve fine sizes (below No.8 sieve)
- Data sent to PC in control house or lab
- ~$35,000

Automated Asphalt Content Using a Plant's Controls

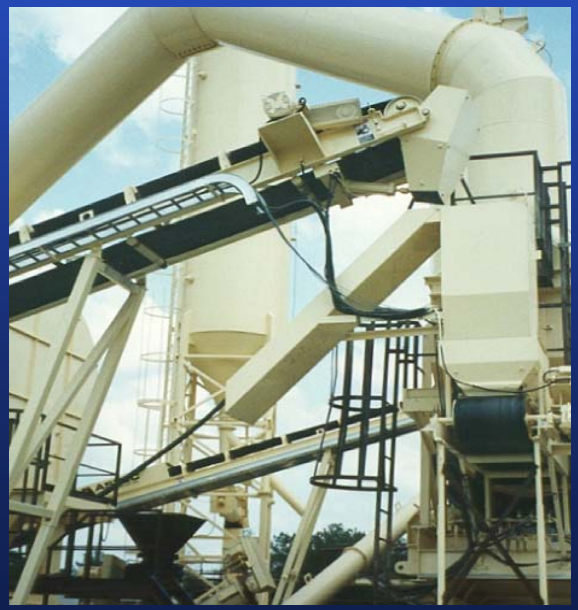
We already measure binder flow rate (gal./min. → tons/hr) with a flow meter or non powered positive displacement pump.

And we measure feed rates of aggregates and RAP (tons/hr) with belt scales, tachometers and a computer integrator

Asphalt Meter Calibration

- Calibration Tank used to calibrate and check the asphalt meter
- Hands-free, therefore safer and more accurate
- ~ $15,000

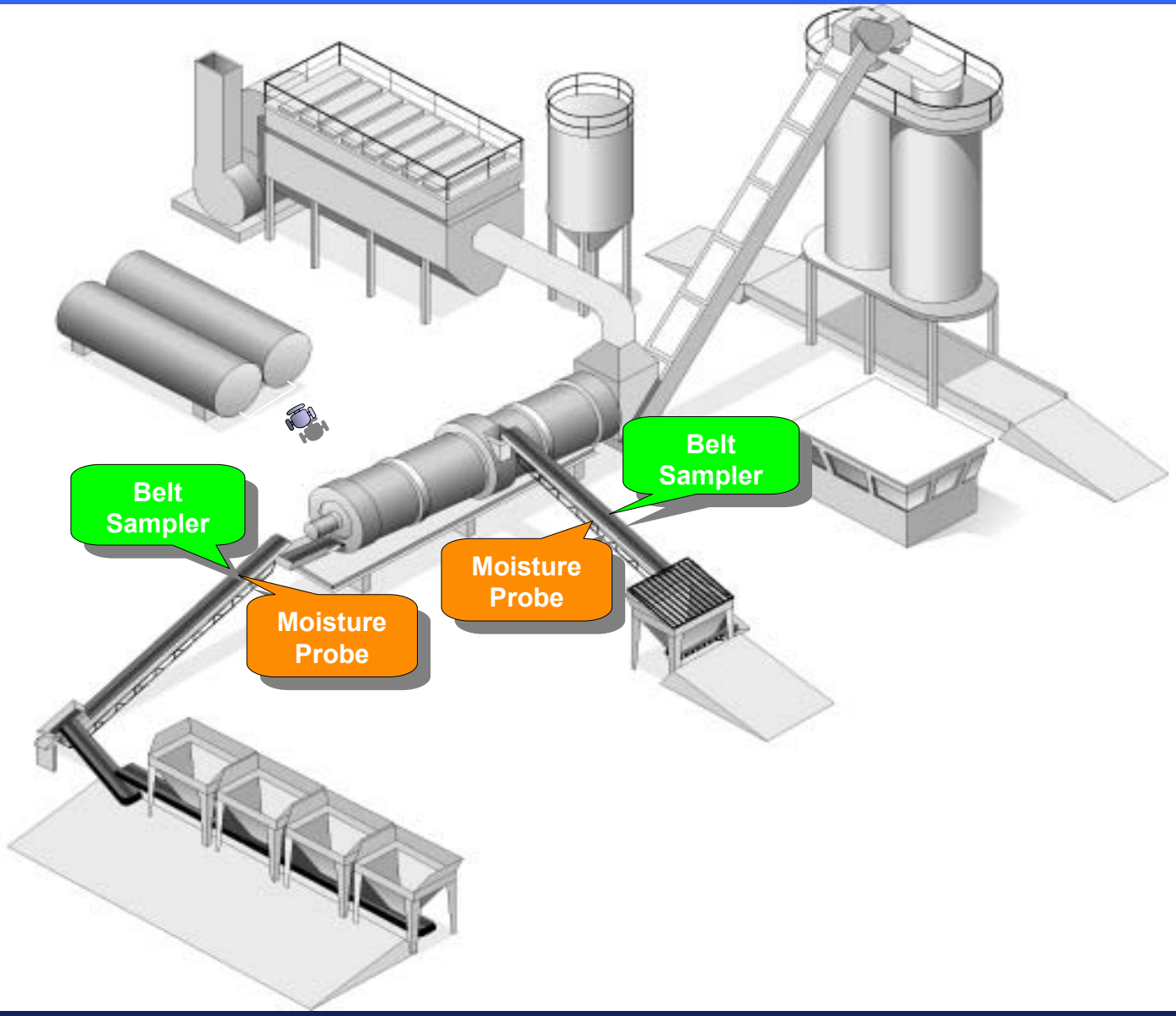
Belt Scale Calibration

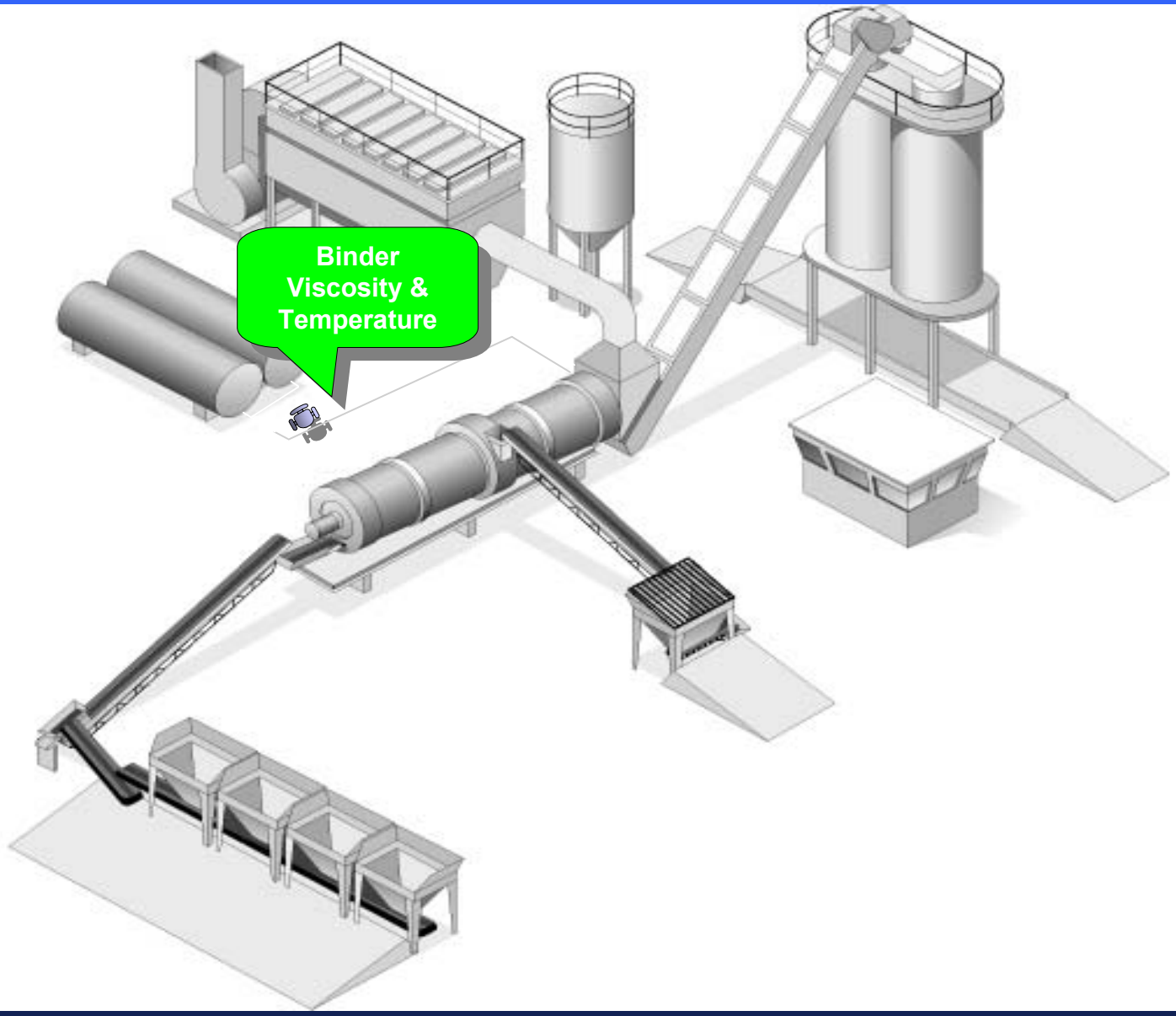


- Proper calibration of belt scales using material over the weigh bridge and diverted to a tared truck.
- Need better training on this.
- Need moisture content

Moisture Content Gage

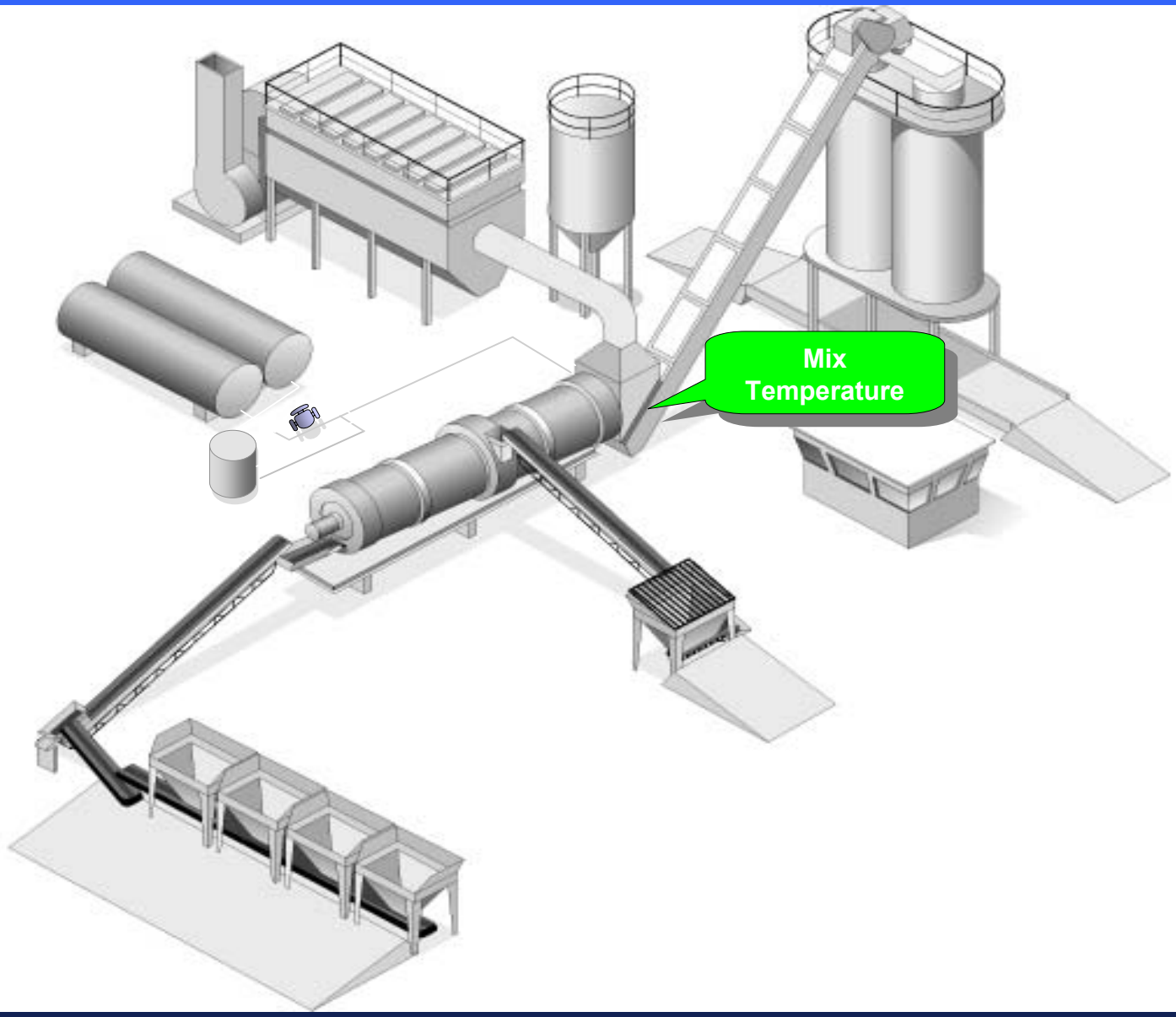
- Measures moisture content of aggregate on belt or in a bin.
- Requires calibration for each different material.
- Data is used to adjust weight reading of the belt scale.
- ~ $3360 per probe


Belt Sampler
Belt Sampler
Moisture Probe
Moisture Probe


Binder
Viscosity &
Temperature

In-Line Viscometer & Temperature System

- Measures the viscosity & temperature of the binder.
- Mounts on a by-pass line from AC tank to injection point.
- ~$17,000

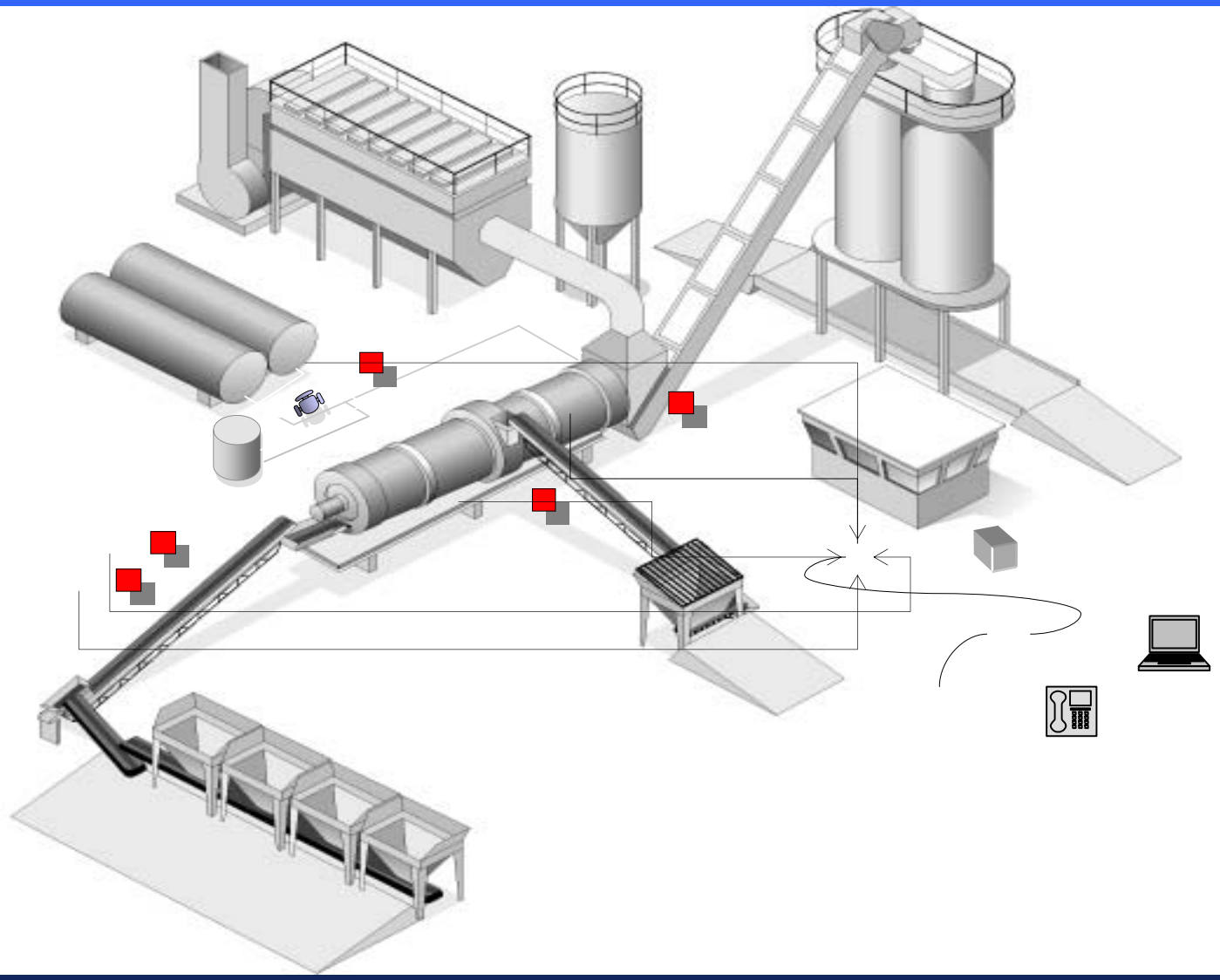

Mix
Temperature

Mix Temperature Gage

- Mix temperature is often monitored by the plant operator, usually at the point of discharge from the mixer.
- Analog chart recorder is common, but we want a digital record.

Robotic Truck Sampler

- Obtains a large sample of HMA from a truck load of HMA.
- Safer because the technician does dot have to get in the truck bed.
- Samples should be more representative of the load – avoid sampling of segregated material



For More Information on Automation, please contact:

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Questions?

National Center for Asphalt Technology

NCAT

AUBURN UNIVERSITY