

RAP Management Best Practices



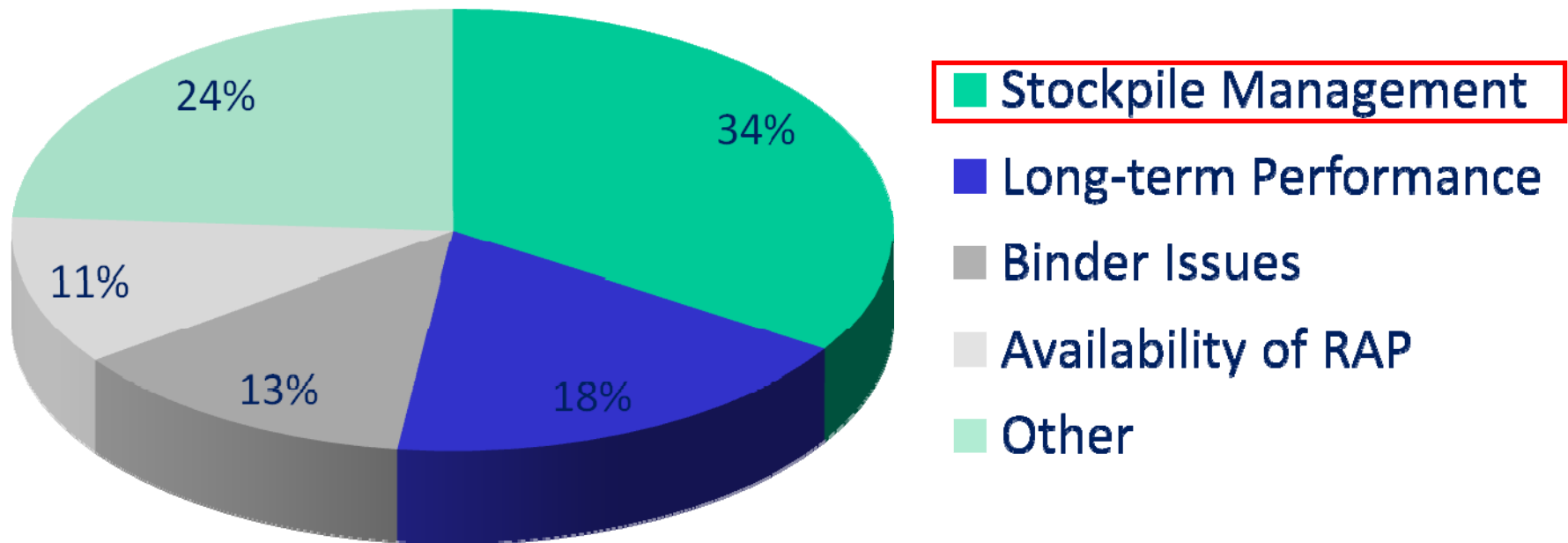
- RAP Needs Analysis
- Milling for Success
- Multiple-source RAP piles
- Crushing Considerations
- Screening Options
- Best Practices for Stockpiling
- Sampling and Testing of RAP Stockpiles
- Production of Recycled Asphalt Mixes

Disclaimer

- This presentation represents opinions and ideas of Randy West
- The purpose of the presentation is to get feedback (positive and negative) from the audience
- After vetting this through several committees and refining the information, it is expected to become a published best practices document



Barriers to Increasing RAP



Principles of RAP Management

- Good materials management practices should always be part of the quality control program for any asphalt mix production operation
- As RAP contents increase, it becomes more important to accurately determine properties of RAP and control its consistency



RAP Needs Assessment

One of the first steps to be considered in RAP management is to determine the maximum percentage of RAP that is likely to be used at the particular asphalt plant. That percentage may be controlled by one or more factors such as...

- the supply of RAP at the plant
- agency specifications
- consistency (uniformity) of the RAP
- plant type or other limitations



RAP Inventory Analysis



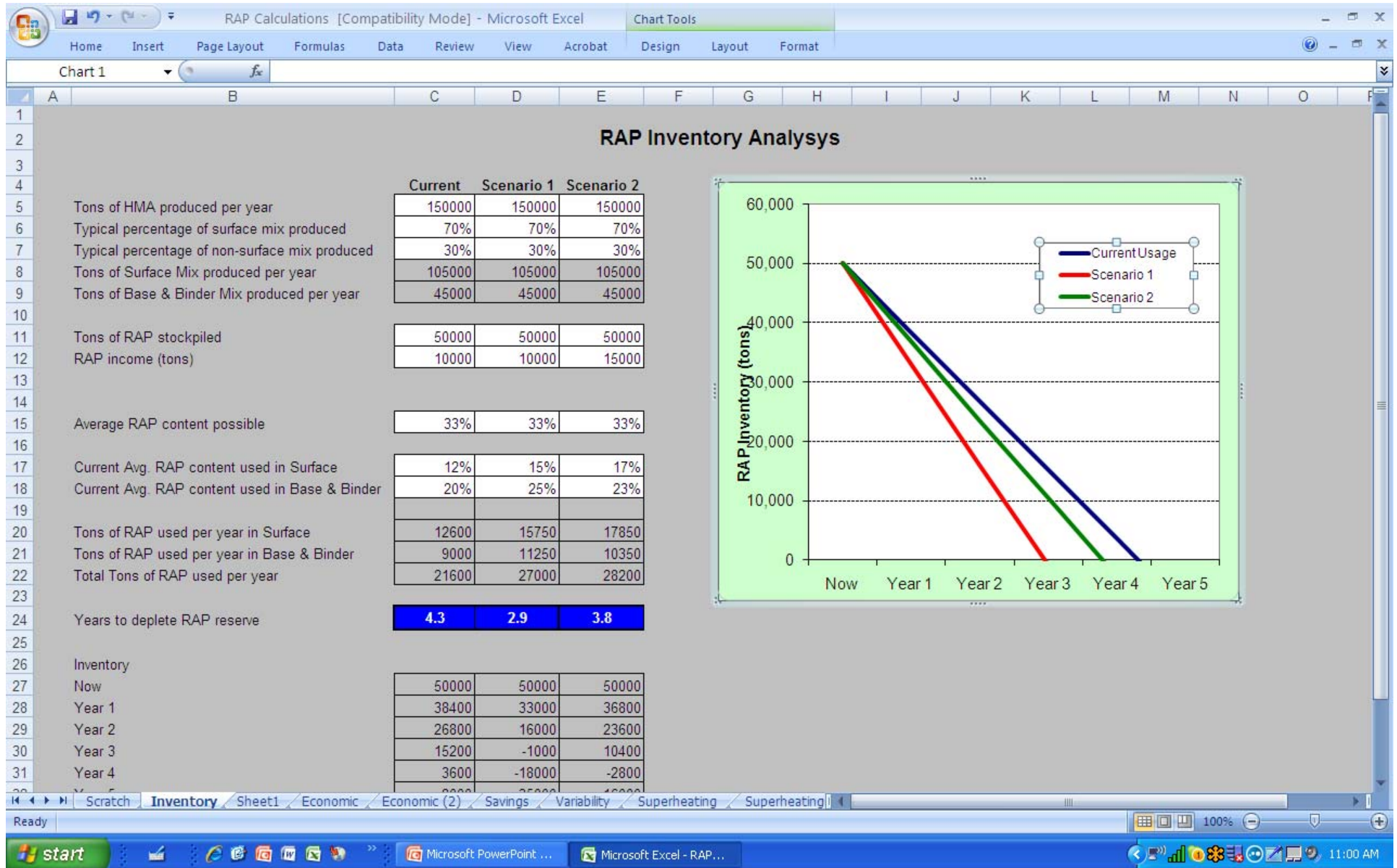
1. Inventory RAP on-site: determine the quantity of:
 - Ready to be used RAP
 - Unprocessed RAP
 - Typical amount of RAP received per year
2. Annual HMA Production by Mix Type



RAP Inventory Analysis

3. Use a simple worksheet to...
 - Determine the quantity of RAP needed for each mix type based on the target RAP and maximum RAP contents. These are the “RAP demand target” and “RAP demand maximum”
 - Compare the supply quantities of RAP from the inventory analysis to the demand quantities





Collecting RAP

RAP will be collected from various sources over time. One decision is when should RAP from a new source be kept separate and when to combine materials from different sources. There is an advantage to keep millings from large jobs in separate stockpiles. Often these millings are very consistent and can be used straight in new mixes without further screening or crushing, saving processing costs.



Agency Requirements on RAP Sources

Some agencies only allow RAP obtained from their projects to be used in their mixes. This restriction hinders the use of RAP to its full advantage. The quality of materials (e.g. aggregate source properties and polishing characteristics) in the RAP can and should be verified with routine testing as part of mix design and quality control



Milling for Success

- The primary reason for milling is to remove distressed pavement layers and restore a good profile for the overlay.
- Milling depth should therefore carefully the competency of existing layers and must avoid leaving thin layers that are likely to scab.
- It is important that milling be done such that the RAP is not contaminated.



Milled RAP



Keep millings from different projects in separate stockpiles.

Milled RAP can typically be used “as is” in HMA without further crushing.



Multiple Source RAP
also known as **GOK** piles

God **O**nly **K**nows what's in there





Rubble



Rejected Mix



Plant Waste



Small Jobs

Multiple-Source RAP

- GOK piles can be an agglomeration of materials from milled projects, pavement rubble, rejected mix, and plant waste.
- It should be obvious, but unprocessed GOK RAP stockpiles are **not suitable** for use in new mixes.

GOK RAP Stockpiles

- Can be processed to yield a uniform RAP material
- What are the necessary steps to process this materials?

RAP Processing Tips

- Avoid contamination from the beginning
- Mix it up while feeding the screen or crusher
- Don't over crush
- Fractionation helps for design of high RAP mixes
- Watch the weather when processing
- Blend again when moving stockpiles



GOK RAP Stockpiles



- It is vital to prevent dumping of any deleterious materials in the GOK pile from the beginning.
- Clearly instruct all truck drivers hauling materials to the yard where to dump different types of materials

08/18/2006



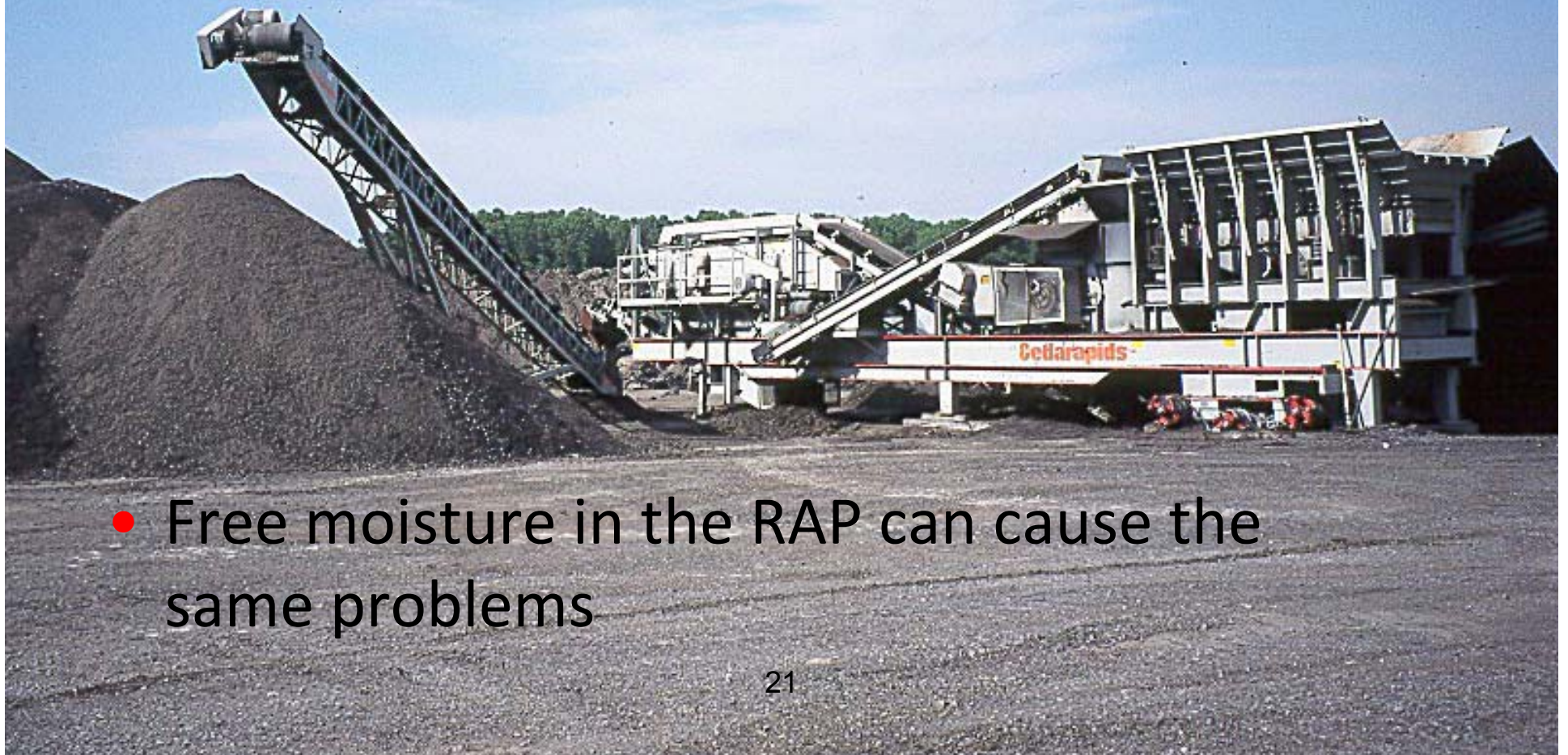
Mix up the GOK material
while feeding it into the
Processing Unit

RAP Processing

- It is important to minimize crushing of RAP because it increases its dust (P200) content which often limits the amount of RAP that can be used and successfully meet mix design requirements.
- Choose crushing top size carefully
- Screening prior to crushing will help reduce unnecessary breakdown

Weather

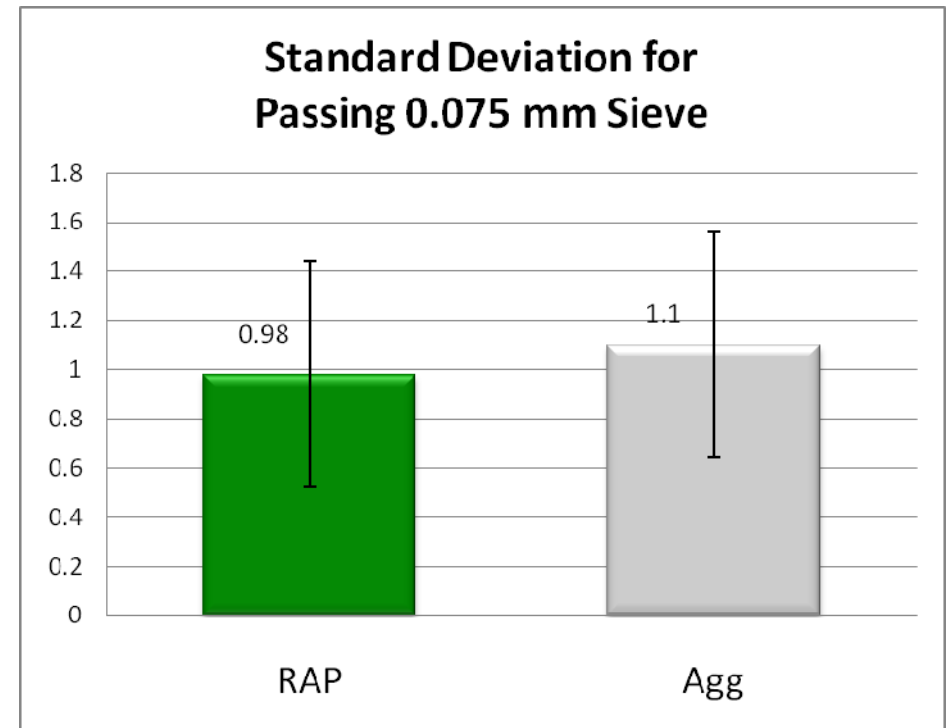
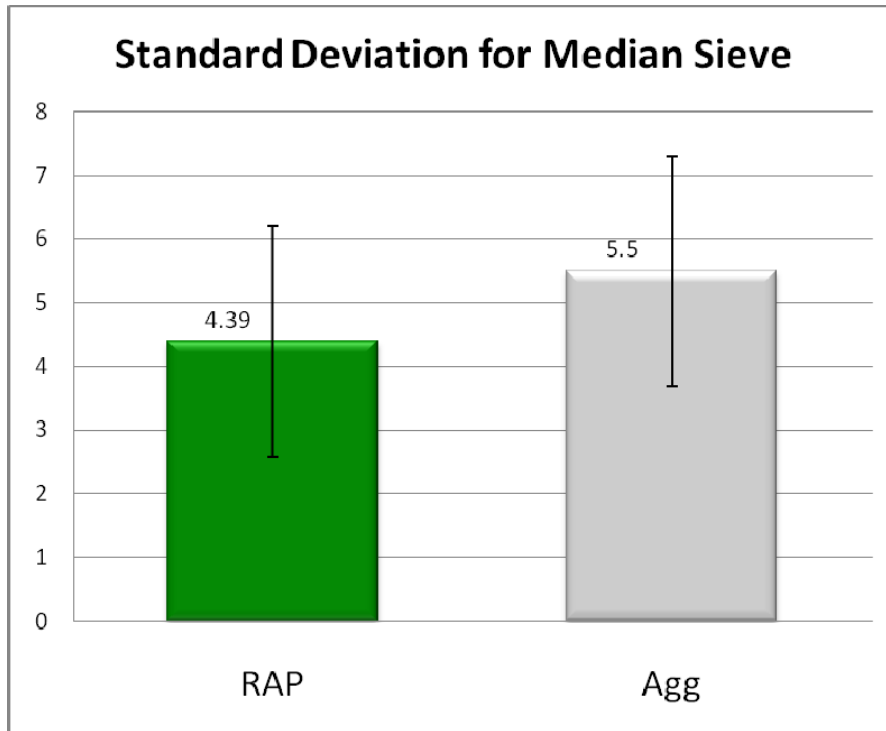
- Cool weather helps minimize caking of RAP in crushers and blinding of screens



- Free moisture in the RAP can cause the same problems

Variability: RAP vs. Aggregate

Based on 74 RAP stockpiles in 14 states, and 60 Aggregate stockpiles in 6 states



Fractionated RAP

3/4 x 3/16" RAP
In back

-3/16" RAP

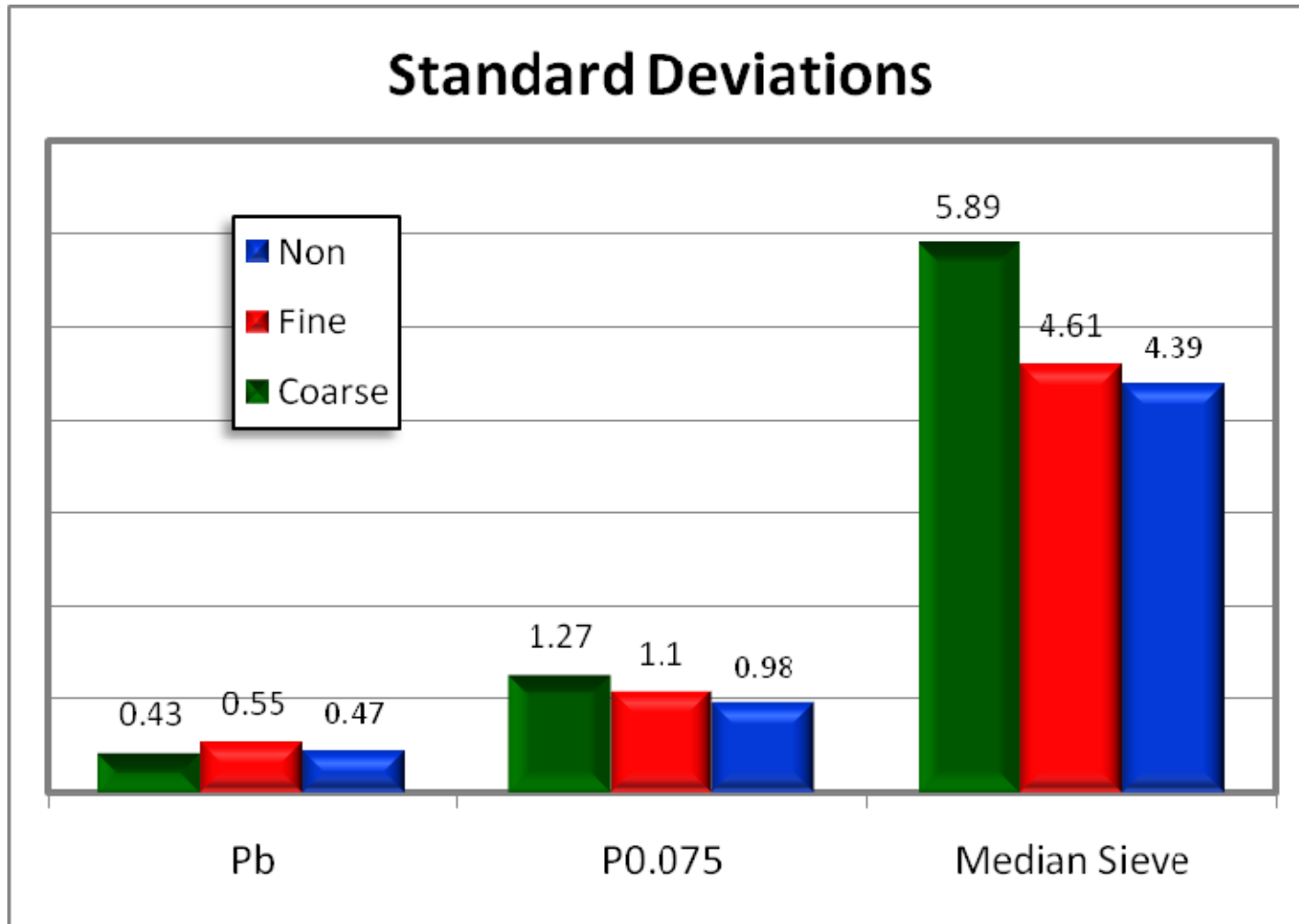
+3/4" RAP

- Screening RAP into two or more sizes
- A huge advantage for mix design. Allows RAP to be used in practically any mix type

Fractionating RAP

- However, the practice should not be mandated; it should be the contractor's business decision if and when to fractionate RAP.

Fractionated vs. Unfractionated

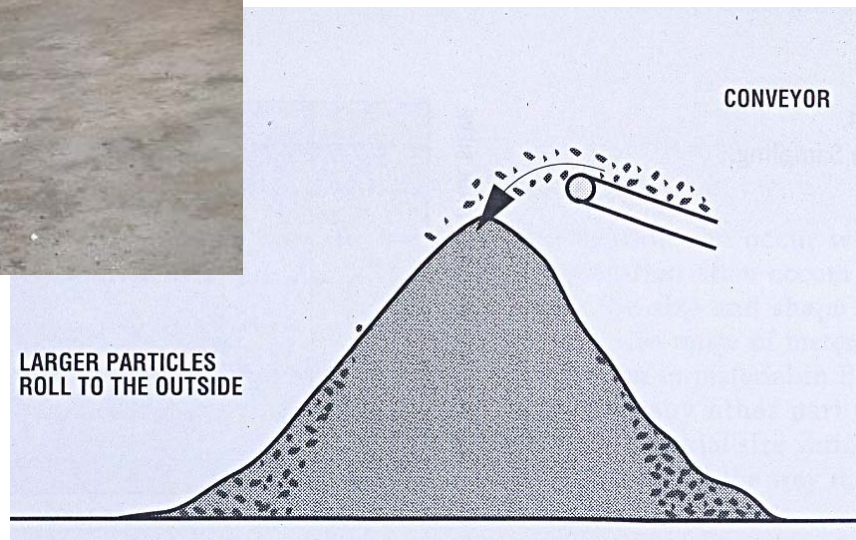




Stockpiling RAP



Building steep sided stockpiles will create segregation within the pile

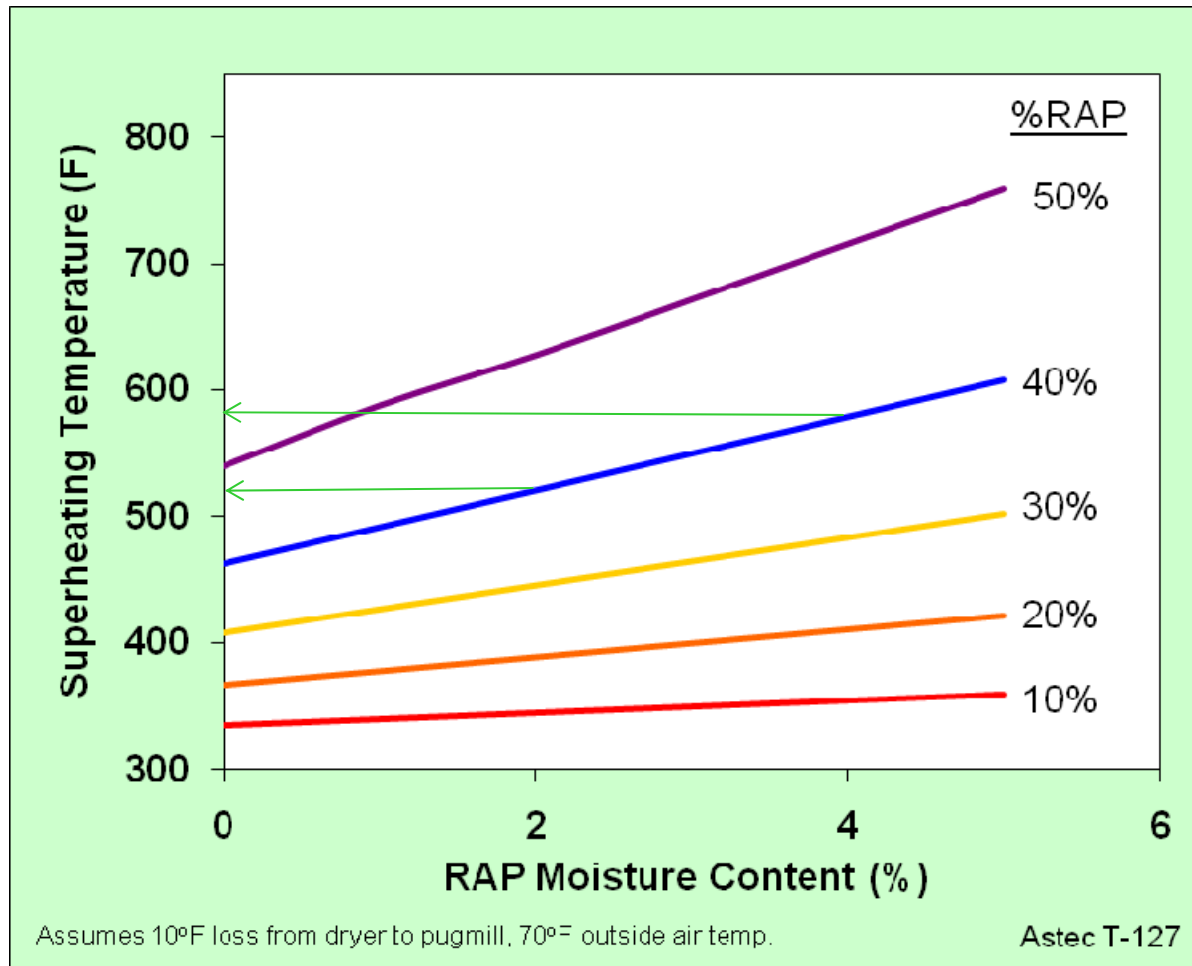


Stockpiling RAP



- Minimize Moisture in RAP
 - Covered Stockpiles
 - Sloped Pavement Underneath

Effect of RAP Moisture on Superheating Temperature



Sampling of RAP

- The goal of sampling RAP is to obtain representative samples for evaluating materials properties.
- Samples are needed from throughout the stockpile to assess variability. A minimum sampling frequency of 1 per 1000 tons with a minimum of 10 samples is strongly recommended.



Sampling of RAP

- The best method to sample RAP is to use a loader to create flat-topped miniature stockpiles
- A good time to sample is when a stockpile is being built at its final location
- Do not combine samples from different parts of the stockpile. Tests need to be performed on individual samples to assess uniformity.





Photo courtesy of Tim Murphy





Photo courtesy of Tim Murphy





Photo courtesy of Tim Murphy





Photo courtesy of Tim Murphy





Photo courtesy of Tim Murphy





Photo courtesy of Tim Murphy





Photo courtesy of Tim Murphy





Photo courtesy of Tim Murphy



Testing of RAP

- General properties:
 - asphalt content
 - aggregate gradation
 - aggregate bulk specific gravity
 - fine aggregate angularity
 - fractured face count
 - flat & elongated percentage
 - deleterious materials



Testing of RAP

- Depending on agency specifications, aggregate source properties may also need to be tested
 - LA Abrasion
 - Sulfate Soundness
- For use of RAP in friction courses, additional aggregate properties such as acid insoluble, loss on ignition, or petrographic analysis may be needed.



Testing of RAP

- Asphalt Content: ignition method is preferred. An aggregate correction factor must be assumed. For regions that utilize dolomite aggregates that have erratic correction factors, a solvent extraction method is recommended.



Testing of RAP

Aggregate bulk specific gravity: estimated from a three step process

1. Determine G_{mm} (w/ dryback) of RAP sample
2. Calculate G_{se} using the G_{mm} from step 1 and the asphalt content from the ignition method (or extraction test if ignition method is not reliable)
3. Estimate G_{sb} from G_{se} using a typical offset value or regression from historical mix designs with the aggregates in the region



Why Use This Process?

- Research has shown that this process is more accurate than recovering the aggregate from solvent extraction or ignition test and performing T84 and T85
- This process is much faster



Potential Errors with the Gse→Gsb Process

- The potential errors include...
 - Loss of RAP fines when using the bowl method for Gmm
 - The asphalt content (Pb) used in the Gse calculation could be wrong
 - The binder specific gravity (Gb) used in the Gse calculation could be wrong
 - The correction factor between Gse and Gsb could be wrong

Potential Errors with the Gse→Gsb Process

- Creates uncertainty with VMA, a very important property related to durability
- Thus, it is important to conduct durability performance tests for high RAP mixes
- Durability Tests
 - Moisture Susceptibility: T 283
 - Fatigue: Beam Fatigue (T 321), AMPT Continuum Damage, or DCSE
 - Thermal Cracking: IDT Creep & Strength (T 322) or other method



Testing of RAP

- Other RAP aggregate properties – tests can be performed on aggregate recovered from the **ignition oven**.
 - Gradations
 - Fine aggregate angularity
 - F&E
 - Fractured faces
 - LA Abrasion
 - Sulfate soundness

Premature conclusion

RAP Sampling & Testing Flowchart



At least 10 samples when building stockpile

Split each sample

Ignition method tests

Max. specific gravities

Combine samples for other aggregate tests

gradations

asphalt contents

Gse → Gsb

Pete Capon Rieth-Riley RAP Summaries [Compatibility Mode] - Microsoft Excel

Sieve Size- Per Cent Passing									
Test #	1.0"	3/4"	1/2"	3/8"	#4	#8	#16	#30	
1	100.0	100.0	95.0	84.5	58.1	44.8	32.7	24.6	
2	100.0	98.9	96.7	91.1	71.2	53.8	43.9	35.2	
3	100.0	100.0	96.4	90.2	66.8	49.9	36.2	25.9	
4	100.0	100.0	95.5	89.0	66.4	50.0	39.1	30.1	
5	100.0	100.0	96.6	89.8	67.1	49.2	35.9	26.8	
6	100.0	100.0	95.5	88.9	62.0	45.6	34.4	26.5	



Summary & Analysis of RAP Data

- Calculate average and standard deviation of asphalt contents, gradations, and estimated Gsb
- Compare to the recommended tolerances

RAP property	Max. Standard Deviation (%)
Asphalt Content	0.5
% Passing Median Sieve	5.0
% Passing 75 micron Sieve	1.0

Screening to Remove Oversized RAP Particles



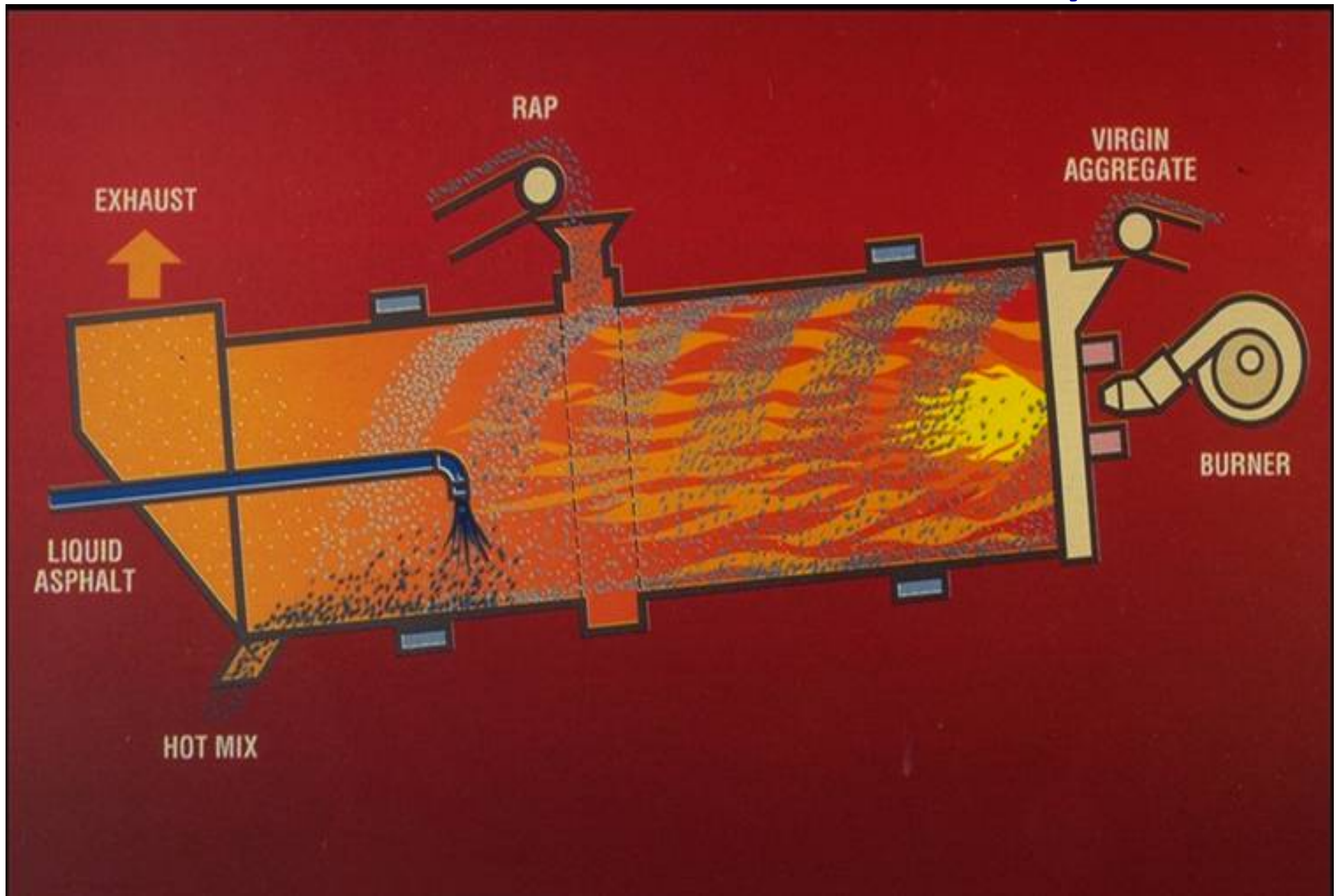
Screening to Remove Oversized RAP Particles



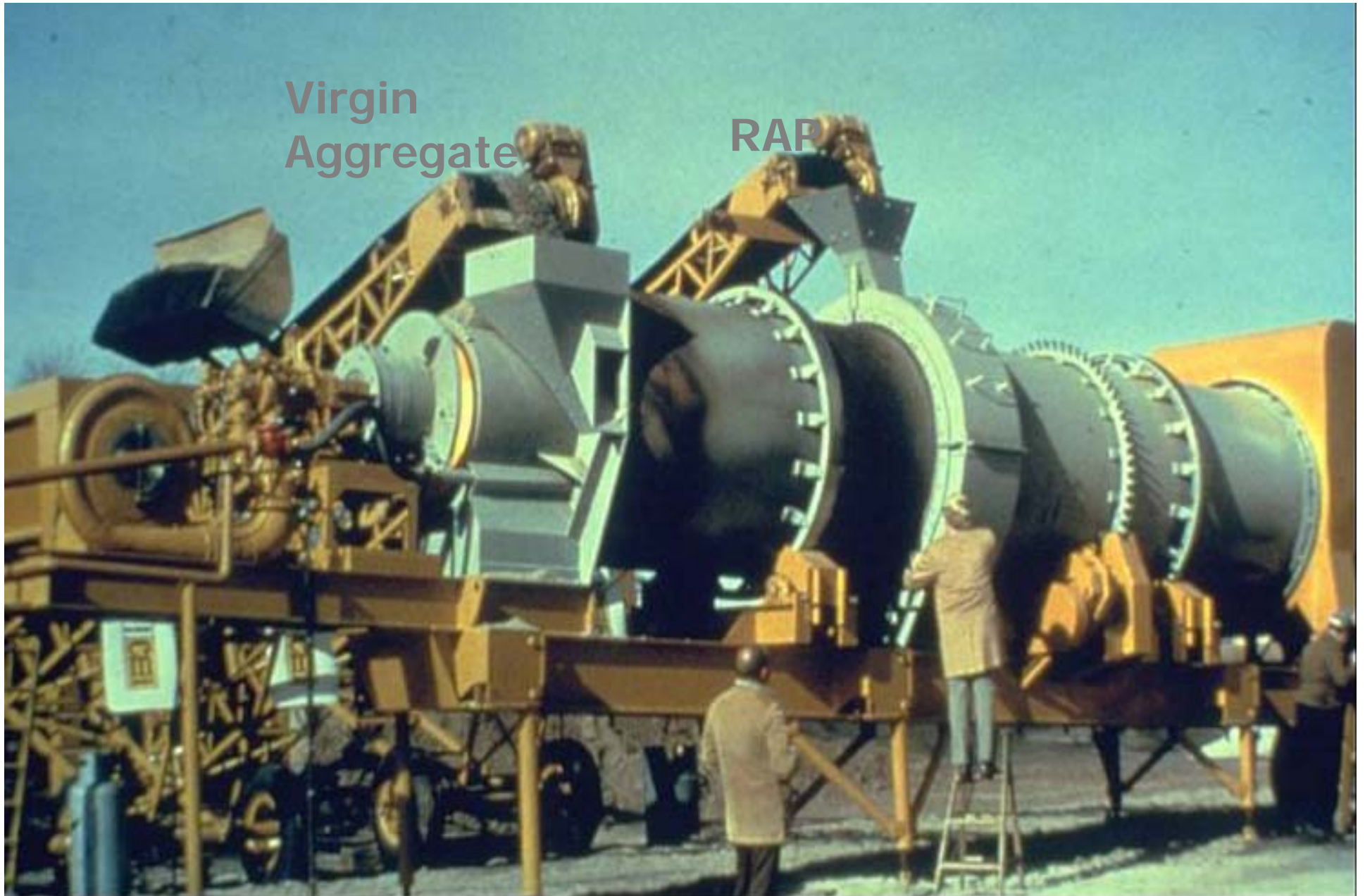
In-Line Crushing of RAP

- Not a Good Idea
 - Gradation of RAP is altered and unknown going into the mix

Drum with Center Entry



Drum Plant Showing Center Entry



Feedback

- What items do you disagree with?
- What items do you agree with?
- What seems unrealistic?
- What needs to be added?



Thank You





Recovering and Testing RAP Aggregates

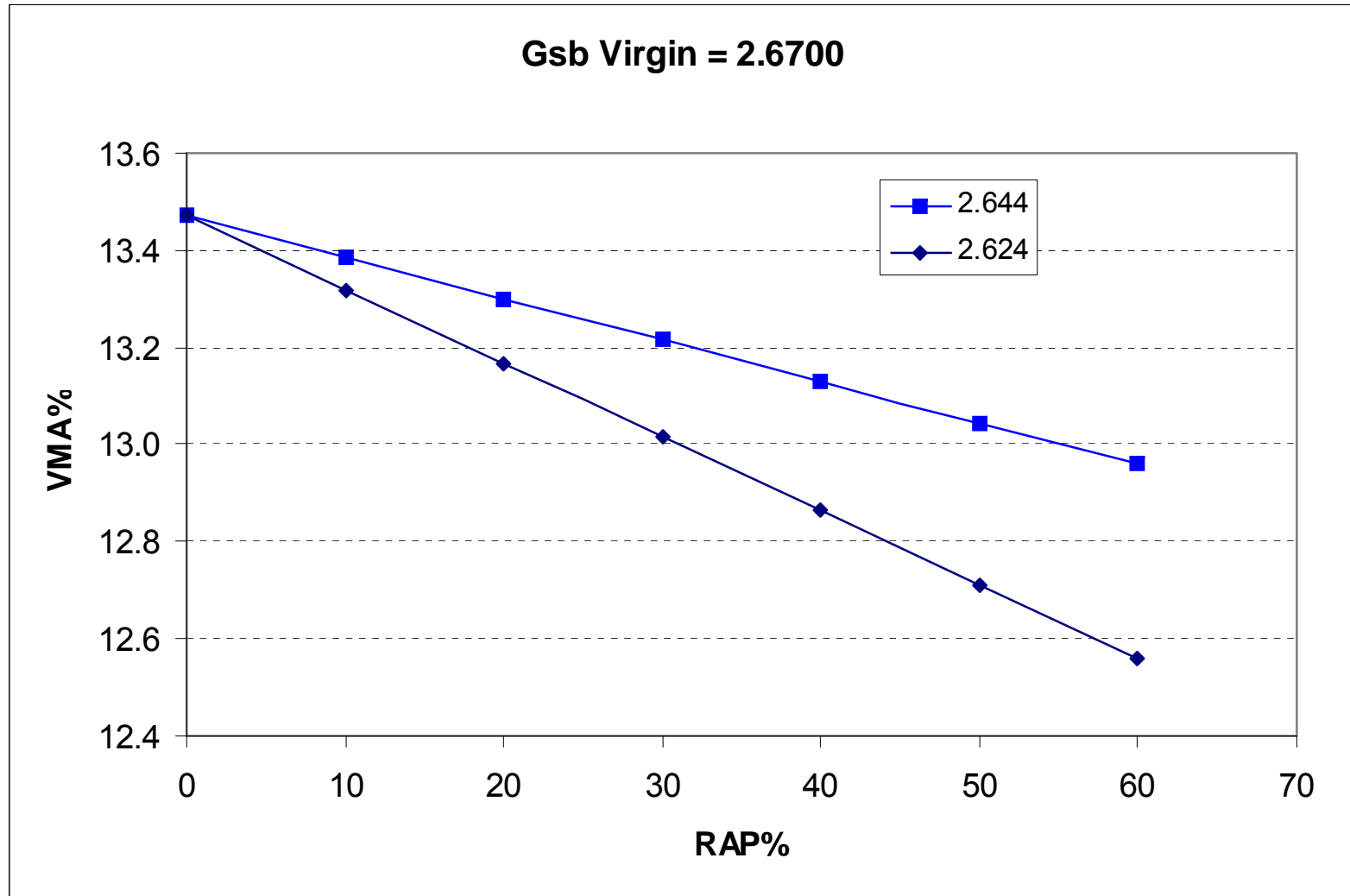


- Cooperative research with UNR
- Four aggregates – made RAP by aging mix
- Gsb and aggregate consensus properties known before manufacturing “RAP”
- Gmm, Centrifuge, reflux, and ignition oven
- Recover aggregates and retest
- Compare aggregate and binder properties

Differences from Known G_{sb}

Aggregate	Average Difference			
	Centrifuge	Ignition	Reflux	Estimate
Alabama	-0.025	0.008	-0.027	0.006
Florida	0.001	0.045	-0.018	-0.022
Lockwood	0.009	-0.005	-0.018	0.002
Handley	0.189	-0.014	-0.019	0.002

Effect of RAP Agg. Gsb on VMA



Recommendations on Testing RAP

- Asphalt content by ignition oven
 - Solvent extraction for dolomitic limestones
 - RAP Aggregate:
 - Bulk Specific Gravity is the most important
 - Gmm & Pb → Gse → Gsb
 - Gradation
 - Consensus properties
 - Source properties
- } Further Analysis Needed

NCHRP 09-46

- Recommend best practices for RAP management
- Mix design procedure for high RAP content (>25%) mixes
 - Goal is to maintain current procedure with minor changes
 - Use a mix stiffness test evaluate effective binder to avoid binder recovery and blending issues
 - Recommend performance tests

