



HIGH RAP MIXTURES

Properties of Plant Mixes Containing High Asphalt Binder Replacement


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Objective


- How much RAP can be used?
 - Considerations
 - Quality product
 - Mixing plant
 - Placement
 - Compaction
- 

Is RAP Available?





Scope

- How much RAP can go through a plant?
 - Trials up to 70%
 - Produce and Place on Low Volume Road
 - Measure quality
 - Measure properties
- 



Asphalt Binder Replacement

$$\% \text{ Asphalt binder replacement} = \frac{\% \text{ recycled binder}}{\% \text{ total binder}}$$


- RAP
- Coarse RAP
- Fine RAP
- Shingles






Typical Asphalt Binder Content

● RAP	4 – 5%
● Fine RAP	5 – 7%
● Coarse RAP	2 – 3%
● Manufacturer Scrap	18 – 22%
● Post Consumer	22 – 25%





Experiment

- Field Experiment
 - Focus on High Binder Replacement
 - RAP
 - Post Consumer Asphalt Shingles
- 



Phase One

RAP

- 50%
- 60%
- 70%

Post Consumer Shingles

- 0%
- 3%

Counter flow drum mix plant

Embedded burner

- RAP inlet capacity
- Mixing chamber volume

Water injection

- Mixing aid
- 

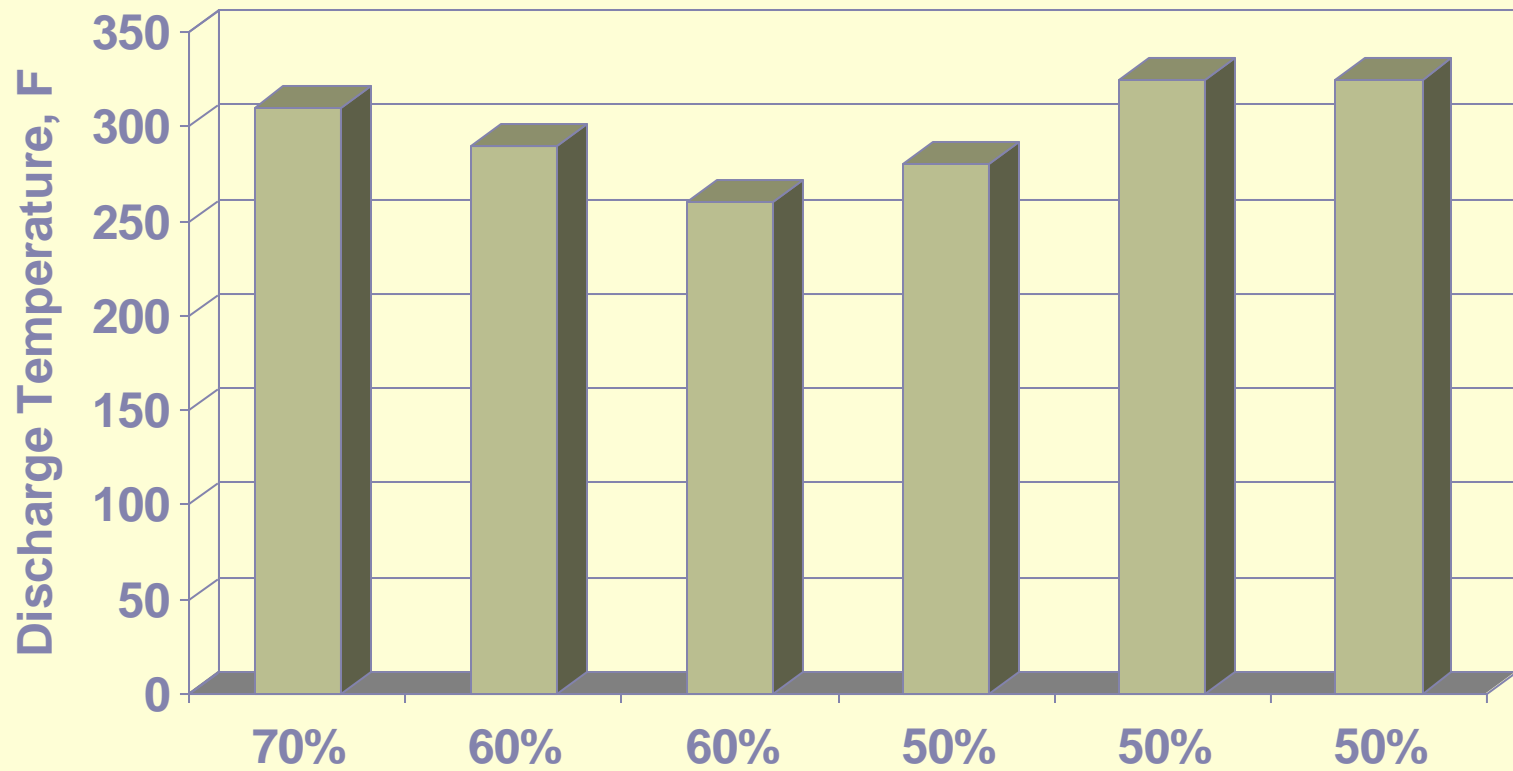




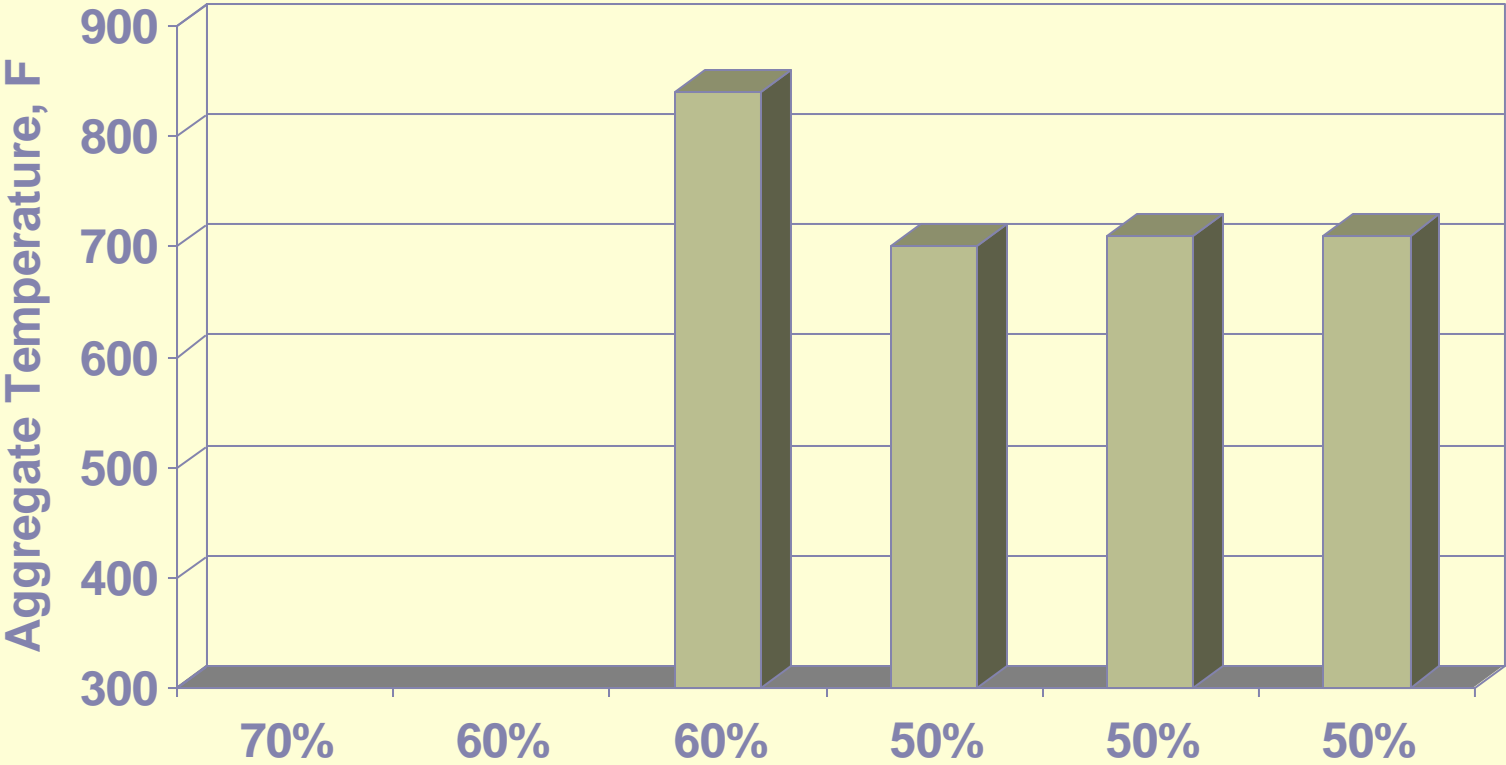
Phase One Mixes

Mix	Size	RAP	RAS	AC	BR
1	25.0	70	0	6.0	33
2	25.0	60	0	4.1	41
3	12.5	60	0		(47)
4	12.5	50	3	5.6	29
5	12.5	50	3	7.1	31
6	12.5	50	3	6.6	33

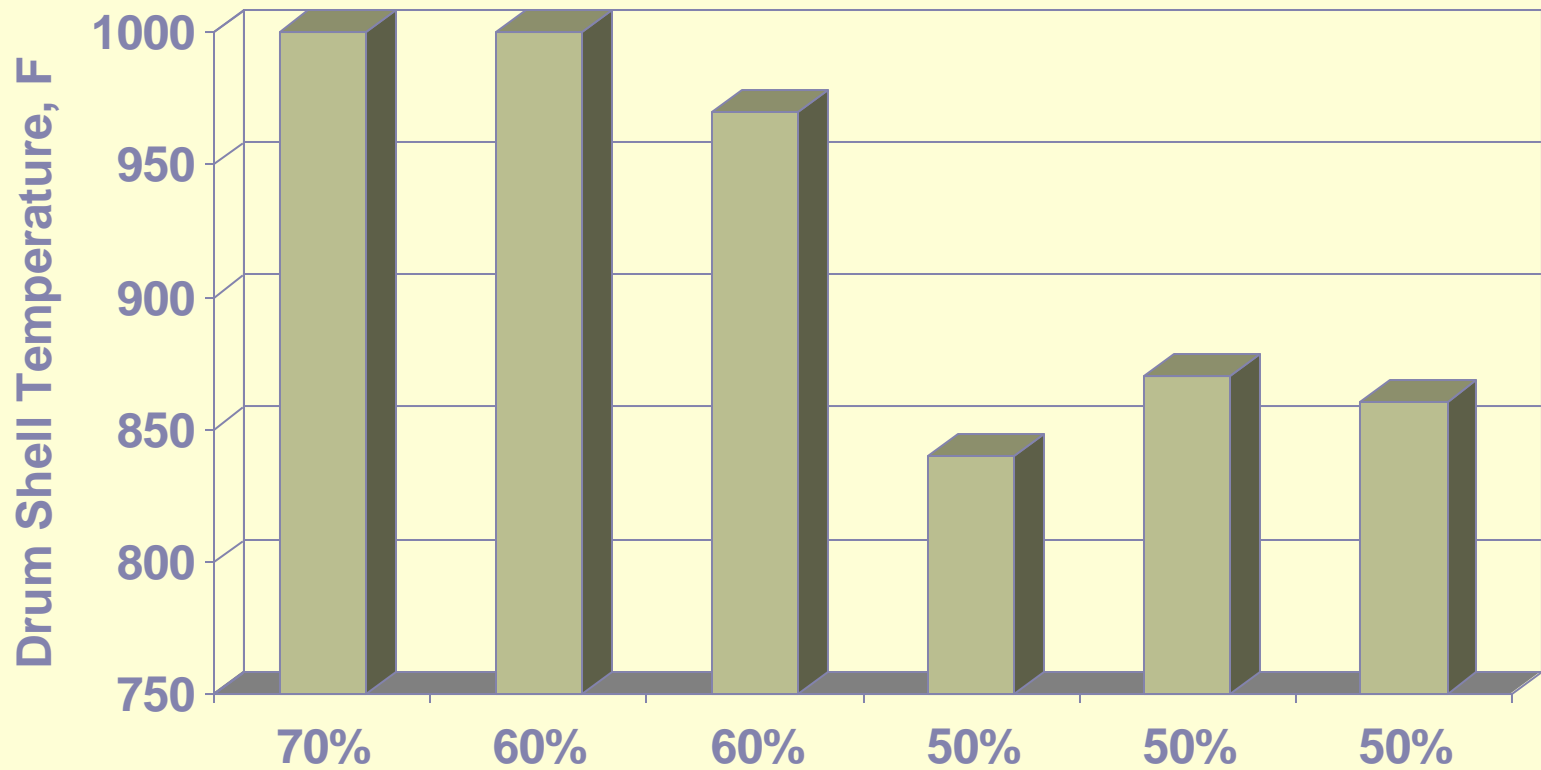
Discharge Temperature



Aggregate Temperature



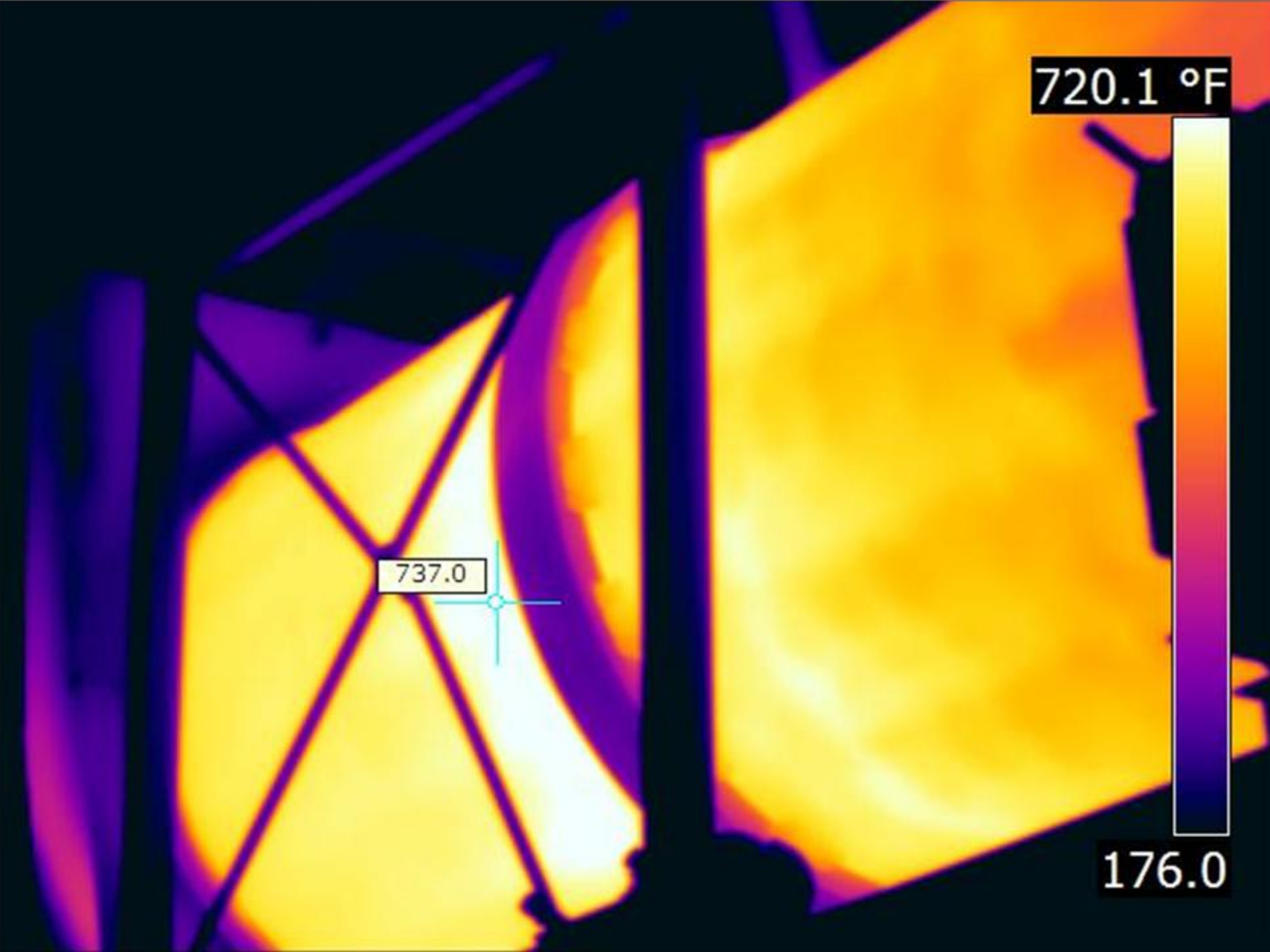
Drum Temperature



720.1 °F

737.0

176.0



60% RAP




70% RAP






Decisions from Phase One

- Maximum 50% RAP
 - Drum Shell Temperature
 - max 800 F
 - Aggregate Temperature
 - max 700 F
 - Exhaust Temperature
 - min 220 F
 - max 390 F
- 



Phase Two Experiment

- Counterflow drum mix plant
 - With mixing drum
 - 19 mm NMPS
 - 1.0 in crushed gravel
 - ½ in crushed limestone
 - ½ in pea gravel
 - Natural sand
- 



Counter Flow Drum

RAP Feeder

Mixer Drum

1.0 inch Crushed Gravel





1/2 inch Crushed Limestone

½ inch Pea Gravel



Natural Sand





Phase Two Recycled Materials

- Fine RAP
 - Coarse RAP
 - Post Consumer Shingles
- 



Post Consumer Shingles

Post Consumer Shingles





Coarse RAP ($\frac{1}{2}$ to 1 inch)

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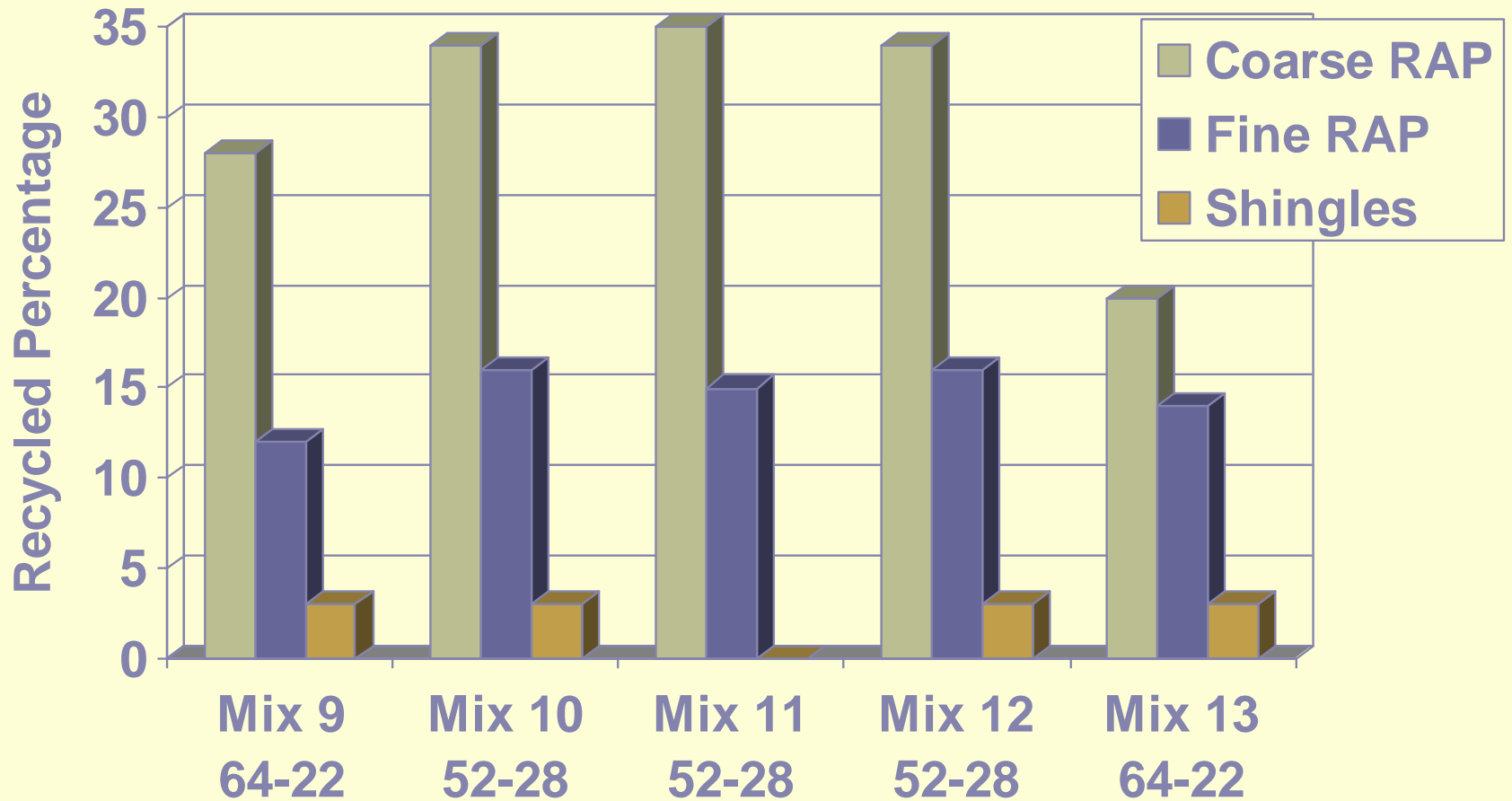


Fine RAP (minus 1/2 inch)

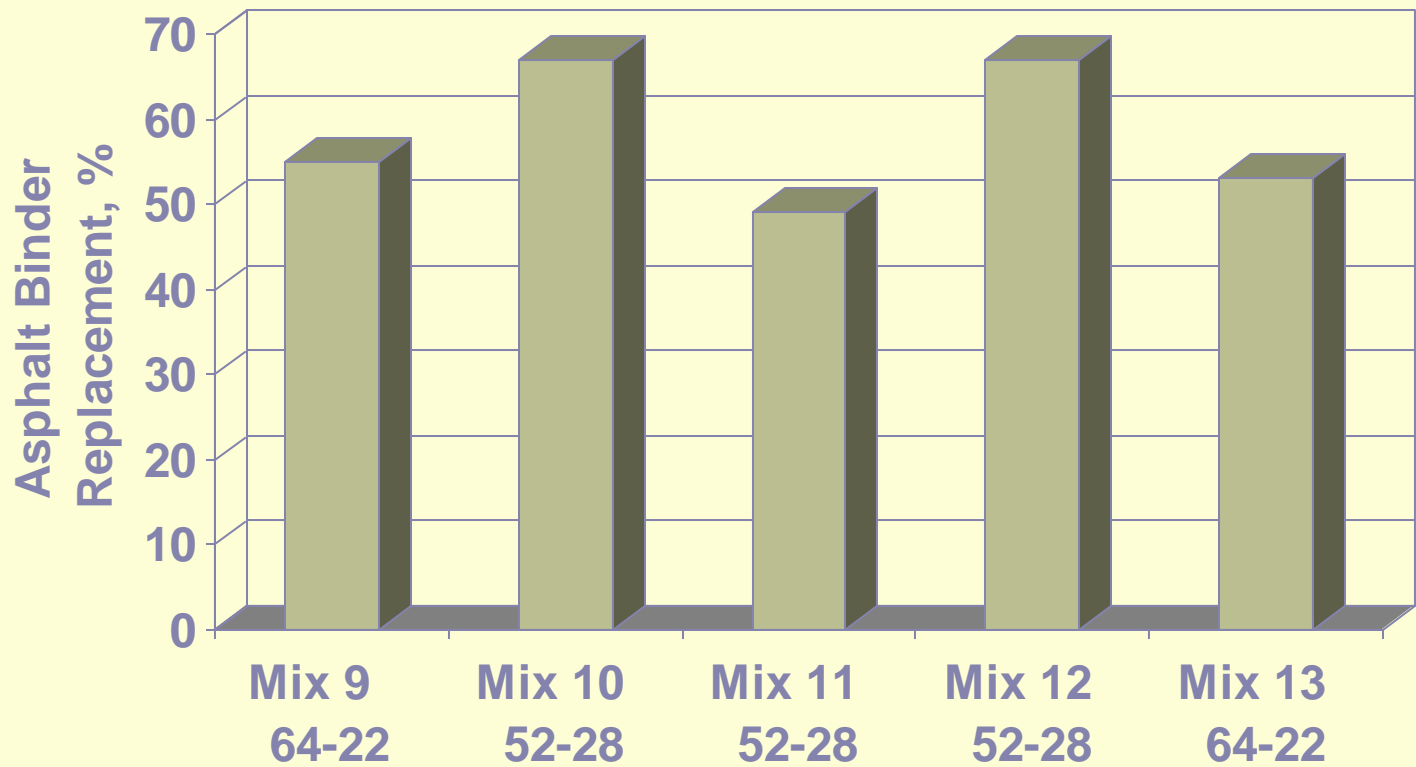
Fine RAP (minus 1/2 inch)



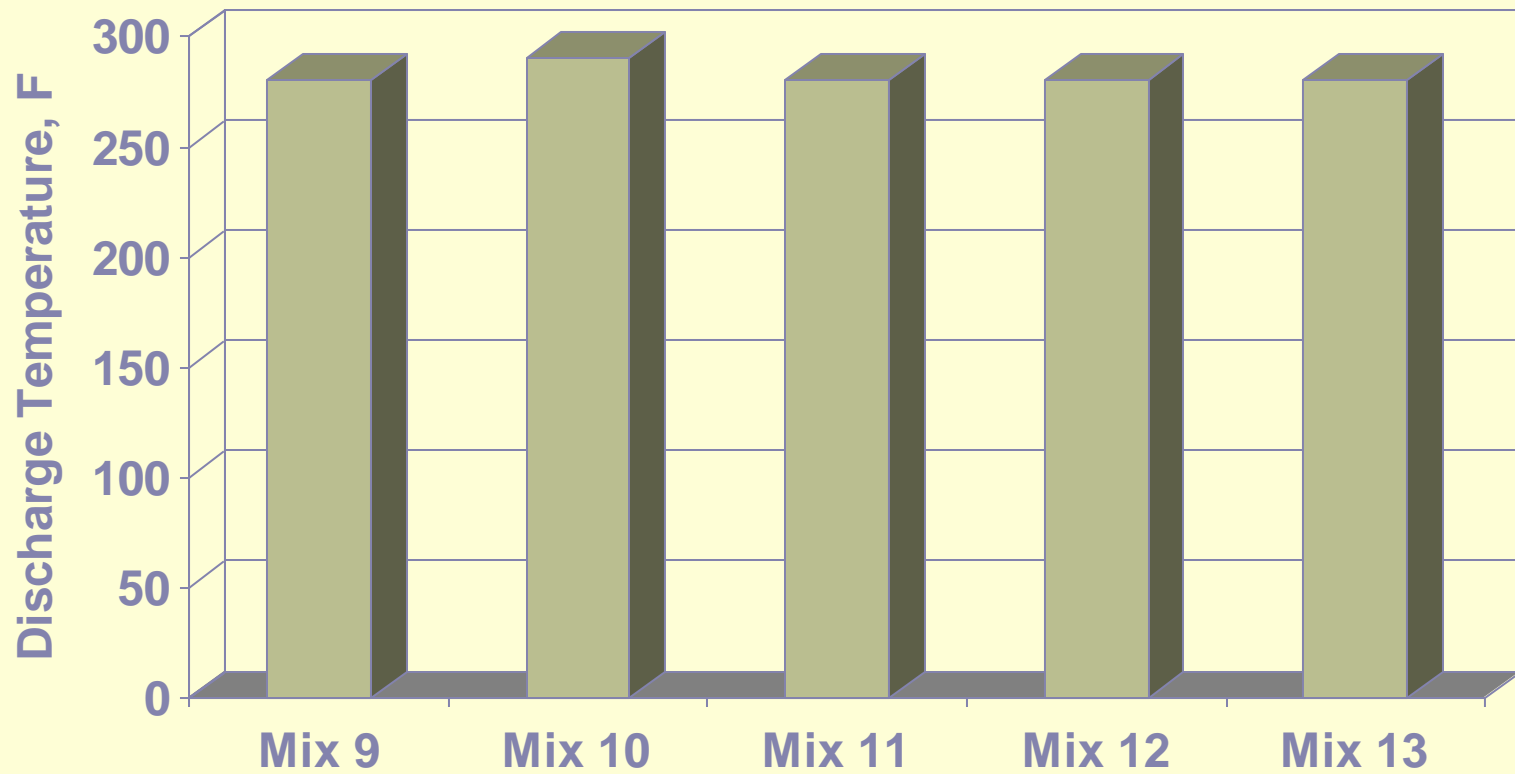
Recycled Components



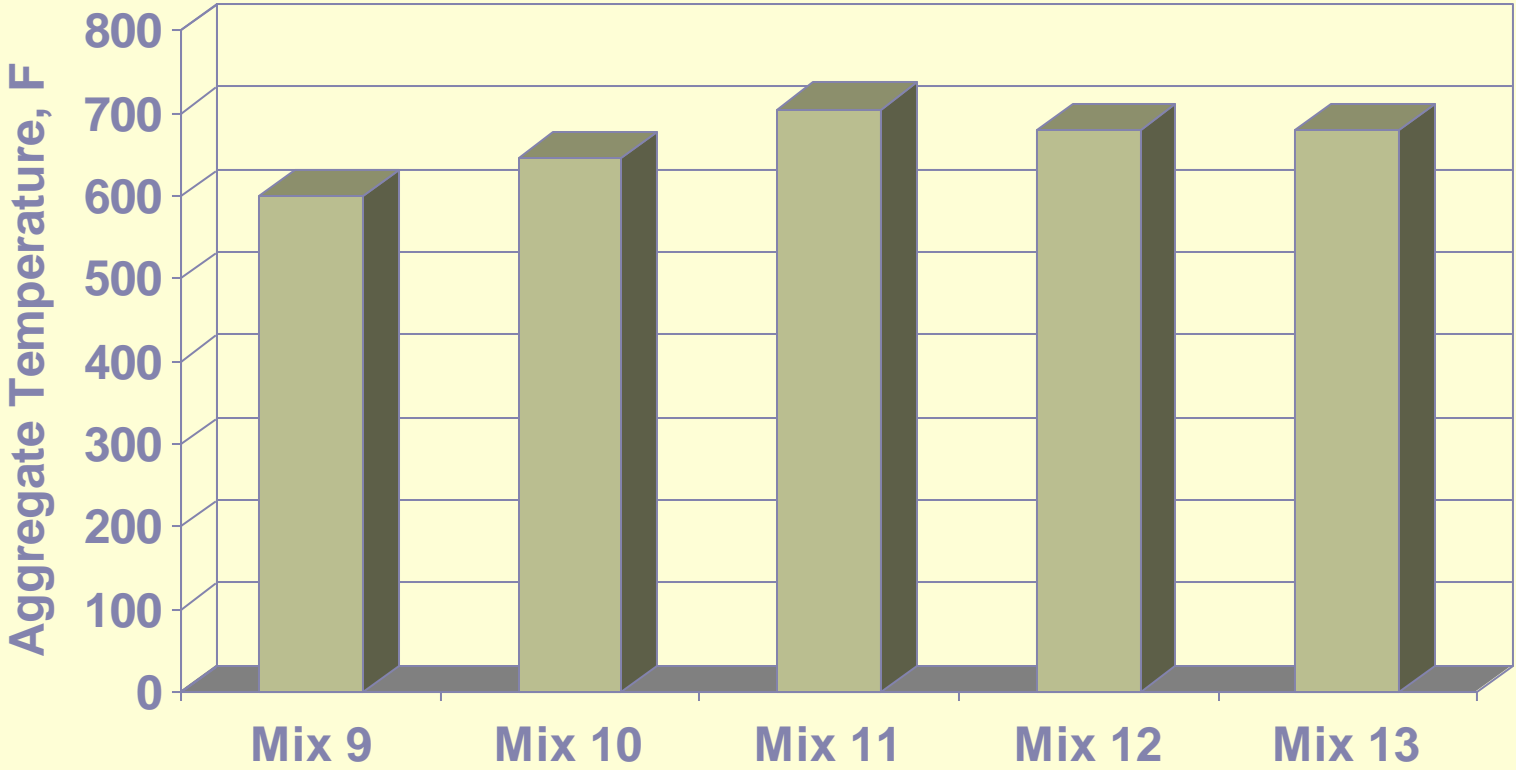
Asphalt Binder Replacement



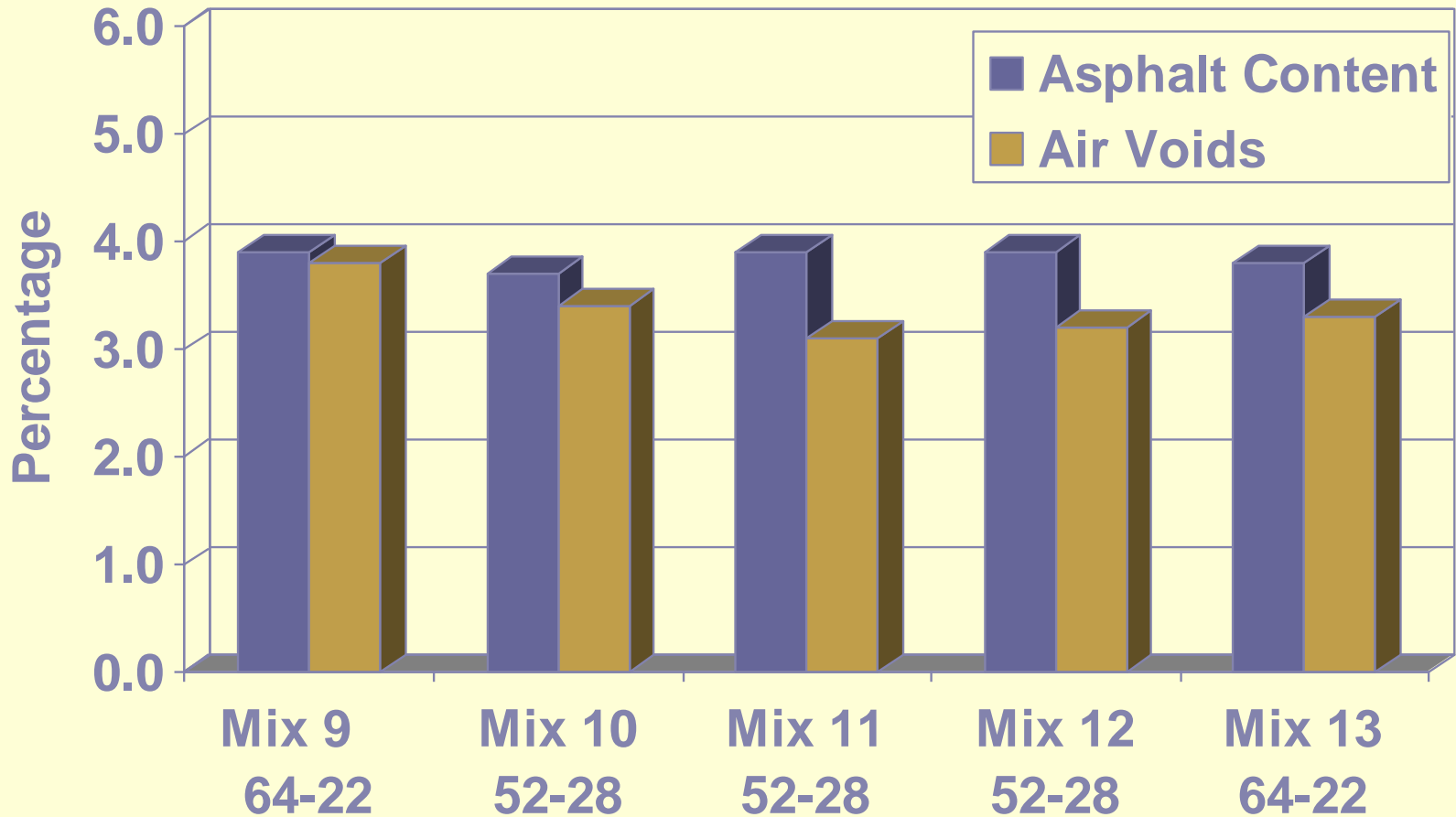
Discharge Temperature



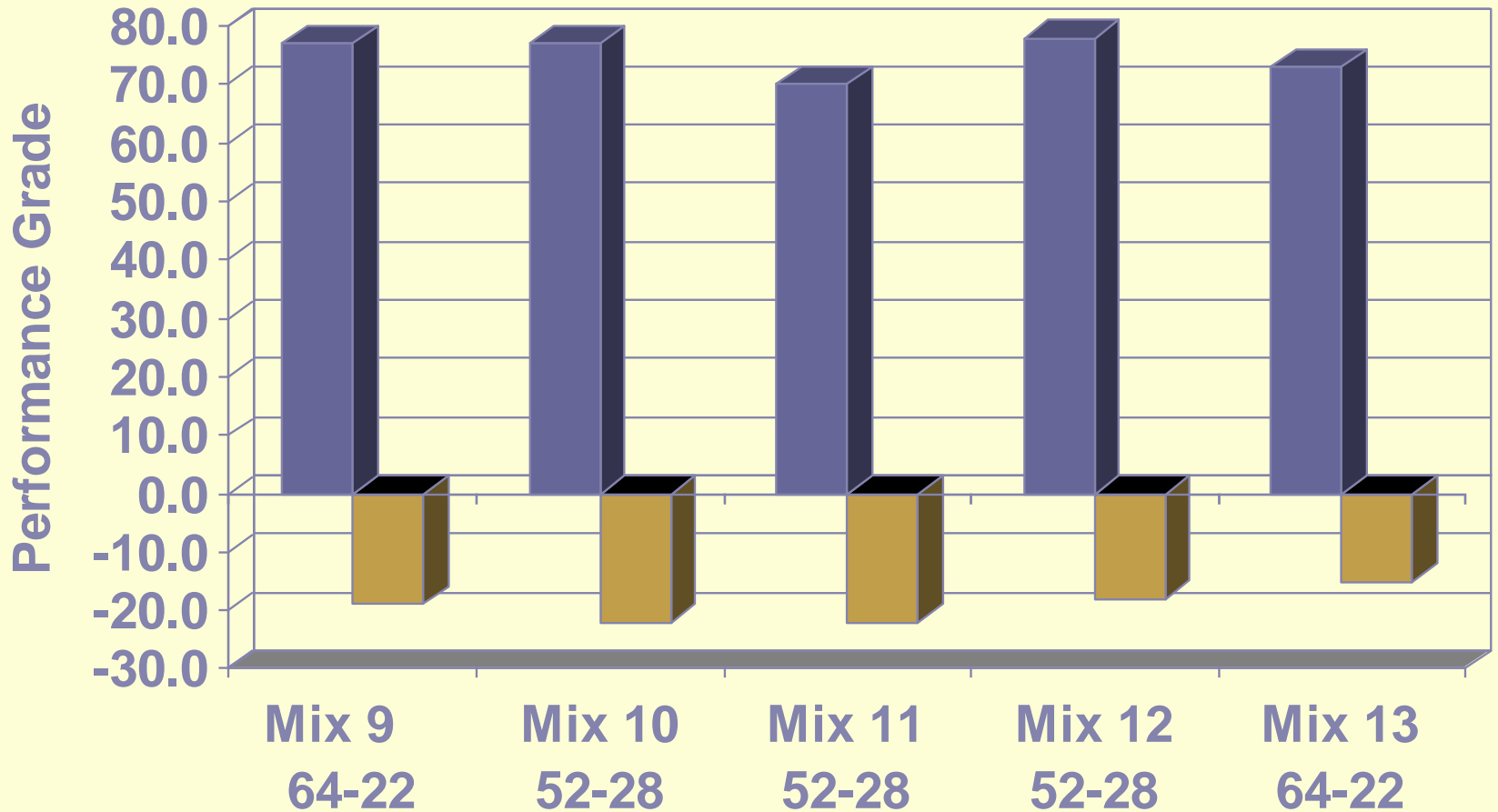
Aggregate Temperature



Volumetric Properties



Asphalt Binder Grade





Blending Analysis

- M323 to calculate the limiting amount $\% RAP = \frac{T_{blend} - T_{virgin}}{T_{RAP} - T_{virgin}}$

- Predicted Temperature of Blend

$$T_{blend} = T_{virgin} + \% RAP (T_{RAP} - T_{virgin})$$






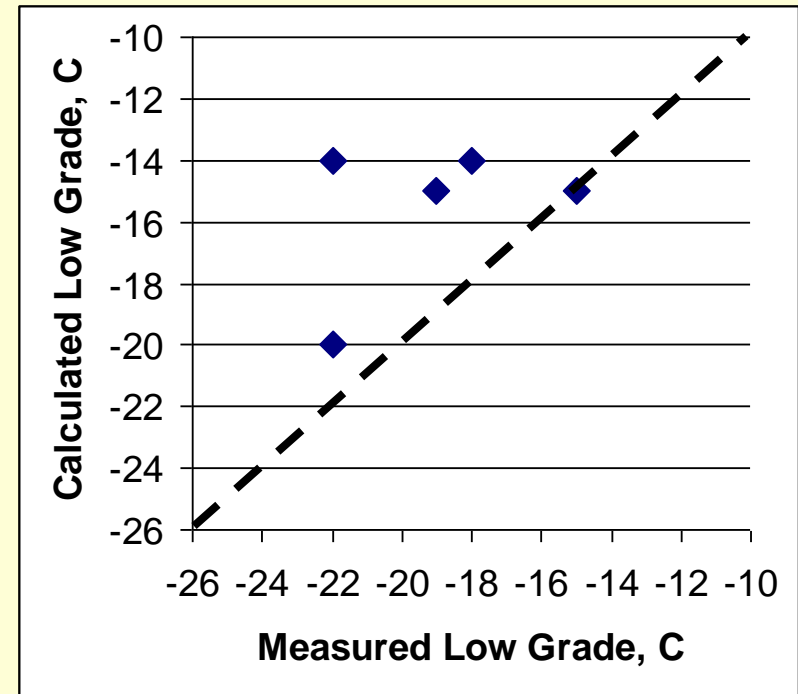
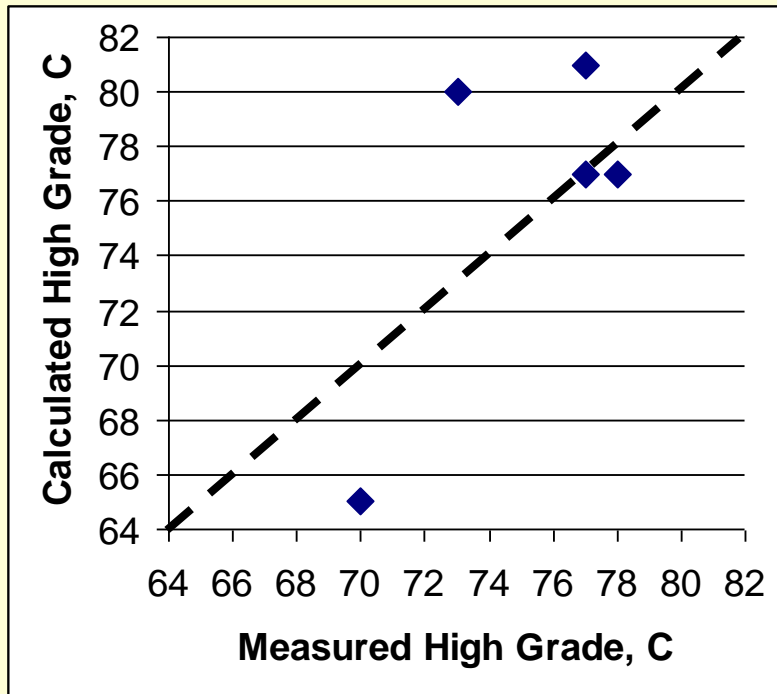
Blending Analysis

- For multiple recycled materials

$$T_{blend} =$$

$$\frac{\%RAP_F x T_{RAP_F} + \%RAP_C x T_{RAP_C} + \%RAS x T_{RAS} + \%Virgin x T_{virgin}}{\sum (\%RAP_F + \%RAP_C + \%RAS + \%Virgin)}$$


Calculated vs Measured

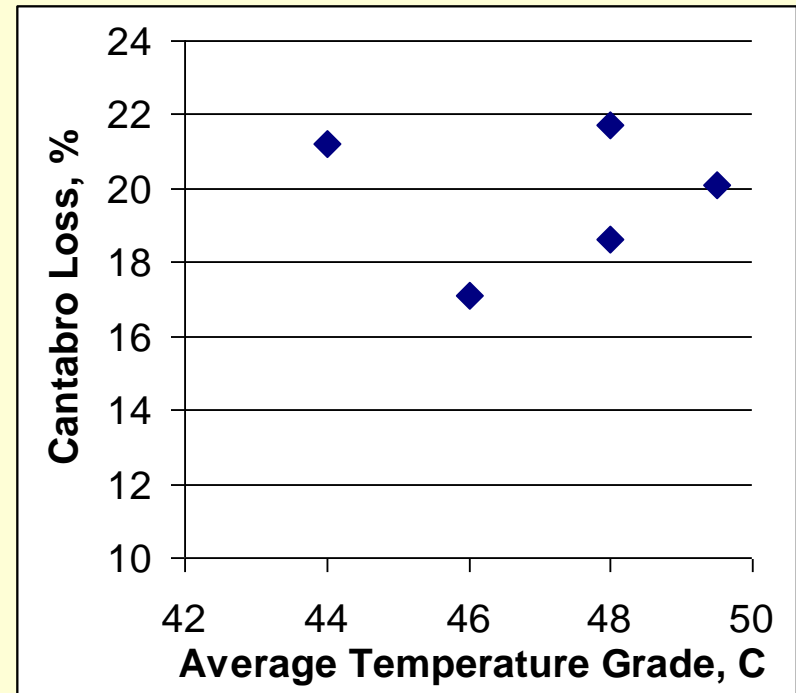
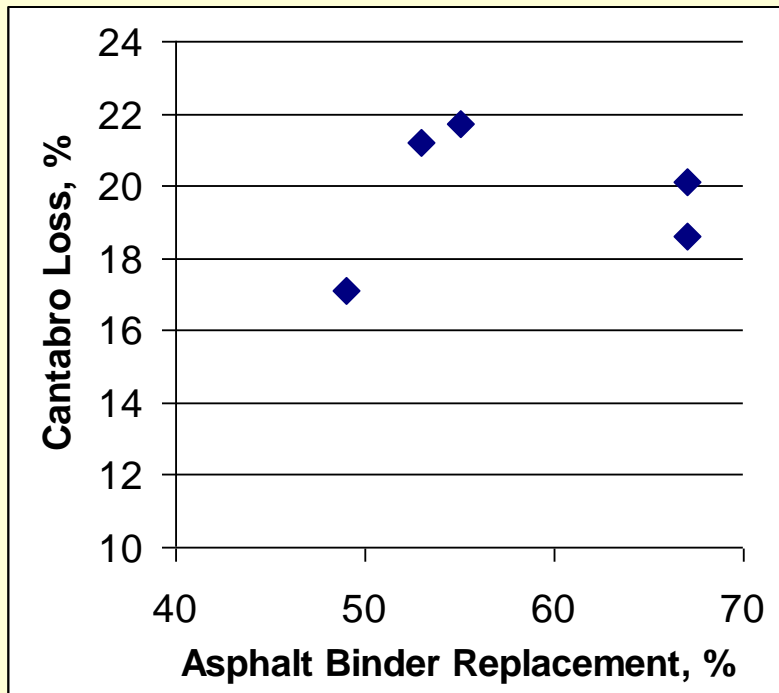


Cantabro Loss Test (Durability)

- LA Abrasion Test Machine
- Test without Steel Balls



Cantabro Test (Durability)






Placement

● County Road resurfacing

- 50 mm base
 - 19.0-mm mix
- 38 mm surface

● Placed

- May 31, 2011
 - June 1, 2011
- 



Construction Conditions

● Haul time

- 30 minutes approx

● Weather

- 85F sunny

● Paver

- Roadtec RP150
 - 50 to 60 ft/min

● Compactor

- Bomag BW266
 - 3 vibratory passes, 1 static





Existing Condition

05.31.2011



Laydown Operation



Uncompacted Mat




Compaction



Compacted Mat



Paving Crew Observations

- Flows through paver
 - Mat lays well
 - (little handwork in this application)
 - Compacts well
 - No tenderness
- 




conclusions






Phase 1 Conclusions

- 50% RAP is reasonable maximum
 - With conventional counterflow drum
 - Criteria selected for
 - Drum shell temperature
 - 800°F maximum
 - Virgin aggregate temperature
 - 700°F maximum
 - Bag house exhaust
 - 220°F minimum
 - 390°F maximum
- 



Phase 2 Conclusions

- Volumetric Properties Can Be Controlled
 - With 50% RAP
 - With 67% asphalt binder replacement
 - Durable Mixtures Can Be Produced
 - With 67% asphalt binder replacement
 - 18% from RAS
 - 49% from RAP
- 





RAP in HMA

● Black Rock?

- Limestone
 - 3 million – 12 million psi
- Aged Asphalt Binder
 - 150,000 psi glassy stiffness
 - 1,500 psi (50F)

500 times stiffer

● Homogenous Blending?

- No

● Partial Blending??



Partial Blending

- Composite Material
 - Virgin Binder
 - Reclaimed Binder

