Cold In-place Recycling

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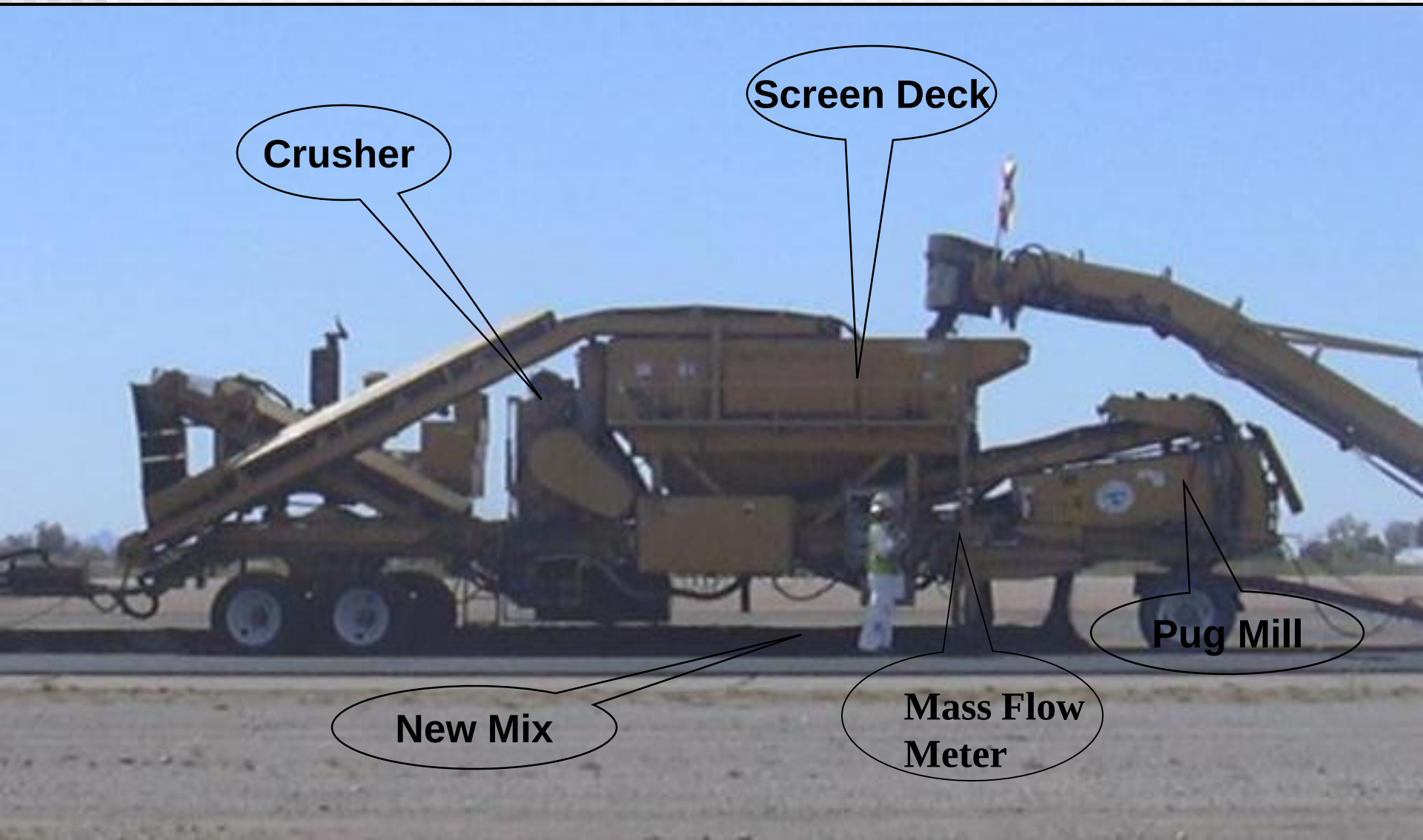
Cold In-place Recycling (CIR)

Distressed Pavement = New Pavement Using A Train of Equipment that:

- Mills deteriorated pavement (Typically 2.5 to 4 inches)
  - Reclaimed asphalt pavement (RAP)
- Crushes RAP to gradation
- Mixes with recycling agent
- Re-Paves recycled mix
- Compacts to specified density
- Readies for surface treatment

Typical CIR Crushing, Sizing and Mixing Train

Recycling Plant



New Recycled Mix Windrowed

Pick Up and Paved

Compacted

Compacting Equipment

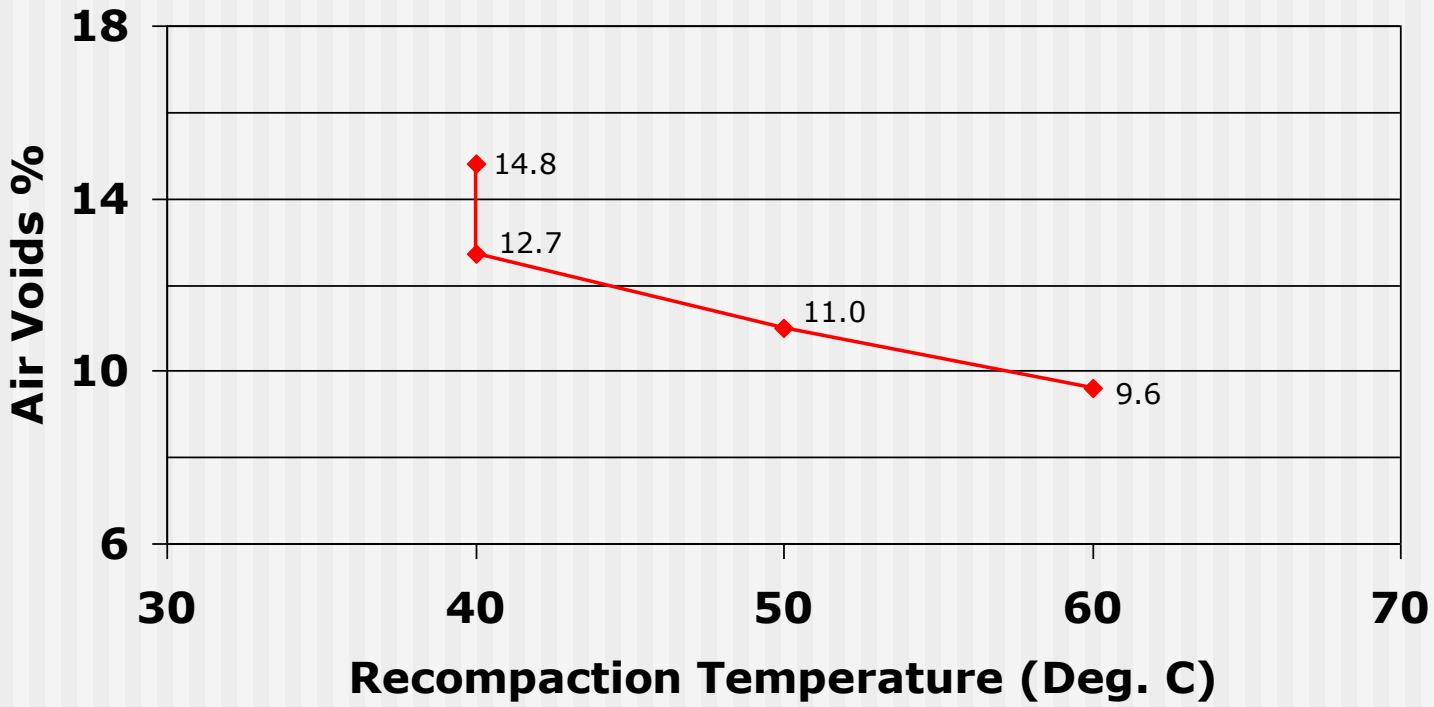
- Minimum 1 pneumatic-tired roller at least 25 tons
- At least 2 double drum vibratory steel-wheeled rollers at least 10 tons
- Minimum width at least 66-inches.
- All rollers must have working water spray systems.

Fog Sealed and Sand Blotted

Open to Traffic

Supplemental Compaction (Reroll after a few days cure)

Best opportunity to reduce air voids if done properly

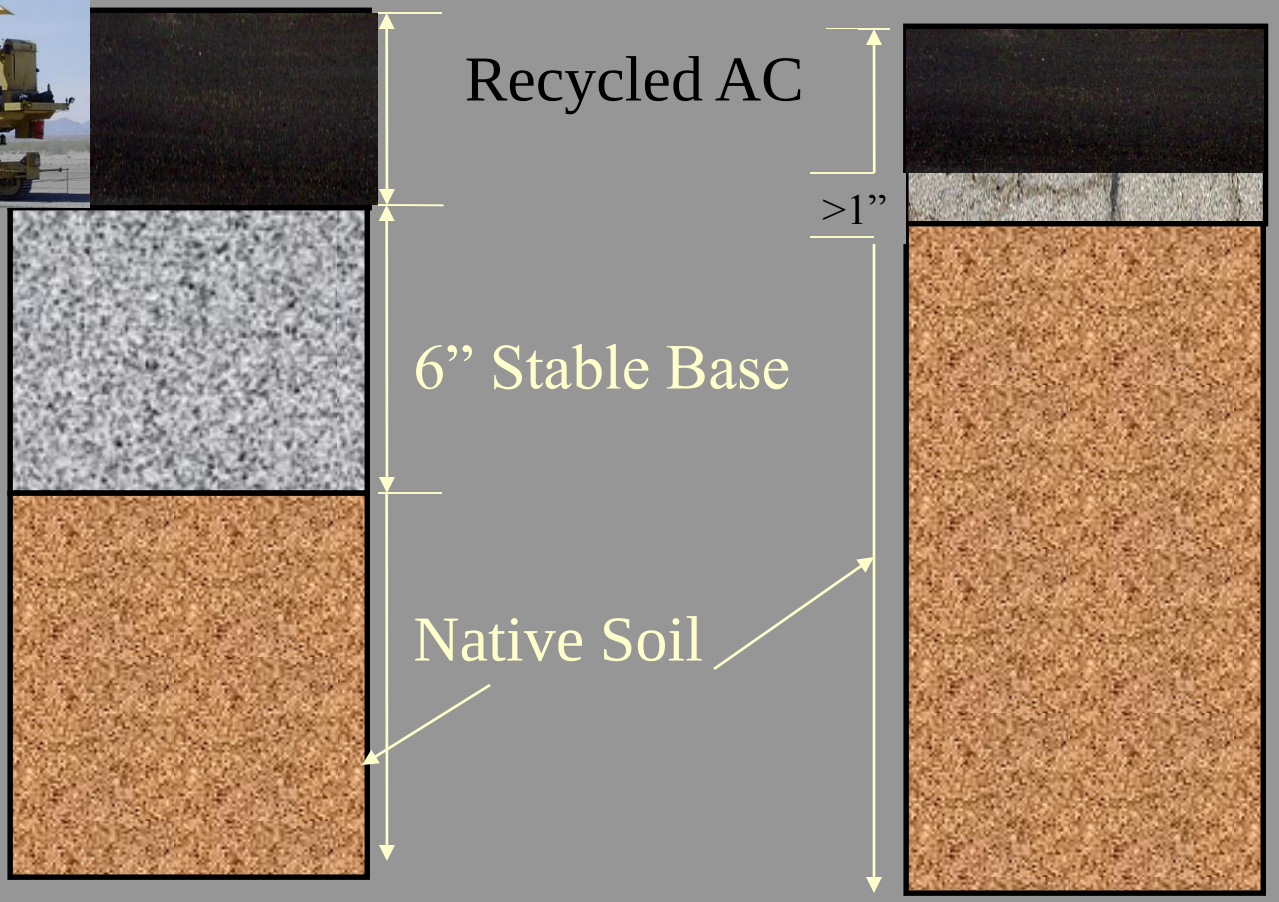



QUALITY
PROPER SITE SELECTION

Cold In-place Recycling (CIR) – Preservation/Minor Rehab.

Recycle AC to:

- Stable Base
- Within 1” of less Supportive Material



Poor Subgrade Will Not be Fixed by CIR

Cracking Pattern Disrupted Does Not Need to Go Full Depth

70% Rule for Mitigation of Reflective Cracking

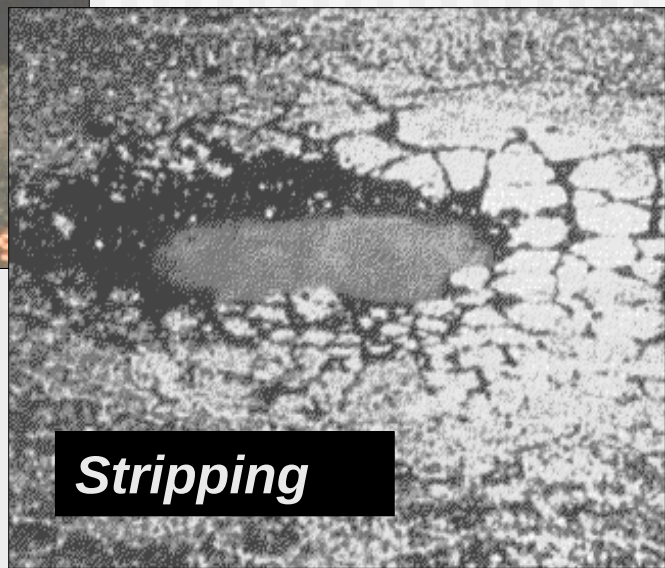
Pavements with Difficulty to CIR

Paving fabric makes it messy!

Asphalt Rubber

Thin AC and getting into the subgrade.

Avoid base problems!



Proper Site Selection
Roadway Geometry

Main mill 12.5-feet wide cutter. Allows for full lane width and overlap. Close to 14’ wide.

Does Not Mean Limited to Big Open Highways

Supplemental Mill

Highway Shoulders to 5’ Wide

Urban Areas
Turning Lanes and Tight Areas

Proper Site Selection
Material Balance

Will swell. Finished voids about 9 to 15%.
Consider shoulders that are not recycled and changes in grade


QUALITY
DURING DESIGN

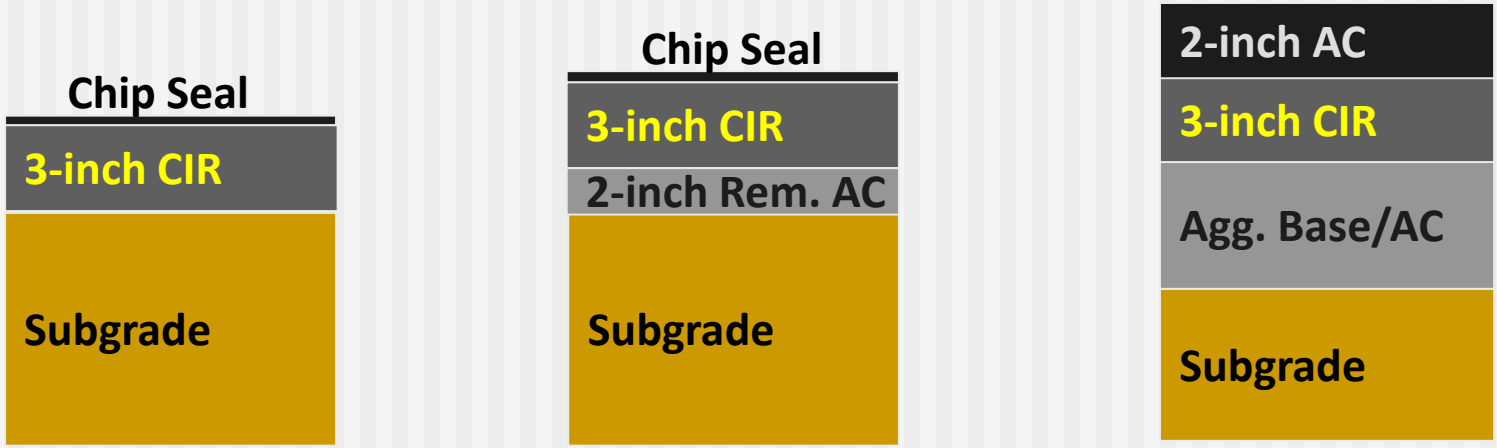
Structural Design Considerations
Structural Number

ARRA BARM II	0.30 – 0.35
Virginia Center for Transportation Innovation and Research/VDOT Interstate 81 Project	0.35 – 0.39
Adaption and Verification of AASHTO Pavement Design Guide - Ontario Department of Ministry	0.28 – 0.38
NCAT Test Track Testing Cold Central Plant Recycling	0.36 – 0.39

Based on 10 Million ESALs

NCHRP 9-51 - Material Properties for CIR and FDR for Pavement Design

Not All 3” CIR Is The Same



It’s About the Mix and
How it is Used in the Structural Design

Structural Design Considerations
Strength Development

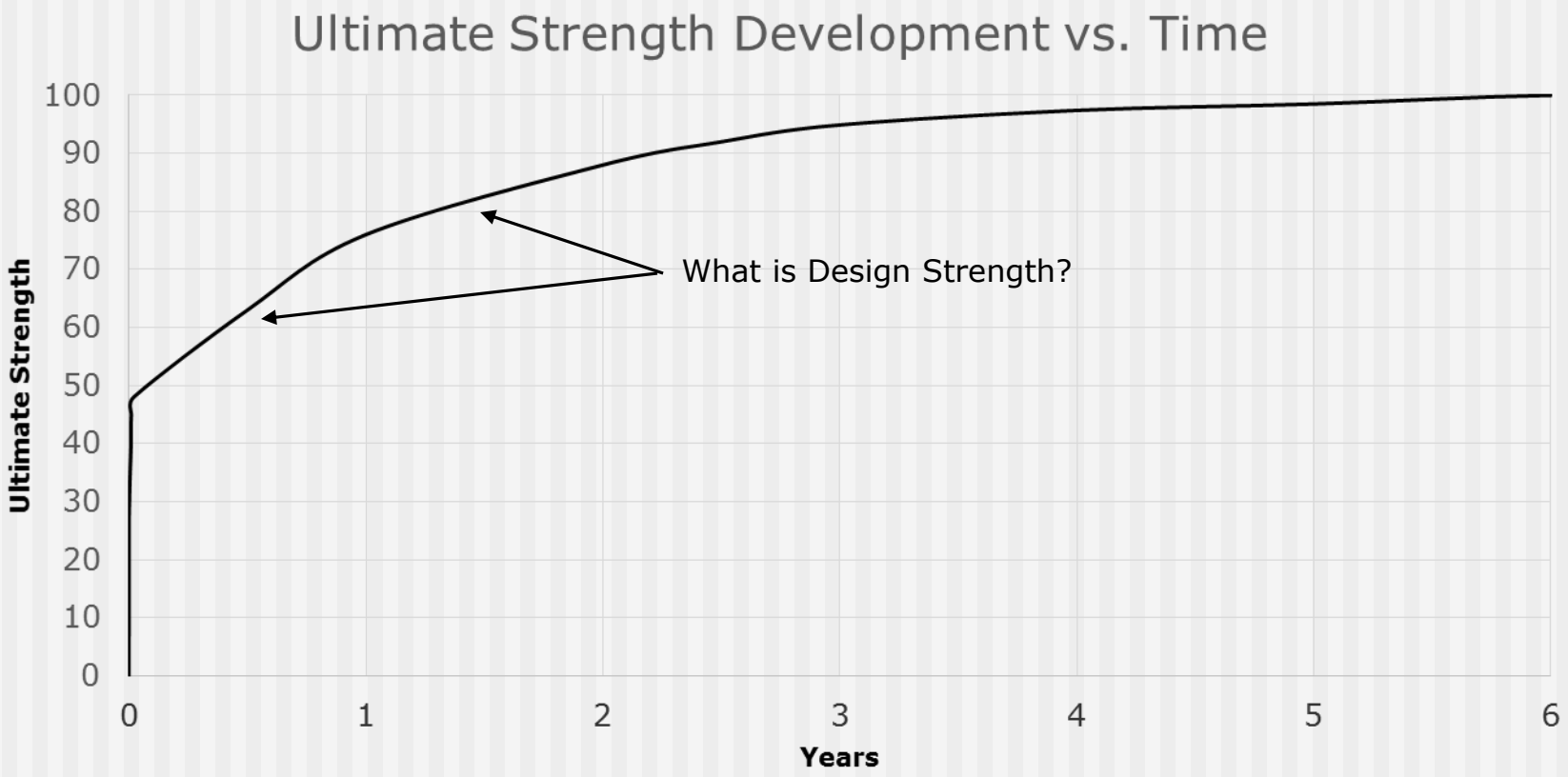
Initial Curing – A short time period that permits the recycled mixture to gain sufficient cohesion to be less susceptible to surface disturbance. Opened to traffic. A few hours.

Intermediate Curing – Time required for recycled mixture to build sufficient strength prior to placement of the surface course. Depends on recycling agent and environmental conditions. A few days.

Final Curing - Time required for the recycled mixture to reach its ultimate strength. Typically for CIR 6 years.

Intermediate Curing and Coring

Final Curing



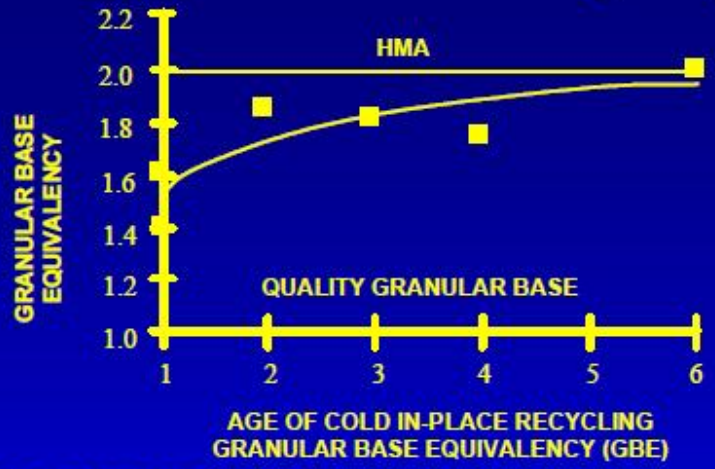
Emery, 2007

LAS VEGAS ARRA 2007 SEMI-ANNUAL MEETING OCTOBER 2007

CIR WITH EMULSION GRANUAR BASE EQUIVALENCY FACTORS (GBE)

TYPICAL CIR STABILIZED BASE CORES

JEGEL NAT

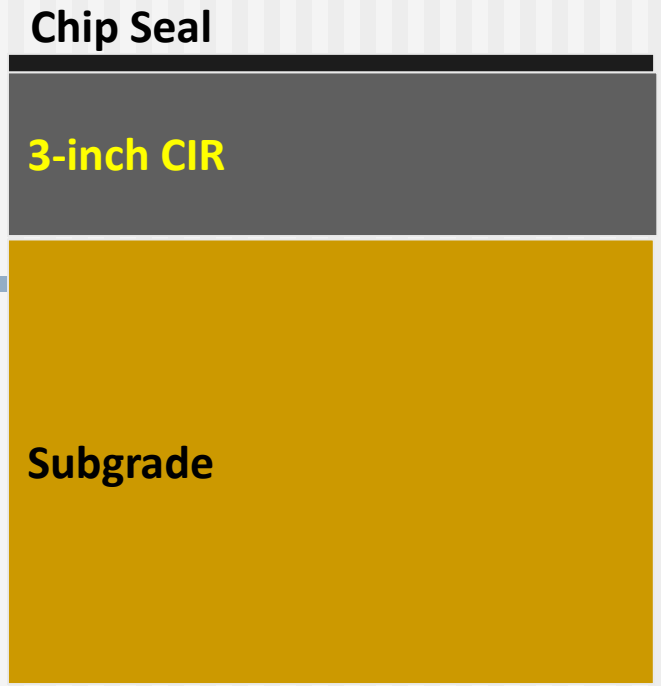


GBE BASED ON ONTARIO EXPERIENCE

• NEW PROJECTS	
• HOT-MIX ASPHALT INCLUDING HIR	2.0
• GRANULAR BASE (CRUSHED, CBR ≥ 60)	1.0
• GRANULAR SUBBASE (CBR < 60)	0.67
• RESURFACING PROJECTS	
• OLD HOT-MIX ASPHALT	1.25
• OLD GRANULAR BASE	0.75
• OLD GRANULAR SUBBASE	0.50
• CIR AND FDR	1.80
• RECONSTRUCTION PROJECTS	
• OLD HOT-MIX ASPHALT	1.0
• OLD GRANULAR BASE	0.6
• OLD GRANULAR SUBBASE	0.4

CTAA 1996

Life Just a Few Years?



Yielding Support

- Can Lead to Curing Fatigue
- Contamination in Mix – Reduction in Performance

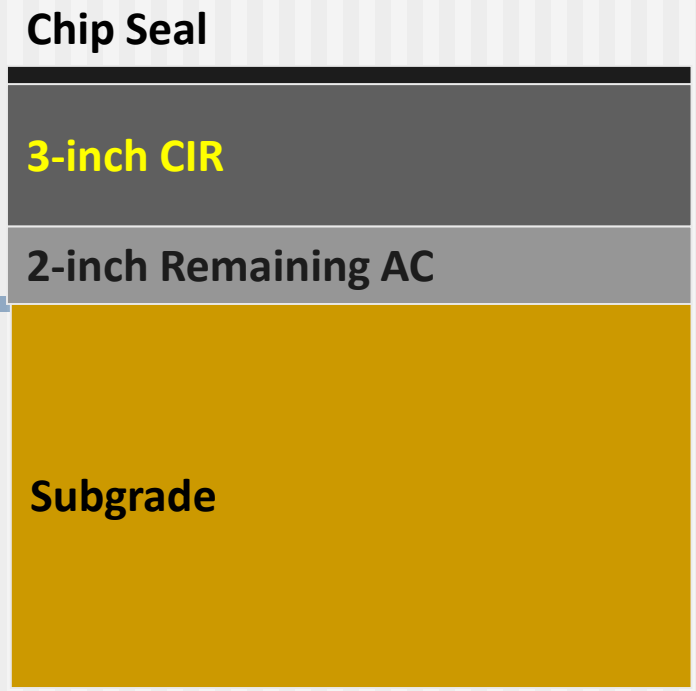
Thinner Surface Course

- Less Thermal Insulation – Higher Temperature Impacts
- More Environmental Harding
- Less Resistance to Traffic Shear Forces

Underlying Support Critical For Performance

Curing Fatigue Cracking

Longer Life
6 to 10 Years



Solid Support

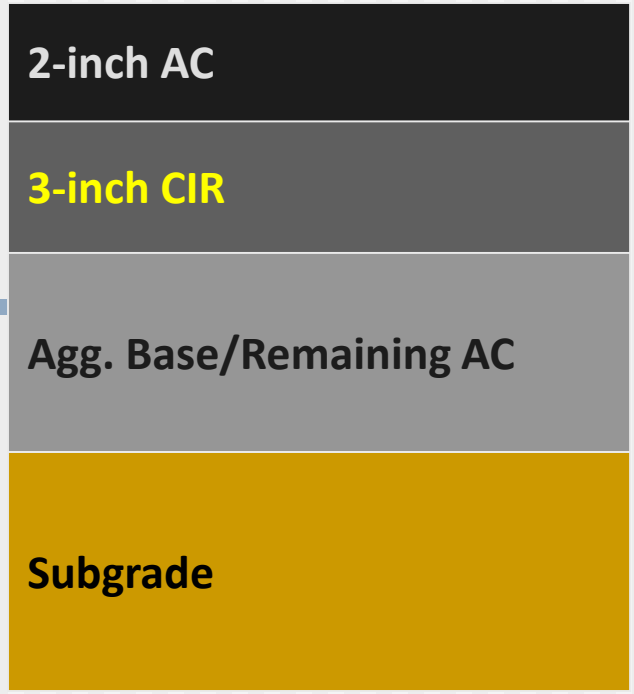
- Full Strength Development
- No Contamination

Thinner Surface Course

- Less Thermal Insulation – Higher Temperature Impacts
- More Environmental Harding – Less Resistance to Reflective Cracking
- Less Resistance to Traffic Shear Forces

Life Based on Traffic Forces

Long Life
7-20 Years (Perpetual?)



Full Strength Development
No Contamination of Mix

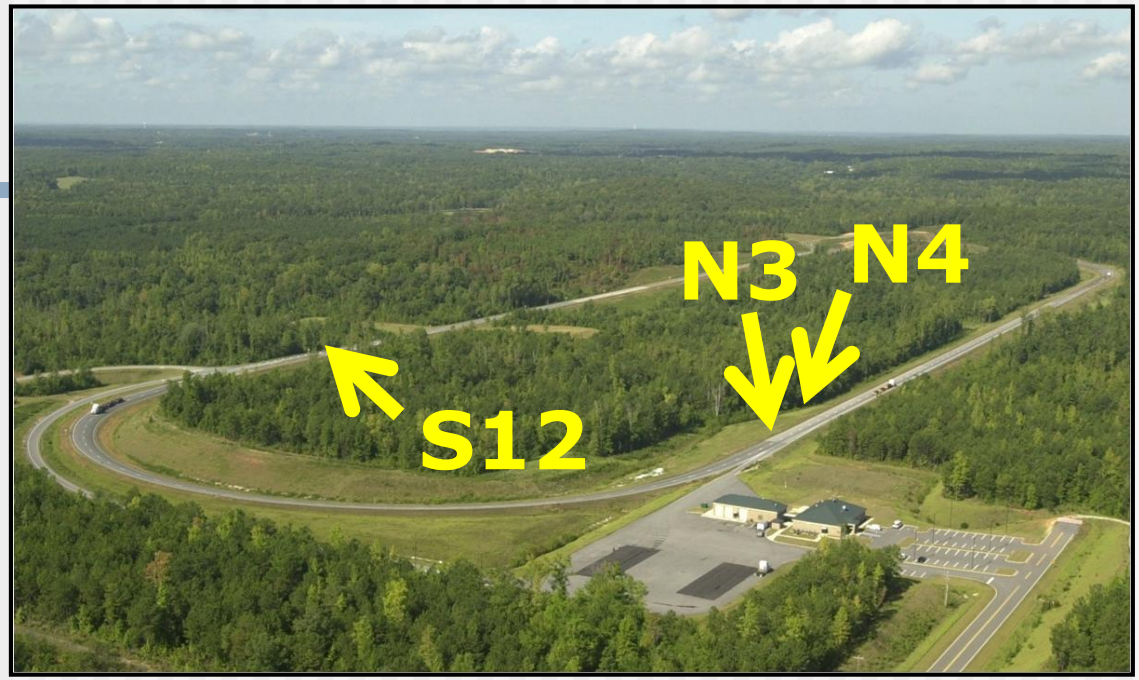
Surface Course Provides

Thermal Insulation – Less Temperature Impacts
No Environmental Harding – Resistance to Reflective Cracking
Resistance to Traffic Shear Forces

Life Based on Proper Structural Design

NCAT Test Track, 2012

- 10 million ESALs
  - Applied in 2 years
  - First cycle completed 2014
- Anticipate continuing as part of 2015 track cycle



N3

6-inch AC
5-inch CCPR
6-inch Agg Base
Subgrade

N4

4-inch AC
5-inch CCPR
6-inch Agg Base
Subgrade

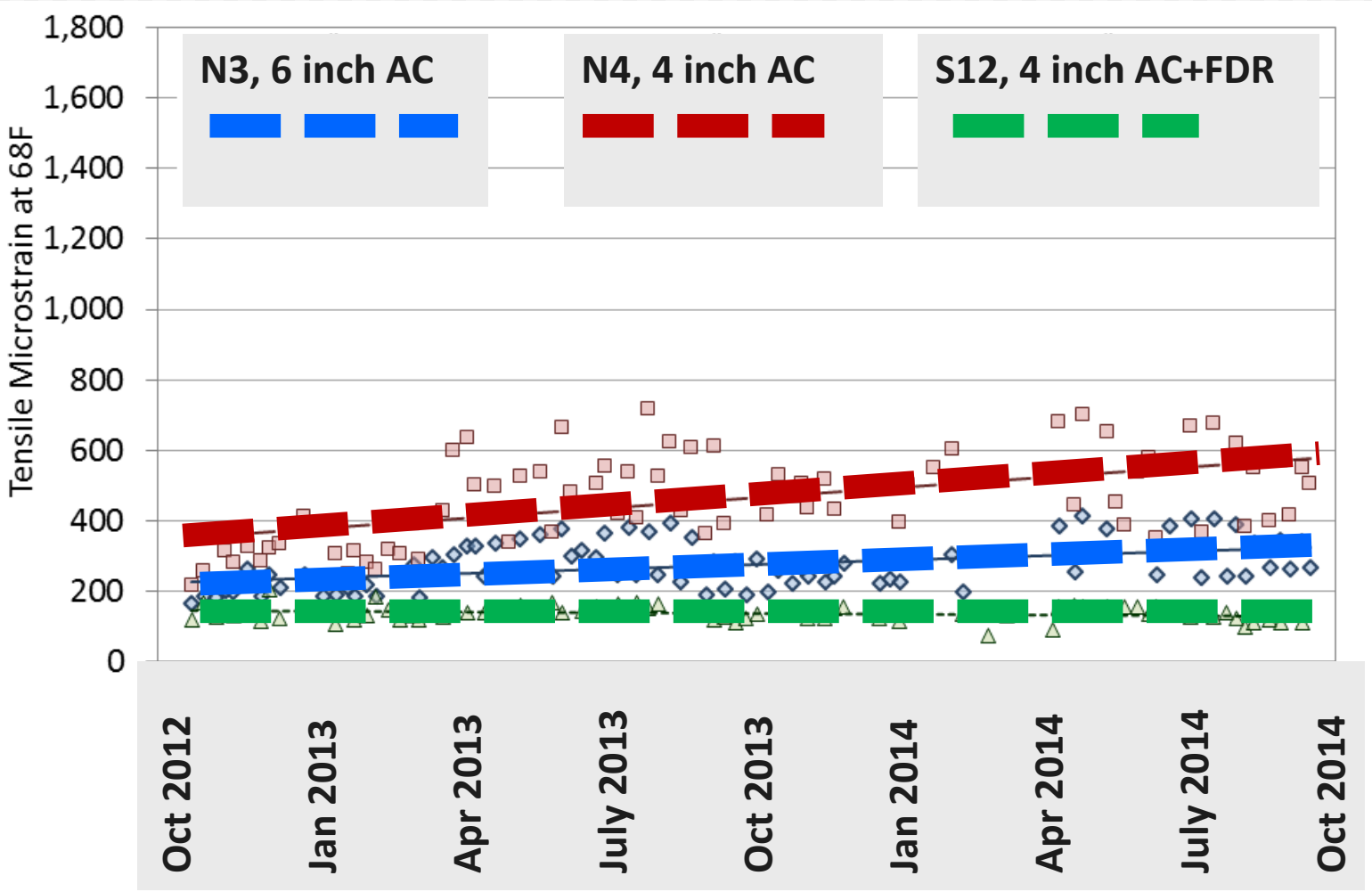
S12

4-inch AC
5-inch CCPR
8-inch FDR
Subgrade

Slide Courtesy of
Brian Diefenderfer, Ph.D., P.E.
Virginia Center for Transportation Innovation and Research / VDOT

NCAT, Lessons Learned

Tensile Strain Beneath CCPR Layer at 68F



Rutting < 0.25 inches

Will the presence of the FDR section make the CCPR act "perpetually"?

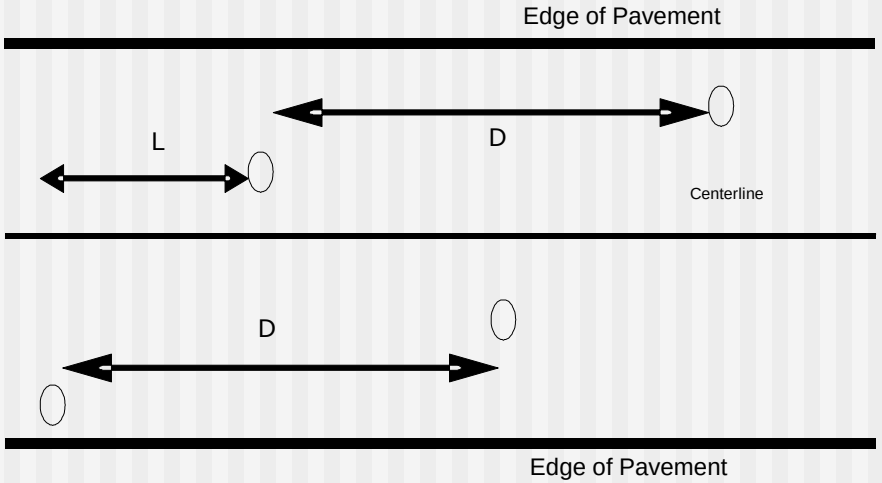
Slide Courtesy of
Brian Diefenderfer, Ph.D., P.E.
Virginia Center for Transportation Innovation and Research / VDOT

Quality Sampling and Mix Design

Coring – For Depth and Use In Mix Design

Cores measured to the nearest 1/8-inch (3-mm) and placed in separate containers and labeled

Cores cut in lab to planned recycling depth and only that portion to be recycled used for mix design



Dynamic Cone Penetrometer (DCP)

Addresses Subgrade:

To Support Train

To Support Temporary Traffic

DCP	Acceptable	Marginal	Poor
Each Set of 10 Blows	< 6 Inches <150 mm	6 to 10 inches 150 mm to 250 mm	> 10 Inches > 250 mm
Inches per Blow **mm per Blow**	0.6 15	0.6 to 1.0 15 to 25	> 1.0 > 25

Mix Design Current Procedures

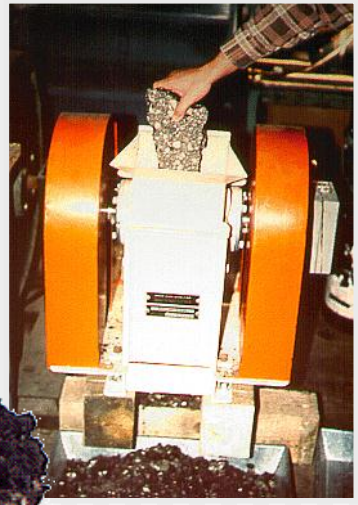
Performance and Volumetric Testing to Address:

- Gradation and Quality of RAP
- Density and Compaction
- Coating
- Stability and Strength
- Moisture Sensitivity
- Air Voids
- Raveling

Lab RAP Analysis

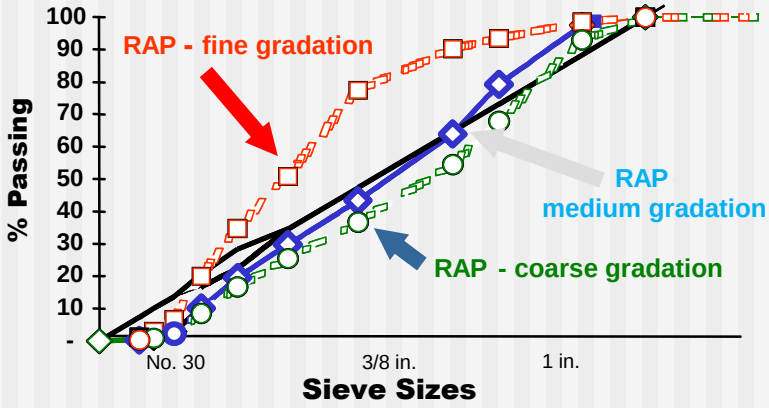
- Extract Binder and Conduct Aggregate Gradation
- Does Parent Gradation Have Sufficient Rock on Rock Stability If Binder Softens Post Construction? What is the Controlling Gradation the RAP or the Parent Gradation?
- Recover Binder
  - Viscosity, Penetration or PG Grading

RAP Gradation Analysis



Lab –

Field cores crushed using a lab mill or lab crusher and recombined to specific gradation bands



Field -

- Field gradation depends upon multitude of factors: milling, weather, etc.
- Gradation compared to lab tested band
- Recycling agent percentage based on applicable gradation

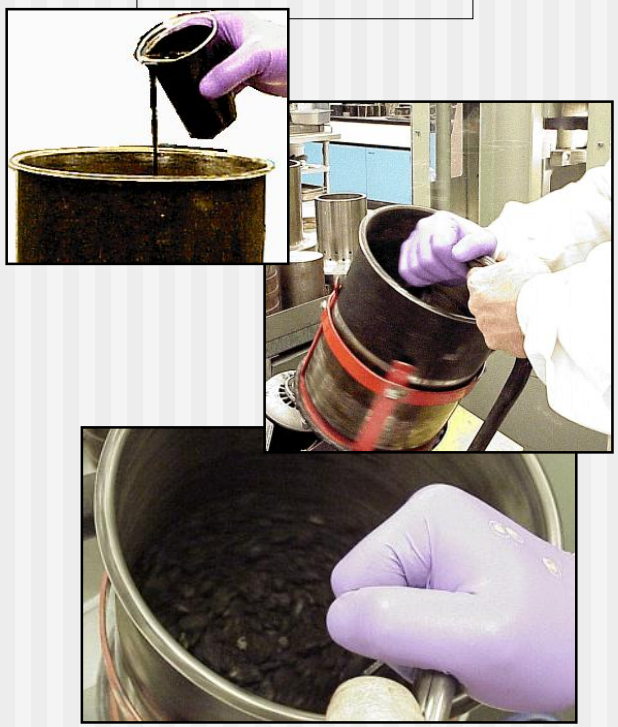
Additive - Corrective Aggregate

RAP – Better Coating

New Aggregate – Better Structure Control

Mixing With Recycling Agent and Additives

Lab



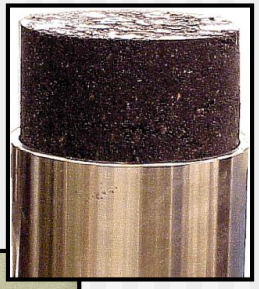
Field

Pugmill

Density Compaction Effort

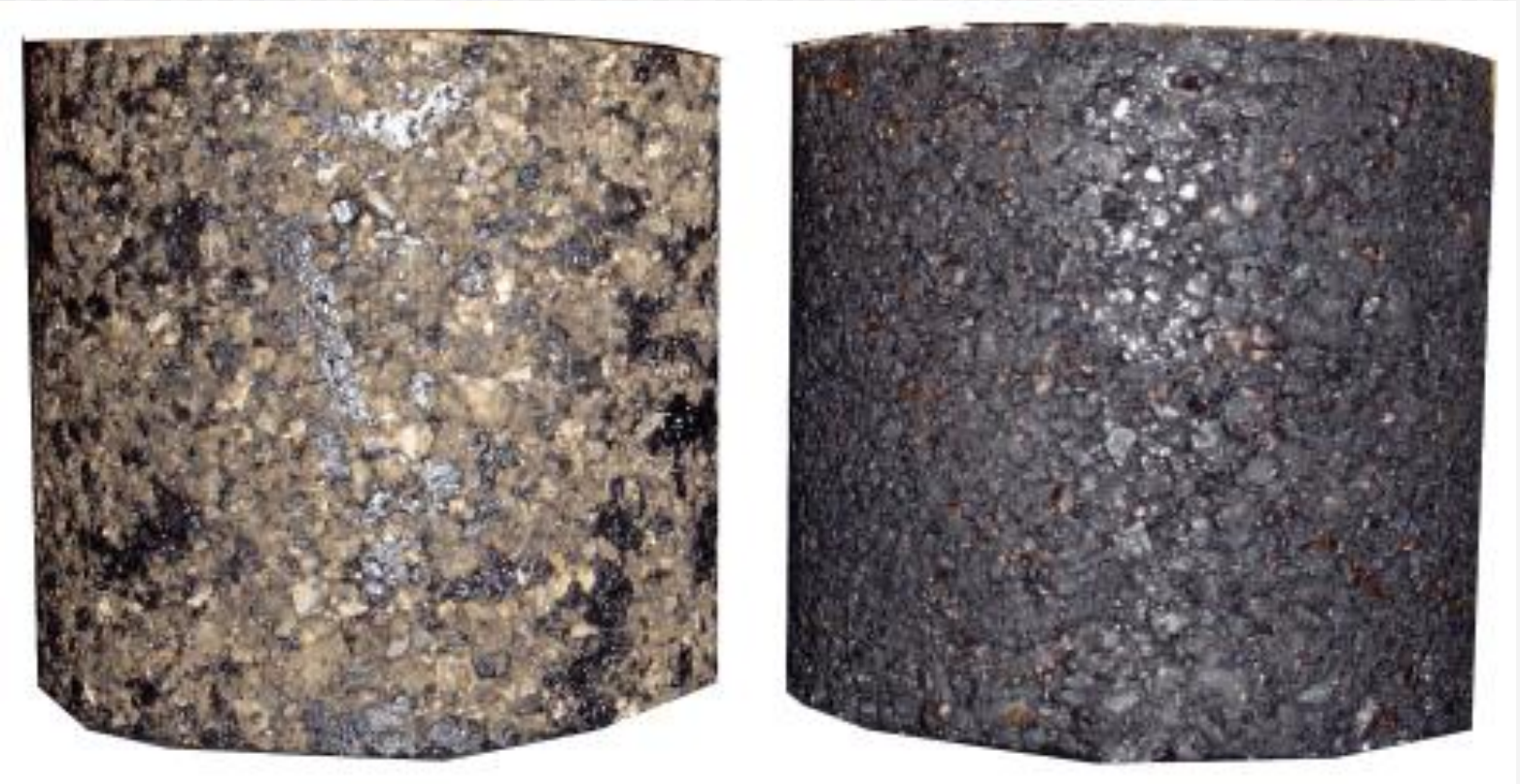
Superpave Gyratory Compactor

Lab

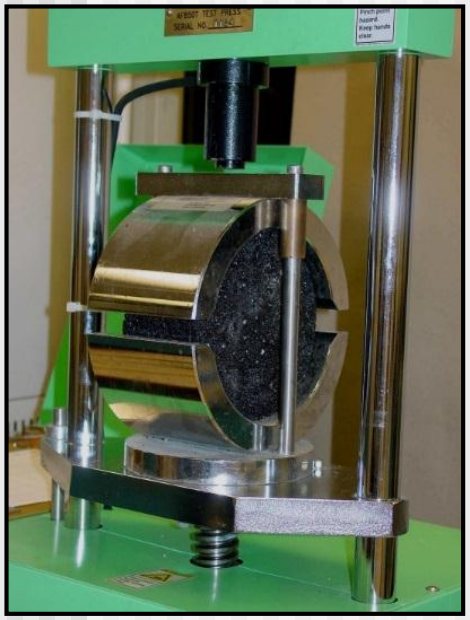


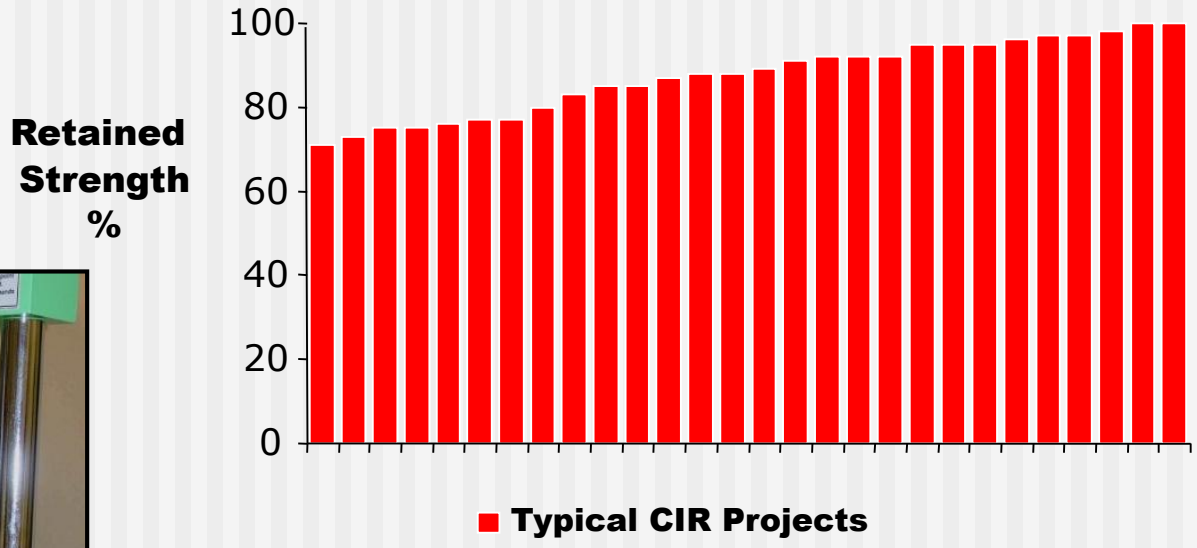
Field

Coating



Test for Stability and Moisture Sensitivity at Appropriate Temperatures by Marshal Stability and/or ITS.





Chemical Additive to Improve?

Freeze Thaw Test May be Appropriate

Lime Slurry or Hydrated Powder

Typically 1 to 1.5%

Commonly with a solvent based emulsion such as CMS2s

Has been used with Engineered Emulsions

Dry Cement

Typically 0.3 to 1.0%

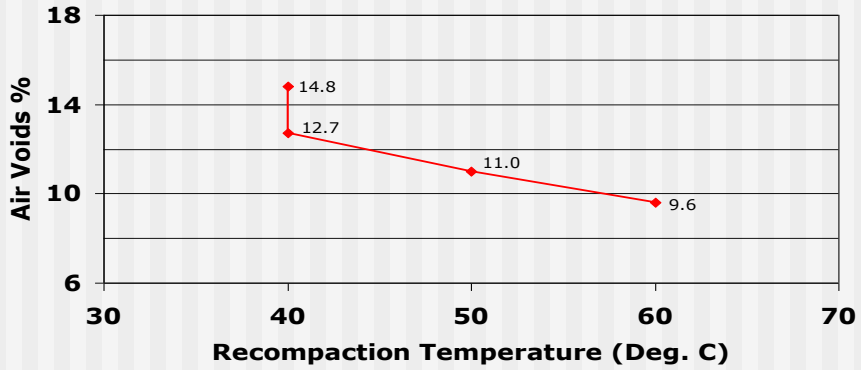
Chemical Additives

- Can Provide Early Strength and Hardening
- Avoid Changing From Ductile to Brittle Behavior
- Consider Depth of Recycling and Underlying Support
  - Thin/Thick CIR
  - Ductile/Rigid CIR
  - Flexible Support vs Rigid Support
- Maintain Residual Asphalt to Additive Ratio
  - Cement 3:1

Air Voids

Potential to Reduce Post Construction
- Future Temperatures
- Softening of RAP

How to Decrease
- Mineral or Chemical Fillers
- Higher Binder Contents
- Good Supplemental Compaction Procedures



Raveling Test

Proper CIR

Inadequate CIR

Compacted at 77°F Tested at 50°F and 50% Humidity

Does That Represent Construction Conditions/Long Term Performance?

In Summary
Let's Get It Right!

Due Your Homework Before Construction to Avoid Surprises

Good Recycling Contractors Want Stringent Quality Standards and Specifications

More Agency Successes Lead to More Successful Contractors

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