Asphalt Rubber
The Arizona Experience

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Terminology

- CRA – Crumb rubber asphalt (aka asphalt rubber)
- ARAC – Asphalt Rubber Asphaltic Concrete
- AR-ACFC – Asphalt Rubber Asphaltic Concrete Friction Coarse
History: Charles MacDonald

- City of Phoenix Materials Engineer
- Experimented with mixing crumb rubber from ground tires with asphalt in early 1960’s
- Patented the MacDonald Process or Wet Process for making Asphalt Rubber
History: Early ADOT

- Began experimenting with the use of asphalt rubber in the early 1960’s
  - 1964 band aid type maintenance application
  - 1968 spray applications
  - 1968-1972 six projects with seal coat type applications
  - 1972 Stress Absorbing Membrane (SAM) and interlayer (SAMI) experiment
History: More Early ADOT

- 1974-1989 more than 600 miles of SAM or SAMI asphalt rubber applications
- 1988 one-inch open-graded asphalt rubber asphalt concrete friction course (AR-ACFC) placed on I-19
History: I-19 Project (1988)

- 10.0 % asphalt rubber by weight of mix
- Placed on plain jointed concrete pavement
- First reflection cracks noted in 1996
- Sections no longer in service because of I-10/I-19 interchange project not because of poor performance
- Experimented with recycling in this section
History: ARAC

- 1990 placed on I-40 near Flagstaff
- 2” thick Structural Overlay
- Gap graded mix
- Placed on severely cracked and failed concrete pavement
- Least reflection cracking of any application
What is Asphalt Rubber?

- A mixture of
  - Aggregate
  - Crumb Rubber Asphalt (Wet Process) (crumb rubber + asphalt cement) OR
  - Terminal Blend AR Binder (asphalt cement + SBS + crumb rubber)
Ground Tire Rubber
Specifying CRA

- Base Asphalt Cement
- Minimum 20% crumb rubber by weight of binder [100% pass #10 sieve]
- Rotational Viscosity
- Penetration
- Softening Point
- Resilience
CRA Blending

- Minimum 20% crumb rubber by weight of asphalt cement
- Crumb rubber added to 350 – 400°F asphalt cement
- Crumb rubber and asphalt cement mixed
- Asphalt rubber reacted for at least one hour at 325 – 375° with agitation
Asphalt Cements in CRA

- Type 1 Hot Climate PG 64-16 (Phoenix)
- Type 2 Moderate Climate PG 58-22 (Prescott, Flagstaff)
- Type 3 Cold Climate PG 52-28 (Alpine, highest elevations)
CRA Properties Influenced by

- Asphalt Cement
- Amount of crumb rubber
- Crumb rubber gradation
- Reaction temperature and time
Effect of Rubber Quantity

Viscosity

Viscosity @ 350 F, cp

Rubber Percent by Weight of Total Binder

Asphalt - AC-20
Rubber - No. 16 sieve maximum nominal size
Ref: "Design Methods for Hot-mixed Asphalt Rubber Concrete Paving Materials," James G. Chehovits, Proceeding of the National Seminar on Asphalt-Rubber, October 1989
Viscosity

Monitors fluid consistency of binder to:

- Ensure pumpability
- Identify binder changes which might affect mix placement and compaction
- Can be done in field
Resilience

- Appears to be a reliable measure of the elastic properties of the asphalt rubber binder.

- Expressed as a percentage of rebound for the binder.

- Resilience is one of the most important properties of AR binders and is considered a primary indicator of performance.
ADOT Rubber Mixes

- AR-ACFC
  - Final wearing surface (friction course)
- ACFC with terminal blend
  - Final wearing surface
- ARAC
  - Structural Lift
AR-ACFC

- Open graded – Typically 95% 3/8” Chips and 5% Fines
- Typically around 9.5% asphalt rubber (by wt of total mix) (range 8.9% to 10.0%)
- Used as final wearing surface, not structural
- On asphalt pavements, typically ½ inch thick
- On concrete pavements, typically 1 inch thick

- Get as much asphalt binder in the mix as possible without draindown
How much rubber in AR-ACFC

- 20% rubber by weight of asphalt cement
- Approximately 9.5% asphalt rubber binder in mix
- Works out to about 1.75% rubber in the mix
ARAC

- Gap graded (to allow space for rubber particles)
- Typical binder contents 6.5% to 8.0%
- Very limited use recently
ARAC Design

- Design for 4.5 to 5.5% air voids
- Minimum VMA specified
- Have to watch for building of VMA by binder
Early Mix Usage

![Graph showing the usage of Early Mix from 1985 to 2005. The x-axis represents years (1985 to 2005) and the y-axis represents Tons Mix in Thousands. Two lines are shown: one for ARAC and one for AR-ACFC. The ARAC line shows a steady increase with a peak in the early 2000s, while the AR-ACFC line shows a more volatile pattern with peaks in 1995 and 2000 and a significant decrease towards 2005.](image_url)
Recent Mix Usage

![Graph showing recent mix usage from 2005 to 2014. The graph indicates a decline in usage over time, with a notable peak in 2011. The lines represent AR-ACFC, ARAC, and EP ARAC.]
What does Asphalt Rubber do for us?

- Nature of wet process asphalt rubber binder allows the use of approximately 2% more binder than with asphalt cement.
- Elastic properties slow reflective cracking.
- Asphalt rubber binder does not seem to age as rapidly as asphalt cement.
- It lasts!
- Reduces noise – Quiet Pavement Program.
- It is not without its cost.$$
About 1000 Tires Per Lane Mile
Crumb Rubber Asphalt

How is it made?
An aerial view of a portable Asphalt-Rubber Plant setup at a Hotplant.

- **RUBBER STAGING AREA**
- **BLENDER**
- **VIRGIN AC TANK**
- **AR BLEND TANK**
- **Hotplant**

**Standard AC Heat Tank**
Mix Placement
Placement

- Seasonal placement (not too cold, not too hot)
- Not as workable as traditional mixes (minimize raking)
- Application of lime water can be used after paving to help “cure” the surface
Asphalt Rubber Performance
Smoothness

![Graph showing smoothness over age with two lines representing PCCP and PCCP_ARFC.](image-url)

- **Age (YR)** on the x-axis.
- **Ride (In./Mile)** on the y-axis.
- Two lines in the graph:
  - Blue line for PCCP.
  - Pink line for PCCP_ARFC.

(Additional details or explanations about the graph can be added here if needed.)
Rutting

Rut Depth vs. Age

- Overlays / Inlays
- AR-ACFC

Year
Rut Depth, inches
Maintenance Costs

![Maintenance Cost graph]

- Overlays / Inlays Neat asphalt only
- Asphalt Rubber projects

Maintenance Cost $/lane -Mile

Year

Maint. Cost

0 2 4 6 8 10 12

0 200 400 600 800 1000 1200 1400 1600
Cracking

Percent Cracking vs Age

- Overlays / Inlays
  - Neat asphalt only

- Asphalt Rubber projects
Smoothness

(AR-ACFC v. ACFC)

Smoothness vs Age for AC pavements
Friction Levels
AR-ACFC v. ACFC
I-17 SB ARFC placed in 1994, elev. 6800’
I-17 SB MP 312 – 337

Year

Cracking (%) Roughness (in/mi)


Roughness
Cracking

I-17 SB MP 312 - 337
I-19 AR-ACFC
placed in 1988, elev. 2700’
I-19
Project built in 1988

I-19, MP 59, Roughness/Cracking vs Age

Cracking
- Series 1

Roughness
- Series 2

Year

Crack (%) vs Age
Roughness (in/mi)
Its Perfect, isn’t it?

When things go wrong....
Problem 1
I-17

The new Problem
I-40 - Jack Rabbit
SR 260

The Summer Problem
Questions?