EPA Disclaimer

Overview of Rubberized Asphalt Technology

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EPA Scrap Tire Work Group Webinar

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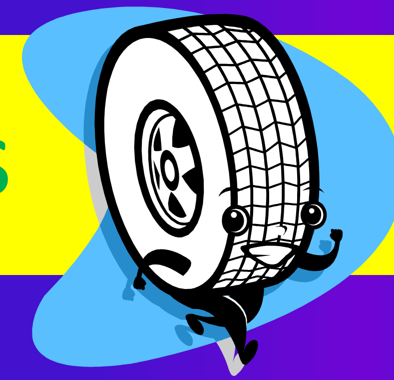
Presentation Overview

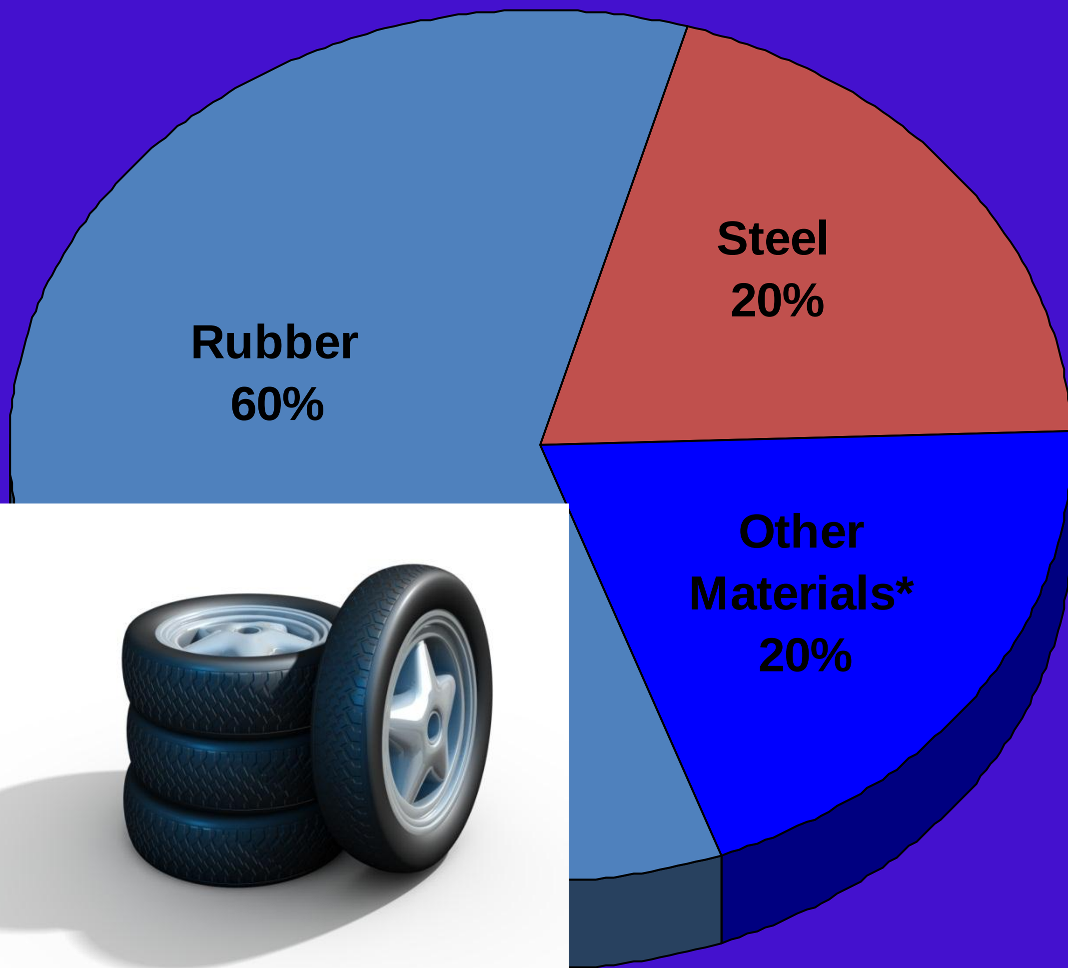
- Introduction to Rubberized Asphalt
- History
- Terminologies
- Crumb Rubber Issues
- Different Technologies
- Advantages and Disadvantages
- Specifications
- Research Findings
- Conclusions

U.S. Scrap Tires

- 303 million scrap tires generated annually (1 tire/ person)

Passenger Car Tires





***Other Materials include fiber, oils, waxes, and pigment**

Typical Composition of a Tire

- Synthetic Rubber
- Natural Rubber
- Sulfur and sulfur compounds
- Silica
- Phenolic resin
- Oil: aromatic, naphthenic, paraffinic
- Fabric: Polyester, Nylon, Etc.
- Petroleum waxes
- Pigments: zinc oxide, titanium dioxide, etc.
- Carbon black
- Fatty acids
- Inert materials
- Steel Wire

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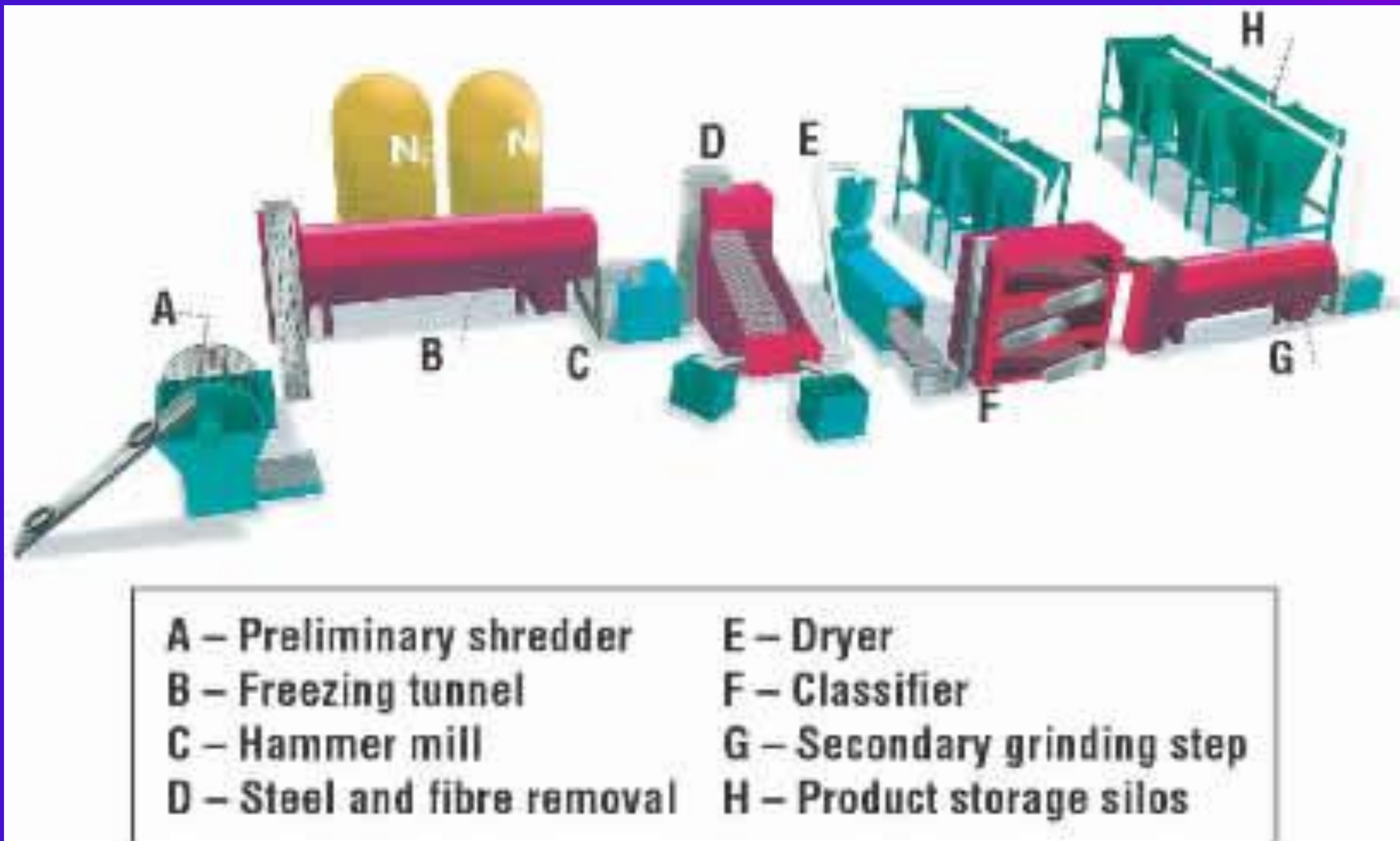
Whole Tire Processing

- Not a new industry, processing/reclaiming has existed as long as tires have existed
- Ambient systems: 1930s
- Cryogenic systems: 1970s
- Wet grind processing 1970s
- Cryogenic/Ambient processing

Cryogenic Crumb Rubber Process

- Whole tire size reduced by various means
- Fed into cryo chamber
- Frozen with liquid nitrogen to -184º C (-300º F)
- Hammer mill reduces crumb to particles of various sizes
- Steel removed magnetically throughout process
- Sorted and screened to specified size
- Fine grinding to reduce further particle size if needed

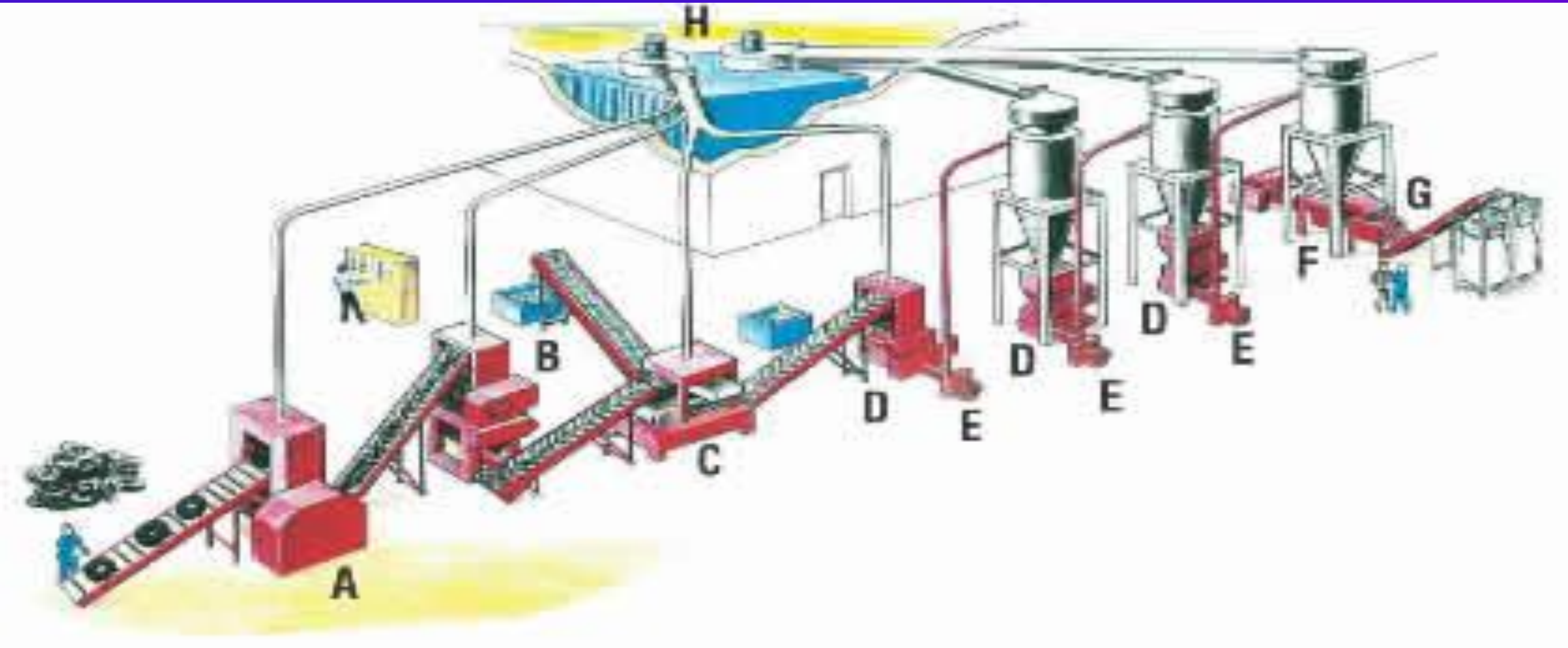
Schematic of Cryogenic Processing



Ambient Crumb Rubber Process

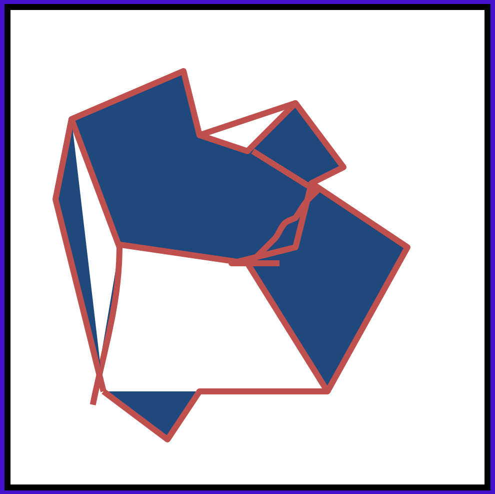
- Whole tire fed through shredder
- Shreds processed through grinding mill
- Steel removed by magnets through out system
- Product sorted to size by screening process
- Fabric removed by shaker tables and vacuum
- Product reduced further by grinding mills

Schematic of Ambient Processing



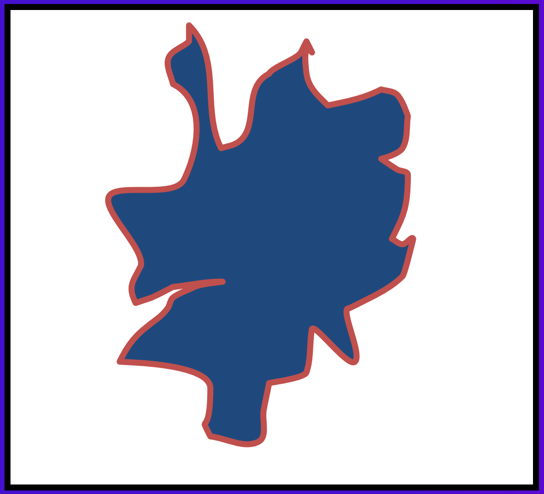
A – Preliminary shredder
B – Granulator
C – Steel and fibre removal
D – Consecutive fine grinding steps
E – Pneumatic conveying system
F – Windsifter
G – Secondary magnetic separation
H – Fibre and dust removal

Particle Morphology



Cryogenic:

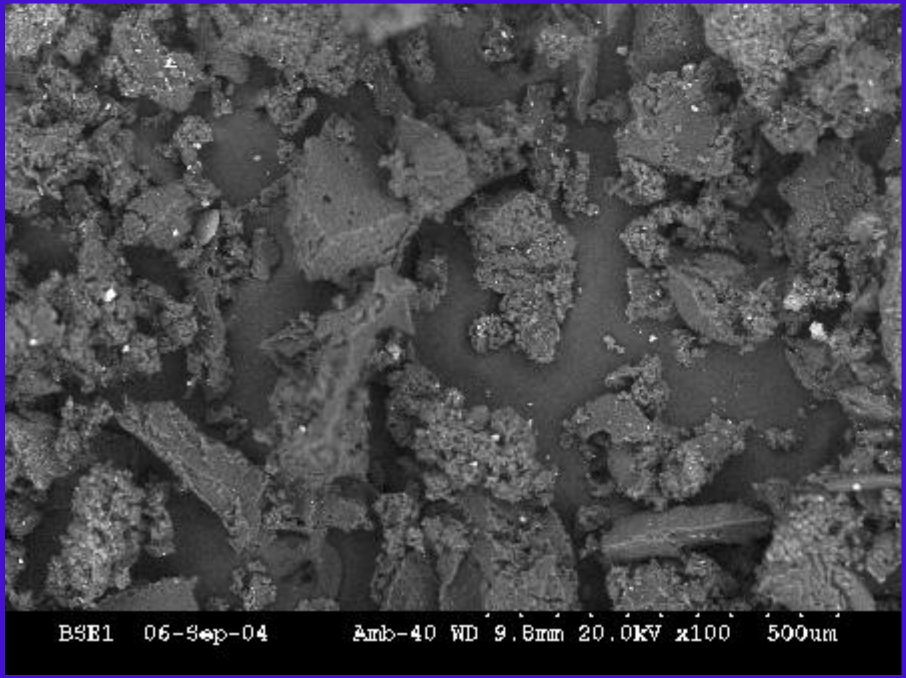
Angular or prismatic shape, smooth surfaces, low surface area.



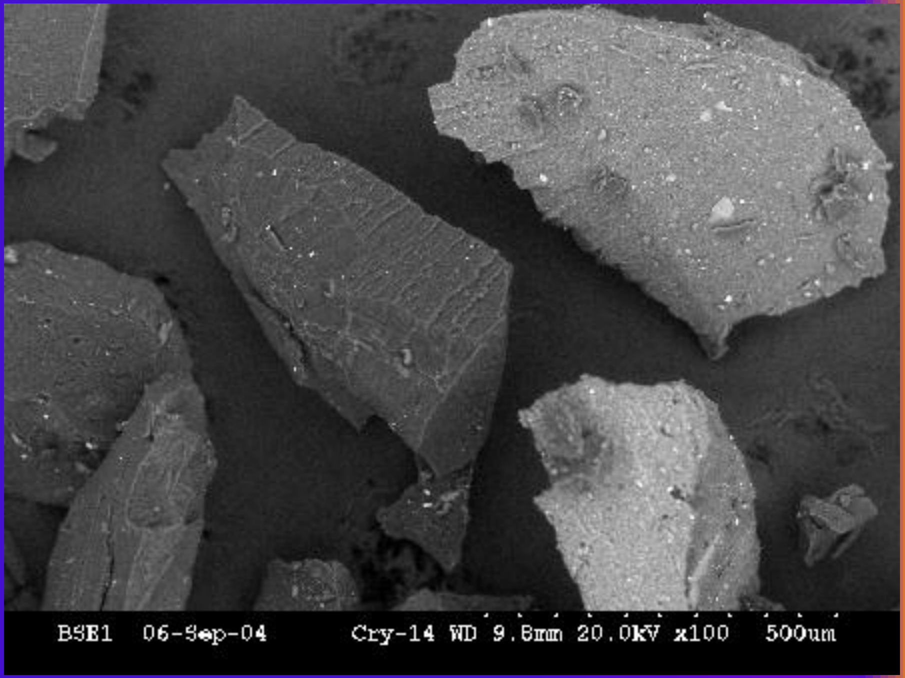
Ambient Grind:

Rough irregular shape with high surface area.

Scanning Electron Microscopy (SEM) of Crumb Rubber Modifiers



Ambient CRM



Cryogenic CRM

Quality Control: Crumb Rubber

- Size
- Percentages in the Mix
- Amb vs. Cryo
- Binder Source: Compatibility Issues
- Fiber Content
- Steel Content
- Moisture Content

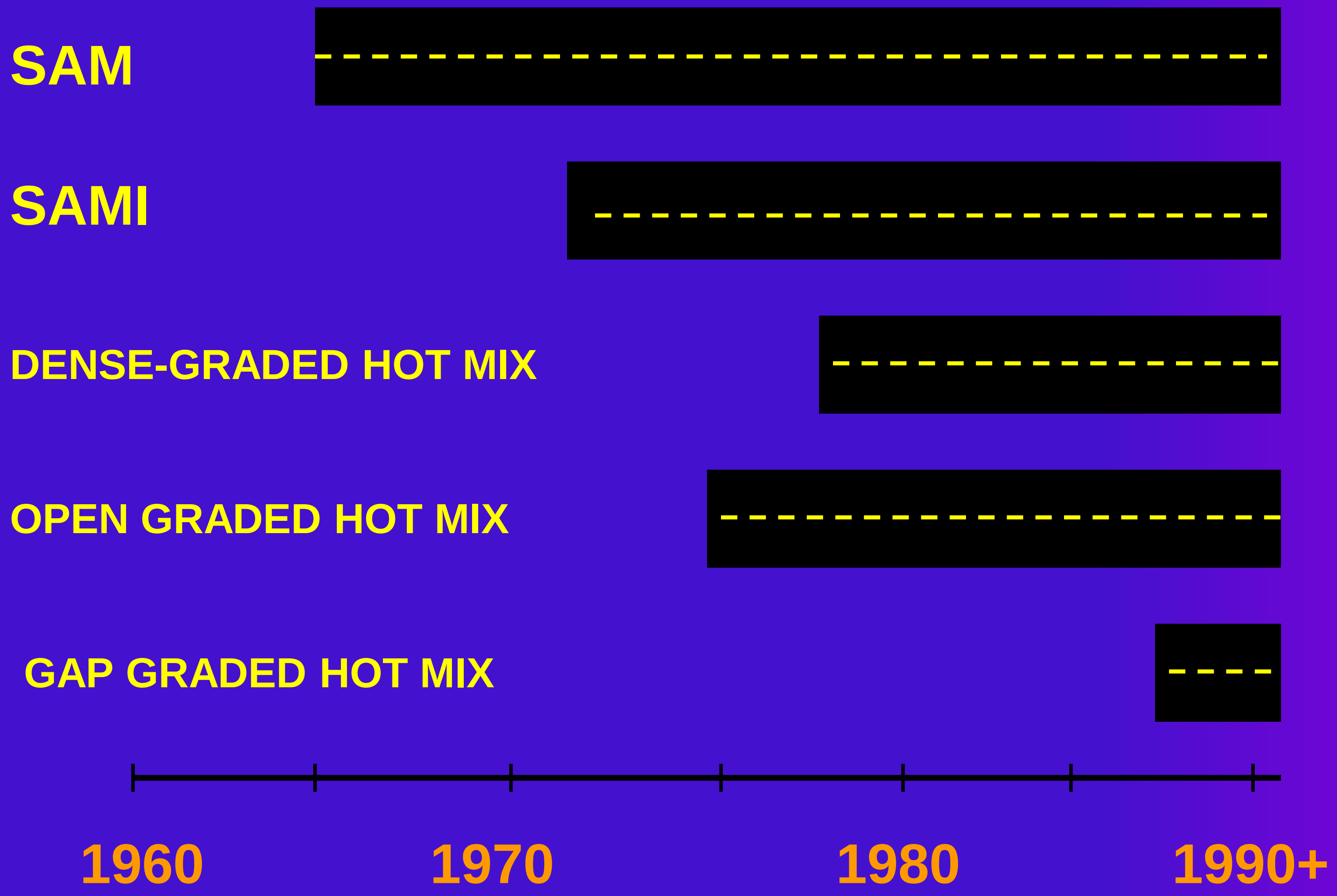
Introduction to Rubberized Asphalt

- Virgin Asphalt Binder + Crumb Rubber
- Factors to consider:
  - Grade of Virgin Asphalt Binder
  - Crumb Rubber Content
  - Crumb Rubber Source
  - Process (Dry vs. Wet)

Historical Overview of Rubberized Asphalt

- 1960’s: Charles McDonald
- 1970’s: Phoenix and ADOT (SAM); FDOT develops specifications for DGFC and OGFC wearing courses; European system (Dry Process)
- 1980’s HMA applications, Industry Group develops
- 1990’s ISTEA controversy, Patents expire, Industry Grows

Rubberized Asphalt History



Florida Legislative Mandate

SB 1192 in 1988 directed that

- FDOT should expand its use of GTR
- FDOT should review and modify its specs to accommodate use of GTR
- Construct demonstration projects

Terminologies

- Wet Process
- AR Binder (ASTM, Min 15%)
- On Site Blending
- Rubberized Asphalt
- Terminally Blended
- Dry Process
- Crumb Rubber
- RM Binder: Rubber Modified Binder
- CRM (Crumb Rubber Modifier)
- GTR (Ground Tire Rubber)
- GTR Modifiers
- RAC: Rubberized Asphalt Concrete

Types of Applications

- Rubber-modified surface course (R-M SC)
  - Dense-graded friction course (DGFC)
  - Gap graded friction course (GGFC)
- Rubber-modified open-graded friction course (R-M OGFC)
- Stress absorbing membrane (SAM)
- Stress absorbing membrane interlayer (SAMI)

Methods of Application

- Dry Process
- Modified Dry Process
- Wet Process
- Modified Wet Process
- Terminal Blending
- New Technologies: Pellets!!

Wet Process

- CRM + binder: HMA plant or provided by a supplier
- Anywhere from 5% to >20% CRM by weight of binder
- ASTM: Minimum 15% CRM: Asphalt Rubber (AR)
- Different amounts are used in various states, depending on the type of mix and size of CRM used

Dry Process

- Dry process (i.e., PlusRide)
  - CRM + aggregate
  - 2% to 4% CRM by weight of the asphalt concrete mixture
- Modified Dry Process (e.g., GA DOT)
  - Example: 9.5 mm mix:
    - 10% CRM (Binder wt)+4.5% Vestenamer (wt of CRM)

Terminal Blending

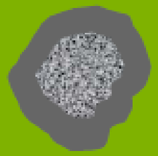
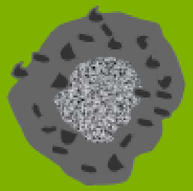
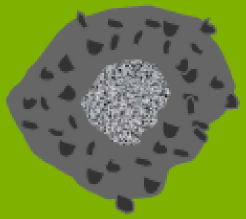
- Off site
- Transported by agitated trucks
- Fine CRM: 3% to over 10% is used
- Sometimes, other additives are added to the matrix

The Why Part (one of them)!!

Significantly higher binder content without drain down

Thicker film thickness on aggregate

Reduced oxidation - Increased durability - Increased resistance to reflective cracking

Dense Graded 4.6% HMA 9 Micron	
Gap Graded 7.4% Asphalt Rubber 18 Micron	
Open Graded 9.2% Asphalt Rubber 36 Micron	

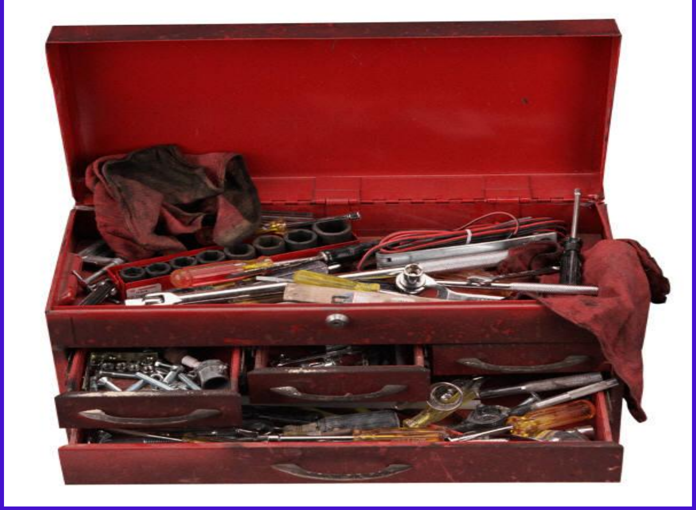
Other Specific Considerations

- Size of the rubber (fine vs coarse)
- Percentages of the rubber (5 vs 20%)
- Compatibility of the binder (i.e., source)
- Reaction (curing) time (15 min vs 2 hrs)
- Amb vs. cryo CRM
- Blending techniques (low vs high shear)
- MANY more!!

Not only one option/answer!!

Many options/solutions!!

A Tool in Your Toolbox!!



Rubber-Modified Surface Course

- Roughly 5% asphalt binder and 95% aggregate
- Rubber-modified dense-graded friction course (R-M DGFC)
  - 5% to 10% rubber by weight of virgin binder
- Rubber-modified gap-graded friction course (R-M GGFC)
  - 18% to 20% rubber by weight of virgin binder
- 500 to 2,000 tires per kilometer of a two-lane highway

Paving with R-M Surface Course

Compaction of R-M Surface Course

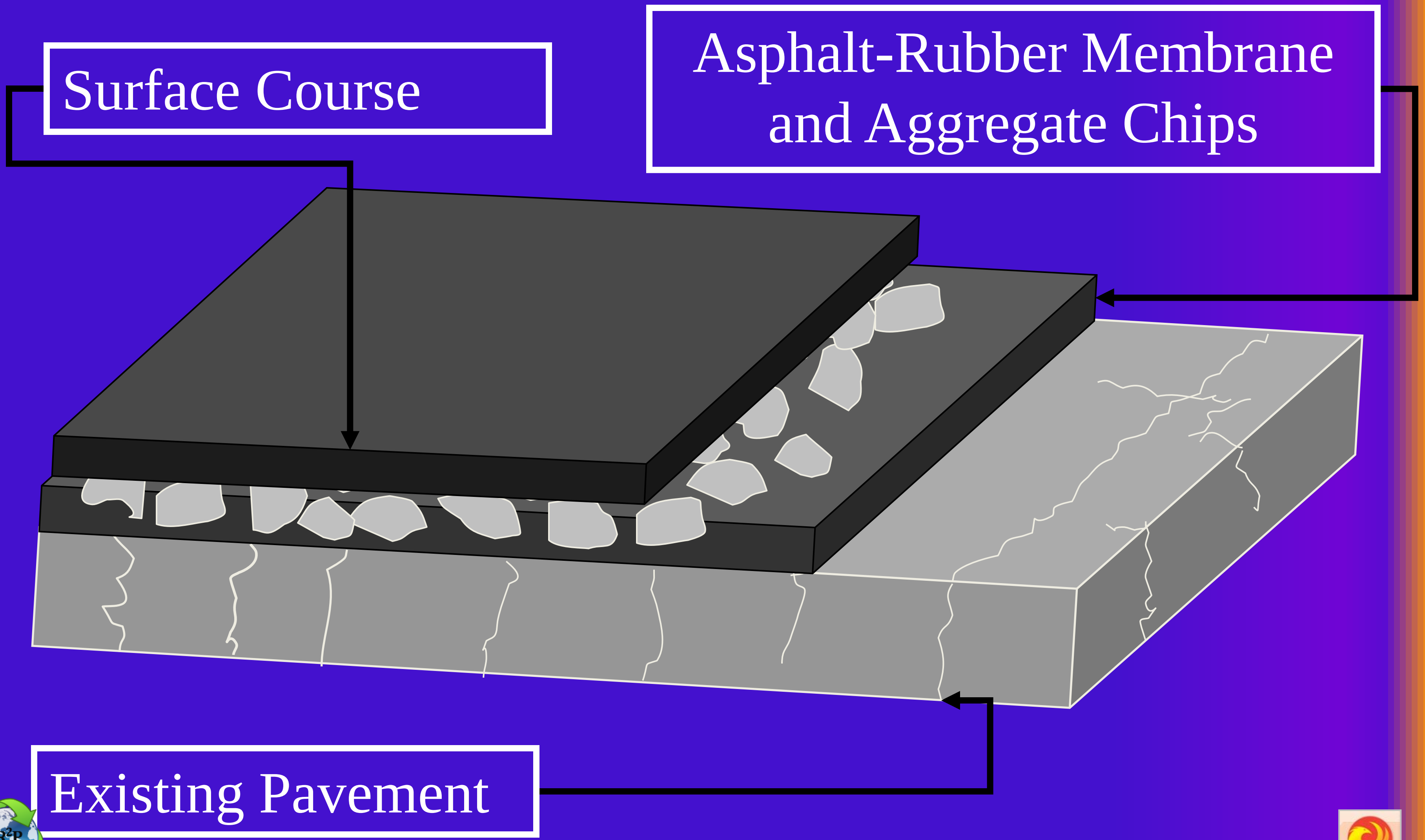
Rubber-Modified Open-Graded Friction Course

- Used to decrease noise, increase skid resistance, and increase surface drainage
- Roughly 93% aggregate, 7% asphalt binder, and NO fibers
- 12% to 20% rubber by weight of virgin binder
- 700 to 1,200 tires per kilometer of a two-lane highway

Stress Absorbing Membrane Interlayer

- Used to prevent reflective cracking
- Consists of:
  - Layer of rubber-modified asphalt binder
  - Layer of crushed stone
  - Layer of new HMA
- 20% to 23% rubber by weight of virgin binder
- 1,500 to 1,700 tires per kilometer of a two-lane highway

Stress Absorbing Membrane Interlayer



Stress Absorbing Membrane Interlayer

Applying Asphalt Binder Layer

Stress Absorbing Membrane Interlayer

Applying Aggregate to Asphalt Binder Layer

Stress Absorbing Membrane Interlayer

Seating Aggregate with Rubber-Tire Rollers

Stress Absorbing Membrane Interlayer

Placing HMA Surface over Aggregate Layer

Lubbock, Texas -1985

(Before SAM Application)

Lubbock Texas - 2000

(After 15 Years of Performance)

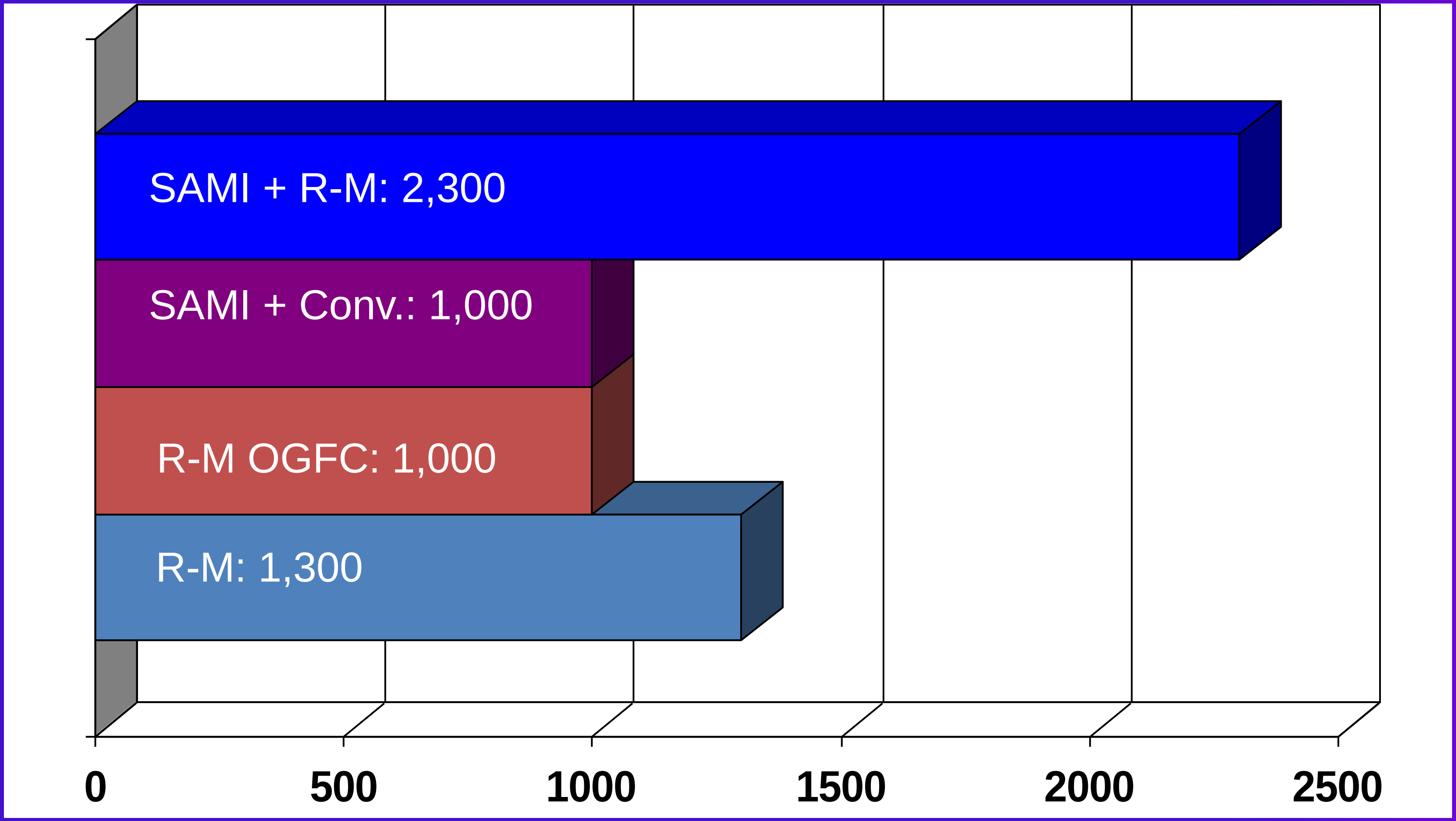
Before SAMI Application

After 16 Years of Performance

Average Tires Used

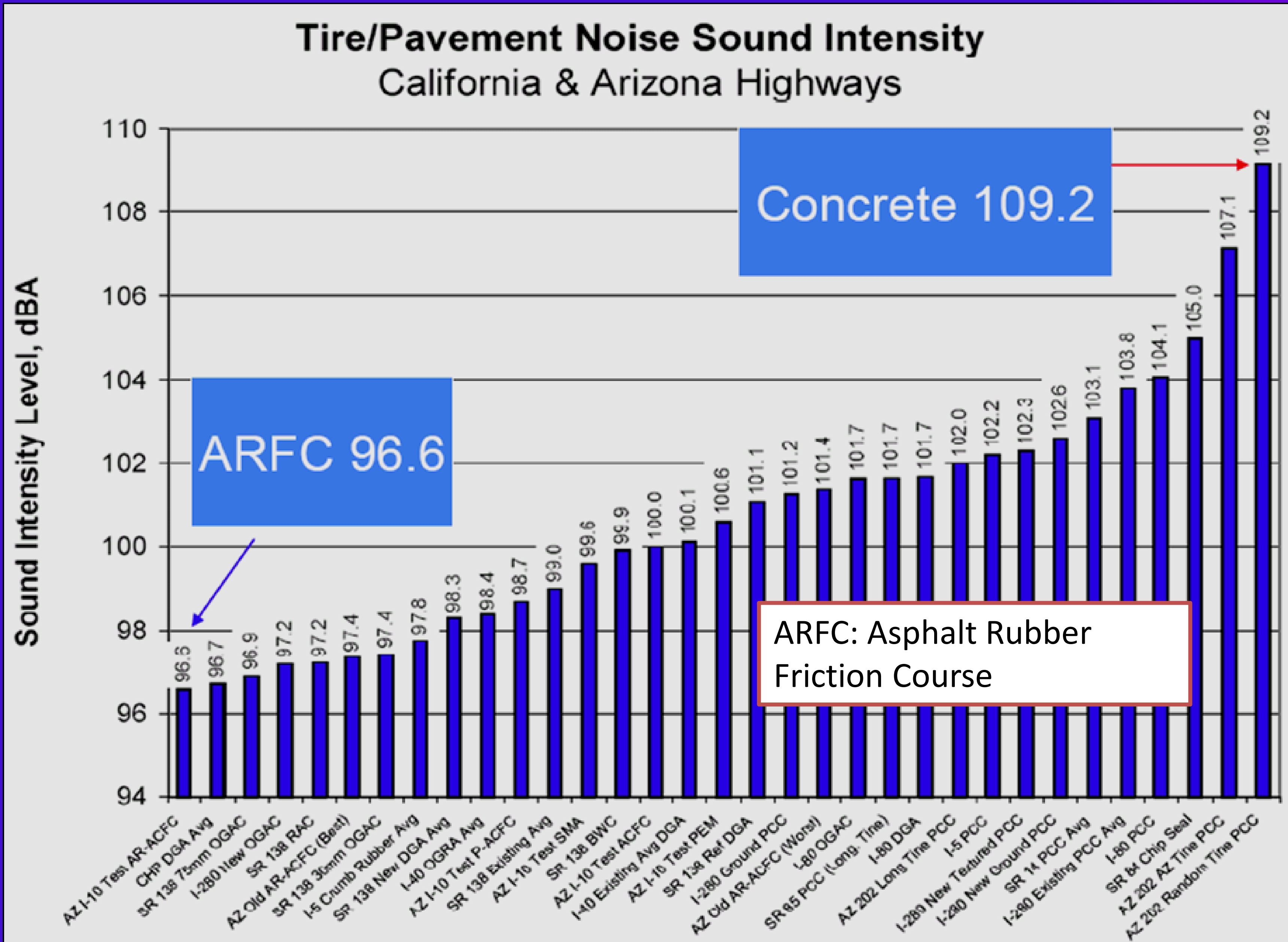
(Per Kilometer of Two-Lane Highway)

SAMI: Stress Absorbing Membrane Interlayer; R-M: Rubber Modified Mix; Conv.: Conventional HMA Mix; OGFC: Open Graded Friction Course



Advantages of Rubberized Asphalt

- Longer overall pavement life
- Increased crack resistance
- Increased rut resistance
- Reduced oxidation (slower aging)
- Reduced maintenance needs/cost
- Increased skid resistance
- Standard HMA production, paving, and compaction equipment can be utilized



Tire/Pavement Noise Sound Intensity
California & Arizona Highways
Sound Intensity Level, dBA
110
108
106
104
102
100
98
96
94
Concrete 109.2
ARFC 96.6
ARFC: Asphalt Rubber Friction Course
AZ I-10 Test AR-ACFC 96.5
CHP DGA Avg 96.7
SR 138 75mm OGAC 96.9
I-280 New OGAC 97.2
SR 138 RAC 97.2
AZ Old AR-ACFC (Best) 97.4
SR 138 30mm OGAC 97.4
I-5 Crumb Rubber Avg 97.8
SR 138 New DGA Avg 98.3
I-40 OGRA Avg 98.4
AZ I-10 Test P-ACFC 98.7
SR 138 Existing Avg 99.0
AZ I-10 Test SMA 99.6
SR 138 BWC 99.9
AZ I-10 Test ACFC 100.0
I-40 Existing Avg DGA 100.1
AZ I-10 Test PEM 100.6
SR 138 Ref DGA 101.1
I-280 Ground PCC 101.2
AZ Old AR-ACFC (Worst) 101.4
I-80 OGAC 101.7
SR 65 PCC (Long. Tine) 101.7
I-80 DGA 101.7
AZ 202 Long Tine PCC 102.0
I-5 PCC 102.2
I-280 New Textured PCC 102.3
I-280 New Ground PCC 102.6
SR 14 PCC Avg 103.1
I-280 Existing PCC Avg 103.8
I-80 PCC 104.1
SR 84 Chip Seal 105.0
AZ 202 AZ Tine PCC 107.1
AZ 202 Random Tine PCC 109.2

ADOT I-19, Asphalt Rubber Project Tucson, AZ MP 58-60
Maintenance Cost Comparison

Performance Indicators	Values Before Overlay	14 Years After Overlay
Ride inches/mile	172	70
Skid (Mu Meter)	38	64
Rutting (inches)	N/A	0.11
Percent Cracking	N/A (Trans Joint)	1%
Maintenance Cost /Lane Mi/Year	$857	$59

Why Rubberized Asphalt?

Good For The Environment!

Eliminates Waste Tires

Safe!!

Better Skid Resistance

Durable!!!

Longer Lasting

Rubberized Asphalt: Safety

Less Susceptible To Icing

Less Water Spray & Better Skid Resistance

Safety

Disadvantages of Rubberized Asphalt

- Higher initial cost
- Lack of experienced contractors in early stages of implementation
- Requires either use of blending unit or use of terminally blending process
- Requires agitated binder storage tank like using a polymerized binder

State	Applications Used	% Rubber by Weight of Binder	Crumb Rubber Particle Size
Arizona	GGFC and OGFC	20%	2.0 mm (#10 mesh)
California	3-Layer System (OGFC, SAMI, OGFC)	14% to 23%	-
Florida	ARMI (SAMI), DGFC, and OGFC	5% to 20%	425 µm (#20 mesh) to 850 µm (#40 mesh)
South Carolina	DGFC, SAMI, and OGFC	10% to 20%	850 µm (#40 mesh)
Texas	GGFC and OGFC	15% to 20%	2.0 mm (#10 mesh) to 1.18 mm (#16 mesh)

Key:

GGFC = Gap Graded Friction Course

SAMI = Stress Absorbing Membrane Interlayer

OGFC = Open Graded Friction Course

ARMI = Asphalt Rubber Membrane Interlayer

DGFC = Dense Graded Friction Course

Material Considerations

- Physical Aspects
- Chemical Compatibility
- Present & Future Environmental Issues
- Views of Public, Engineers, & Decision Makers
- Life-Cycle-Cost Issues
- Proper and Easy to Follow Specs!!

Too much information!!

Confusing Information!!

Research

- Many years and many countries
- RAP
- Warm Mix
- High and Low T Susceptibility
- Effects of Percentages & Types of CRM
- Chemical Compatibility
- Effects of CRM Size

Conclusions

- NOT a New Topic Anymore!!
- Environmental Issues (Green, LEED)
- Cost Issues (Initial and LCCA)
- Compatibility Issues
- Recycling of the New Pavement
- Public Perceptions
- Acceptance by Governmental Agencies


I am so glad that he is finished With his boring talk!! You can wake up now.

Contact

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Thank you!!