Rubberized Asphalt

Technology Overview

Serji Amirkhanian

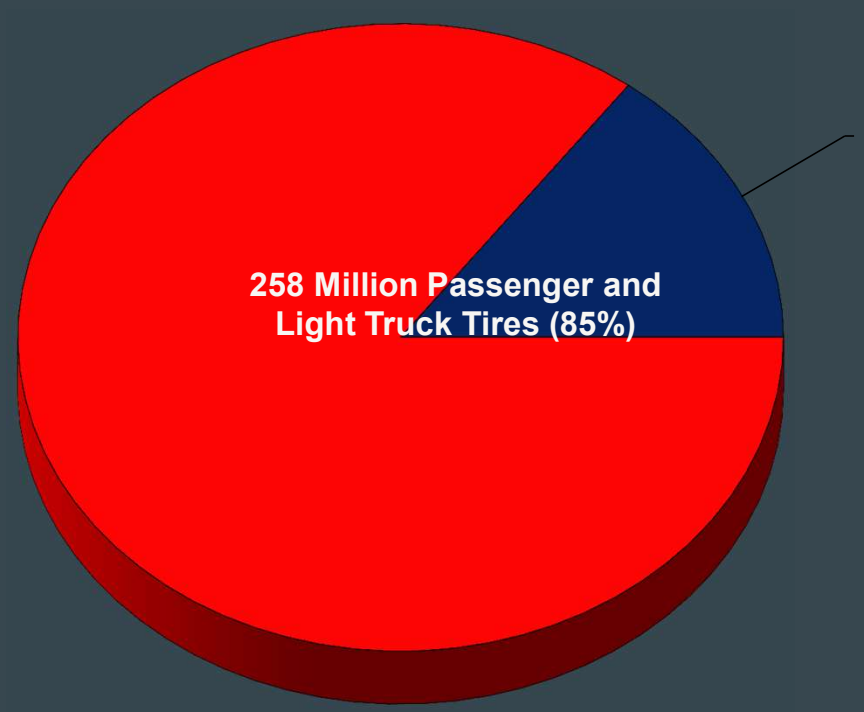
EPA Scrap Tire Work Group Webinar | February 21, 2013

Presentation Overview

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

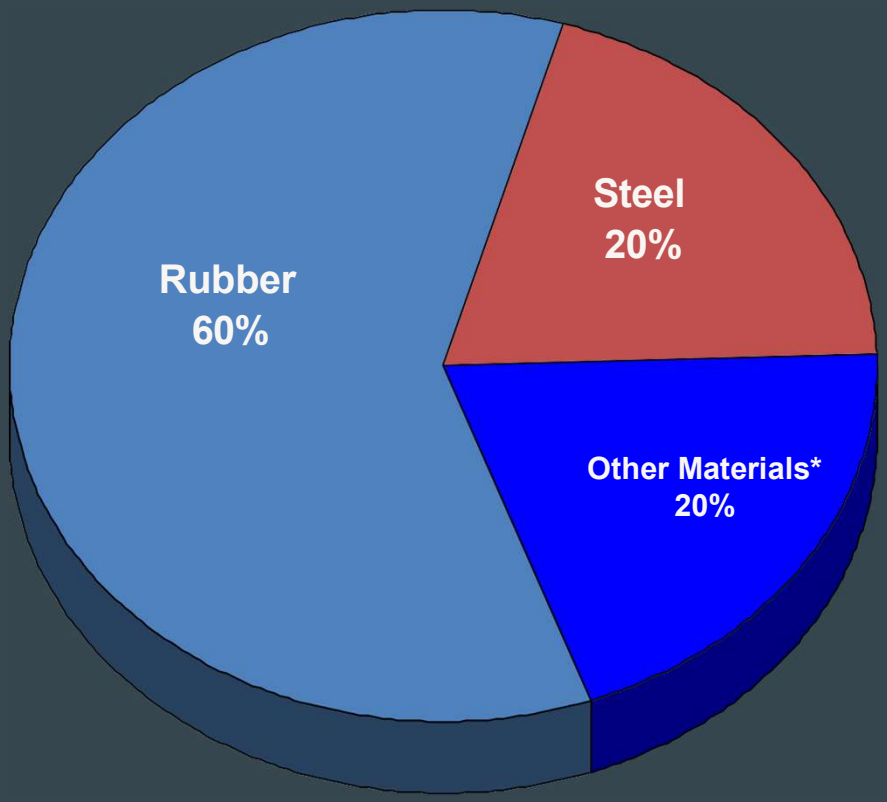
U.S. Scrap Tires

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



45 Million Heavy Truck and Commercial Tires (15%)

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

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

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

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

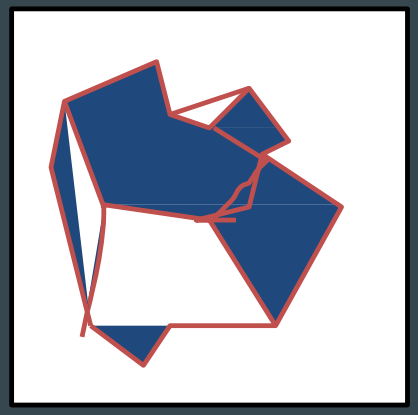
Cryogenic Crumb Rubber Process

- 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

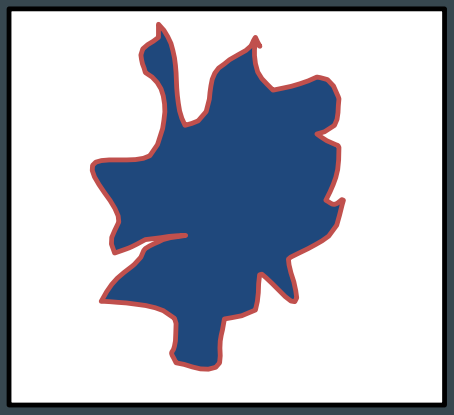
Ambient Crumb Rubber Process

- 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

Particle Morphology

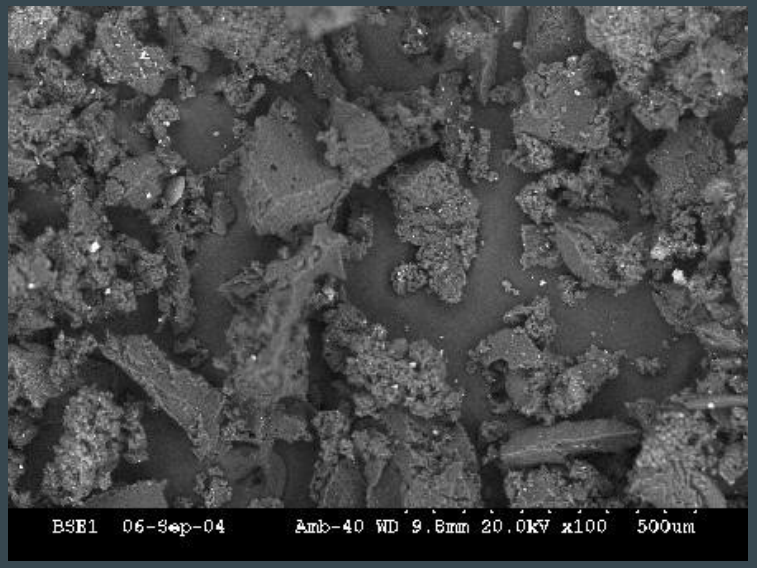


Cryogenic:
Angular or prismatic shape, smooth surfaces, low surface area.

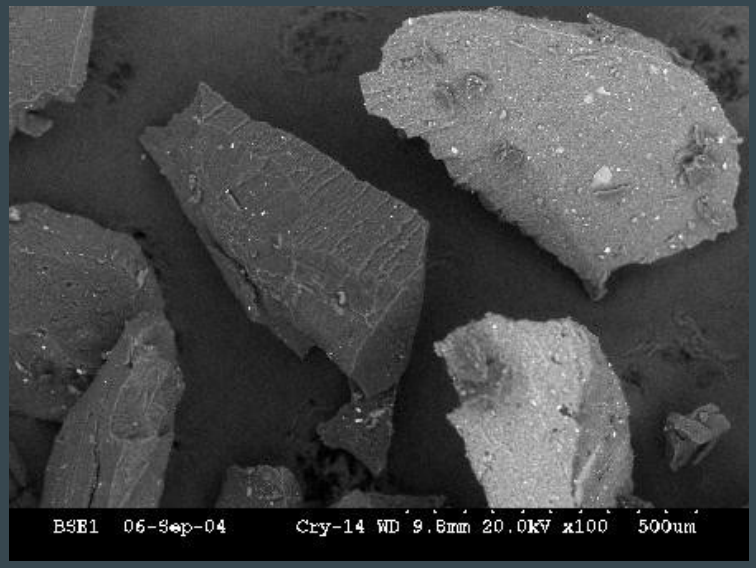


Ambient Grind:
Rough irregular shape with high surface area.

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

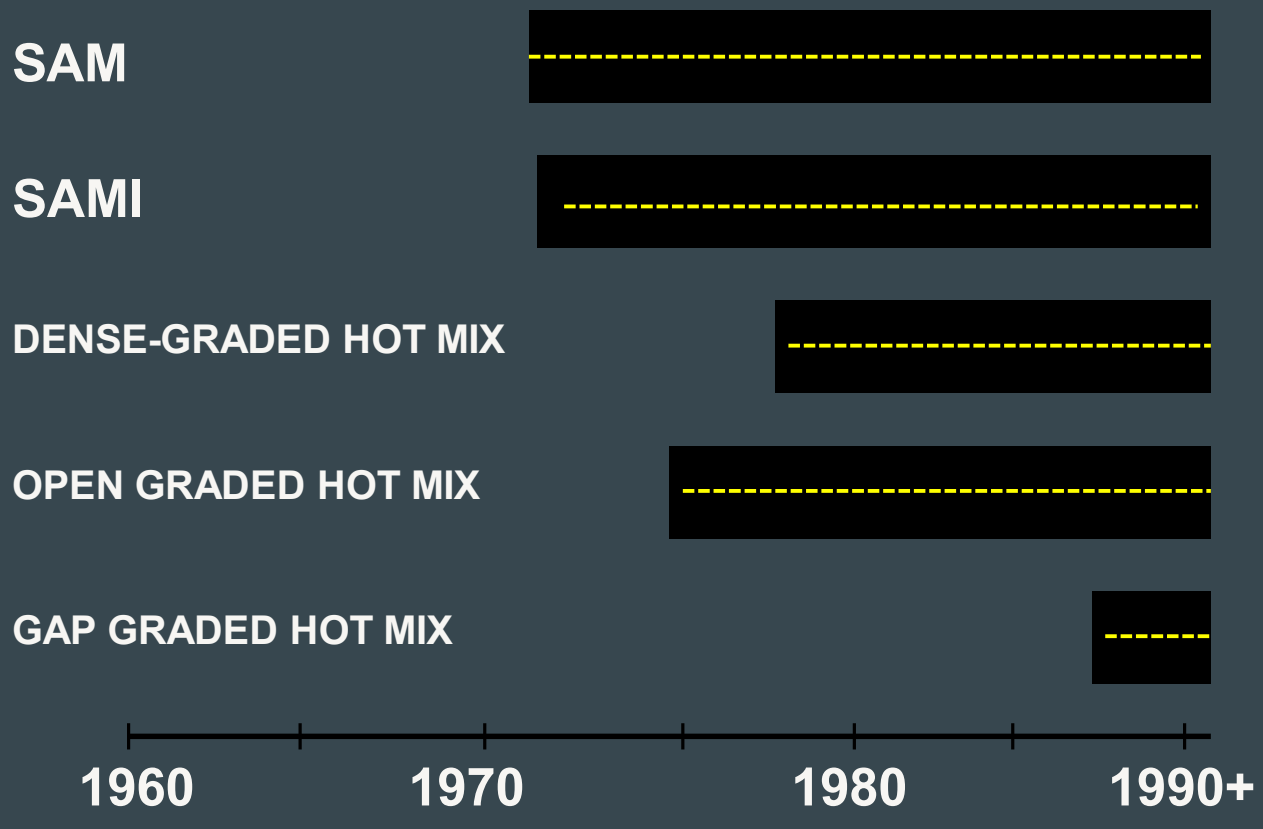
Introduction to Rubberized Asphalt

- 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



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

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!!

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

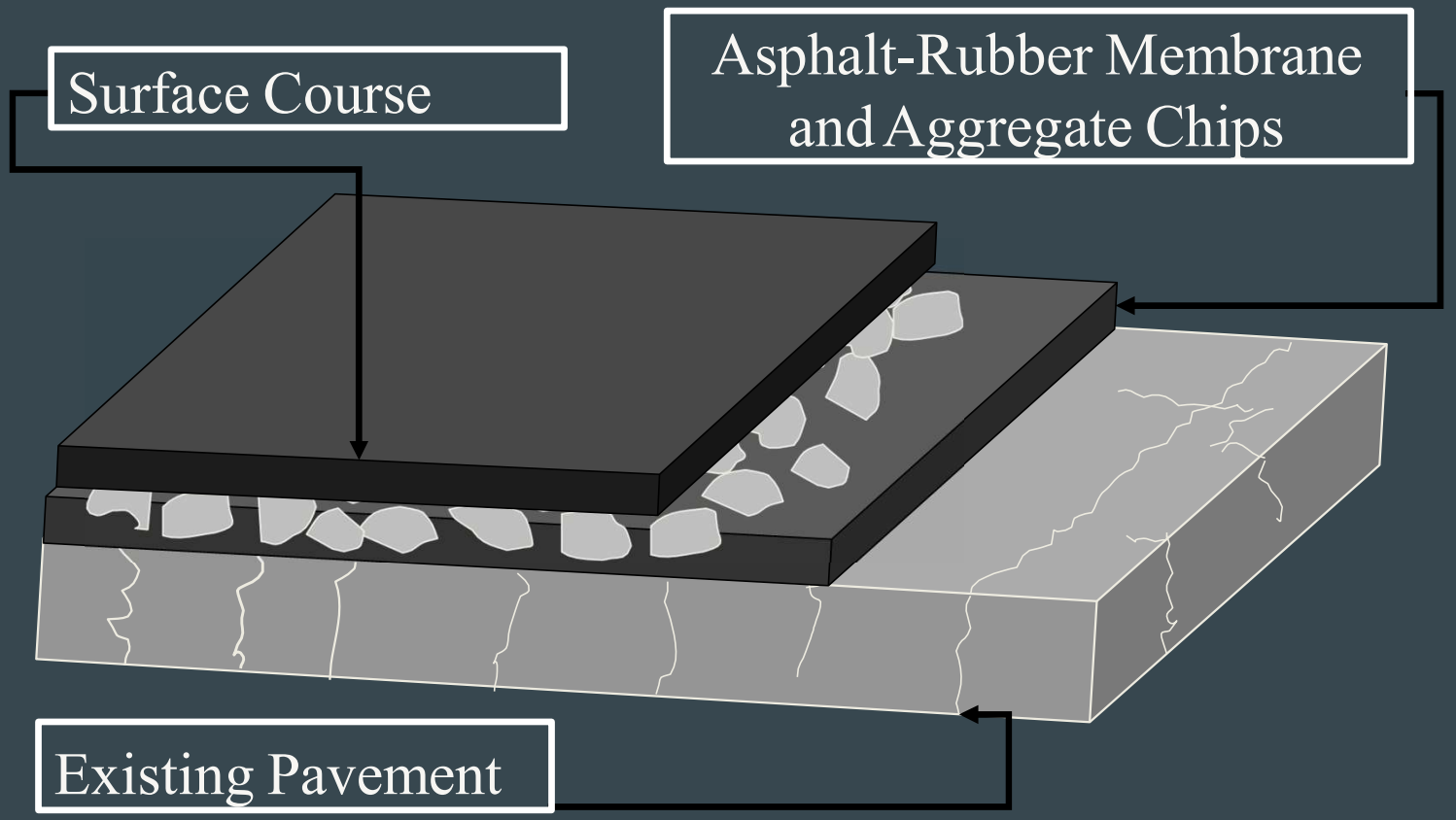
Paving with R-M Surface Course

Compaction of R-M Surface Course

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 -2000
After 15 Years of Performance

Before SAMI Application

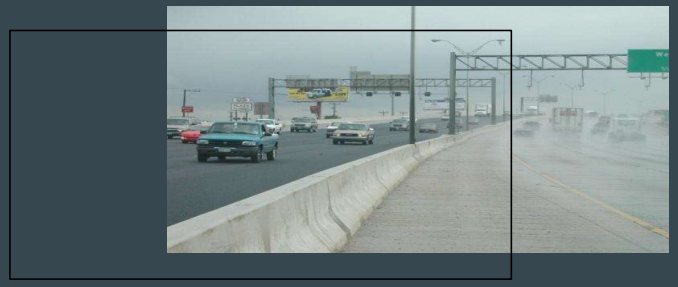
Advantages of Rubberized Asphalt

- 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

Rubberized Asphalt: Safety

Less Susceptible To Icing

Less Water Spray & Better Skid Resistance



Safety

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!!

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

- Environmental Issues (Green, LEED)
- Cost Issues (Initial and LCCA)
- Compatibility Issues
- Recycling of the New Pavement
- Public Perceptions
- Acceptance by Governmental Agencies