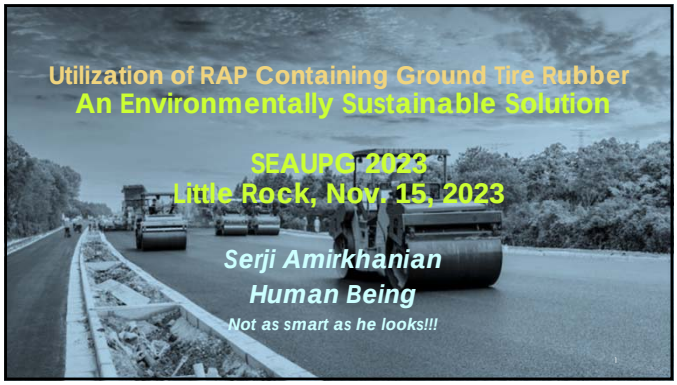
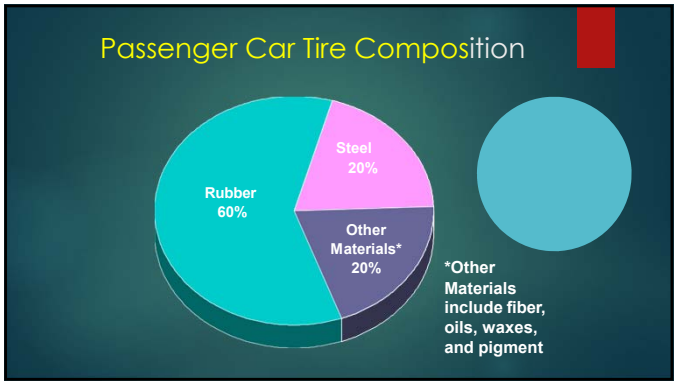
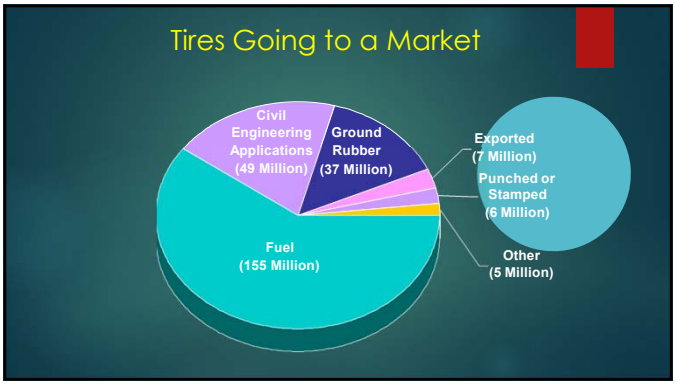

Utilization of RAP Containing Ground Tire Rubber
An Environmentally Sustainable Solution
SEAUPG 2023
Little Rock, Nov. 15, 2023
Serji Amirkhanian
Human Being
Not as smart as he looks!!!


U.S. Scrap Tires
330,000,000 scrap tires produced annually (1 tire/ person)
258 Million Passenger Tires (85%)
45 Million Truck Tires (15%)
280
50


Passenger Car Tire Composition
Rubber 60%
Steel 20%
Other Materials* 20%
*Other Materials include fiber, oils, waxes, and pigment


Tires Going to a Market
Civil Engineering Applications (49 Million)
Ground Rubber (37 Million)
Exported (7 Million)
Punched or Stamped (6 Million)
Fuel (155 Million)
Other (5 Million)


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


NOT a new concept!!
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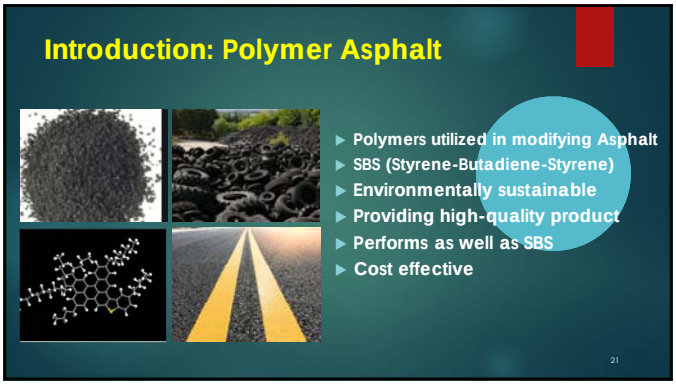
In 1959: Some city streets in London, Ontario were laid with hot mix asphalt (HMA) containing 0.25% rubber.
Arizona and California, among many states, have been utilizing these materials for decades
California: For the past 25 years: 80,000,000 tires: Rubberized Asphalt
We have learned much for the last 60 years!!
Your grandparents' rubberized asphalt is not the same as what we use now!!



Types of Applications

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

Methods of Application

- Dry Process
- Modified Dry Process
- Wet Process
- Modified Wet Process
- Terminal Blending
- New Technologies:
  - Pellets
  - Surface modified crumb rubber

Dry Process

- Dry process (i.e., PlusRide)
  - CRM + aggregate
  - 2% to 4% CRM by weight of the asphalt mix
- 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

Wet Process

- CRM is added to the asphalt, mixed, and reacted
- Some other additives might be added, but not necessary
- 5% to 20+% CRM by weight of binder depending on use

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!!

Advantages of High Viscous Asphalt Rubber Binder

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	

Asphalt Rubber Myths

- The contractor's tanks will be damaged
- The Contractor needs specialized equipment
- The Blend Design is a difficult one
- All CRM Binders are the same
- "If used, will my workers die?"
  - My answer: Research has shown: We're …….
- "If used, do we have to wear masks and other PPEs?"
  - My answer: Research has shown: We're …….

Asphalt Rubber
Minimum 15% Crumb Rubber

AR System Neat Asphalt

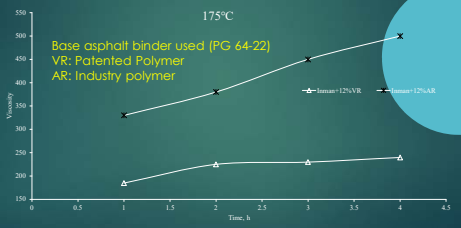
Binder Field Testing

A Sample Is Taken And Checked For Viscosity From Each Batch Of Material Produced.

- Haake viscometer or equivalent
- Viscometer must be calibrated
- Viscosity range 1500 - 4000 cP @ 177° C
- Target viscosity for hot mix binder is about 2000 - 3000 cP
- Viscosity is a very good indicator of other binder properties

1,500 – 4,000 cP (Centipoise) @ 177° C

Viscosity Testing



Advantages of Rubberized Asphalt

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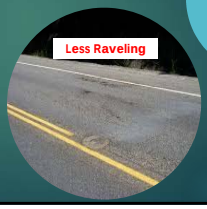
Advantages of Rubberized Asphalt (Some Field Examples)

Rubberized asphalt pavements:
1) Have very few crack after 15 years of service.
2) Have no potholes after 15 years of service.
3) Have much less raveling after 20 years of service.
4) Much less maintenance cost and safer roads.



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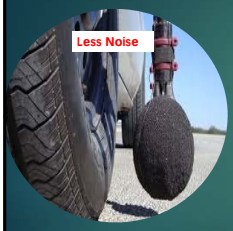
Advantages of Rubberized Asphalt



- Special rubberized asphalt pavements have proven to be an excellent mixtures for lowering the noise level of traffic by an average of 5 dBA and in some cases up to 8 dBA.
- This is important since high noise levels have been identified as a health issue in many communities around the world.

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Advantages of Rubberized Asphalt

Rubberized asphalt mixtures will keep their dark colors for a longer period and provide the following benefits:
- Less Cracking
- Less Potholes
- Longer Life
- Safer During Night-Time Driving

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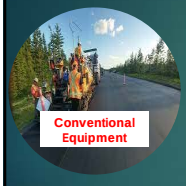
Advantages of Rubberized Asphalt



- During the construction process, conventional Equipment could be used to complete the project.
- The only requirement will be a piece of equipment utilized in mixing the crumb rubber to the asphalt binder (wet process).

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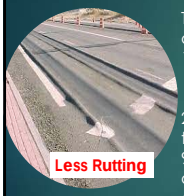
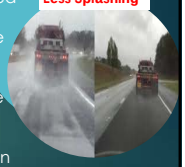
Advantages of Rubberized Asphalt



Two major benefits of utilizing rubberized asphalt:
1) Rubberized asphalt mixtures are one of the best rut resistant materials in the world.
2) Rubberized mixtures (OGFC) reduce the splash caused after a rainstorm by 90+%. This has reduced the rate of accidents by up To 80% in some portion of Texas.



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Rubberized Asphalt Experiences

- Arizona, California, Florida,, Texas, New York, ……..
- Excellent Performance 35+ Years

Compared To Conventional Mixtures:

- Fewer Cracks
- Cheaper (Life Cycle Cost)
- Less Rutting
- Longer Life
- Less Maintenance
- Environmentally Sustainable

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Materials Used

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- Three recycled mixtures containing laboratory-aged CRM RAP were incorporated into HMA designed with three different aggregate sources and two CRM binders.
- 3 virgin mixtures, used as control, were made using the same aggregate and the CRM binder sources.
- CRM binders: graded as PG 70-22 or PG 76-22: 2 base binders of PG 64-22 with 10% ambient CRM (-40 mesh) by weight of the binder.
- Testing: ITS, APA, resilient modulus and GPC

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TABLE 3 Results of Superpave mixture designs (aggregate sources L, C, and B made with virgin (V) or containing laboratory-prepared RAP (R))

Specification		Type of Superpave mixture					
Sieve	Limit	LV	LR	CV	CR	BV	BR
12.5mm	97-100	100	100	100	100	100	100
9.5mm	80-100	96	96	100	100	92	92
4.75mm	58-75	63	63	67	67	62	62
2.36mm	42-60	45	45	48	48	46	46
0.6mm	19-40	25	25	27	27	21	21
0.15mm	8-20	8.1	8.1	8.4	8.4	11.9	11.9
0.075mm	3-8	7.3	7.3	7.2	7.2	7.4	7.4
Test results							
Max specific gravity		2.419	2.413	2.386	2.371	2.591	2.557
%Max density at N_{des}	96	96.0	96.0	96.0	96.0	96.0	96.0
%VMA	Minimum 15.5	17.9	17.5	16.9	17.3	16.0	16.0
Optimum asphalt content (%)		6.2	6.0	5.9	6.1	5.0	5.1

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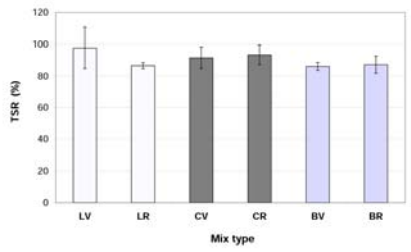

FIGURE 3 Tensile Strength Ratio (TSR) results of mixtures made with aggregate sources L, C, and B made with virgin (V) or laboratory-prepared RAP materials (R).

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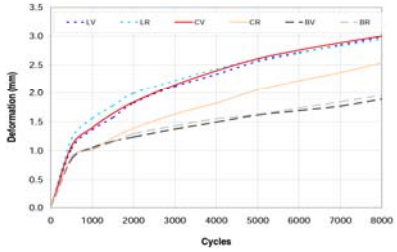

FIGURE 4 Asphalt Pavement Analyzer (APA) test results (aggregate sources L, C, and B made with virgin (V) or containing laboratory-prepared RAP (R)).

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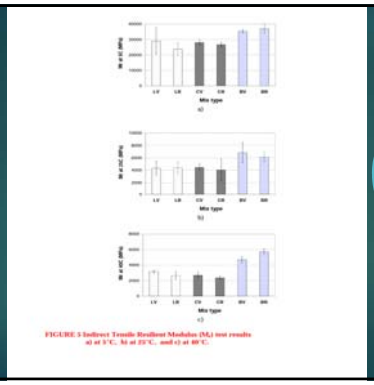

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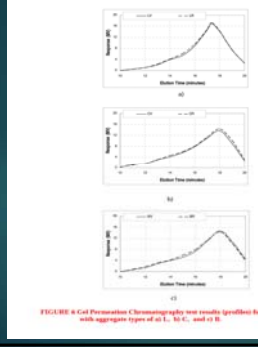

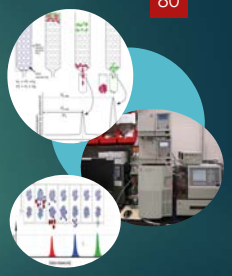

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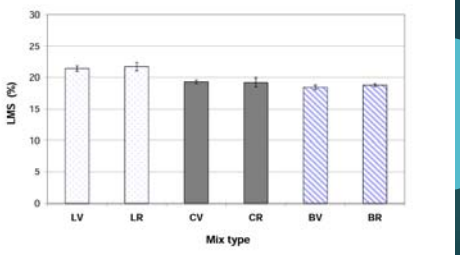

FIGURE 7 Gel Permeation Chromatography test results (LMS, %).

Conclusions

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- The properties of the recycled mixtures containing 15% CRM RAP were comparable to those of the control mixtures.
- The results indicated that the difference in rutting resistance between the recycled and the virgin mixes was not significant.
- There was no significant difference (at α=0.05 level) between the ITS values of the virgin and recycled mixtures.
- The resilient modulus of the recycled mixtures showed no significant difference compared to the control regardless of the aggregate sources and the test temperatures.
- The GPC results showed that the molecular size distribution profiles of the three recycled mixtures which a laboratory-aged RAP of 15% was used: similar to that of the three virgin mixtures.
- Laboratory test results indicated that, overall, there were no statistical differences, at 5% level, between control and CRM mixtures.

Results

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- Environmental testing: Very little difference between the emissions from CRM and Virgin mixtures produced in a typical asphalt plant.
- Recycled CRM mixture: VOC emissions were lower than the range for standard HMA.
- Trace metals, volatile organics, and semi volatile organics may be leached from asphalt rubber, but at levels too low to be environmentally significant or hazardous.
- The addition of rubber improves the oxidative properties of a binder relative to the base asphalt.
- At 30% CRM RAP content, rubber-tired pneumatic rollers perform reasonably well with standard release agents.
- The performance of the recycled CRM mixtures, after several years, were excellent.

Major (& the only one) Conclusion

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Just Use It!!
Just Use It!!
Just Use It!!
Just Use It!!
Why? It's just another polymer!!


Thank You
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