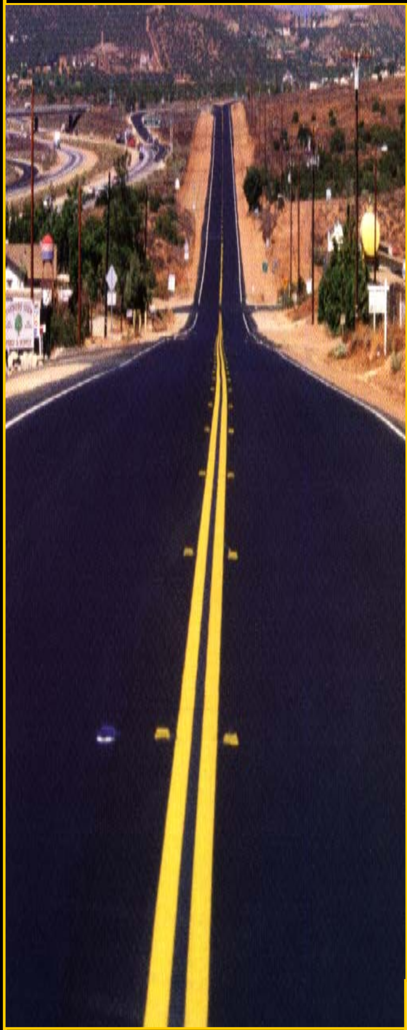
USE OF ASPHALT RUBBER IN PAVEMENTS



Technology Transfer RHMA 101

INTEGRATED WASTE MANAGEMENT BOARD

Presented by

R. Gary Hicks Ph.D., P.E.
CP2 Center

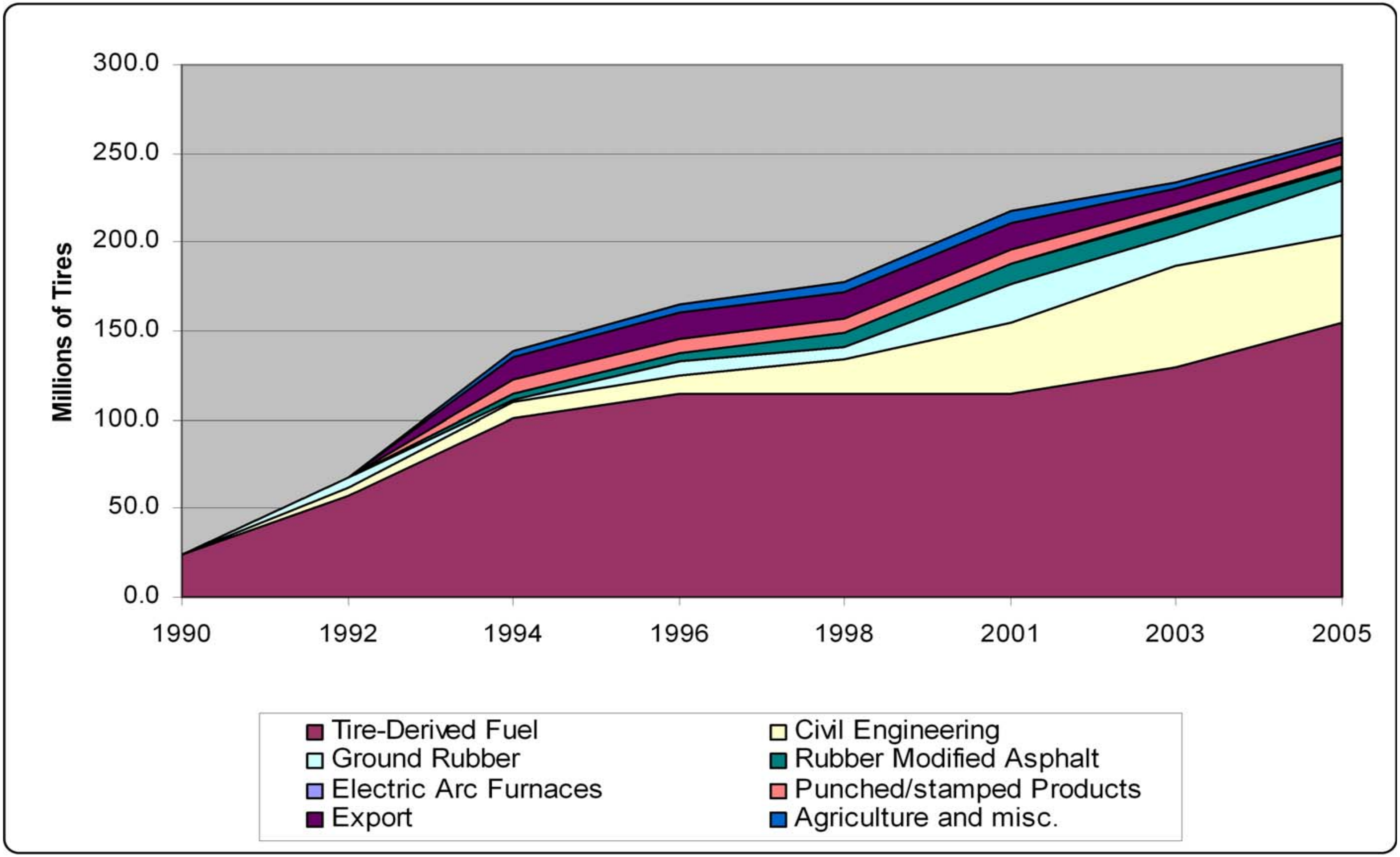
January 5, 2009

CP2 CENTER

PRESENTATION TOPICS

1. ASPHALT RUBBER-RHMA "101"
2. HISTORY OF ASPHALT RUBBER
3. RHMA APPLICATIONS
4. RHMA USAGE GUIDELINES
5. BENEFITS AND LIMITATIONS
6. IMPLEMENTATION

U.S. Scrap Tire Market Trends, 1990-2005



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WHAT IS ASPHALT RUBBER ?

Section 1

ASPHALT RUBBER ASTM D8

A blend of asphalt cement, reclaimed tire rubber and certain additives in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles.

RELATED SPECIFICATION: ASTM D 6114

Standard Specification for Asphalt Rubber Binder.

High viscosity material that typically requires agitation to keep CRM particles dispersed.

Asphalt Rubber Types

WET PROCESS-with agitation

Adding graded rubber to asphalt and mixing and reacting-requires agitation

Wet PROCESS – No Agitation

Adding fine rubber typically < #30 to asphalt at the terminal-generally little or no agitation. Often referred to as terminal blend

DRY PROCESS

Use CRM as substitute for 1-3% of Aggregate by mixing crumb rubber directly with aggregate used for asphalt concrete

Wet Process-with Agitation

1

AR 101

- Method of modifying asphalt cement with CRM and other components
- Most widely used in California, Arizona, Florida and Texas
- Contains 18-22 % crumb rubber – agency spec vary
- Particle size ranges from # 8 to #10 top size
- Type 1 Asphalt Cement and tire rubber (AZ, FL and TX)
- Type 2 Asphalt, tire rubber, high natural CRM + extender oil (CA)

Wet Process-with Agitation

1

AR 101

- Thoroughly mix CRM & other components with hot (400-425ºF) asphalt cement
- Interact at 350-375ºF for designated period (typical minimums 45-60 minutes)
- CRM particles swell, exchange oils with AC
- Rotational Viscosity is discriminator for appropriate use

Wet Process-No Agitation

- Contains from <5%-15 % crumb rubber
- Particle size ranges from 40 to 80 mesh top size
- Can also contain polymers
- Used in Arizona ,Florida, Texas, and California
- Often referred to as Terminal Blend

Wet Process-Agitation vs. No Agitation

1

AR 101

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Dry Process

1

AR 101

- Substitutes CRM for 1 to 3% of aggregate in hot mix
- Not considered to modify binder, although some interaction with CRM may occur in place over time (absorbs light fractions)
- CRM gradations have ranged from coarse (-1/4”) to fine (-#80)

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Asphalt Rubber Binder

COMPONENTS

- Crumb Rubber (including HNR)
- Asphalt Cement
- Additives
- Blended to meet specific specs

Crumb Rubber Modifier - CRM

Produced from grinding up whole scrap tires, tread buffings, and other waste rubber products. Crumb rubber comes in a variety of grades and designations presented by particular size and/or source.

CRM Used For Wet Process

CRM Product

Asphalt Cements

AR 101

Come in a variety of grades

Typically a softer binders is used for RHMA than for conventional hot mix

	PG 64-10
Hot climates	PG 64-16 (AR-4000)
Moderate climates	PG 58-22 (AR-4000)
Cold climates	PG 52-28 (AR-2000)

Additives

Used in conjunction with the CRM to enhance interaction and produced desirable properties

- Extender oils
- Anti-strip agents
- High natural rubber (HNR)
- Polymers – typically limited to no agitation

Interactions Depend On

1

AR 101

1. Asphalt Cement Source & Grade
2. Rubber Type/Source
3. Amount Of Rubber
4. Gradation Of Rubber
5. Interaction Time
6. Interaction Temperature

Advantages of High Viscosity AR Binder

1

AR 101

- Allows higher binder content and increased film thickness-resulting in increased durability (moisture resistance and aging resistance)
- Improves aggregate retention
- Minimizes drain-down problems
- Increases resistance to fatigue and reflection cracking
- Increases resistance to bleeding, flushing and deformation

HISTORY OF ASPHALT RUBBER

Section 2

History of AR Use

- Used since the 1960's
- Used in chip seals, inter-layers, and HMA
- Use extensively in Arizona, California, Florida and Texas
- Design and construction guides now available from some agencies

Ravendale Project

- First CA project to use reduced thickness RHMA when compared to the conventional AC design thickness
- Different thickness test sections of RHMA, dry process, and conventional AC mixes
- Performance monitored for nearly 20 years

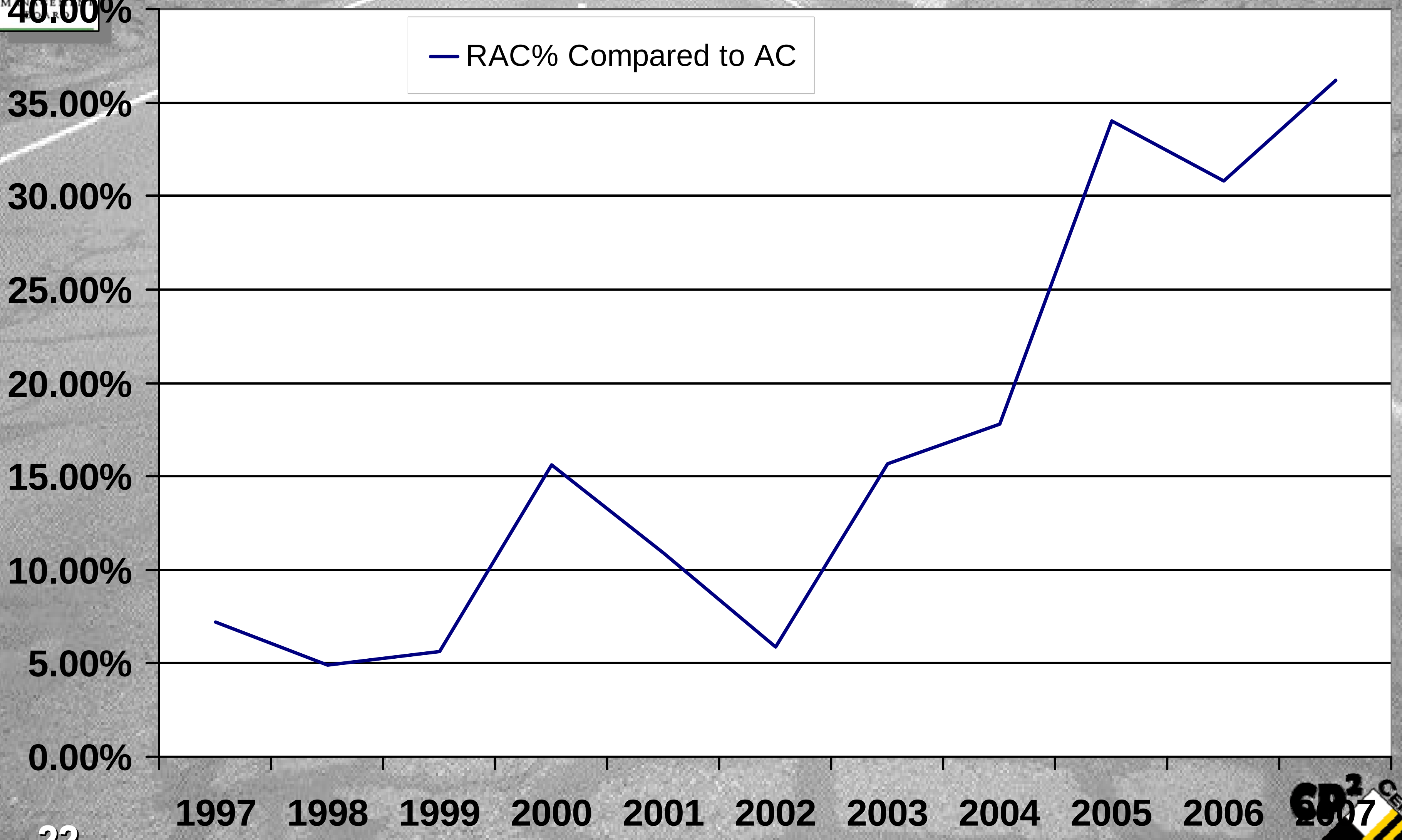
CALTRANS Reduced Thickness Design

- CALTRANS developed the interim guidelines in 1992
- Based on laboratory and long-term field data (two decades)
- Supported by research efforts

Design Of RHMA Overlays

- Uses a deflection based design method
- Up to 50 % reduction in thickness compared to conventional AC design thickness
- Over 200 reduced thickness projects

Caltrans RHMA Usage (% of AC Used)



Findings

Thickness of RHMA rubber mixes can be reduced by a factor of 2 and still give the same performance for resistance to reflective cracking

Reduced thickness first incorporated into the Caltrans design process in 1992

Adopted in Rehabilitation manual in 2002

AR Applications

ASPHALT RUBBER

SPRAY APPLICATIONS	Chip Seals AR Interlayers
HOT MIX ASPHALT	Dense-Graded HMA (RHMA-D) (Use with no agitation only) Gap-Graded HMA (RHMA-G) Open-Graded HMA (RHMA-O) Open-Graded High Binder HMA (RHMA-O-HB)

Rubberized Asphalt Concrete *RHMA*

3

AR Applications

High viscosity AR binder most effective in gap and open-graded mixes used in upper 60 mm of pavement

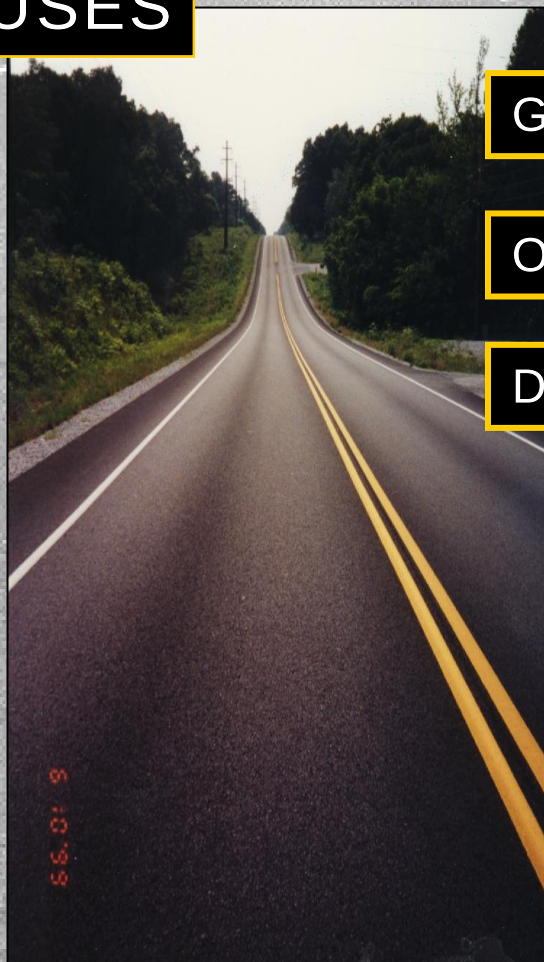
For resisting reflective cracking, Caltrans allows reduced thickness for gap-graded RHMA overlays of structurally sound pavements

Hot Mix Asphalt *HMA*

3

AR Applications

USES



GAP GRADED MIXES	RHMA-G
OPEN GRADED MIXES	RHMA-O
DENSE GRADED MIXES	RHMA-D

RHMA-D Only with no agitation binders

Used primarily in Arizona, California, Florida and Texas

Reduced thickness only by Califronia

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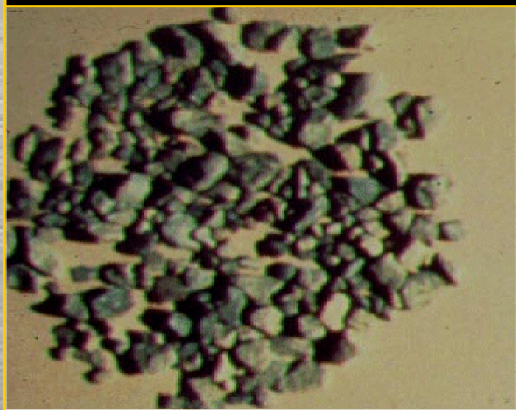
Aggregate Gradation Comparison

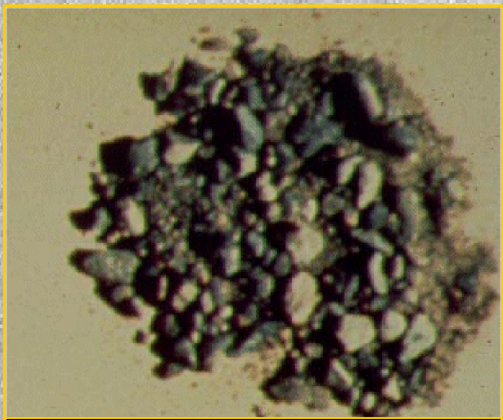
3

RHMA Applications

Open Graded



Gap Graded



Dense Graded

Dense-Graded HMA *RHMA-D*

EARLY USE

Limited performance improvements vs. cost

Inadequate void space to accommodate sufficient AR binder to modify behavior

Discontinued use with high viscosity binder

Gap Graded Mixes *RHMA-G*

- Currently the workhorse mix in CA
- Normally used in thicknesses from 30 to 60 mm
- Thickness reduction allowed when this mix is employed

HOT MIXES *RHMA-O*

Open-Graded

- Widely used in California as surface course
- Free draining with reduced splash and spray
- Does not add any structural value

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HOT MIXES *RHMA-O-HB*

3

RHMA Applications

Open-Graded High Binder

Widely used in Arizona as surface course

Also used in Caltrans as surface course

Not as free draining, but improved durability

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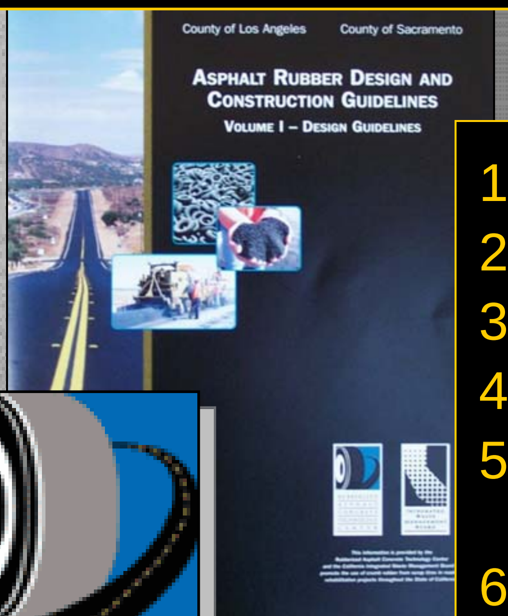
AR USAGE GUIDELINES

Section 4

Design Guide-Contents

Rubberized Asphalt Concrete Technology Center (RACTC)

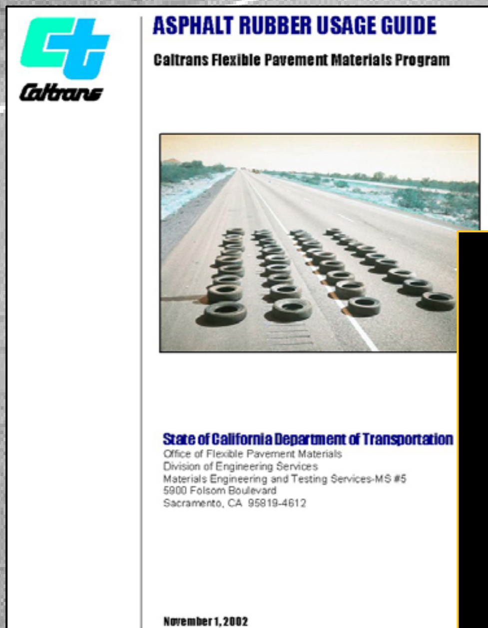


www.rubberizedasphalt.com

1. Introduction
2. Asphalt Rubber
3. AR Design Considerations
4. AR Materials Issues
5. AR Construction Issues-HMA & Chip Seals
6. Pre-construction meeting
7. Environmental considerations
8. Current/Future Developments
9. References

Caltrans Design Guide

RAC USAGE GUIDELINES


ASPHALT RUBBER USAGE GUIDE

Caltrans Flexible Pavement Materials Program

State of California Department of Transportation
Office of Flexible Pavement Materials
Division of Engineering Services
Materials Engineering and Testing Services-MS #5
5900 Folsom Boulevard
Sacramento, CA 95819-4612

November 1, 2002

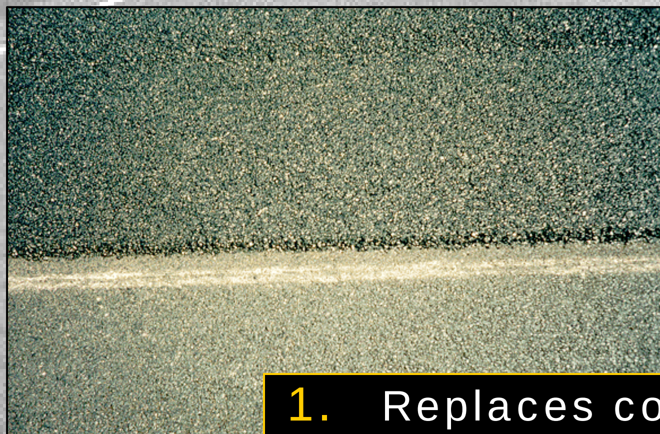
1. Introduction
2. Asphalt rubber product design, selection and use
3. Production of AR binders and mixtures
4. Construction and inspection guides
5. References

www.dot.ca.gov/

Where and Why Used?

4

RAC USAGE GUIDELINES



1. Replaces conventional mixes where paving temperatures and haul distances are favorable
2. More resistant to cracking and fatigue

Particularly Reflection Cracking

AR Design Considerations

1. BINDER DESIGN
2. STRUCTURAL DESIGN

Asphalt Rubber Blend Profile

Design 4

Developed to evaluate compatibility between materials used

Checks for stability of the blend over time

Should be required for each project

Binder Design

Design 4

RAC USAGE GUIDELINES

ASPHALT RUBBER

TEST	MINUTES OF REACTION					SPEC. LIMITS @ 45 MINUTES (CALTRANS 7/2002)
	45	90	240	360	1,440	
VISCOSITY, CP HAAKE@ 190C	2400	2800	2800	2800	2100	1500 - 4000
RESILIENCE@ 25C (% REBOUND)	27	--	33	--	23	18 Minimum
R & B SOFTENING PT., C (ASTM D36)	59.0	59.5	59.5	60.0	58.5	52 - 74
CONE PEN @ 25C (ASTM D217)	39	--	46	--	50	25 – 70

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Asphalt Rubber Tests

Design 4

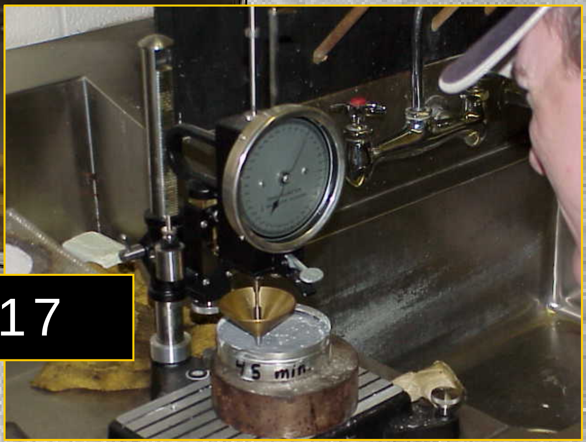
RAC USAGE GUIDELINES

- CONE PENETRATION
- RESILIENCE
- R&B SOFTENING POINT
- FIELD VISCOSITY

Cone Penetration

Design 4

RAC USAGE GUIDELINES



ASTM D 217

Resilience

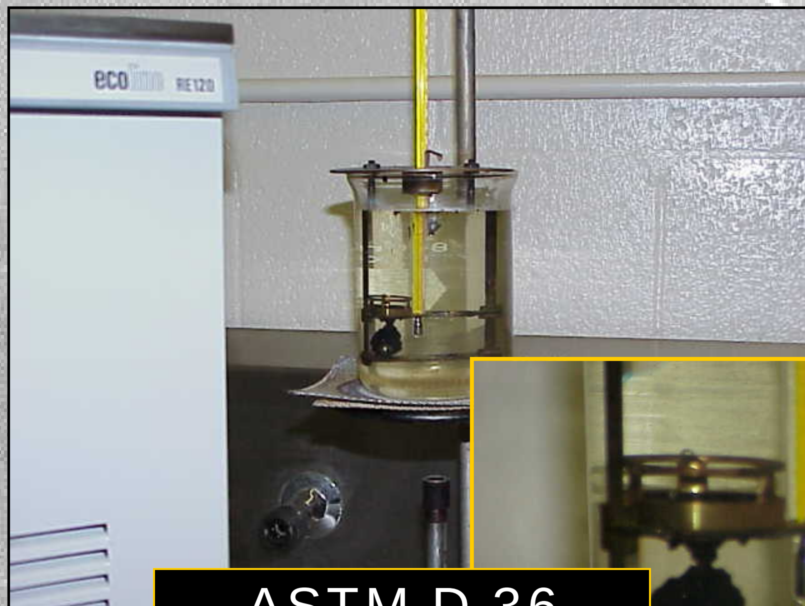
Design 4

RAC USAGE GUIDELINES

ASTM D 5329

Formerly ASTM D 3407

R&B Softening Point



ASTM D 36

Field Viscosity

Haake Viscometer

Old style – New Digital Model available

Pavement Structural Design 4

When RHMA-G is used as overlay material

- » Design for conventional HMA thickness
- » Determine RHMA-G overlay thickness according to FPRM
- » RHMA-G overlay thickness generally half that of the HMA overlay thickness

New pavements

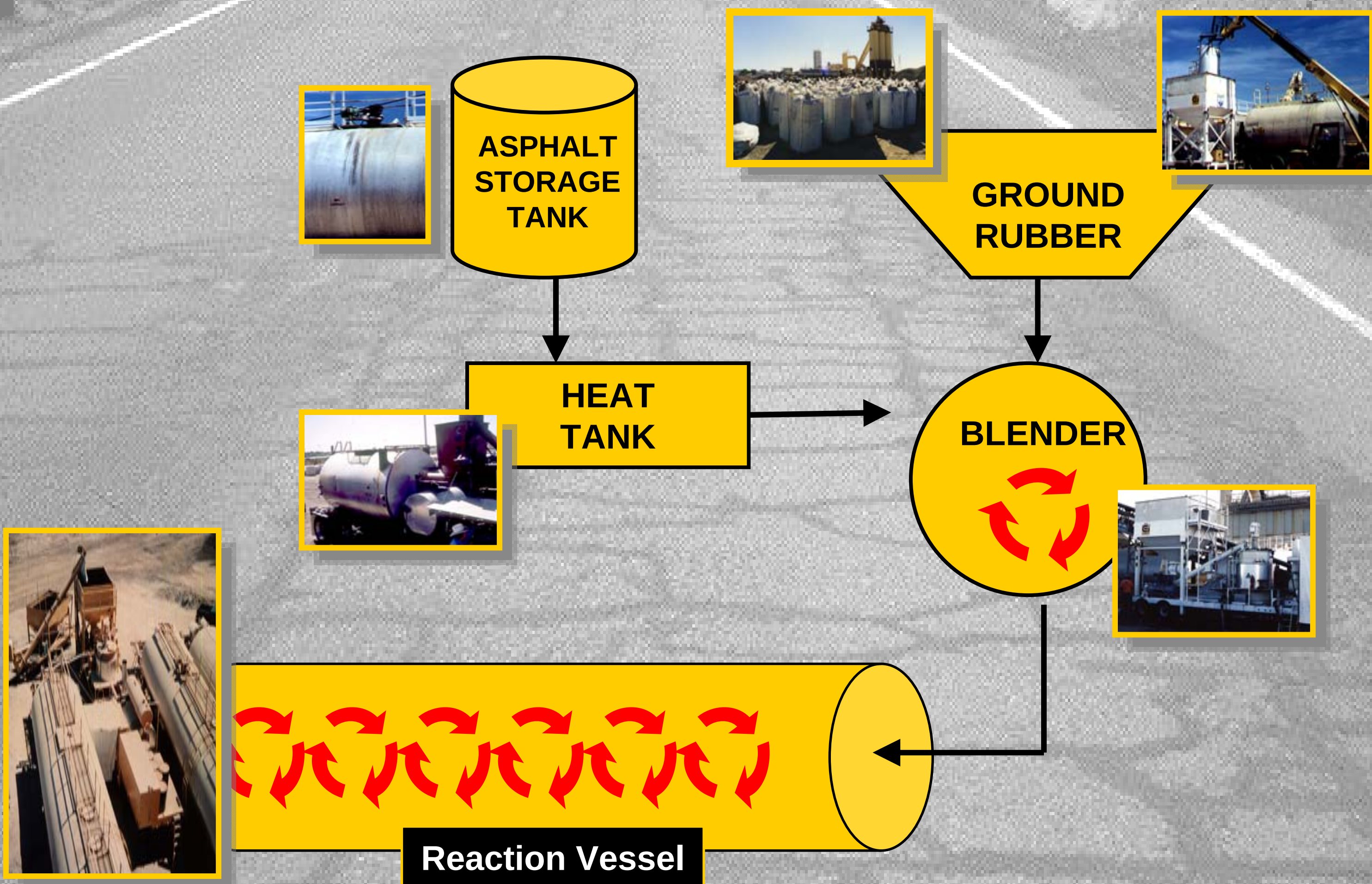
- » Caltrans does not reduce thickness for the use of RHMA in new pavement construction

AR Binder Production

4

1. Overview of process
2. Hold over and reheating issues
3. Documentation
4. Sampling & Testing requirements

AR Blending Schematic

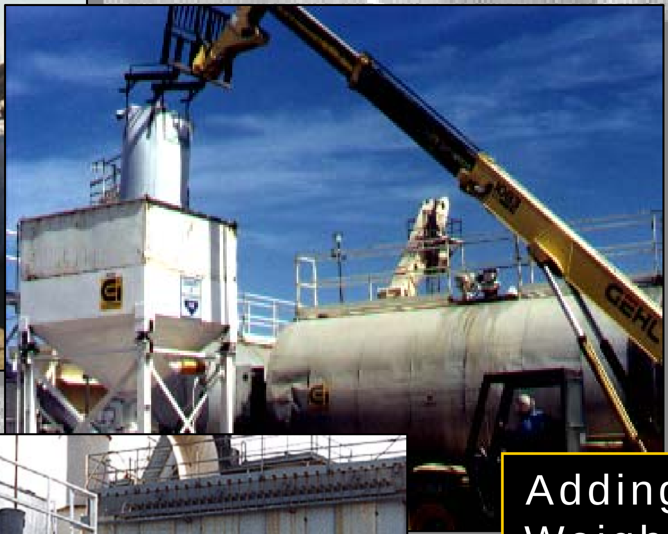


AR BINDER Process

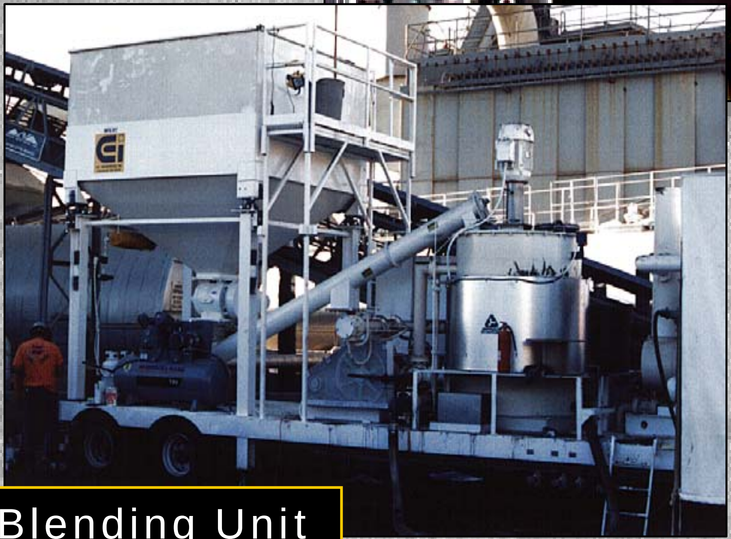
Production 4

RAC USAGE GUIDELINES

CRM Supply



Adding CRM to Weigh Hopper



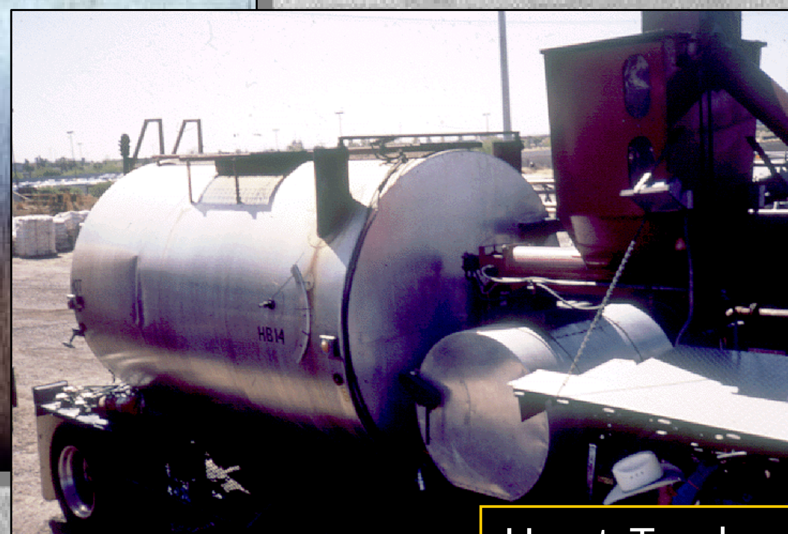
Blending Unit

AR Binder Process

Production 4

RAC USAGE GUIDELINES

AC Storage Tank



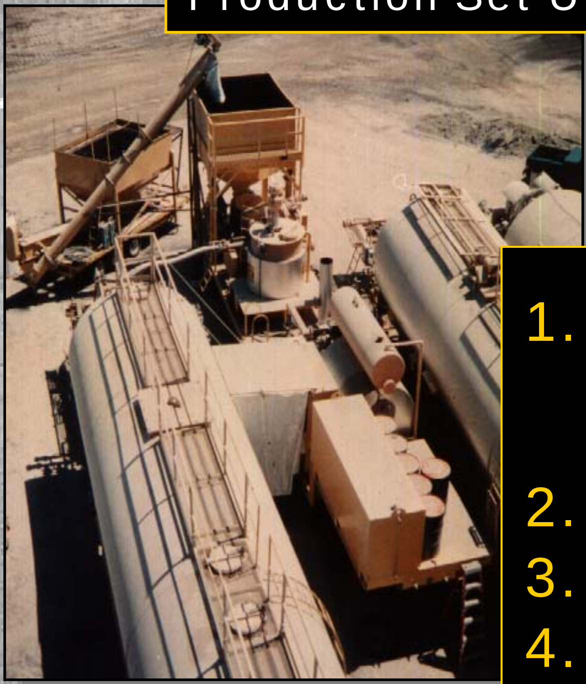
Heat Tank

Holdover and Preheating Issues

4

RAC USAGE GUIDELINES

Production Set Up



Caltrans Specs

1. Heating must be discontinued 4 hrs after 45 minute reaction period
2. Two reheat cycles are allowed
3. Specification compliance
4. Restoring viscosity

Documentation

- Certificate of compliance
- AR binder design
- AR binder production log

Uses for High Viscosity Binders- Hot mixes

INCREASES COST SO USE WHERE MOST EFFECTIVE

1. Most effective in gap-graded and open-graded mixes
2. Most effective in relatively thin surface lifts (max 60 mm)
3. Gap-graded is used as structural layer, equivalent to DG
4. Open-graded is used as surface friction course
5. Increased resistance to rutting, fatigue and reflective cracking a function of binder content
6. Not suitable for DGAC

AR Hot Mixes

Production 4

RAC USAGE GUIDELINES

RHMA - G

- Similarities to conventional DGAC
- Mix production
- Importance of temperature
- Sampling and testing requirements
- Construction

AR Good Practices

1. Same as DGAC
2. Quality Control
3. Inspection

Troubleshooting

- Segregation
- Smoke
- Appearance

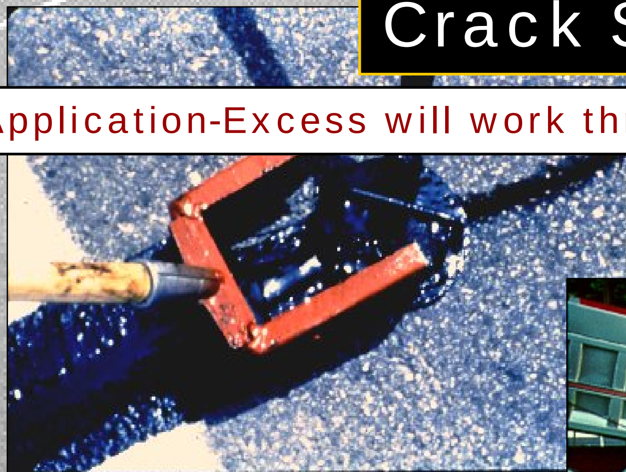
Good Practices

- Production
- Delivery
- Placement
- Compaction

Preparation for Paving

Crack Sealing

Minimal Application-Excess will work through overlay and cause fat spots



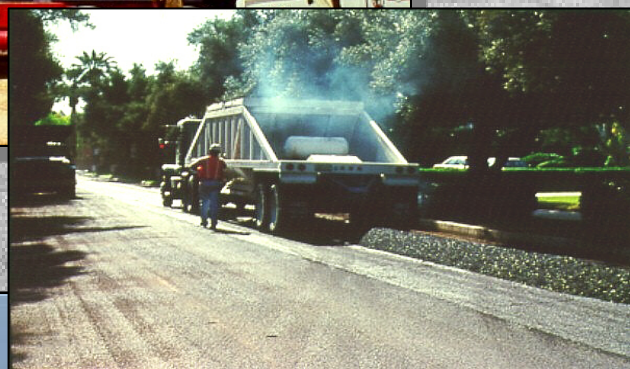
Patching

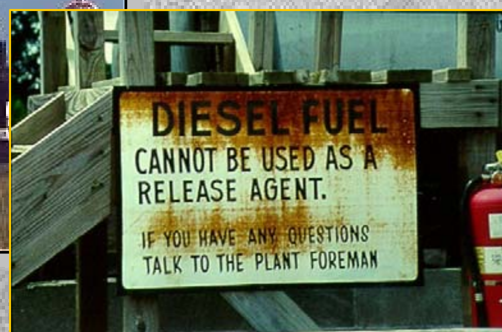
Tack Coat

AR Delivery Equipment

Construction 4

RAC USAGE GUIDELINES





ITEMS TO WATCH FOR

1. Release agents
2. Plant production
3. Mix delivery
4. Placement
5. Compaction
6. Balanced production

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AR Placement

Minimum Handwork and Raking

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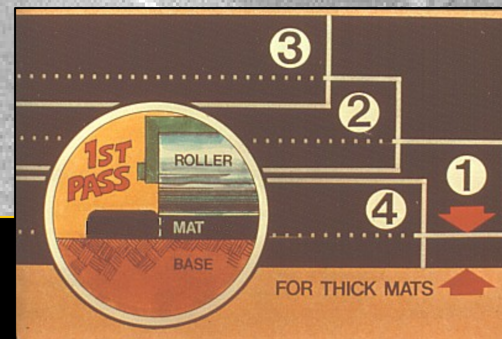
Hot Mix Compaction

Construction 4

RAC USAGE GUIDELINES



1. Good practices
2. Temperature requirements
3. Factors affecting compaction
4. Test strips and rolling patterns
5. Finishing

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Factors that Affect Compaction

For all AC and RHMA mixes:

1. Lift thickness
2. Air temperature
3. Pavement/base temp.
4. Mix temperature
5. Wind velocity
6. Sunlight or lack thereof

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SAMPLING AND TESTING

Construction 4

RAC USAGE GUIDELINES

STANDARD PRACTICES AS PER HMA

QC TESTING REQUIREMENTS

- Tests
- Frequency

QA TESTING REQUIREMENTS

- Tests
- Frequency

VISCOSITY OF BINDER CONTENT

- Field GO NO-GO Test

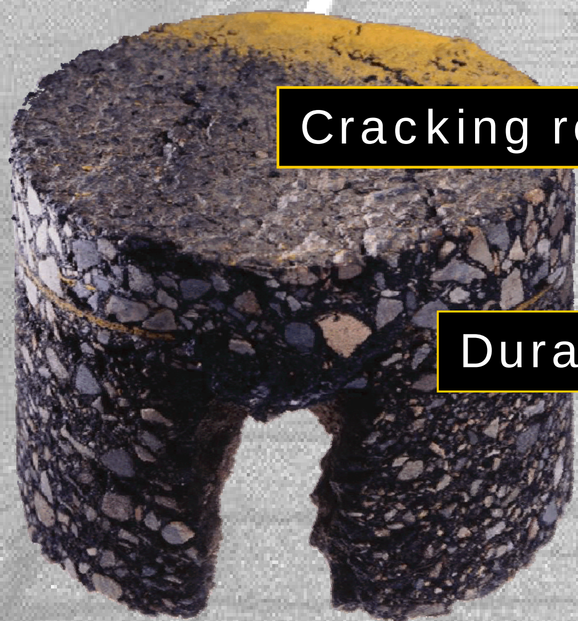
AR Benefits

5

BENEFITS

- Improved durability as surface layer
- Resistance to fatigue cracking
- Resistance to reflection cracking
- Resistance to aging
- Can be used in reduced thickness
- Reduced noise
- Lower life cycle costs
- Environmental

Improved Performance



Cracking resistance

Durability-aging resistance

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Increased Cracking Resistance

5

BENEFTIS

8” of Conventional Overlay After Twelve Years of Performance

5” of Asphalt Rubber Overlay After Twelve Years of Performance

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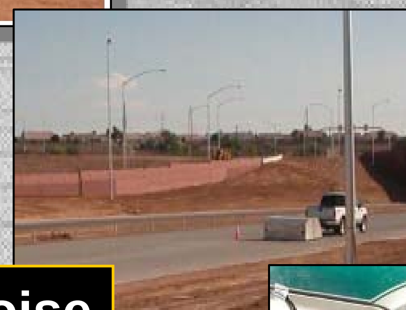
Reduced Noise

5

BENEFITS

IMPORTANT IN URBAN ENVIRONMENTS



Methods of Measuring Noise

- Wayside
- Close proximity
- Noise intensity

How Is *Noise* Controlled ?

At the Source

Vehicle & Tire Emissions

Through Distance

3 dBA Reduction for Each Doubling of Distance
25ft=70dBA, 50ft=67dBA, 100 ft=64

Through Obstructions

Berms, Walls, and Combination of Both

Noise Levels By

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SURFACE TYPE-CPX MEASUREMENT	
104.9	Random Transverse (Wisconsin Method)
102.5	Uniform Transverse (ADOT Method-3/4")
99.1	Longitudinal (ADOT Method-3/4")
95.5	Whisper Grind (Industry Method)
91.8	ARFC (ADOT Method)

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LCCA Study by Hicks and Epps

BENEFITS

- Establish strategies for analysis period
- Establish M&R activity timing
- Estimate agency costs
- Estimate user and non-user costs
- Develop expenditure streams
- Compute net-present value
- Analyze results

LCCA Results *Deterministic Approach*

BENEFITS

Scenario	Present Worth ($/yd)	
Preservation – Chip Seal		
▪ Conventional	18.39	
▪ AR	15.87	2.25
Preservation – Thin HMA		
▪ Conventional	20.69	
▪ AR	17.33	3.36
Structural Overlay		
▪ Conventional	21.97	
▪ AR	14.63	7.34

LCCA Results *Probabilistic Model*

Scenario	% of times savings result
Preservation - chip seal	86
Preservation - thin HMA	82
Structural Overlay	86

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Environmental Benefits

5

BENEFITS

1. Reduces landfill problems
2. Tire stockpiles
3. Value added products
4. Recycling of wastes
5. Noise abatement

Linear tire fill

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RAC Limitations

5

LIMITATIONS

- Increased initial costs must be offset by improved performance
- Not amenable to raking
- Higher temperatures for placement and compaction
- Environmental issues - air quality and odor concerns
- Knowledge of users and good HMA practices

Cost Considerations

HOT MIX

could be cheaper with high oil price

Offset if used in thinner layers

Offset by increased service life

Construction Considerations

5

LIMITATIONS

Control of temperature is most important

Handwork is more difficult

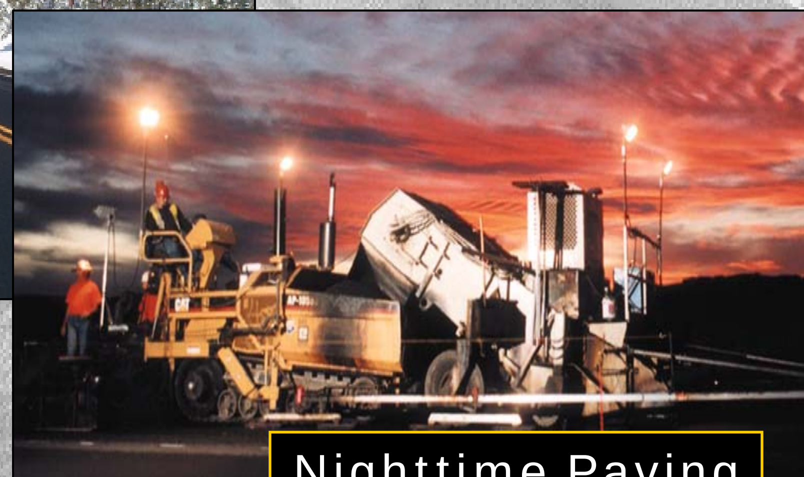
Material is stickier

- Cold or wet weather
- Considerable handwork
- Long haul
- Temperature considerations

Climatic

LIMITATIONS

Cold Weather Paving



Nighttime Paving

Environmental Concerns

LIMITATIONS

ENVIRONMENTAL - AIR QUALITY

Smoke issue in parts of CA

Can be controlled

HEALTH & SAFETY

No increased risk per numerous studies

RECYCLING OF AR MIXES

Stockpile uniformity – per conventional HMA

No indication of problems with Air Quality

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Frequently Asked Questions ?

5

LIMITATIONS

Frequently Asked Questions

1. Is the use of AR technically sound and cost effective? — YES
2. AR be used in cold weather climates? — YES
3. Can AR be rehabilitated and/or recycled? — YES
4. Why isn't AR more widely used by other agencies? — Education

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Implementation

- Educating users
- Benefits of AR
- Identifying best places to use AR
- Understanding the Limitations
- Successes and no failures

Conclusions

6

- AR has been used since the 1960's in chip seals and thin hot mix overlays
- AR design and construction guides are now available
- AR has proven to be a cost effective treatment for pavement maintenance and rehabilitation
- Despite the many successes, its use is still limited to a few states

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Conclusions

6

- Good standard practices and understanding of the materials are required for design, production, and construction of AC and RHMA pavements.
- AR is a cost effective treatment for pavement maintenance and rehabilitation


INTEGRATED WASTE MANAGEMENT BOARD
Contact details see next page

Questions ?

The Beginning

Keeping roads good with asphalt paving materials

R. Gary Hicks

rghicks@csuchico.edu

http://www.cp2info.org/center