This Lecture
- Module 1: Introduction of AR
- Module 2: Structure Design of RAC
- Module 3: AR Material

Module 1: Introduction Outline
- History of Asphalt Rubber (AR)
- Caltrans Experience with RAC
- Advantages of AR
- Primary References

Course Objectives
- Basics of RAC
  - History of Asphalt Rubber
  - What is RAC and why use it?
- Design and Construction of RAC
  - Structural and material design
  - Construction
- Inspection and Basic Trouble Shooting

History of Asphalt Rubber
- Used since the 1960's
- Used in chip seals, inter-layers, and hot mix asphalt
- Used extensively in Arizona, California, Florida and Texas
- Design and construction guides now available from some agencies

History of Asphalt Rubber (Cont.)
- Applications
  - Asphalt rubber chip seals and interlayers
  - Overlays and wearing courses
- Performance
  - Variable results in early years
  - Most effective in retarding reflection cracking as a thin surface layer
  - Mixes perform satisfactorily if properly designed and constructed
Caltrans Experience with RAC

- 1970’s – Used for chip seals and hot mix
- 1983 – Ravendale project - reduced thickness
- 1995 – Over 100 RAC projects constructed
- 2001 – Over 210 RAC projects constructed
- 2003 – CIWMB/Caltrans partnership
- 2005 – AB338 mandates increased RAC use (20% AC in 2007 to 35% in 2013)

Caltrans Use of RAC

- Largest Use
  - Thin overlays (RAC-G)
  - Mitigate reflective cracking
  - Reduced thickness
- Other Uses
  - Friction course (RAC-O)
  - Durable sacrificial course (RAC-O-HB)
- Performance
  - Successful in all applications
  - Problems generally due to construction issues

Tires Used in RAC

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Tires Used in RAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>914,700</td>
</tr>
<tr>
<td>1998</td>
<td>913,400</td>
</tr>
<tr>
<td>1999</td>
<td>1,143,000</td>
</tr>
<tr>
<td>2000</td>
<td>3,967,900</td>
</tr>
<tr>
<td>2001</td>
<td>1,733,300</td>
</tr>
<tr>
<td>2002</td>
<td>703,900</td>
</tr>
<tr>
<td>2003</td>
<td>1,126,500</td>
</tr>
<tr>
<td>2004</td>
<td>1,788,800</td>
</tr>
<tr>
<td>Total</td>
<td>12,291,800</td>
</tr>
</tbody>
</table>

Caltrans RAC Usage (% of AC Used)

<table>
<thead>
<tr>
<th>Year</th>
<th>RAC % Compared to AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>0%</td>
</tr>
<tr>
<td>1998</td>
<td>5%</td>
</tr>
<tr>
<td>1999</td>
<td>10%</td>
</tr>
<tr>
<td>2000</td>
<td>15%</td>
</tr>
<tr>
<td>2001</td>
<td>20%</td>
</tr>
<tr>
<td>2002</td>
<td>25%</td>
</tr>
<tr>
<td>2003</td>
<td>30%</td>
</tr>
<tr>
<td>2004</td>
<td>35%</td>
</tr>
<tr>
<td>2005</td>
<td>35%</td>
</tr>
</tbody>
</table>

Caltrans Research with RAC Products

- 1999 – HVS confirmed “1/2 - thickness”
- 2003 – HVS on 8 field constructed overlays (6 Test Sections)
- 2004 – Fre-33 (9 Test Sections)
- 2005 – Men-20 (4 Test Sections)
- 2005 – SJ-5 and Ker-99 (rubberized bonded wearing course, RBWC)

RBWC on I-5
Caltrans Challenges with RAC

- 1997 – 00: 10 pilot projects using MB
- 2002 – 04: Five RAC (5-year warranty) projects throughout the State
- 2004 – 05: Full-scale field experiments

MB and HVS

- 10 pilot projects using RMB (1997 - 2000)
- Performance: 8 good, 1 fair*, and 1 poor*
- HVS Sites – UC Berkeley
  - 45 mm RAC-G, Field Blend
  - 45 mm Type G (MB), TB
  - 90 mm Type G (MB), TB
  - 45 mm MB 15%, TB
  - 90 mm MB 15%, Term. Blend
  - 90 mm DGAC Type A (Control)
- HVS Performance: Exceeding expectations
  * Not materials related

RAC 5-Year Warranty Projects

- 5 Projects Constructed in 2002 - 04
  - 4 – Wet Process (Fre-33, Ven-150, Mer-140, SD-75)
  - 1 – MB-D (terminal) (Las-395)
- Level Playing Field
  - 15% CRM
  - Open specifications
  - 5-Year Performance Warranty Criteria
  > Rutting  > Cracking  > Delamination
  > Bleeding  > Potholing

Fre-33 and Men-20 Projects

- Fre-33 (Firebaugh, 9 test sections, June 04)
  - DGAC (90 mm)
  - RAC-G (45 mm, 90 mm)
  - RUMAC (45 mm, 90 mm)
  - MB-G (45 mm, 90 mm)
  - MB-D (45 mm, 90 mm)
- Men-20 (Dist. 1, 4 test sections, August 05)
  - DGAC (105 mm)
  - RAC-G (60 mm)
  - RUMAC (60 mm)
  - MB-D (60 mm)

Performance evaluation sections
Laboratory performance tests
Comparison to HVS

Advantages of AR

- Good durability – in terms of resistance to cracking and aging
- Environmental friendly – make value-added use of a waste material, reduce traffic noise
- Versatility – can be used in most maintenance and rehabilitation activities, often at reduced thickness for resistance to reflective cracking
- Longer lasting color – for better contrast with striping and marking
- Reduced maintenance – for both chip seals and hot mix

Primary References

- Asphalt Rubber Usage Guide
- Use of Scrap Tire Rubber – State of the Technology and Best Practices
- Synthesis of Caltrans Rubberized Asphalt Concrete Projects
- Feasibility of Recycling Rubber-Modified Paving Materials
- Study on Structural Design Considerations
- Flexible Pavement Rehabilitation Manual
- Asphalt Rubber Design and Construction Guidelines
- RAC-G SSP Version (12-12-05)
- RAC-O SSP Version (12-12-05)

http://www.dot.ca.gov/Videos/Transportation/TRANS_CIWMBPROJECTT021DELIVERABLES.htm
### Summary of Module 1
- Course Objectives and Content
- History of RAC
- Caltrans Experience with RAC
- Advantages of RAC
- References

### Module 2: Structural Design

#### New Pavements and Overlays

### Outline
- Terminology
- Caltrans Practices
- 2005 Study
- Revised Caltrans Practices
- RAC Project Selection
- Cost Analysis

### Terminology
- Hot-mix asphalt (HMA) replaces the term dense-graded asphalt concrete (DGAC)
- Caltrans Highway Design Manual (HDM)
- Caltrans Flexible Pavement Rehabilitation Manual (FPRM)
- Asphalt Rubber Usage Guide (AR Guide)
- Mechanistic-empirical (M-E) based analysis and design

### Caltrans Practice – New Pavements
- New pavements – Caltrans does NOT have a standard practice for the use of RAC in new pavement construction

### Caltrans Practice – Overlays
- Based on FPRM (2001)
- Uses deflection reduction to a tolerable level
- Design for HMA overlay thickness based on TI and existing HMA layer thickness
- Check also for reflective cracking and ride quality
Caltrans Practice – overlays

- When RAC-G is used as overlay material
  - Design for conventional HMA thickness
  - Determine RAC-G overlay thickness according to FPRM
    - Table 3 – Based on structural equivalencies
    - Table 4 – Based on reflection crack retardation
  - RAC-G overlay thickness generally half that of the HMA overlay thickness

2005 Study

- Use of RAC in new pavements?
- Can RAC-G thickness be increased more than 60 mm?
- Does 2:1 thickness reduction for RAC-G provide adequate structural equivalency in overlays?

2005 Study

- Joint effort between Caltrans, UC-PPRC, and MACTEC
- Both new pavements and structural overlays
- Laboratory tests (Cohesiometer)
- Theoretical (M-E) analysis with lab-developed models

Primary Findings – New Pavements

- Limited cohesiometer test results indicate that $G_f$ for RAC and HMA are similar.

Primary Findings – New Pavements

- Theoretical analyses did not show structural benefit for the use of RAC-G of same thickness as HMA.
- This is due, in part, to the lower stiffness (higher strains) which offsets the improved fatigue life and which may cause concerns of rutting in the subgrade soil.

Recommendations – New Pavements

- RAC should be treated the same as HMA for new construction.
  \[(G_f)_{RAC} = (G_f)_{HMA}\]
- Caltrans thickness design provides a minimum structural capacity required for the design conditions. It should NOT be reduced when RAC mixes are used.
**Primary Findings – Structural overlays**

- Based on M-E analysis, the structural benefit of the RAC-G overlay varies with the thickness placed. The greatest benefit occurs in a thin layer of 30 mm to 60 mm thick as compared to HMA of the same thickness.
- The use of reduced thickness for RAC-G overlay is valid; however, not to the extent previously employed by Caltrans.

**Recommendations – Structural Overlays**

- Calculate GE for HMA using current methodology and determine structural overlay
- Design RAC-G overlay in a range of 30 to 60 mm to achieve most structural benefit

**Revised Practice – New Pavements**

- HDM and AR Guide are currently being updated to include information contained in the memo dated 4/24/06 by Caltrans
- Contact Info:
  - Terrie Bressette, METS (916-227-7303)
  - Mehdi Parvini, Division of Design (916-227-5846)
### Revised Practice – New Pavements

- Place on top of conventional HMA or PCC. Do not place directly over aggregates bases (treated or non-treated), subbases, or native soils.
- Place gap-graded RAC (RAC-G) no thicker than 60 mm and open-graded RAC (RAC-O) no thicker than 45 mm. Up to 45 mm of RAC-O may be placed on top of 60 mm of RAC-G.

### Revised Practice – New Pavements

- Do not place underneath conventional HMA or open graded friction course (open-graded HMA).
- Do not reduce the overall pavement thickness when RAC is used. Pavement thicknesses for rehabilitation can be reduced with RAC for reflective cracking only. Reflective cracking is not an issue for new construction.

### Revised Practice – New Pavements

- Place RAC at the temperature specified in Standard Special Provisions. The project engineer should determine this by verifying with the District Materials Engineer and Resident Engineer that these temperatures will exist during the season and times (traffic lane closures) the Contractor will be performing this work. RAC in thin layers can be more sensitive to lower temperatures.

### Revised Practice – Overlays

- Overlay design procedure is now incorporated into new HDM
- Rehabilitation strategies are divided into three categories:
  - Overlay
  - Mill and Overlay
  - Remove and Replace
- Rehabilitation designs are governed by one of the following three criteria:
  - Structural adequacy
  - Reflective cracking
  - Ride quality

### Revised Practice – Overlays

- Overlay procedures for flexible over existing flexible pavement
  - Structural adequacy
    - Principle of reducing deflection to a tolerable level is still the basis
  - The required overlay thickness is determined by dividing gravel equivalency (GE) by gravel factor (Gf)
  - Reflective cracking (table for equivalencies)
  - Ride quality (evaluated based on the
Layer Thickness Equivalencies for Reflective Crack Retardation

<table>
<thead>
<tr>
<th>HMA</th>
<th>RAC-G</th>
<th>RAC-G on SAMI-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 mm</td>
<td>30 mm</td>
<td></td>
</tr>
<tr>
<td>60 mm</td>
<td>30 mm</td>
<td></td>
</tr>
<tr>
<td>75 mm</td>
<td>45 mm</td>
<td></td>
</tr>
<tr>
<td>90 mm</td>
<td>45 mm</td>
<td></td>
</tr>
</tbody>
</table>
| 105 mm* 45 mm, if CW < 3 mm
* 60 mm, if CW ≥ 3 mm, or if underlying material is CTB, LCB, or PCC | N/A for CW < 3 mm
* 30 mm, if CW ≥ 3 mm and underlying material is untreated
* 45 mm, if CW ≥ 3 mm and underlying material is CTB, LCB, or PCC | |

Note: CW = Crack Width

RAC Project Selection – New Pavements

- RAC may be used as final lift of the surface layer for structural purposes, but thickness must be ≤ 60 mm
- If RAC is used to replace a portion of the structural layer, M-E analysis may be used to ensure that fatigue cracking criteria and subgrade cover requirements are satisfied
- RAC may also be used as a non-structural wearing course layer (thickness ≤ 60 mm)

RAC Project Selection – Overlays

- Overlay projects are the best candidates for the use of RAC mixes because existing pavement helps satisfy cover requirements
- If existing pavement is structurally sound and surface cracking is the predominant distress, RAC-G thickness may be reduced up to half of the designed HMA thickness for controlling reflective cracking

RAC Project Selection – Mill & Overlay with RAC

- Projects in which a certain amount of the existing HMA surface is to be removed and replaced are valid candidates for RAC
- Follow the mill and overlay procedure in HDM, check for:
  - Structural adequacy
  - Reflective cracking
  - Ride quality (sufficient)

Cost Analysis – Initial Cost

- 2005 unit costs: $65/ton for HMA vs. $80/ton for RAC. Costs will be higher in 2006.
- In general, initial costs are high; however, reduced layer thickness results in lower costs
- Experienced contractors help keep cost of RAC low

Cost Analysis – LCCA

- Available information indicates that RAC is (in general) cost-effective in the majority of cases when compared to conventional HMA rehabilitation and maintenance strategies.
Caltrans is currently developing a LCCA procedure based on the RealCost Model developed by FHWA. Caltrans procedure has typical M&R schedule for California:
- By various climate region (e.g., coast, valley, desert, and mountain) and for Districts
- By surface type (e.g., HMA, RAC)
- By M&R design life

Caltrans procedure also includes overall rehabilitation construction unit cost for various strategies (e.g., RAC, CAPM 5-year).

The Caltrans LCCA procedure will be ready for use by the end of June 2006.

Summary of Module 2
- Caltrans Practices
- 2005 Study
- Revised Caltrans Practices
- RAC Project Selection
- Cost Analysis

Module 3: AR Material
Specifications and Binder Design

Outline
- Definitions
- Asphalt rubber binder
- Asphalt rubber binder design
- Types of mixes
- Cautions

Definitions
Asphalt Rubber Definition: ASTM D 8
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.
Definitions

Related Specification: ASTM D 6114
Standard Specification for Asphalt Rubber Binder

High viscosity material (usually field-blended) that typically requires agitation to keep CRM particles dispersed.

Definitions

The Wet Process can produce a wide variety of CRM modified binders from high viscosity (field blend) to no agitation (terminal blend) types

- Rotational Viscosity is the discriminator for appropriate use, although rotational viscosity of terminal blends is not typically measured
- May be blended in field or at terminal

Definitions

Wet Process
Method of modifying asphalt cement with scrap tire CRM and other components

- Most widely used approach (AZ, CA, TX, FL, others)
- Thoroughly mix CRM & other components with hot (400-425°F) asphalt cement
- Interact at 350-375°F for designated period (typical minimums 45-60 minutes)
  - CRM particles swell, exchange oils with AC

Definitions

Terminal Blends and MB binders are:

- Low viscosity, no agitation
- Typically ≤ 10% CRM content, some @ 15%
- May include polymers and/or other modifiers
- Content in hot mixes is similar to neat asphalt cement
- MB is not the subject of this presentation

Definitions

Dry Process
Substitutes CRM for 1 to 3% of aggregate in hot mix

- Not considered to modify binder, although some asphalt-CRM interaction may occur in place over time
- CRM gradations have ranged from coarse (~1/4") to fine (#80)
- Mixed performance history – limited current use
  - May be related to mix design – need to account for long term absorption without starting out too rich
  - Not widely used in CA
  - Not the subject of this presentation
Asphalt Rubber Binder

Components:
- Crumb Rubber Modifier (CRM)
  - Scrap Tire Rubber
  - High Natural Rubber Content Scrap Rubber
- Asphalt Cement
- Extender oil - Caltrans

Caltrans Specifications for High Viscosity (Field Blend) AR Binders

- Asphalt modifier: Extender oil at 1 to 6% by mass of asphalt. (For chip seal binders, CT may continue to require minimum 2.5% extender oil.)
- Asphalt + extender oil: 78-82% by total mass of AR binder
- Total CRM: 18-22% by total mass of AR binder, of which:
  - Scrap tire CRM = 73-77% of total CRM
  - High natural CRM = 23-27% of total CRM

Crumb Rubber Modifier (CRM)

- CRM is produced from grinding whole scrap tires, tread buffings, and other waste rubber products. CRM comes in a variety of grades and size designations from various suppliers and/or sources.
- CRM gradation and content affects not only AR binder properties, but also influences the voids structure of RAC-G mixes.
- Gradation limits used by Caltrans and ADOT are broad and allow considerable variation; changes are being considered.
- Check project special provisions to verify CRM gradation limits in effect for specific projects.

High natural rubber CRM is used to improve adhesion and flexibility, chip seal aggregate retention, and to compatibilize asphalt and CRM interactions. It has a high natural rubber content (40-48% by mass) and may be made from scrap tires or other non-tire sources.
- Caltrans also requires that “high natural” be used in binders for RAC mixes.

Asphalt Cements

- Asphalt cements come in a variety of grades and designations.
- AR-4000 was used to make asphalt rubber in the past.
- Caltrans adopted the Performance Graded (PG) system in 2006.
- Do not use modified asphalts as the base asphalt cement for CRM modification.
**PG Asphalt Cements**

- For high mountain and high desert areas, use PG 58-22 as the base asphalt.
- For other areas (coastal, inland valleys, low and south mountain, and desert) use PG 64-16 as base asphalt.

**Additives**

- Extender oils - aid in the interaction of the crumb rubber and asphalt by providing aromatics which are absorbed by the rubber, and help with dispersion by chemically suspending the rubber in the asphalt. Required by Caltrans.
- Anti-stripping agents - used to improve adhesion of binder to aggregate.

**Asphalt & Rubber Interactions**

Interactions Depend On:
- Asphalt Cement Source and Grade
- Rubber Type/Source
- Amount of Rubber
- Gradation of Rubber
- Interaction Time
- Interaction Temperature

**Asphalt Rubber Blend Design Submittals**

- Supplier and identification (or type) of scrap tire and high natural CRM.
- Typical gradation of each type of CRM material used in the asphalt rubber binder design
- Percentage of scrap tire and high natural CRM by total mass of the asphalt-rubber blend.
- If CRM from more than one supplier is used, info will be required for each CRM supplier used.
- Laboratory test results for test parameters shown in the special provisions.

**Asphalt Rubber Blend Design Profile**

- A design profile is developed to evaluate the compatibility between materials used, compliance of component interaction properties, and to check for stability of the AR blend over time. A 24-hour design profile will be required for each project, for hot mix and spray applications.
- Previous AR blend designs may be validated with currently available materials and may be submitted for more than one project.
Asphalt Rubber Blend Design

Example Design Profile

<table>
<thead>
<tr>
<th>TEST</th>
<th>Minutes of Reaction</th>
<th>Spec. Limits @ 45 minutes (Caltrans 12/2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45</td>
<td>1,440</td>
</tr>
<tr>
<td>Viscosity, μP, Haake@ 190°C</td>
<td>2400</td>
<td>2800</td>
</tr>
<tr>
<td>Resilience@ 25°C (% Rebound) (ASTM D5329)</td>
<td>27</td>
<td>--</td>
</tr>
<tr>
<td>R &amp; B Softening Pt, °C (ASTM D34)</td>
<td>59.0</td>
<td>59.5</td>
</tr>
<tr>
<td>Cone Pen @ 25°C (ASTM D311)</td>
<td>39</td>
<td>--</td>
</tr>
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</table>

Types of Rubberized Asphalt Concrete (RAC) Hot Mixes

- Dense-graded (not in use by Caltrans)
- Gap-graded
- Open-graded
- Open-graded (High Binder, HB)

Aggregate Gradation Comparison

Open Graded  Gap Graded  Dense Graded

Dense-Graded Mixes (RAC-D)

- Early use
  - Limited performance improvements vs. cost
  - Inadequate void space to accommodate sufficient AR binder to modify mix behavior
- Discontinued use with high viscosity (field blend) binders
- Suitable for use with no agitation CRM-modified binders (terminal blend) such as

Gap-Graded Mixes (RAC-G)

RAC-G is the most commonly used RAC mix type

- Purpose – Structural mix that provides increased resistance to rutting, fatigue and reflective cracking, and to oxidative ageing, as function of relatively high contents of modified binder.

Gap-Graded Mixes (RAC-G)

- Appropriate use - Most effective in relatively thin surface lifts (max 60 mm) as overlay of aged or distressed flexible or rigid pavements that are structurally sound. May be used as surface course for new construction. Suitable for wide range of traffic volumes and loadings.
**Gap-Graded Mixes (RAC-G)**

- Thickness design
  - See Module 2 for details
  - New pavements
  - Overlays
- Overlay systems – two and three layer
  - SAMI-R, not SAMI-F

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**Gap-Graded Mixes (RAC-G)**

- Standard Special Provisions for RAC-G with high viscosity (field blend) AR binder are currently being updated to address PG binder implementation.

Revisions include:
- Remove test methods from body of SSP, develop corresponding CT Lab Procedures for CRM sieve analysis and measuring rotational viscosity of AR binder
- Format SSP for inclusion in Section 39 of Caltrans Standard Specifications

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**Gap-Graded Mixes (RAC-G)**

- Adjustments to Hveem Mix Design Method (CT 367), including:
  - Modify (coarsen) aggregate gradation requirements, particularly for 600 μm sieve, to facilitate achieving minimum VMA (18%).
  - Add maximum VMA limit of 23%.
  - Test 3 briquettes at each binder content, use average values for calculations and plots.

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**Gap-Graded Mixes (RAC-G)**

- Adjustments to Hveem Mix Design Method, cont’d
  - Design air voids content may range from 3 to 5% based on traffic index and climate, and as designated by the Engineer in project special provisions.
  - Still requires minimum AR binder content of 7.0% by weight of dry aggregate to provide durability. (Must have sufficient binder content to provide expected performance benefits.)

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**Gap-Graded Mixes (RAC-G)**

- Adjustments to Hveem Mix Design Method, cont’d
  - Use Caltrans Laboratory Procedures LP-1 through LP-4 for volumetric calculations.
  - Report Voids Filled with Asphalt (VFA) and Dust Proportion for information only.
  - Plot average unit weight, stability, % air voids, VMA, and VFA, versus asphalt rubber binder content.

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**Open-Graded Mixes (RAC-O, RAC-O-HB)**

- Standard Special Provisions for RAC-O and RAC-O-HB are also currently being updated to incorporate PG binder implementation.

- Changes are similar to those for RAC-G, but with less impact on mix design method. Effects of CRM gradation and content in binder have relatively little effect on voids structure of open-graded mixes.
Open-Graded Mixes (RAC-O)

Purpose:
RAC-O is designed to provide a free-draining surface (reduced splash, spray, and hydroplaning) that maintains good frictional characteristics in wet or dry conditions. Such mixes are not considered to be structural elements and no thickness reduction applies. RAC-O is typically placed in thin lifts, nominally 24 to 30 mm thick.

Appropriate Use:
RAC-O may be used as an overlay or as a surface for new construction where traffic flow is essentially uninterrupted by signalization, such as freeways, and some rural and secondary highways.

Open-Graded Mixes (RAC-O)

Do not use open-graded mixes where there is a significant amount of stop and go traffic or turning vehicles, such as city streets or in parking lots. These porous low modulus pavements are susceptible to tire scuffs from simultaneous braking and turning motions, and to damage from leaking vehicle fluids. Caltrans does not use RAC-O in snow country.

RAC-O Mix Design

RAC-O mixture design is performed according to California Test 368, with asphalt rubber binder content set at 1.2 times the optimum bitumen content for the designated PG binder grade. A check test is used to verify that binder drain down is not excessive.

If long hauls are anticipated, drain down should also be checked in the laboratory for the expected haul time.

Open-Graded Mixes (RAC-O-HB)

- RAC-O-HB mixes have higher binder contents (1.6 times demand for PG asphalt instead of 1.2)
- HB provides improved friction course durability and performance due to thicker AR binder films.
- Drain down check is more critical for high binder mixes.
- RAC-O-HB does not drain as freely as RAC-O due to higher binder content, but still drains more freely than DGAC.

RAC-O and RAC-O-HB provide more than safety benefits. Have also proved to:
- Provide smooth ride
- Significantly reduce tire noise

Joint Caltrans/ADOT/FHWA studies are in progress to measure and document noise reduction over a ten-year period.
The specifications and mix design methods discussed in this presentation apply to use of high viscosity asphalt rubber binders (field blend) in gap- and open-graded RAC mixes. No agitation binders (low viscosity, terminal blend) should never be directly substituted for high viscosity binders in any RAC mix. The two different types of CRM-modified binders have very different viscosity ranges and behave very differently from each other in asphalt concrete hot mixes.

A brief introduction to RAC materials and specifications. More detailed information on CRM-modified materials can be found on the Caltrans web site:

Previous site: http://www.dot.ca.gov/hq/esc/Translab/fpmRAC.htm
New web site: http://www.dot.ca.gov/hq/esc/Translab/fpmlab/CALTRAN_S_CIWMBPROJECTT021DELIIVERABLES.htm

Read project special provisions for RAC carefully to assure what requirements are in effect pending implementation of updated SSPs – project docs rule.