Today decides tomorrow!!!

CIVL 441 Transportation Engineering

Asphalt Rubber

Objectives

- Module 1: Introduction of Asphalt Rubber (AR)
- Module 2: Structural Design of Rubberized Hot Mix Asphalt (RHMA)
- Module 3: Construction
- Module 4: Inspection

Module 1: Introduction Outline

- History of Asphalt Rubber (AR)
- Caltrans Experience with RHMA
- Advantages of RHMA
- Primary References

History of Asphalt Rubber

- Used since the 1960's
- Used in chip seals, inter-layers, overlays, wearing courses, and hot mix asphalt pavements
- Used extensively in Arizona, California, Florida and Texas
- Design and construction guides now available from some agencies

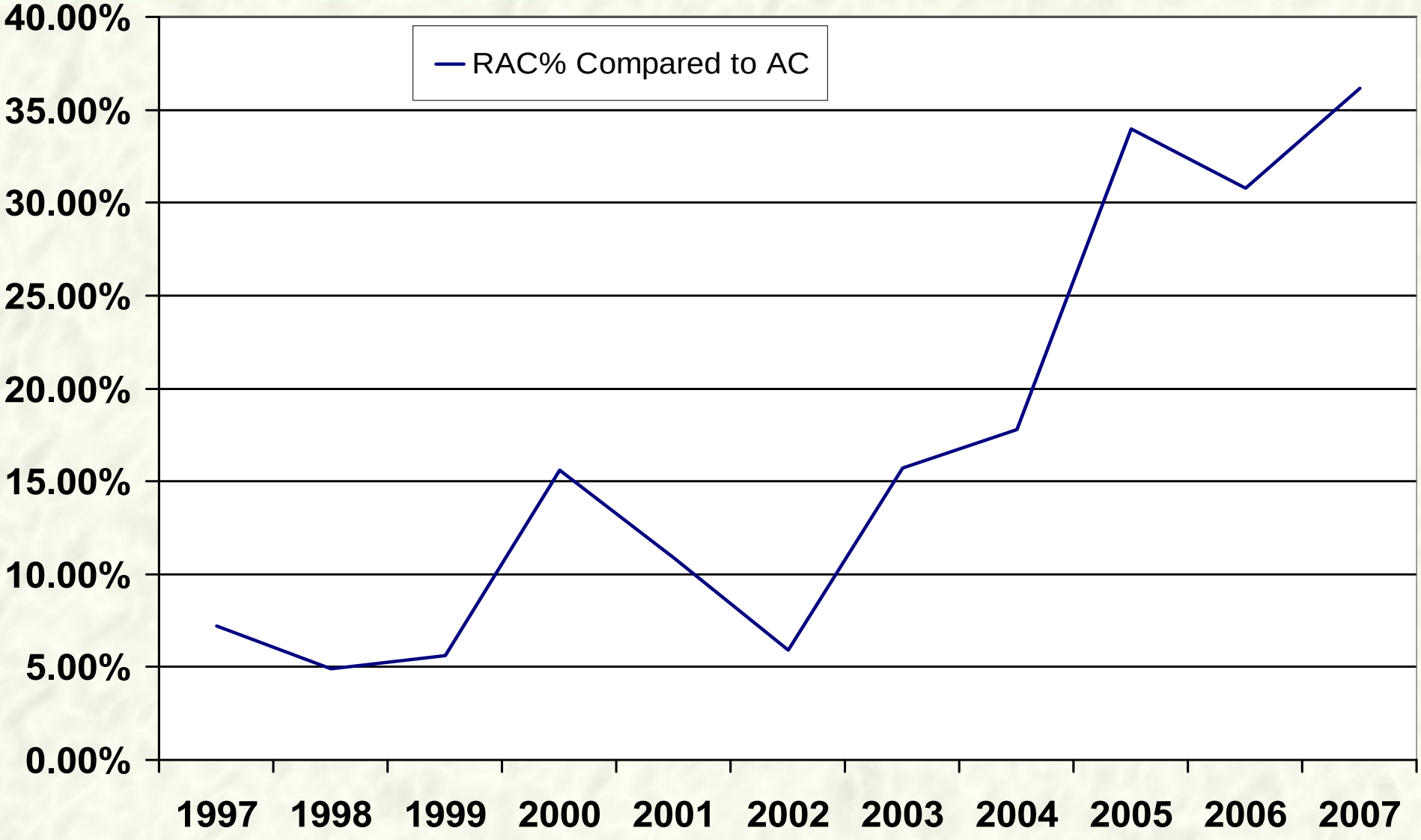
History of Asphalt Rubber (Cont.)

- 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 Use of RHMA

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

Caltrans RHMA Usage (% of AC Used)



Rubberized Bonded Wearing Course (RBWC) on I-5

MB and HVS

- **10 pilot projects using Rubberized Modified Binder (RMB) (1997 - 2000)**
- **Performance: *8 good, 1 fair*, and 1 poor****
- **HVS Sites – UC Berkeley**
  - ***45 mm RHMA-G, Field Blend***
  - ***45 mm Type G Modified Binder (MB), Terminal Blend (TB)***
  - ***90 mm Type G (MB), TB***
  - ***45 mm MB 15%, TB***
  - ***90 mm MB 15%, TB***
  - ***90 mm DGAC Type A (Control)***

- **HVS Performance: Exceeding expectations**

** Not materials related*

RHMA 5-Year Warranty Projects

- 5 Projects Constructed in 2002 - 04
  - 4 – Wet Process (Fresno-33, Ventura-150, Merced-140, San Deigo-75)
  - 1 – MB-D (terminal) (Lassen-395)
- Level Playing Field
  - 15% CRM
  - Open specifications
  - 5-Year Performance Warranty Criteria include
    - > Rutting
    - > Cracking
    - > Delaminating
    - > Bleeding
    - > Potholing
- Regular Review and Evaluation

Fresno-33

- **Fresno-33 (Firebaugh, 9 test sections, June 04)**
  - **DGAC (90 mm)**
  - **RHMA-G (45 mm, 90 mm)**
  - **RUMAC (45 mm, 90 mm)**
  - **MB-G (45 mm, 90 mm)**
  - **MB-D (45 mm, 90 mm)**

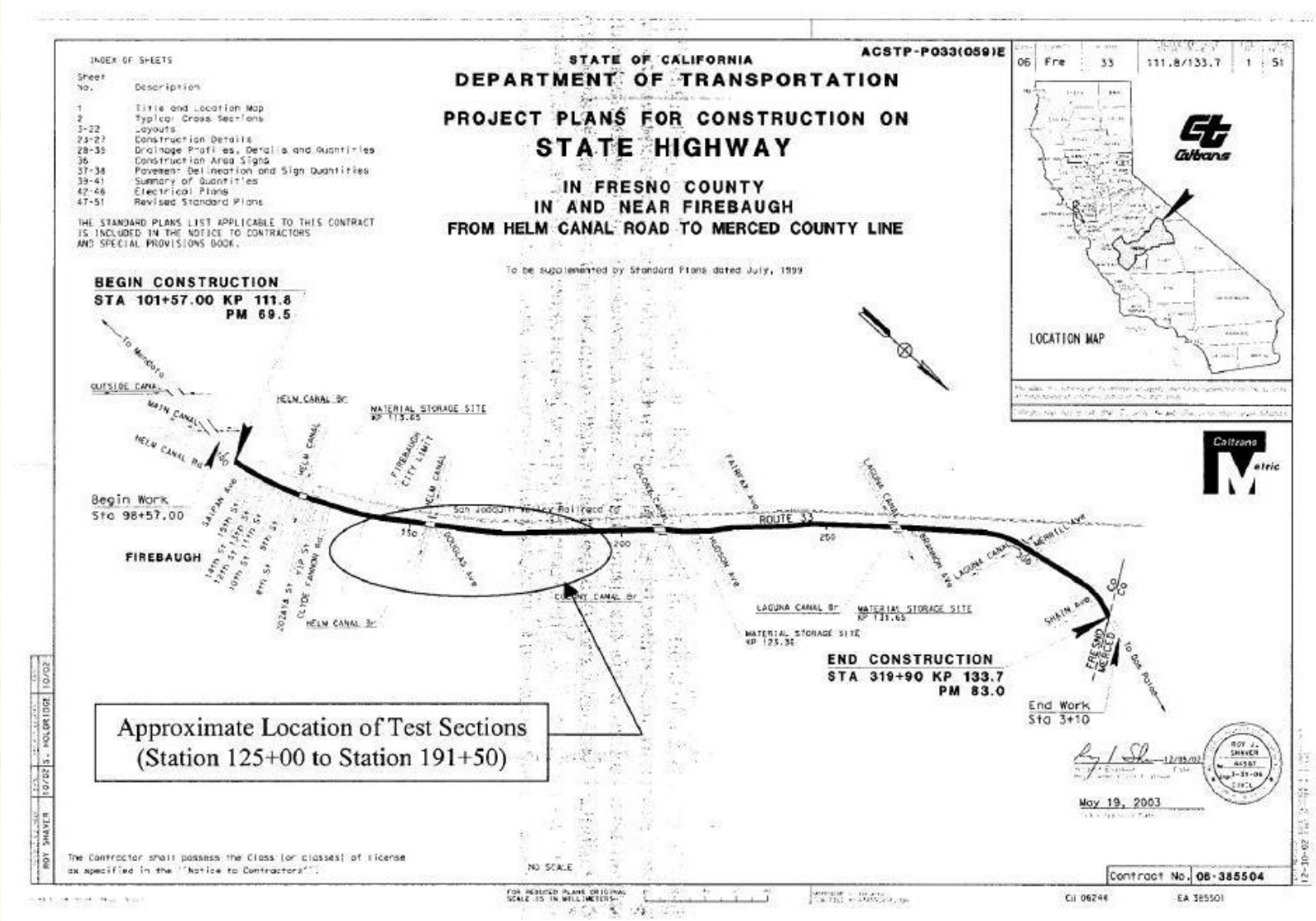
    - *Performance evaluation sections*
    - *Laboratory performance tests*
    - *Comparison to HVS*

Firebaugh Background

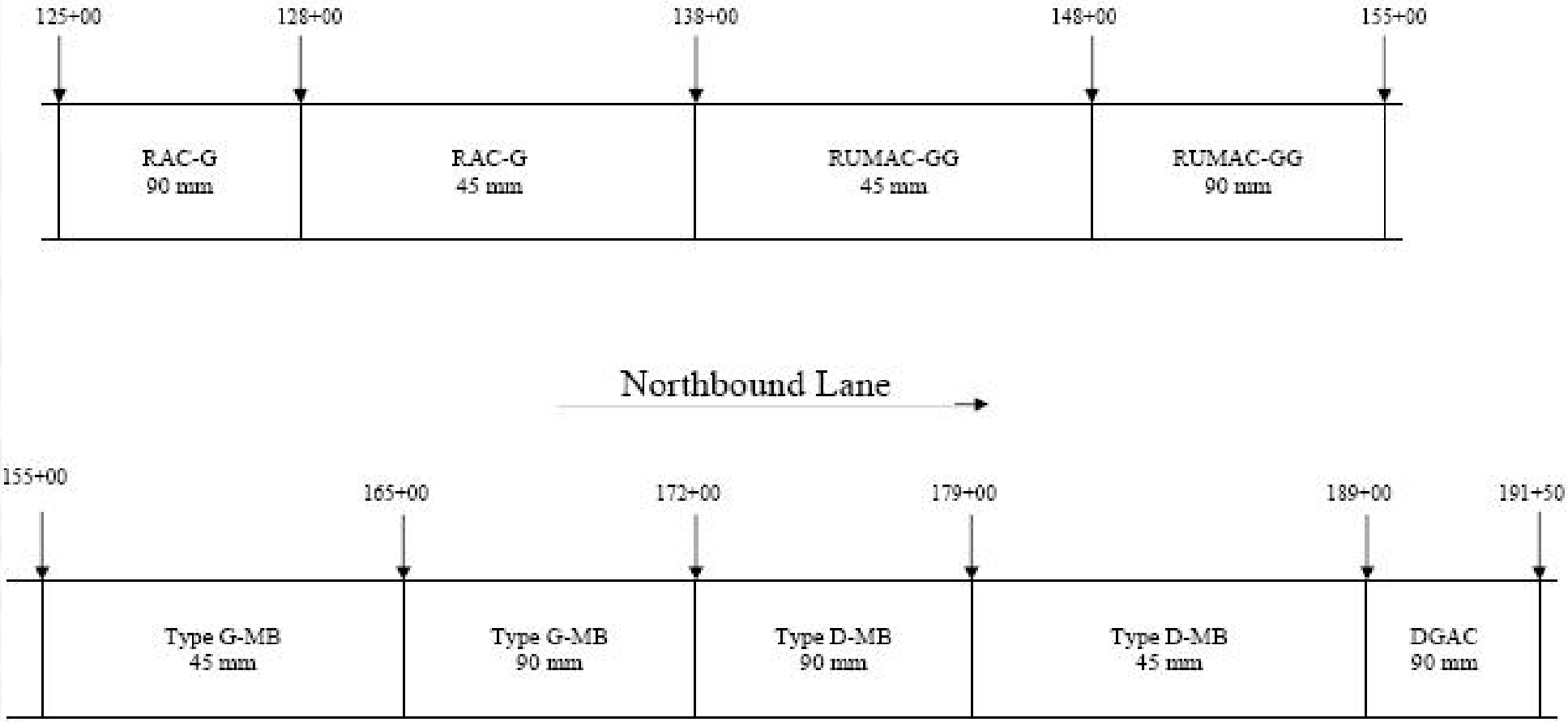
- In 2004 Caltrans, with funding provided by the California Integrated Waste Management Board (CIWMB) launched a full scale experimental design and construction project using rubberized asphalts as an overlay on existing distressed pavement sections.

- The main focus of this project was to observe the field performance of various mixes of RHMA with different thicknesses, and to evaluate the constructability of the RHMA mixes.

Fresno-33 (Firebaugh)



Fresno-33 (Firebaugh), Test Sections



Test Section Mixes

Material Type	Section	Process	Thickness (mm)	Length (m)	Test Section		PES Location	
					Begin	End	Begin	End
RAC-G	1	Wet	90	300	70.956	71.143	70.985	71.080
	2		45	1000	71.143	71.764	71.391	71.486
RUMAC	3	Dry	45	1000	71.764	72.386	72.100	72.195
	4		90	700	72.386	72.821	72.495	72.590
MB-G	5	Terminal	45	1000	72.821	73.442	73.000	73.095
	6		90	700	73.442	73.877	73.500	73.595
MB-D	7	Terminal	90	700	73.877	74.312	74.055	74.150
	8		45	1000	74.312	74.934	74.500	74.595
DGAC	9	Control	90	13000	74.934	83.069	75.000	75.095

- (RAC-G) – Rubberized Asphalt Concrete, Gap Graded (Wet Process)
- (RUMAC) - Rubber Modified Asphalt Concrete, Gap Graded (Dry Process)
- (MB-G) - Type-G Modified Binder (terminal blended wet process)*
- (MB-D) - Type-D Modified Binder (terminal blended wet process)*

* - The project specifications required the MB binders to have at least 15% rubber by weight of asphalt.

Fresno-33 (Firebaugh) Existing Pavement Distresses

Firebaugh Construction

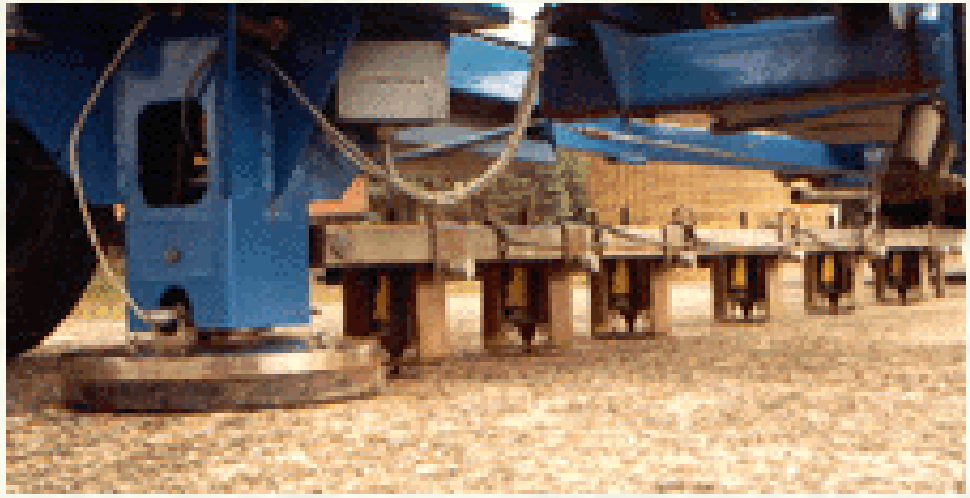
- **Paving began in April 2004 and was concluded in June of 2004**

Heating of Type D-MB Transverse Joint with a Blowtorch prior to Paving Type G-MB

Windrow of Type G-MB

Evaluation of Field Results

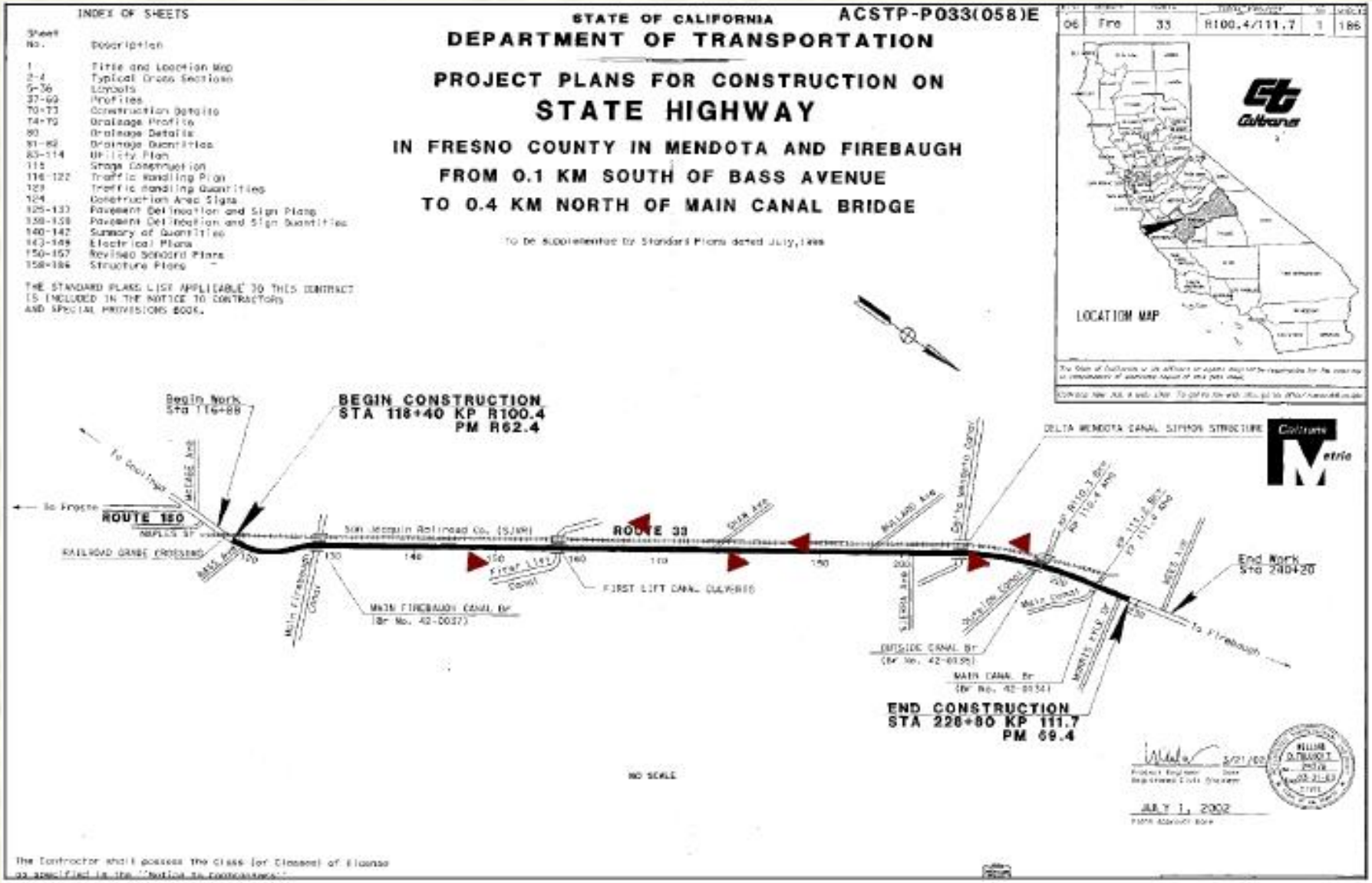
- Three rounds of post-construction performance monitoring were conducted on the project. FWD (Falling Weight Deflectometer) testing was performed during all three rounds.
- Within each project, four to nine 152-meter performance evaluation sections (PESs) were established for long-term performance monitoring.



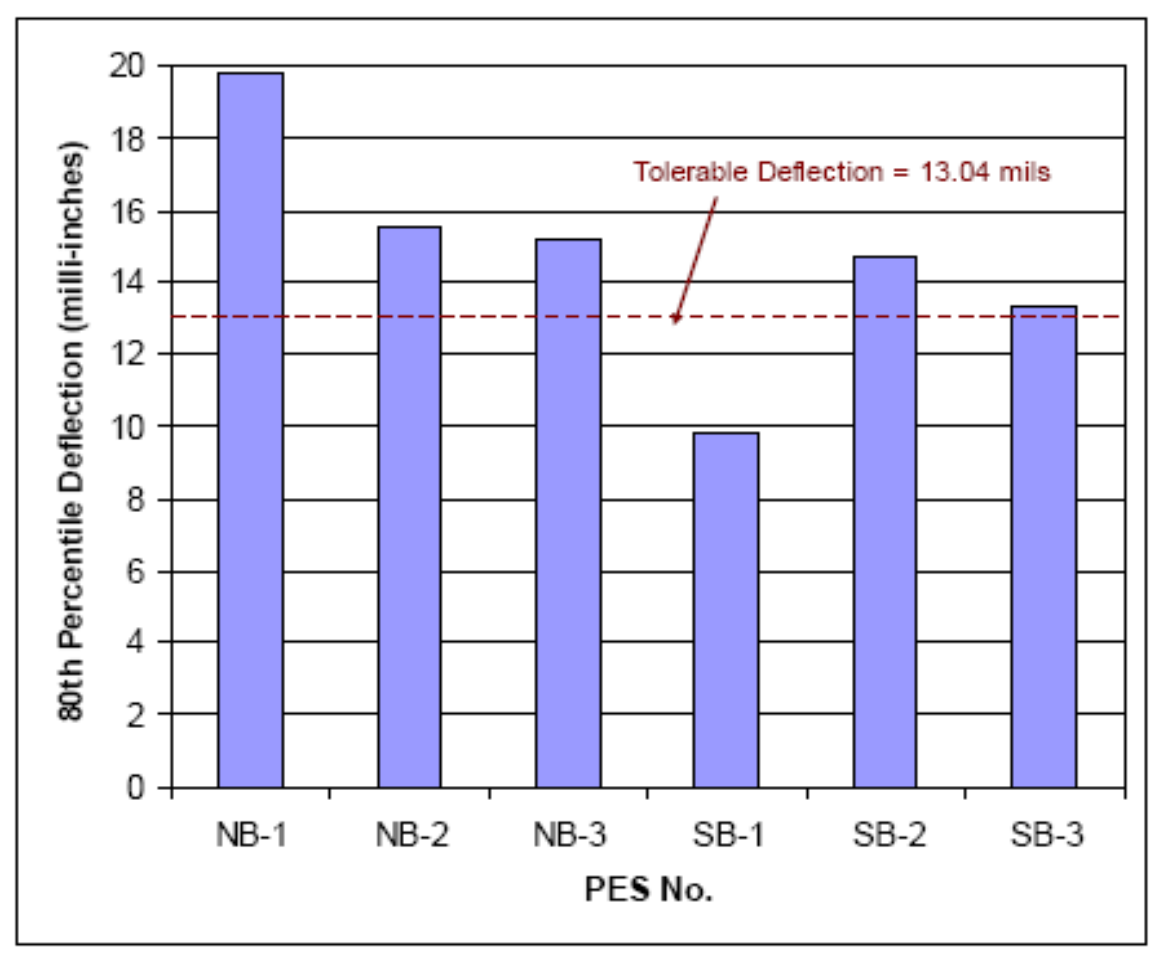
Evaluation of Field Results

- A condition survey took place during the last round of the three round evaluations.
- Detailed pavement condition surveys – Distress surveys were conducted according to standard Caltrans definitions for distress type, severity, and extent.
- The surveys involved measurements of rutting, cracking, raveling, flushing, and other distresses as well as digital photographs.
- The tests and surveys serve as key components of the performance monitoring program.

Firebaugh Test Section Locations

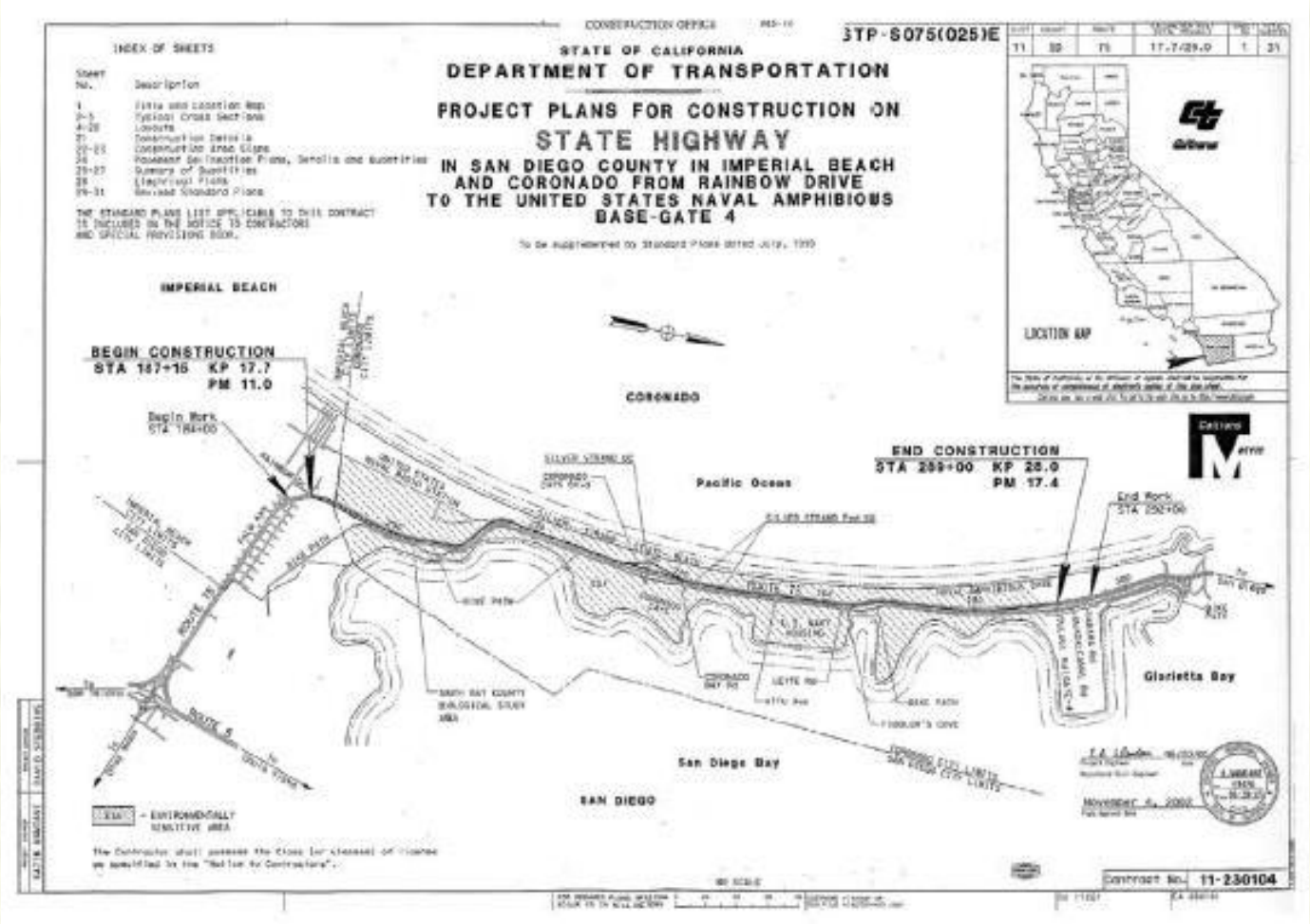


Firebaugh Results



- The bar graph compares the 80th percentile deflections with the tolerable value.
- Those that have an 80th percentile deflection greater than the tolerable value are considered structurally inadequate and less likely to survive the 10-year design period.

SAN DIEGO COUNTY, HIGHWAY 75



The San Diego RAC Warranty project is located along the two southbound lanes and shoulders of State Highway 75, District 11, San Diego County, between Coronado and Imperial Beach, CA. The project extends 6.4 miles.

Highway 75 Distressed Pavement

San Diego 75, Design Considerations

- The project area is located within the Caltrans "South Coast" climatic area. Precipitation, temperature, and traffic volume data were the key factors used to develop a mix design and pavement thickness.

San Diego Temperature and Precipitation Data

Element	Annual
Average Max Temp (°F)	69.9
Average Min Temp (°F)	56.4
Average Total Precipitation (in)	10.22
Average Total Snow Fall (in)	0.0
Average Snow Depth (in)	0.0

San Diego 2003 Annual Average Daily Truck Traffic Data (AADT)

Post Mile	Kilo Post	Leg	Description	Vehicle AADT Total	Truck AADT Total	Truck % Total Vehicle	EAL 1-Way (1000)	Year Ver/Est
9	14.5	A	SD JCT RTE 5	71000	2130	3	151	85V
18.47	29.7	B	CORONADO POMONA AVE	30000	570	1.9	51	86E
19.586	31.5	B	JCT RTE 282	32000	768	2.4	46	84V
19.586	31.5	A	JCT RTE 282	26000	884	3.4	81	86E

Ver=Verified; Est=Estimated

Structural Design Considerations

- Caltrans engineers determined a 60 mm gap-graded rubberized asphalt concrete (RAC-G) overlay was necessary to achieve desired results

Materials and Mix Design

- The asphalt rubber binder was an AR-4000 with 20% CRM (75% scrap tire and 25% high natural) and 3% extender oil

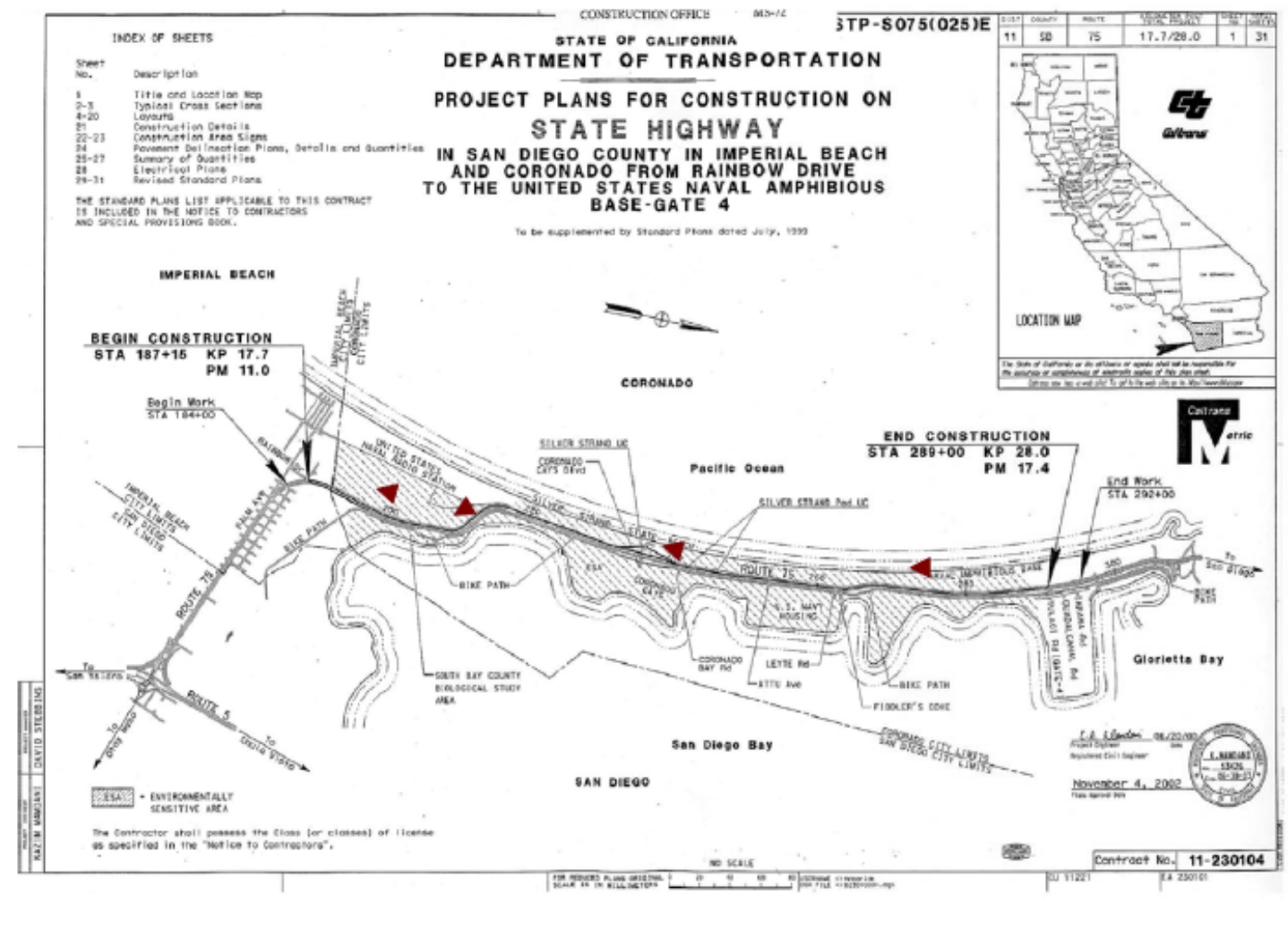
San Diego 75, Construction

- **Paving took place between April 25 2003 and May 15 2003.**
- **The Equipment used is shown in the table bellow.**

San Diego RAC Paving Equipment

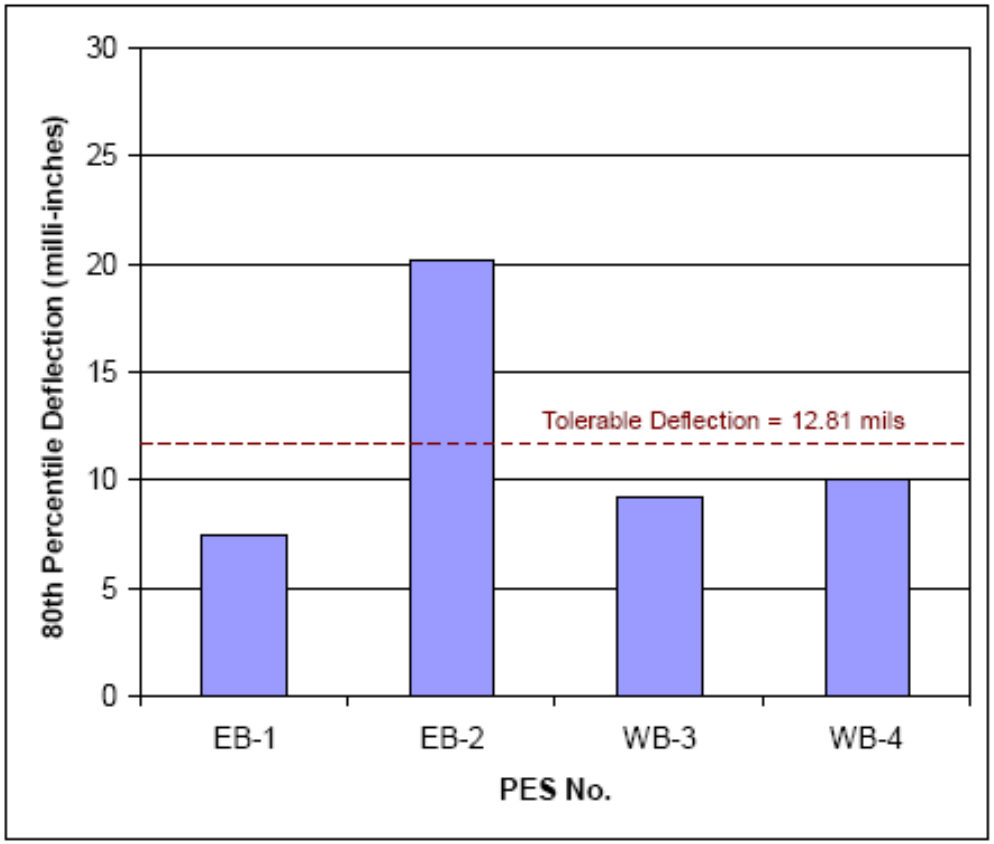
Make	Type	Model
Merle Husky/Cat	Vibratory Paver	Model AP 1055B
Caterpillar	Steel Wheel Vibratory Roller	Model CAT 364C
Ingersoll Rand	Steel Wheel Vibratory Roller	Model DD110
Teamstar	2000 gal Tack Truck	
Terra Gator	Sanding Truck	1603T
	R/T Backhoe w/ Spreader Box	
Brace	Brace Broom	BD250B

Field Observations and Results



- **Location of PESs**

Field Observations and Results



- The graph indicates that three of the four PESs have 80th percentile deflections that clearly satisfy the tolerable deflection criteria.
- The pavement can be expected to provide good structural performance over the 10-year design period.

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 asphalts

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
- RHMA-G SSP Version (12-12-05)
- RHMA-O SSP Version (12-12-05)

http://www.dot.ca.gov/hq/esc/Translab/fpmlab/Caltrans_CIWMB%20Project%20T021%20Deliverables.htm

Summary of Module 1

- Course Objectives and Content
- History of RHMA
- Caltrans Experience with RHMA
- Advantages of RHMA
- References

Module 2: Structural Design

New Pavements and Overlays

Module 2: Outline

- Terminology
- Caltrans Practices
- 2005 Study
- Revised Caltrans Practices
- RHMA Project Selection
- Cost Analysis

Terminology

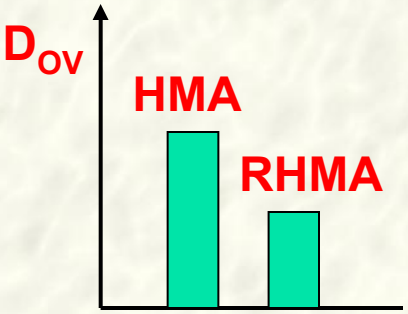
- Hot-mix asphalt (HMA) replaces the term dense-graded asphalt concrete (DGAC)
- Caltrans Highway Design Manual (HDM)
- Caltrans Flexible Pavement Rehabilitation Manual (FPRM)
- Asphalt Rubber Usage Guide (AR Guide)
- Mechanistic-empirical (M-E) based analysis and design

Caltrans Practice – 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 prior to pavement design

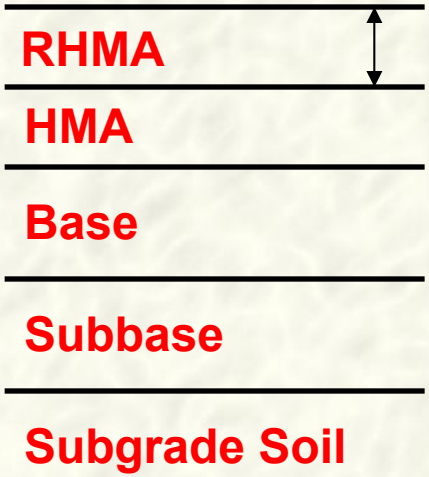
Caltrans Practice – Overlays

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



2005 Study

- How should RHMA be used in new pavements?
- Can RHMA-G thickness be increased more than 60 mm?
- Does 2:1 thickness reduction for RHMA-G provide adequate structural equivalency in overlays?

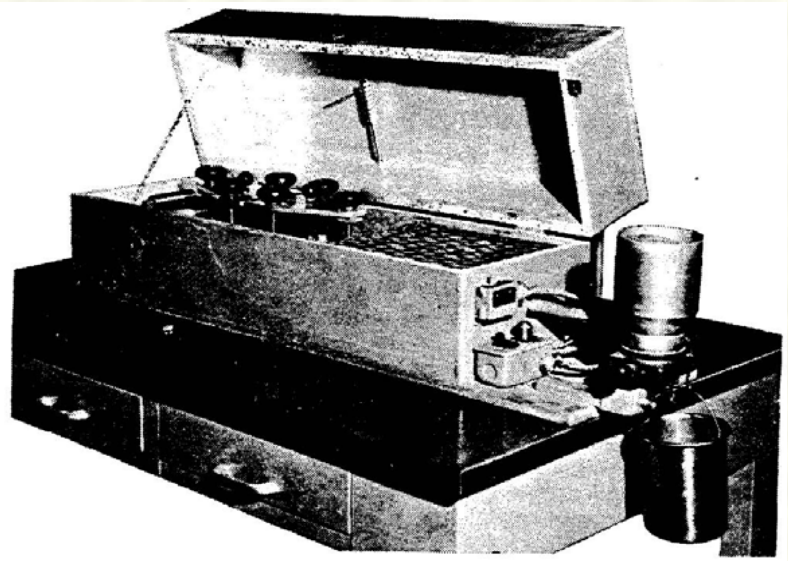


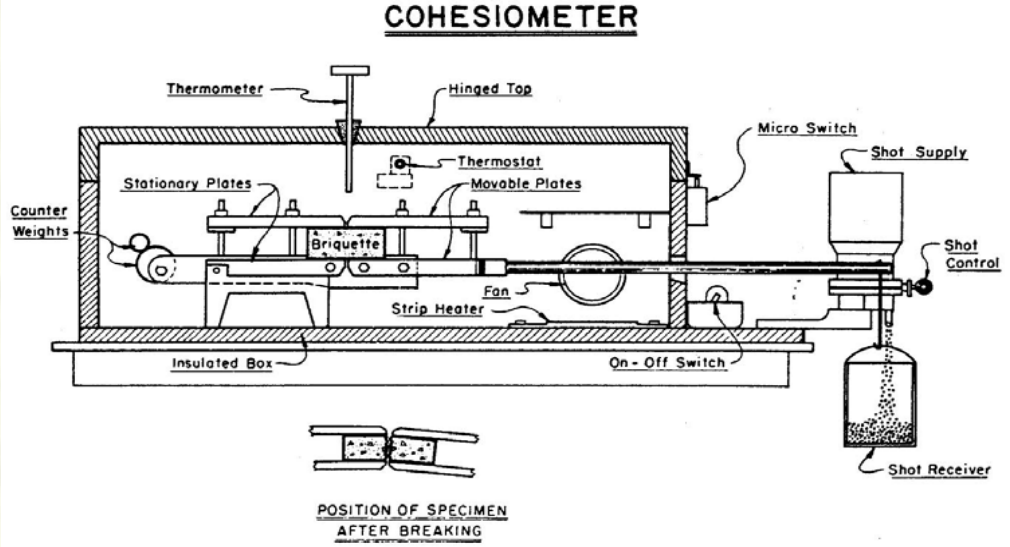
2005 Study

- Joint effort between Caltrans, UCPRC, 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 RHMA and HMA are similar.**

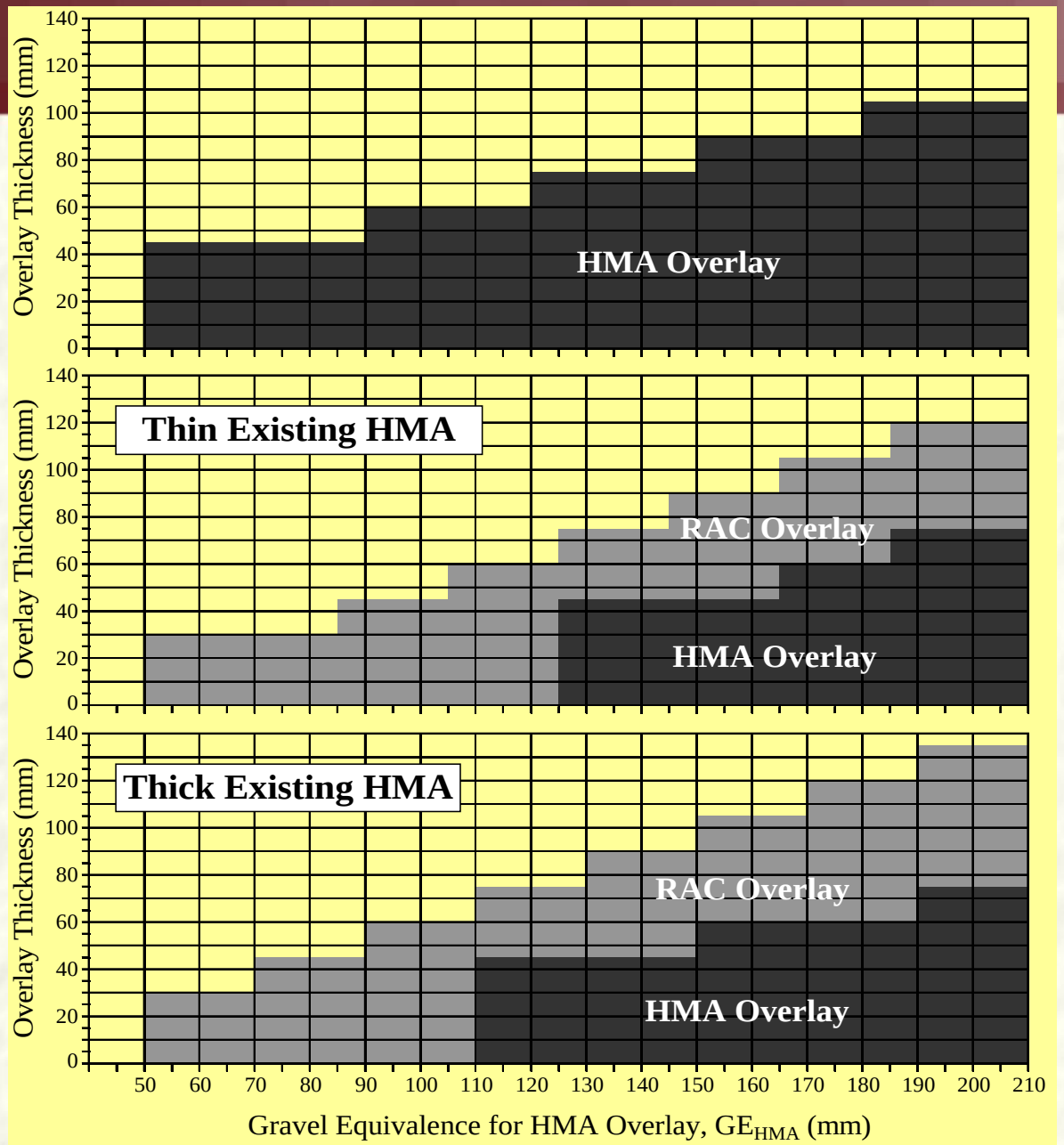




Primary Findings – Structural Overlays

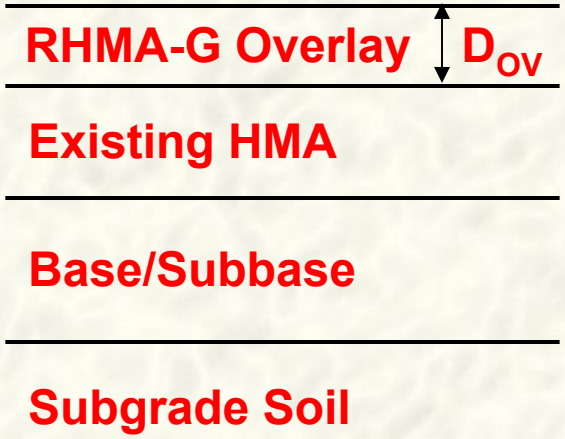
- Based on M-E analysis, the structural benefit of the RHMA-G overlay varies with the thickness placed. The greatest benefit occurs in a thin layer of 30 mm to 60 mm thick as compared to HMA of the same thickness.
- The use of reduced thickness for RHMA-G overlay is valid; however, not to the extent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

Simplified Overlay Thickness Design Charts

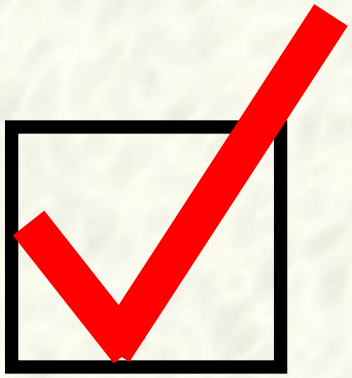


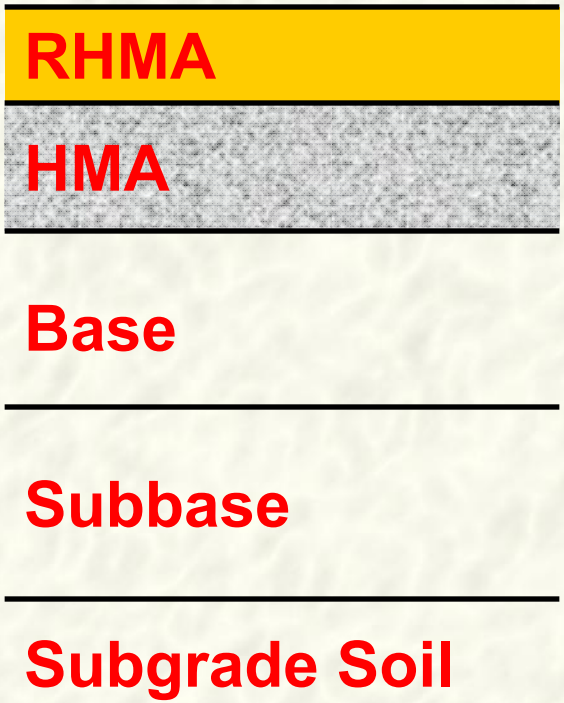
Recommendations – Structural Overlays

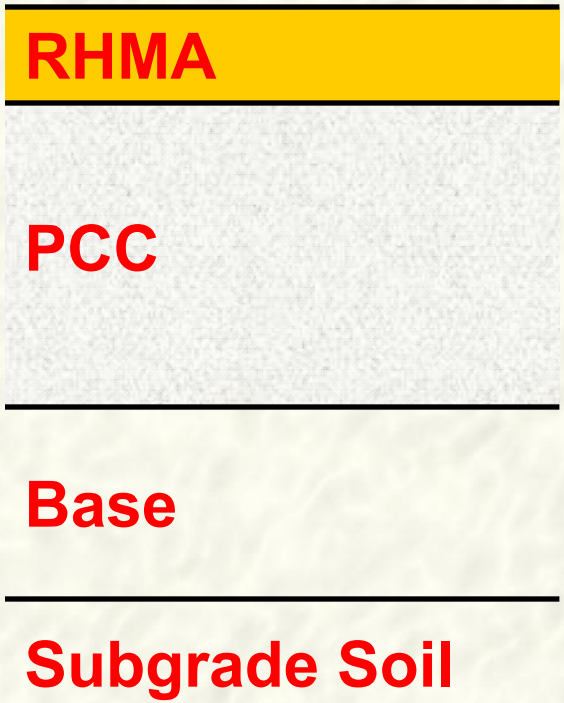
- Calculate GE for HMA using current methodology and determine structural overlay
- Design RHMA-G overlay in a range of 30 to 60 mm to achieve most structural benefit



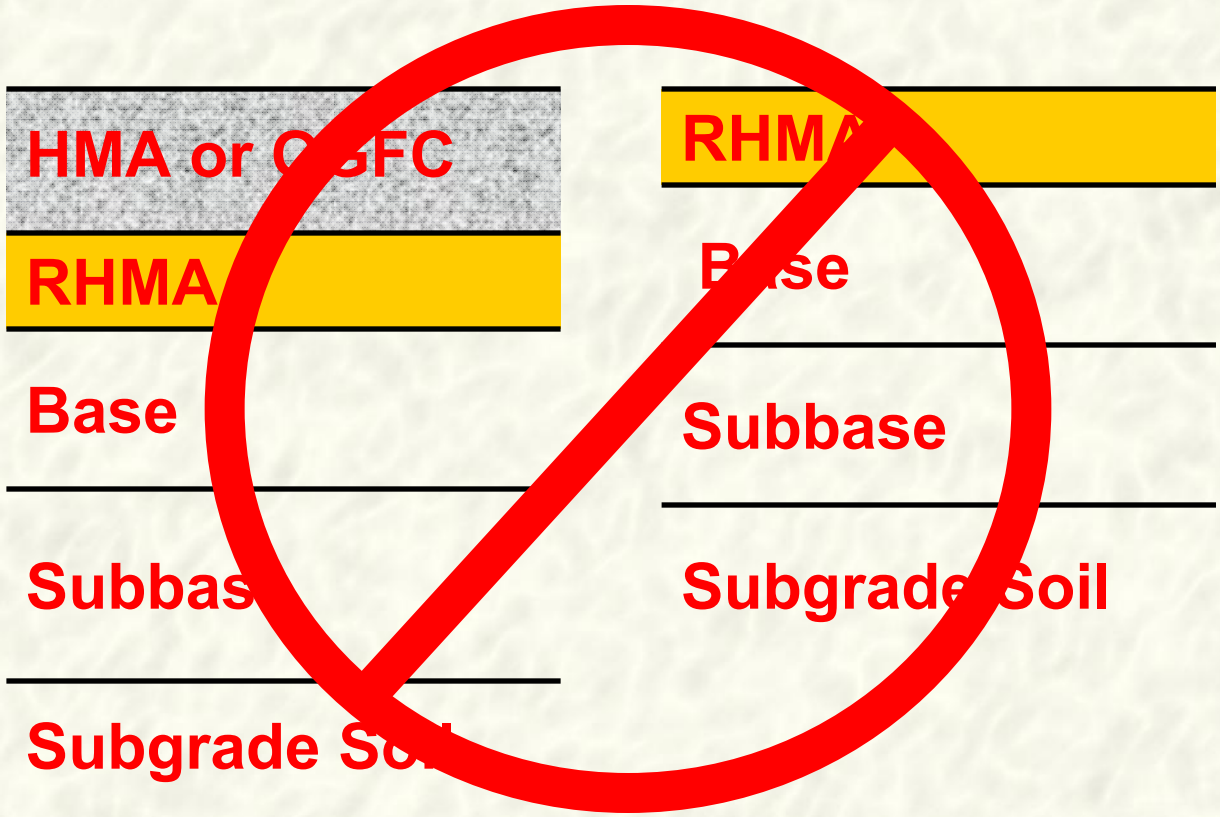
RHMA Usage in New Pavements







RHMA Usage in New Pavements

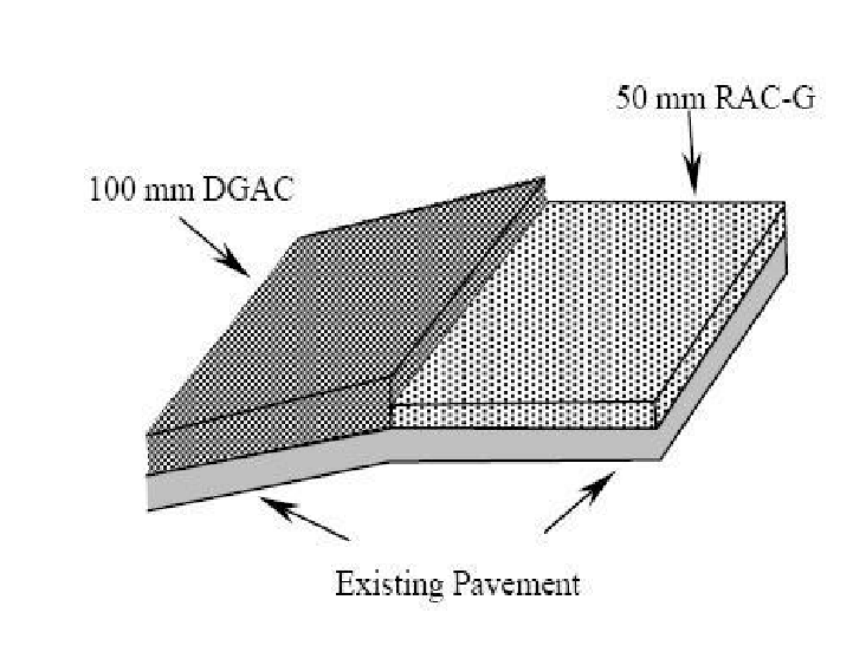


RHMA Usage in New Pavements

Material Type	Max Thickness
RHMA-G	60 mm
RHMA-O	45 mm
RHMA-O on RHMA-G	45 mm on 60 mm

Revised Practice – New Pavements

- Place on top of conventional HMA or PCC. Do not place directly over aggregate base (treated or non-treated), subbase, or native soil.



Revised Practice – New Pavements

- Place gap-graded RHMA (RHMA-G) no thicker than 60 mm and open-graded RHMA (RHMA-O) no thicker than 45 mm. Up to 45 mm of RHMA-O may be placed on top of 60 mm of RHMA-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 RHMA is used. Pavement thicknesses for rehabilitation can be reduced with RHMA for reflective cracking only. Reflective cracking is not an issue for new construction.

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 (G_f)
  - Reflective cracking (table for equivalencies)
  - Ride quality can be evaluated based on the pavement's smoothness

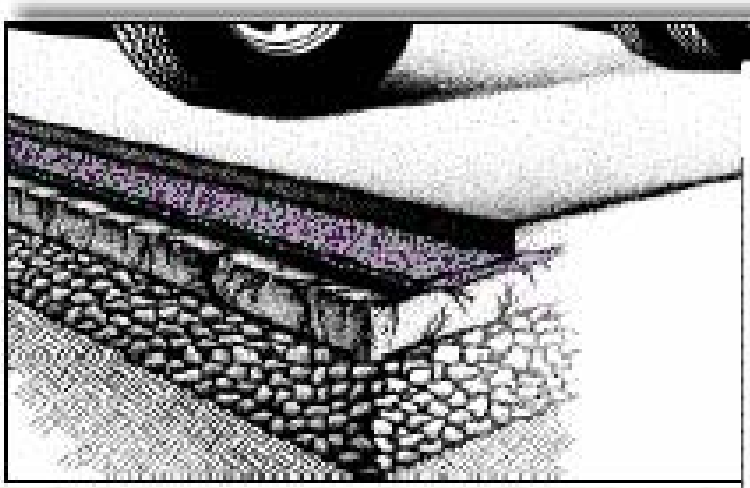
Layer Thickness Equivalencies for Reflective Crack Retardation

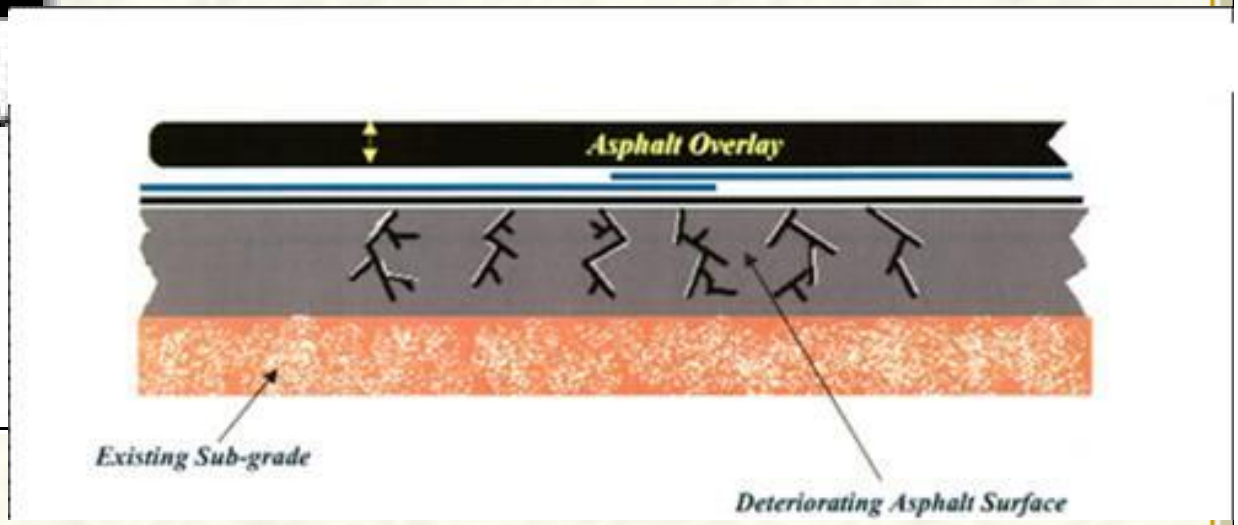
HMA	RHMA-G	RHMA-G on SAMI-R
45 mm	**30 mm**	
60 mm	**30 mm**	
75 mm	**45 mm**	
90 mm	**45 mm**	
105 mm	▪ **45 mm, if CW < 3 mm** ▪ **60 mm, if CW ≥ 3 mm, or if underlying material is CTB, LCB, or PCC**	▪ **N/A for CW < 3 mm** ▪ **30 mm, if CW ≥ 3 mm and underlying material is untreated** ▪ **45 mm, if CW ≥ 3 mm and underlying material is CTB, LCB, or PCC**

Note: CW = Crack Width

RHMA Project Selection – Overlays

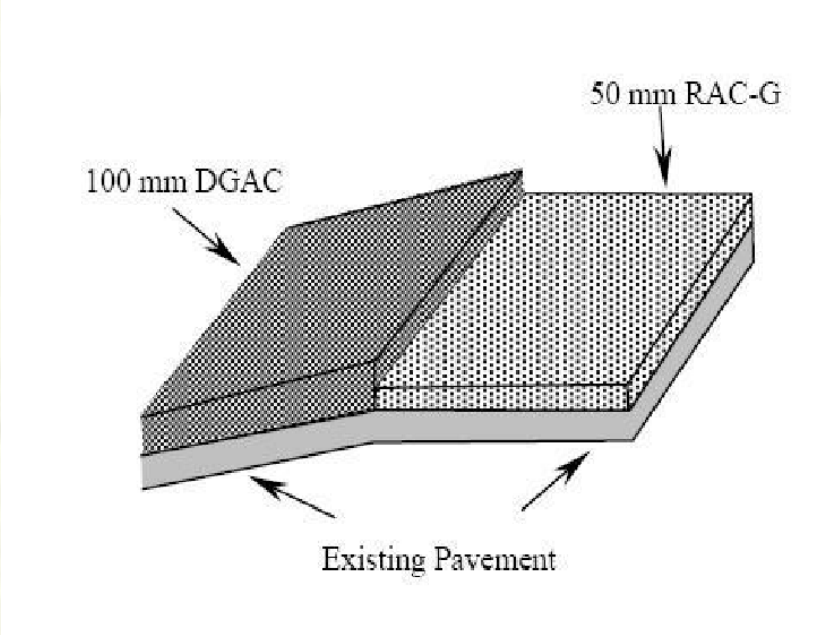
- Overlay projects are the best candidates for the use of RHMA mixes because existing pavement helps satisfy cover requirements

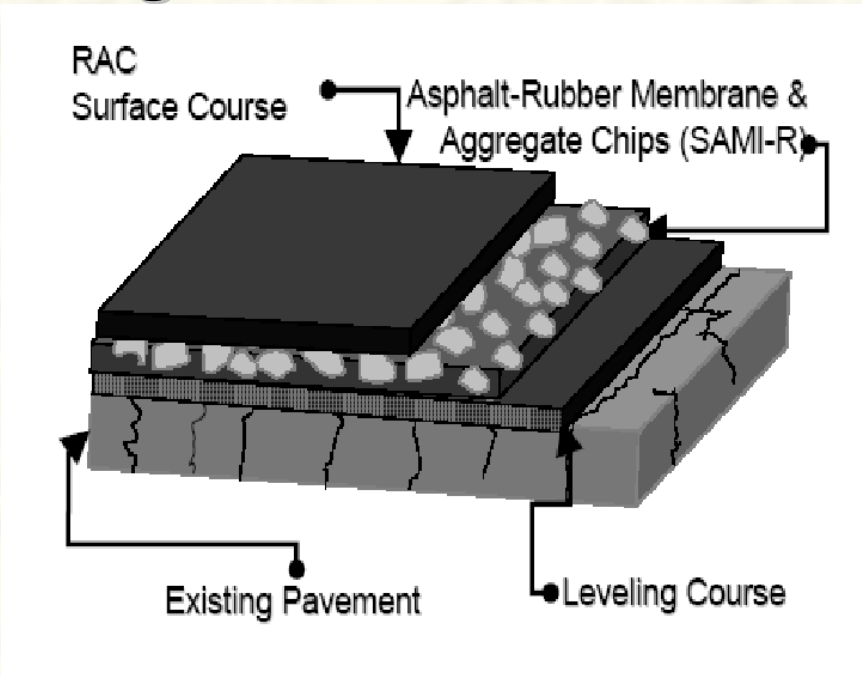




RHMA Project Selection –Overlays

- **If existing pavement is structurally sound and surface cracking is the predominant distress, RHMA-G thickness may be reduced up to half of the designed HMA thickness for controlling reflective cracking**





RHMA Project Selection – Mill & Overlay with RHMA

- Projects in which a certain amount of the existing HMA surface is to be removed and replaced <u>are</u> valid candidates for RHMA

- Follow the mill and overlay procedure in HDM, check for:
  - Structural adequacy
  - Reflective cracking
  - Ride quality (sufficient)

Cost Analysis – Initial Cost

- 2008 unit costs: $96/ton for HMA vs. $115/ton for RHMA.
- Costs for both HMA and RHMA will be higher in 2009.
- In general, initial costs are high; however, reduced layer thickness results in lower costs
- Experienced contractors and engineers help keep cost of RHMA low and quality high

Cost Analysis – LCCA

- LCCA – life cycle cost analysis
- Available information indicates that RHMA is (in general) cost-effective in the majority of cases when compared to conventional HMA rehabilitation and maintenance strategies.

Cost Analysis – LCCA

- Caltrans has developed 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, RHMA)
  - By M&R design life

Cost Analysis – LCCA

- Caltrans procedure also includes overall rehabilitation construction unit cost for various strategies
- The Caltrans LCCA procedure was ready for use by the end of June 2006

Summary of Module 2

- Caltrans Practices
- 2005 Study
- Revised Caltrans Practices
- RHMA Project Selection
- Cost Analysis

Module 3: Construction

Manufacture, Delivery, Placement, and Compaction

Module 3: Outline

- Construction Overview
- Surface Preparation
- Manufacture
- Mix Delivery (Hauling)
- Placement
- Compaction
- Specifications/SSPs

Construction Overview

FOCUS: RHMA surface courses

- **RHMA-G, RHMA-O, and RHMA-O-HB**
- **RHMA placement very similar to typical dense-graded AC overlays, except:**
  - **Typically requires higher placement and compaction temperatures**
  - **For RHMA-G, use vibratory mode for breakdown passes and get 95% of required compaction during breakdown**
  - **Not amenable to handwork**
- **Good practices are required for RHMA production and construction, as for HMA.**

Surface Preparation

GOAL: Provide surface conditions that promote performance of the new RHMA surface.

Same activities as for HMA:

- **Address existing distress**
  - **Seal cracks**
  - **Remove and replace failed pavement**
- **Improve smoothness**
  - **Fill ruts, level, restore or adjust profile**
- **Assure bond with underlying layers**

Surface Leveling

- Techniques
  - Cold milling, cold planing, grinding
  - Leveling course (HMA)
  - Rut filler

Clean and Sweep

- To promote good bonding, mill or grind surface, and remove debris from repaired areas prior to placing overlay
- Wash if necessary
- Make sure surface is dry before overlaying

Apply Tack

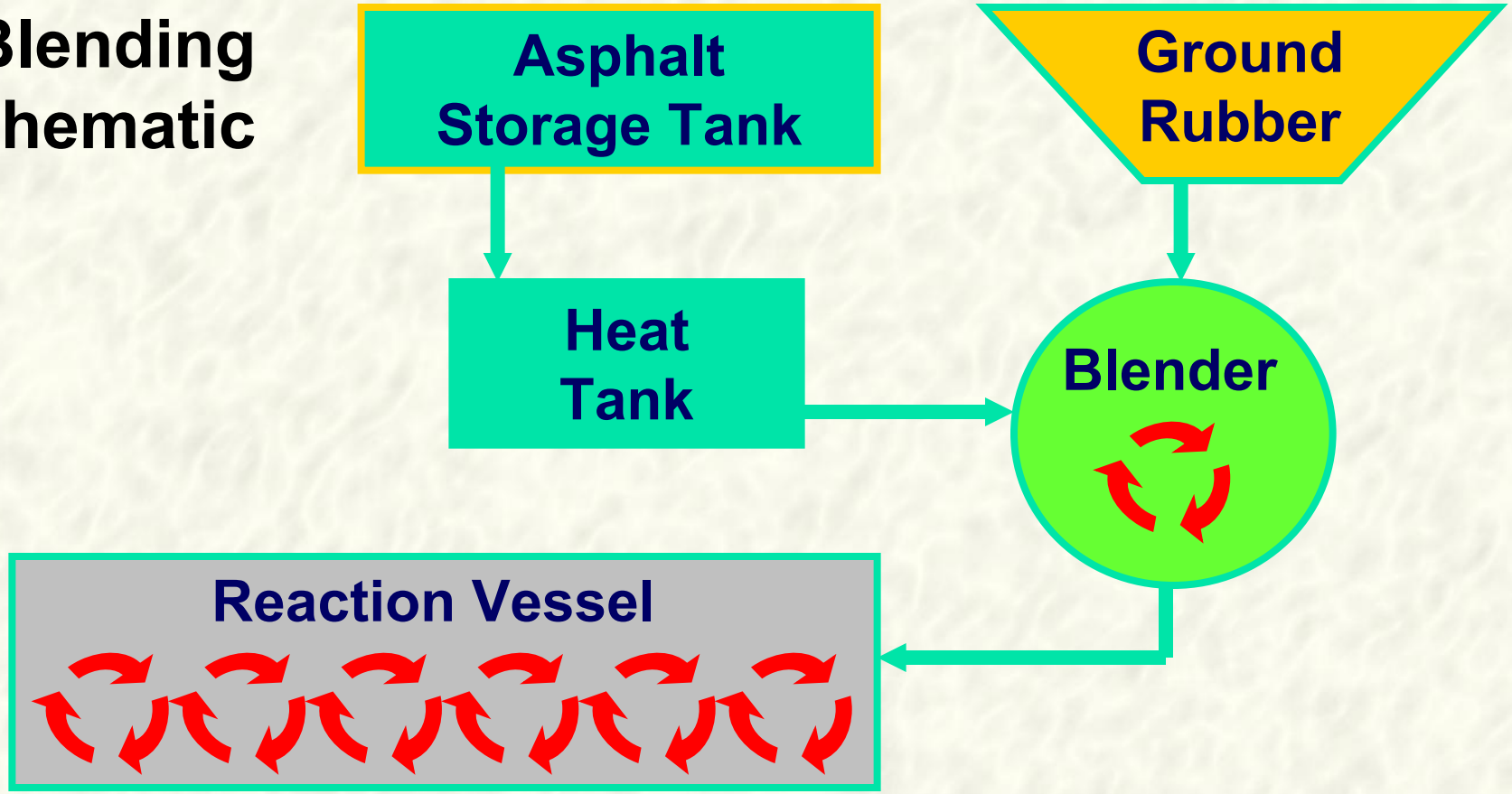
Purpose is to bond pavement layers together. Paving grade asphalt binder preferred for RHMA.

Manufacture

- Primary difference from normal AC plant operations is on-site manufacture of high viscosity asphalt rubber binder.

AR Binder Production Process

Blending Schematic



CRM comes in nominal 2,000 lb "Supersacks"

CRM is weighed in hopper

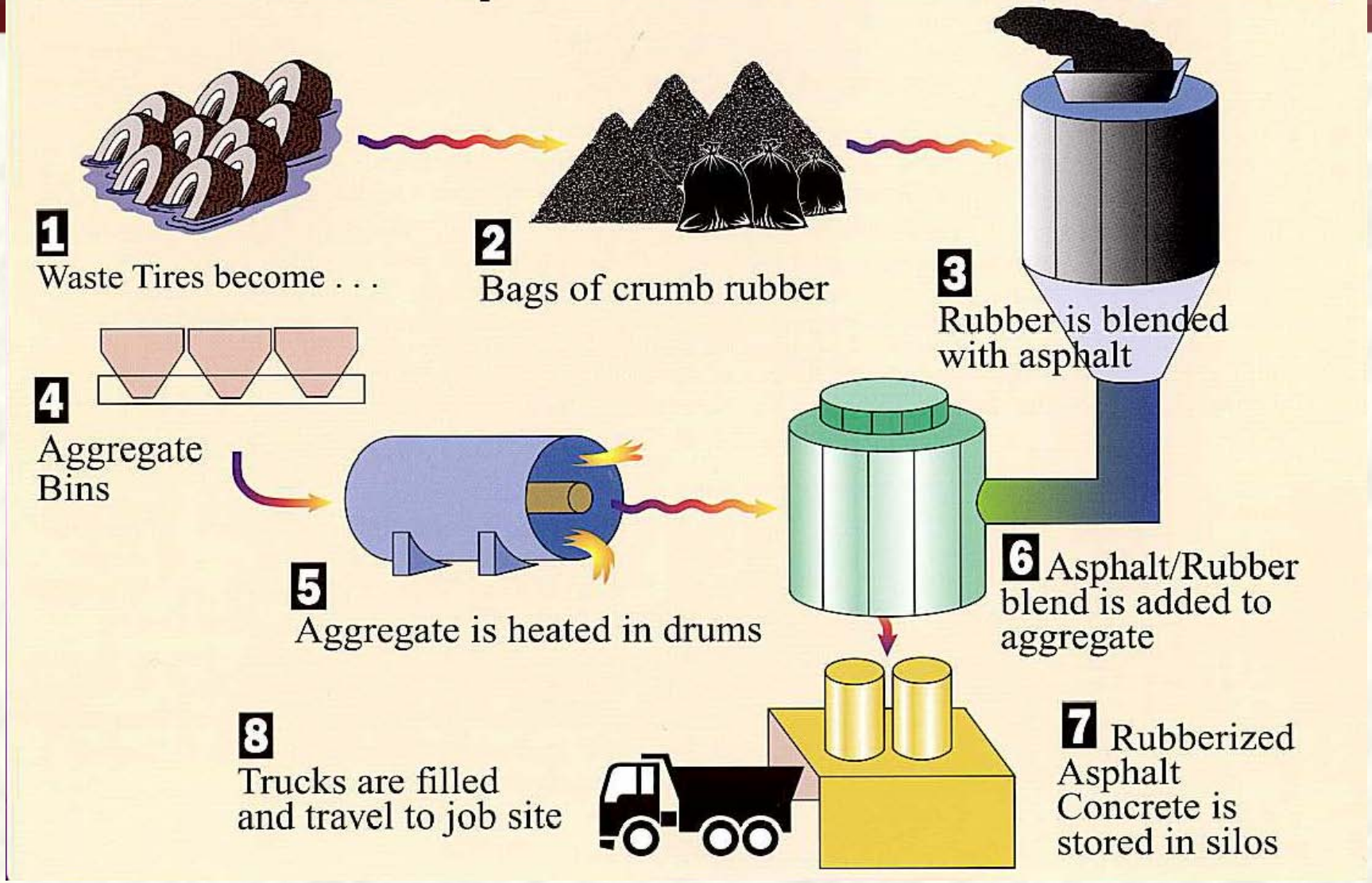
CRM is blended with hot asphalt cement

AR Blending Equipment & Interaction Tank

RHMA Mix Production

- Asphalt rubber binder feed is substituted for normal asphalt cement feed, interlocked and metered into the AC plant
- Little impact on AC plant operations
  - More than one AR binder plant can be used to maintain RHMA production at normal tph rate
  - Primary differences from HMA are in mixing and discharge temperatures
    - Aggregate mixing temperature range 300 - 325ºF
    - AR binder added at ≈ 375ºF

How Rubberized Asphalt Concrete Is Made (wet process)



Mix Delivery (Hauling)

- RHMA mix temperature is critical for placement and compaction
  - Trucks hauling RHMA mixes must be tarped for a long haul
  - Spread temperature 280-325ºF per Caltrans
  - Minimum temperature for start of breakdown rolling is 275ºF per Caltrans
  - Generous compared to other specifications: Green Book requires higher temperatures

Mix Delivery

As for HMA, to promote quality, smoothness, and uniform compaction, must balance all aspects of:

- Mix production (AC plant)
- Mix delivery (trucking)
- Paving operations (non stop)
- Compaction (keep up with the paver)

Mix Segregation

- Aggregate (particle size) segregation
  - RHMA-G may look segregated due to low fine's content – mix texture may look coarse and somewhat open.
    - Sample, test binder content and gradation to verify
  - Segregation causes non-uniform gradation and compaction, may yield interconnected air voids
  - Sources include mix loading/unloading and paver operation

Mix Segregation

- Techniques to reduce aggregate (particle size) segregation
  - Better mix gradations – not much help for RHMA-G or RHMA-O
  - Improved loading and unloading practices
  - Use material transfer vehicle – not always feasible

Thermal Segregation

- Often accompanies particle size segregation
- Results in non-uniform compaction
- Sources include:
  - Processes that result in uneven cooling (hauling, windrows)
  - Managing paver wings
  - Delays in mix delivery and/or placement

Thermal Segregation

- Techniques to reduce thermal segregation
  - Minimize time between loading and placement
  - Truck insulation and tarping
  - Proper paving procedures
  - Material transfer vehicle

Issues Related to Haul Trucks

- Types and characteristics
  - End dump
  - Belly (bottom) dump – do not use windrows when site temperatures are marginally cold
  - Horizontal discharge (live bottom)
- Insulation – tarps required
- Cleaning (truck bed) – NO SOLVENTS!
  - Soap for surfactant
- Truck maintenance

Truck Loading Practices

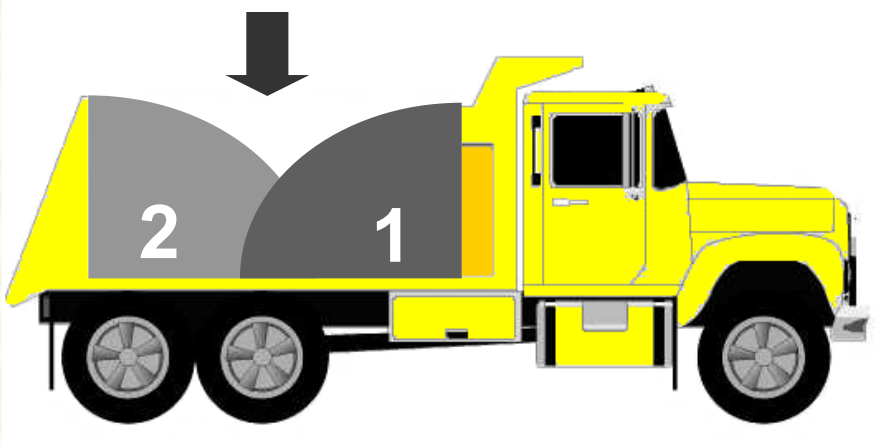
- Primary goal – Avoid segregation!

- What makes a mix prone to segregation?
  - Range of particle sizes, limited fines

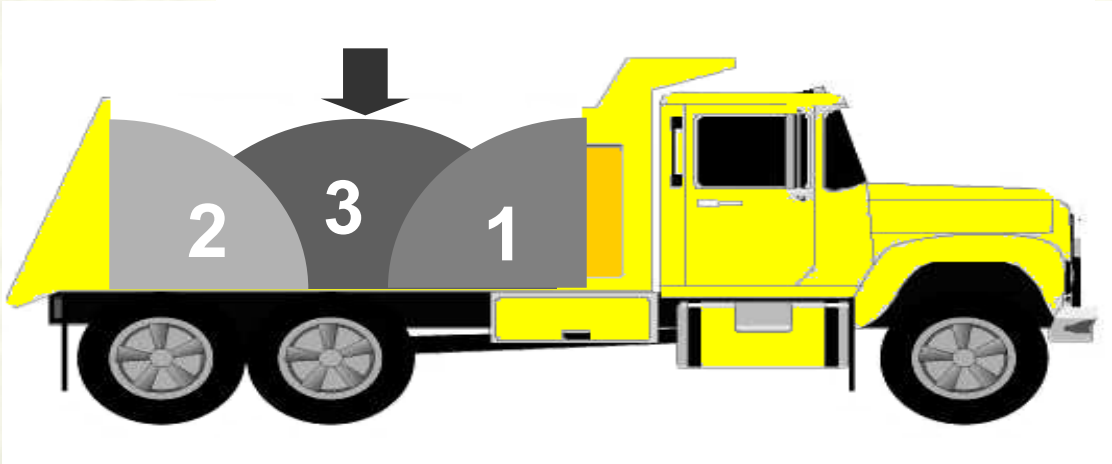
Truck Loading Practices

Preferred practice for end dump trucks:

Short

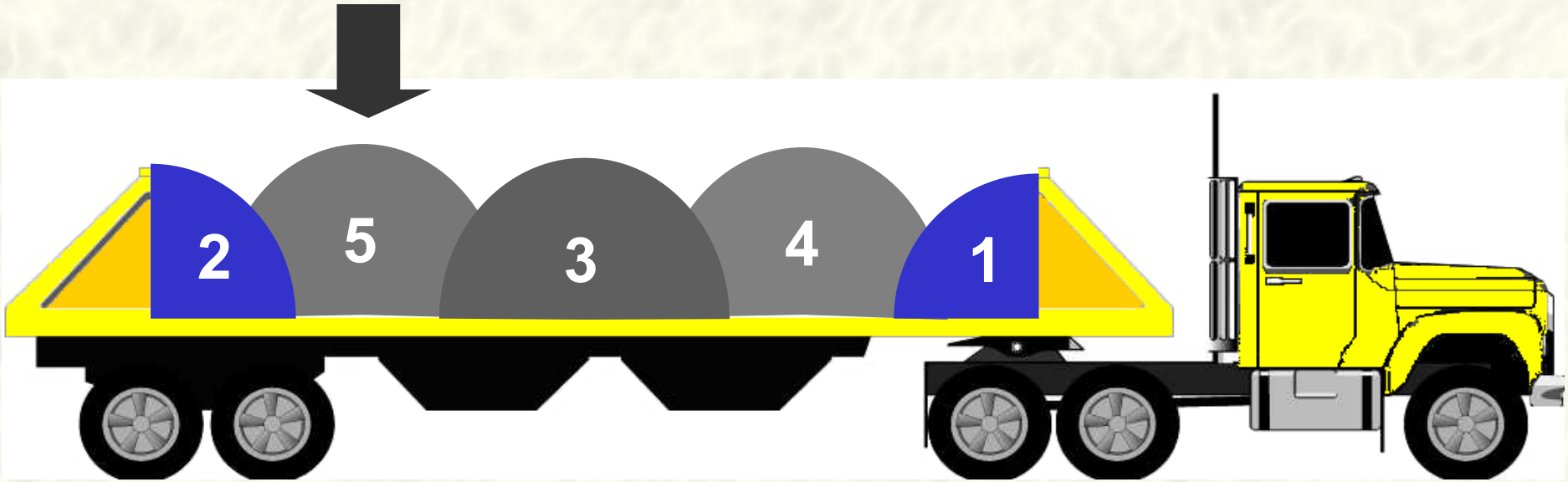


Long



Truck Loading Practices

Preferred practice for belly dump trucks:



Placement (Laydown)

- Purpose – Place mix smoothly at a uniform specified thickness conforming to plan slopes and grades at temperatures above a specified minimum
- Equipment – same as for HMA
  - Tractor unit (paver)
  - Screed unit
- Paver operation - same as for HMA
- Joints – good practices essential

Paver Operation

Use good practices!

References:

- **National Highway Institute (NHI) HMA Construction Course**
- **HMA Paving Handbook 2000**
- **Caltrans Construction Manual**

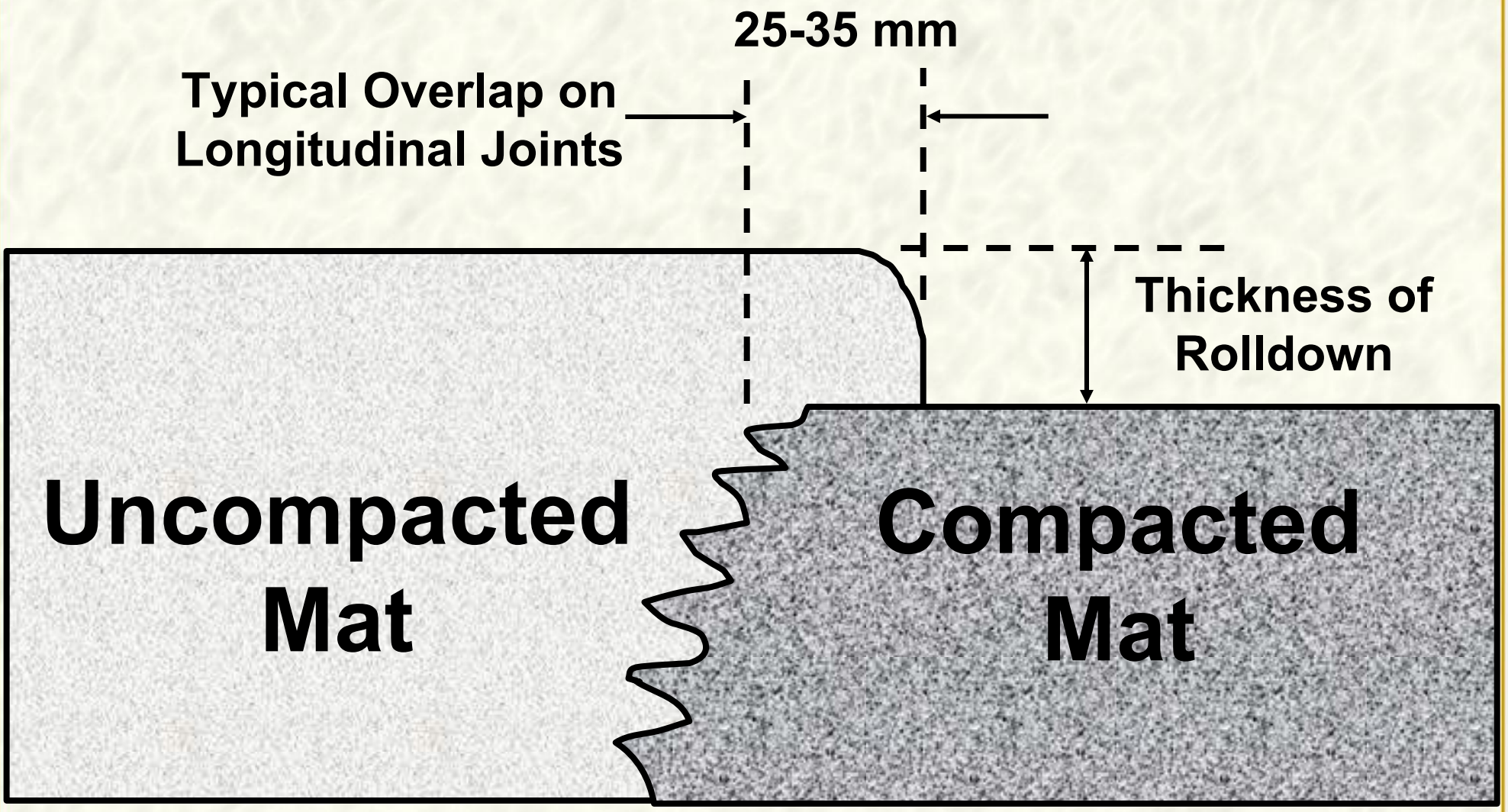
Handwork

- Minimize as much as feasible
- Coarse gradation, stiff binder make handwork difficult
- High temperatures necessary to maintain RHMA workability
- Typically yields coarse, open and rough looking appearance due to limited fines
- Minimize raking and luting
- Do not broadcast excess material

Joints

- Use good practices
- Difficult to feather RHMA mix due to limited fines
- Assume compaction reduces machine placement thickness by ≈ ¼-inch per inch
  - For hand placement, use 3/8-inch per inch difference
- Some raking unavoidable
  - Minimize as possible
  - Rake excess to hot side, not cold side

Joint Overlap



Compaction

Adequate compaction is required to achieve good pavement performance

- Improves resistance to rutting
- Reduces moisture/air penetration and related environmental damage
  - Oxidative aging (embrittlement, raveling)
  - Moisture damage (stripping)
- Improves fatigue resistance
- Reduces low temperature cracking potential
- Improves durability

Compaction

Key factors influencing compaction include:

- **Lift thickness**
- **Air temperature**
- **Base temperature**
- **Spread temperature of RHMA mix**
- **Wind velocity, humidity, & other site factors**
- **Sunlight or lack thereof**
- **Mix properties including binder content**

Temperature is the key to achieving RHMA compaction!

Compaction Temperature (RHMA)

- When air temperature is ≥55ºF,
  - Minimum temperature for starting breakdown rolling is 280ºF
  - Breakdown must be completed before mat temperature drops below 260ºF
- When air temperature is ≥ 65º,
  - Minimum temperature for starting breakdown rolling is 275ºF.
  - Breakdown must be completed before mat temperature drops below 250ºF

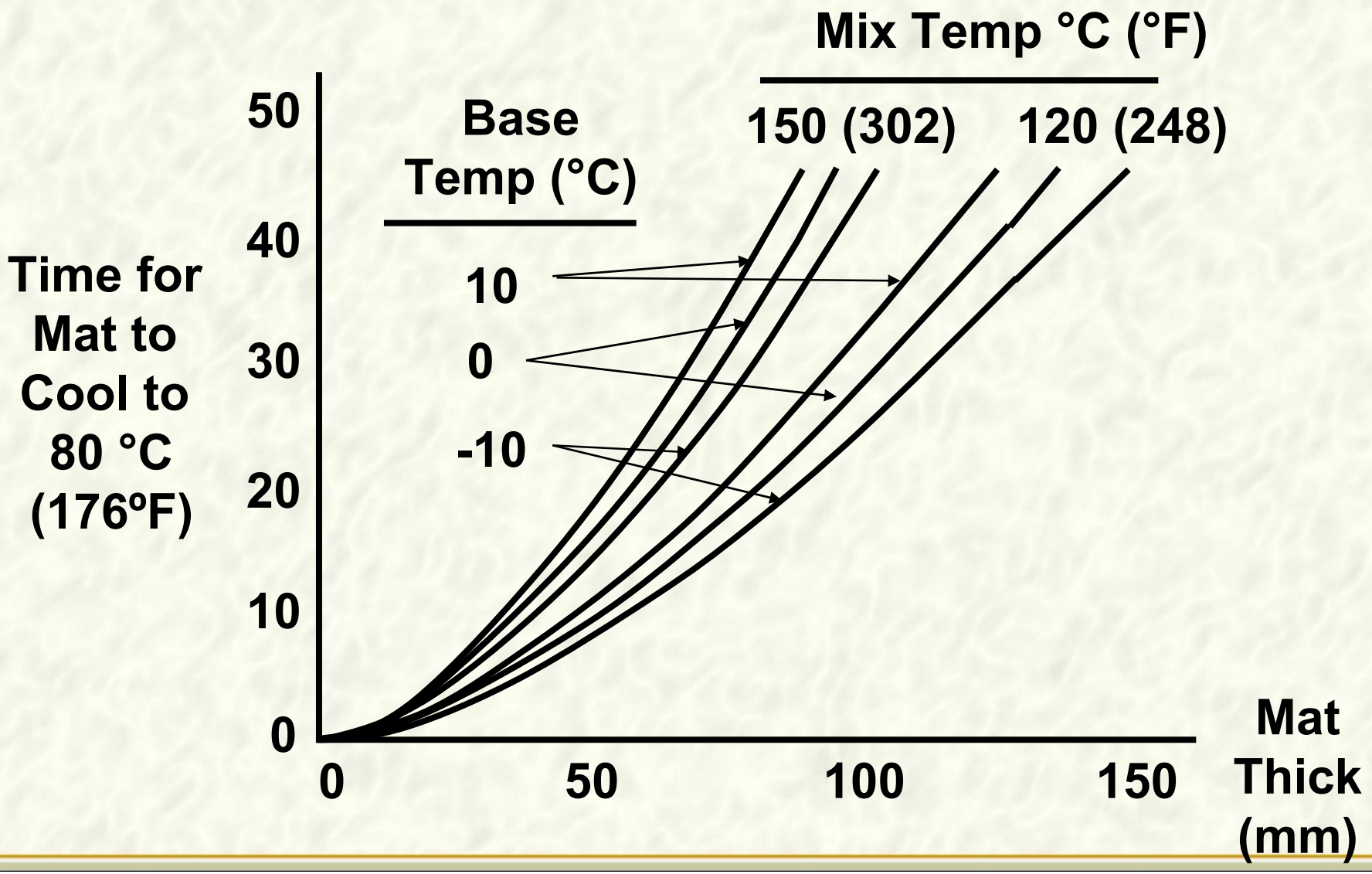
Compaction Temperature

- Specify the same temperatures for RHMA-O and RHMA-O-HB mixes as for RHMA-G
- Working at the minimum temperatures may cause problems with achieving adequate compaction of RHMA-G mixes

Compaction Temperature

- Suggest applying the higher temperature range for open-graded RHMA
  - Based on experience of others, may still be marginally low to provide desired performance
  - Primary problems with low temperature placement of open-graded mixes are raveling and delaminating

Time Available for Compaction



Compaction Requirements

- Caltrans has implemented compaction requirements for RHMA-G mixes
  - Acceptance based on pavement cores
  - Proposed lower limit is 91% of maximum theoretical density (equivalent to maximum 9% in-place air voids)
- No compaction requirements for open-graded RHMA mixes, present or future

Compaction Equipment

- Roller types
  - Static steel wheel rollers
  - Pneumatic-tired rollers – do not use with RHMA
  - Vibratory steel wheel rollers – required for breakdown
- Rolling sequence
  - Breakdown – immediately behind paver in vibratory mode
  - Intermediate
  - Finish

Compaction Equipment

Roller Pattern

- Selection of compaction equipment
- Width of paving
- Width of roller(s) – for RHMA need enough breakdown rollers to cover placement width
- Number of passes needed
- Nuclear gauges for relative density
- Cores for correlation of gauges with in-place density, i.e. air voids content

Specifications/SSPs

- Specifications for RHMA-G, RHMA-O, and RHMA-O-HB can be found in Section 39 of Caltrans standard specifications.
- Follow requirements in project special provisions to assure use of appropriate version

Summary of Module 3

- Construction Overview
- Surface Preparation
- Manufacture
- Mix Delivery (Hauling)
- Placement
- Compaction
- Specifications/SSPs

Module 4: Inspection Guide

Operation, Production, and Trouble Shooting

Hot Mix Asphalt Plant Operations

Plant operations during RHMA mix production are essentially the same as for standard HMA production. CT 109 requirements apply.

<u>Differences</u>

- Production and monitoring of the asphalt rubber binder for wet process mixes.
- Plant mixing temperatures of 300-325ºF may be slightly higher than usual.

AR Binder Production

Required Documentation

- AR Binder Design Profile, including
  - Component identification and proportions
  - CRM gradations
  - AR test results showing compliance with specifications
- Certificates of Compliance for components
  - Asphalt Cement
  - Asphalt Modifier (Extender Oil)
  - Scrap Tire CRM
  - High Natural CRM

Asphalt Rubber Blend Design Example Design Profile

	Minutes of Reaction					Spec. Limits @ 45 minutes (Caltrans 12/2005)
TEST	45	90	240	360	1,440	
Viscosity, cP Haake@ 190ºC	2400	2800	2800	2800	2100	1500 - 4000
Resilience@ 25ºC (% Rebound) (ASTM D 5329)	27	--	33	--	23	18 Minimum
R & B Softening Pt., ºC (ASTM D36)	59.0	59.5	59.5	60.0	58.5	52 – 74 (125-165ºF)
Cone Pen @ 25ºC (ASTM D217)	39	--	46	--	50	25 – 70

AR Binder Production

Inspection items

- Batch sheets or production logs for AR binder that show the amounts (typically by mass) of the components used. Check proportions of:
  - Asphalt Cement
  - Extender oil
  - Scrap tire CRM
  - High natural CRM

AR Binder Production

The AR binder production logs or viscosity testing logs should indicate when the CRM was added.

Before adding AR binder to the aggregate:

- Verify minimum AR interaction time of 45 minutes has elapsed
- Verify AR binder viscosity meets or exceeds the minimum 1500 cPs requirement at 375ºF
- Continue to monitor viscosity hourly during RHMA mix production

AR Binder Production

- As long as interaction time and viscosity meet or exceed minimum requirements, the AR binder may be added to the aggregate, even if viscosity differs from values shown in the design profile.

- The design profile serves as a guide, not as a specification. If viscosity during production differs from design profile by 400 cPs or more for corresponding interaction interval, obtain a binder sample for compliance testing.

RHMA Mix Production

Required Documentation

- RHMA Mix Design including:
  - Individual and combined aggregate gradations
  - Results of individual and combined aggregate quality tests
  - Aggregate source(s) and blend proportions
  - Theoretical maximum specific gravity/density
  - Design AR binder content
  - Design air voids content
  - Design Voids in Mineral Aggregates (VMA)
  - Hveem Stability

RHMA Mix Production

- Verify AC plant complies with CT 109 requirements
- Check aggregate bins
- Sample aggregate cold feed or hot bins as appropriate and verify gradation. Test Sand Equivalent as required
- Verify RHMA mixing and discharge temperatures

RHMA Mix Production

- Visually inspect the RHMA mix in the haul truck before it leaves the plant
- Sample and test RHMA mix according to the project special provisions.
- Tests include gradation, AR binder content, maximum theoretical specific gravity, lab-compacted air voids, and Hveem stability
- Verify that haul trucks are tarped.

RHMA Mix Production

- Maintain inspector's log of pertinent information, including but not limited to:
  - List of samples obtained
  - Plant test results (aggregates and mix)
  - Quantities of AR binder and RHMA mix
  - Binder production temperatures and viscosity measurements, etc.
  - Other required information

Inspection at Paving Site

Before Overlay Placement:

- **Verify surface preparation is complete**
  - **Cracks treated or sealed?**
  - **Damaged areas repaired?**
  - **Milling properly completed (if applicable)?**
  - **Surface clean and swept?**
  - **Tack coat properly applied?**
- **Verify ambient and pavement temperatures are at least 55ºF and rising**

Inspection at Paving Site

- Equipment
  - Verify that paver and rollers meet size requirements, are in good working condition, and qualified operators are on-site
  - Verify sufficient steel-wheeled rollers are available for breakdown and intermediate compaction.
  - Breakdown rollers must have vibratory capability
- Delivery method: Do not use windrows if ambient temperature is marginally cold.

Inspection at Paving Site

Caltrans requirements for RHMA-G, ambient temperature between 55 and 65ºF:

- RHMA-G spread temperature 290-325ºF
- Minimum temperature for breakdown rolling is 280ºF
- Vibratory mode is required for RHMA-G breakdown
- Complete breakdown before RHMA mat temperature drops below 260ºF

Inspection at Paving Site

- Less stringent for ambient temperature ≥ 65ºF
- Other jurisdictions recommend minimum 290ºF for breakdown rolling or completion thereof
- Compaction requirements have been implemented for RHMA-G mixes, with acceptance based on cores

Inspection at Paving Site

Caltrans placement temperature requirements for RHMA-O and RHMA-O-HB ambient temperature between 55 and 65ºF are the same as for RHMA-G.

Other jurisdictions do not recommend placing RHMA-O at temperatures <65ºF.

For open-graded RHMA mixes, use static mode for breakdown compaction. Do not use vibratory mode.

Percent compaction is not a requirement for open-graded mixes.

Inspection at Paving Site

During RHMA placement:

- Collect load tickets and track tonnage placed
- Measure placement thickness and calculate yield
- Observe coordination between RHMA delivery and placement – record if trucks or paver are waiting
- Note any rejected loads of RHMA
- Observe delivery operations - are good practices being used?

Inspection at Paving Site

- Record if windrows are used.
- Monitor RHMA temperatures at spread and during breakdown and intermediate compaction.
- Observe paver operations – note discrepancies from good practice that might impact quality of joints or ride (smoothness).
- Joints at proper locations?
- Observe raking, luting, handwork. Broadcasting of excess mix or over-raking will damage the appearance of the finished pavement.

Inspection at Paving Site

- Observe compaction operations – note discrepancies from good practice that might impact in-place density
  - Breakdown roller(s) following immediately behind paver?
  - Breakdown roller(s) using vibratory mode?
  - Sufficient breakdown rollers operating to keep up with paver?
  - Intermediate static roller(s) keeping up?
  - Finish rollers effective?

Inspection at Paving Site

Rules of Thumb for RHMA-G compaction:

- **Need to get 95% of minimum required density with breakdown coverage to achieve adequate compaction.**
- **Mix temperature is critical for adequate compaction of RHMA-G materials**

After Paving

- Check the appearance of the finished surface for roller marks, scuffs, gouges, or other irregularities
- Check smoothness as required in project special provisions

- Visually evaluate quality of paving joints and identify any areas that may need to be sealed.
- Identify core locations for compaction acceptance

Troubleshooting

- If any type of RHMA mix problem is suspected, obtain samples immediately and test for compliance with project special provisions.
- Log full description of problem and related activities and report to the RE.

Troubleshooting

Possible Problems to Watch For:

- **Segregation: Particle size segregation may be difficult to identify in coarse graded RHMA-G mixtures. May appear segregated even if not, due to small percentage of fines included.**
  - **When in doubt, sample**
  - **ID and record affected truckloads and corresponding placement areas**
- **Size segregation is often accompanied by temperature segregation**

Troubleshooting

- Temperature segregation may be identified using a heat gun or infrared camera
  - To measure actual mix temperature without surface effects, use a 6-inch long thermometer
- Indicate hot and cold spots in the mix that can cause differences in compaction
  - Can see areas in haul trucks and pavers where mix is not circulating and has cooled
  - Shows when material from paver wings is dumped into the hopper and where it comes out behind the screed

Troubleshooting

- **Smoke**
  - **Blue smoke means that the mix is too hot and plant operating temperature needs to be adjusted**
  - **White smoke is steam - too much moisture in the mix. May make mix tender and interfere with compaction. Aggregate needs to be dried longer before mixing with the AR binder.**

Troubleshooting

- Stiff appearance: Too cool or possibly somewhat low AR binder content. Check temperature and get a mix sample for further testing if needed.

- Dull, flat appearance: Low AR binder content and/or excessive fines. Localized areas may indicate insufficient mixing or segregation. Get sample and test for gradation and AR binder content.

Troubleshooting

- Slumped and shiny appearance typically indicates high AR binder content.
  - RHMA-O and especially RHMA-O-HB may look this way and still meet specifications
  - Old descriptive term is “wormy” – mix seems to almost crawl while watched
  - Some complying RHMA-G mixes may also be wormy
  - Visually check for binder drain down in the haul truck bed, sample and test for AR binder content and gradation

Summary of Module 4

- Monitor AR binder production and viscosity results
- Sample AR binder and individual component materials for verification and acceptance
- Observe RHMA temperature and compaction operations
- Compaction acceptance can be based on core samples

Questions ?

The Beginning

Keeping roads good with asphalt paving materials

http://www.cp2info.org/center