CCPIC Technical Update

John Harvey

CEAC Field Summit Conference

Camp Tehama

30 July 2026

City and County
Pavement Improvement Center

Outline

- Introduction to CCPIC
- New CCPIC online self-paced pavement training classes and upcoming live web classes
- New CCPIC asphalt pavement design catalog based on Caltrans CalME
- Update on improving decision making in PMS
- Update on use of RAP in local government mixes
- New HMA with fine dry rubber mixes (RHMA-D)
- Caltrans “balanced mix design”
- Update on 6ppd-q
- Questions and discussion

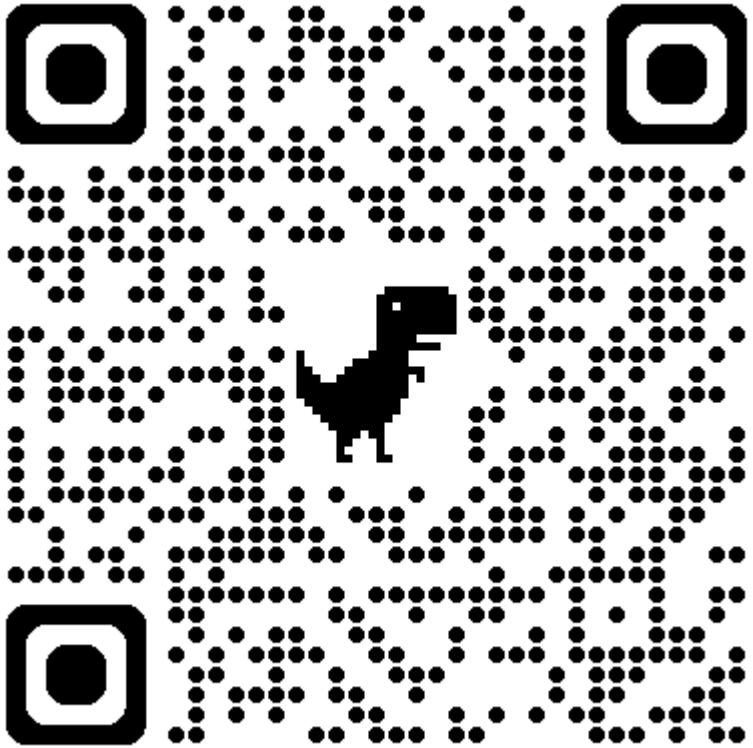
City and County Pavement Improvement Center

- **Sponsored by:**
  - League of California Cities
  - County Engineers Association of California
  - California State Association of Counties
- **Governance Board:**
  - 6 county engineers, 6 city engineers
  - CSAC, CalCities, CEAC
- **Chartered** September 2018

- **University of California Partners**
  - University of California Pavement Research Center (lead)
  - UC Berkeley ITS Tech Transfer
- **California State University Partners**
  - CSU-Chico, CSU-Long Beach, Cal Poly San Luis Obispo

CCPIC Mission and Vision

- **Website**
  - ccpic.ucdavis.edu (no www.)
- **Mission**
  - CCPIC works with local governments to increase pavement technical capability through timely, relevant, and practical support, training, outreach and research
- **Vision**
  - Making local government-managed pavement last longer, cost less, and be more sustainable



CCPIC website

New CCPIC online self-paced pavement training classes and upcoming live web classes

CCPIC Pavement Courses Through UCB Tech Transfer

- CCA-01 Introduction to Pavement Engineering and Management
- CCA-02 Pavement Sustainability
- CCB-01 Pavement Life Cycle Cost Analysis: The Basics
- CCB-02 Pavement Management Systems and Preservation Strategies
- CCB-21 Financing and Cash Flow for Pavement Networks (self-paced online)
- CCC-01 Asphalt Concrete Materials and Mix Design
- CCC-02 Asphalt Pavement Preservation Treatments, Materials, Construction & Quality Assurance
- CCC-03 Pavement Construction Specifications and Quality Assurance
- CCC-21 Concrete Materials and Mix Design
- CCC-22 Cold Recycling of Asphalt Pavements
- CCC-23 Unpaved Road Engineering, Construction & Management
- CCI-02 Concrete Pavement Construction Inspection (self-paced online)
- CCI-03 Concrete Street Improvements Construction Inspection (self-paced online)
- CCI-04 Pavement Preservation Construction Inspection (self-paced online)
- CCI-06 Construction Inspection of Asphalt-Rubber Pavement Materials (self-paced online)
- PD-01 Fundamentals of Inspection Practice

Low cost, subsidized by SB1 and Caltrans LTAP

Buy a package of training, use it how you like

Pavement Engineering & Management (PEM) and Pavement Construction Inspection (PCI) Certificate Programs

- **PEM Certificate Program Overview**
  - For engineers, asset managers, upper-level managers, technicians and construction inspectors
- **Upcoming Live Web Classes!!**
  - Asphalt Pavement Preservation Treatments, Materials, Construction and Quality Assurance
  - Pavement Management Systems and Preservation Strategies

- **New Online Self-Paced Courses!!**
  - Cold Recycling of Asphalt Pavements
  - Unpaved Road Engineering, Construction & Management

CCPIC website for subsidized training

New CCPIC asphalt pavement design catalog based on Caltrans CalME

New CCPIC local government pavement design catalog based on Caltrans CalME

- Catalog generated using Caltrans CalME
  - Mechanistic-empirical method, calibrated against all 50 years of Caltrans 35,000 mile network in 2022
  - Last calibration of R-value method and CT 356 deflection reduction method was around 1970
  - Thinner asphalt surfaces for FDR projects than R-value design, because of unnecessary artifact in R-value method
- CalME software itself approved by Caltrans for local government use
- Coming soon: Site Investigation Guide for Local Government

- Includes:
  - New pavement and reconstruction
  - Full depth recycling
  - Overlays (limited range)
- Inputs needed:
  - Climate zone (from Caltrans map)
  - Traffic Index (guidance on calculating based on truck count)
  - Soil type (CH, CL, SC)
  - Project type (new, rehab)
  - Existing pavemen type (old HMA, old PCC)
  - Surface type (HMA, HMA-PM, RHMA-G)
  - Base type (AB, FDR-C, FDR-Foam

Climate Zone	High Mountain
TI	8
SG USCS	SC
Ex. Pav. Type	Old AC
Surface Type	HMA
Base Type	N/A
Strategy	Rehabilitation with Overlay
Ex. AC Thickness (inch)	6
Intermediate HMA Type	HMA with PG 64 Binder
Surface Thickness (inch)	2.5
Int. HMA Thickness (inch)	0
Base Thickness (inch)	N/A
Sufficient?	YES

Link to new catalog interactive look up tool on CCPIC website

CCPIC website for design catalog lookup tool
More info at CCPIC website under Specifications and Tools

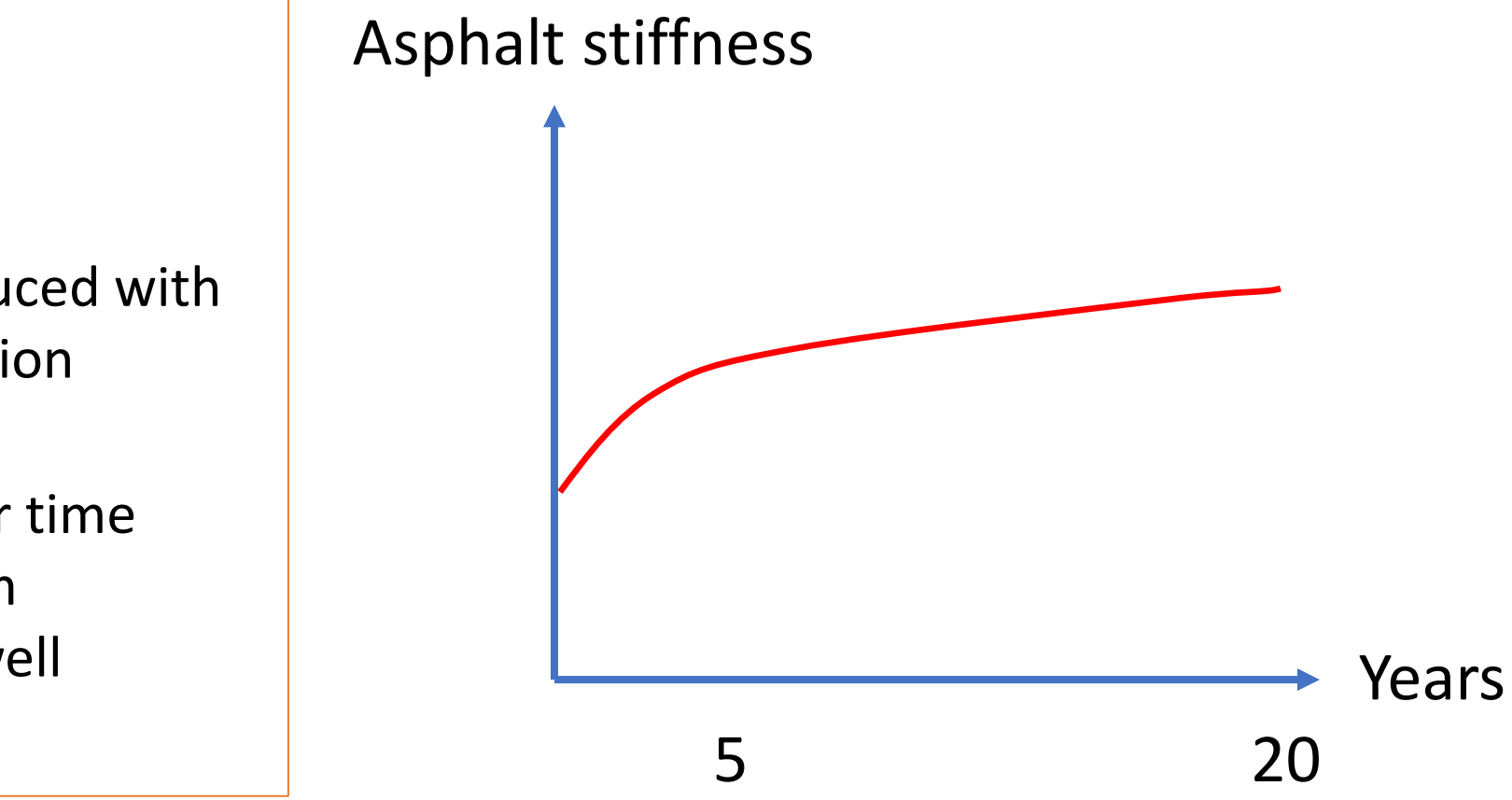
Update on improving decision making in PMS

Update on improving decision making in PMS

- Current PMSs primarily do their engineering through PCI
  - Decision trees for treatment selection
  - Reporting
- PCI does not provide engineering information except that there is a lot of distress or a little distress
- Two key distress groups for asphalt pavement preservation, maintenance and rehabilitation
  - Age related non-load cracking, building on all asphalt, all the time, everywhere
    - Can be slowed or stopped with preservation and then maintenance
  - Fatigue load-related cracking, only occurring on the truck and bus routes, only in the wheelpaths
    - Cannot be slowed much by maintenance, it is loss of structural capacity needing eventual rehabilitation

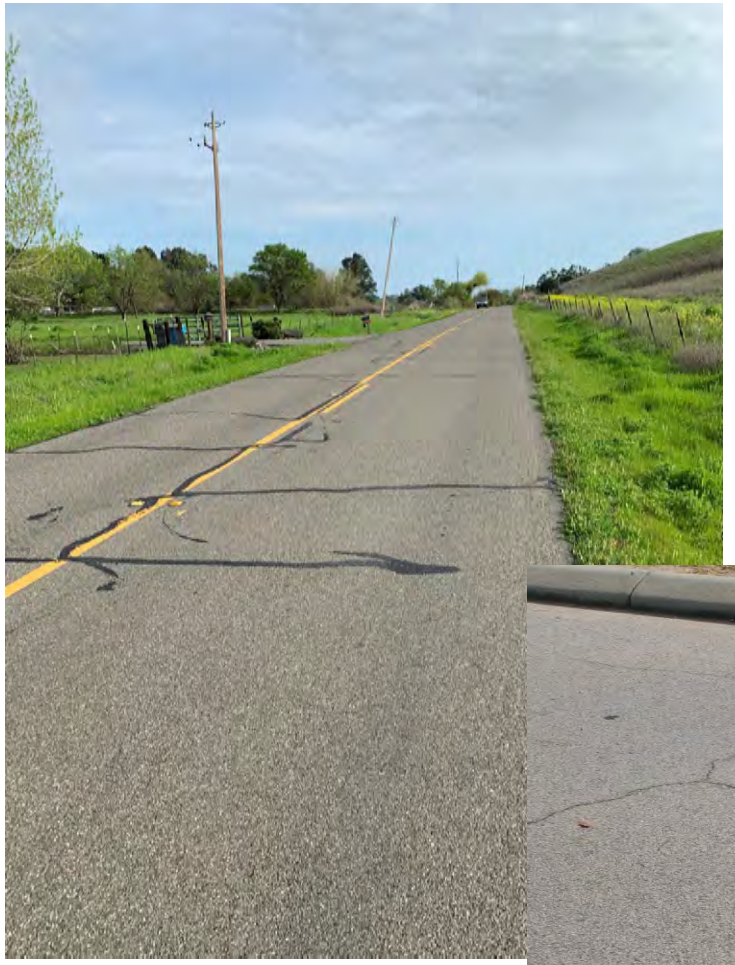
Aging of the Asphalt Binder and its Effects

- **Aging:**
  - Caused by oxidation
  - Faster:
    - Near the surface
    - If high permeability
  - Permeability greatly reduced with better HMA/AC compaction
- **Effects:**
  - Stiffening of the mix over time
  - Won't relax stresses from thermal contraction as well



Age Related: Cracking Progression

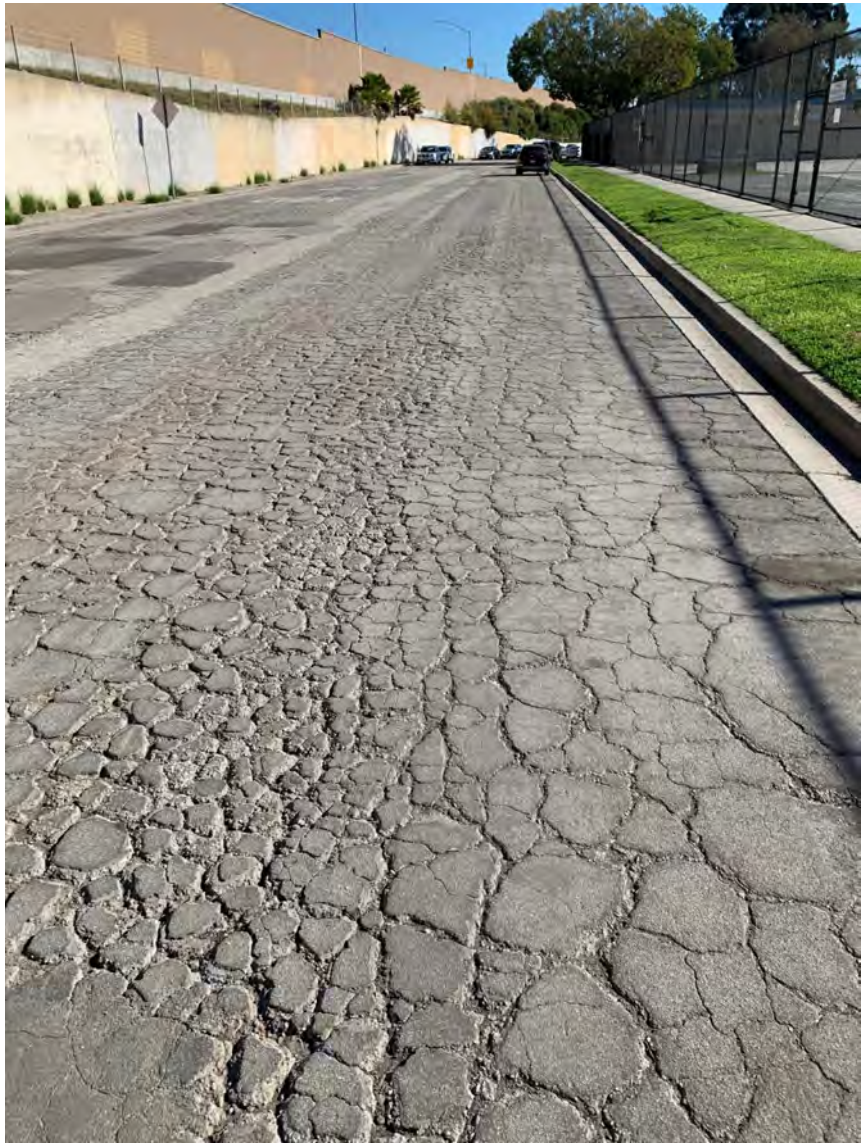
- Begins as top-down transverse followed by longitudinal cracking creating the block pattern
- Top-down due to aging and temperature changes at the surface



Transverse and longitudinal to block cracking as aging progresses

Age Related: Cracking Progression

- As continues to age, cracks into smaller and smaller pieces
- Eventually looks like fatigue cracking from heavy vehicles, but it isn’t
- Fatigue cracking occurs only in the wheelpaths

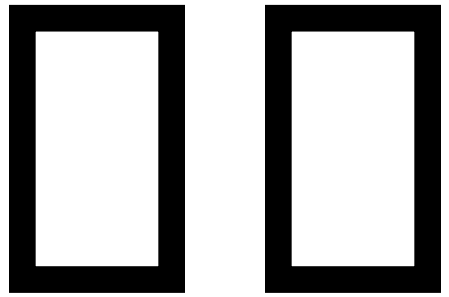


Age-Related Cracking Leading to Block Cracking

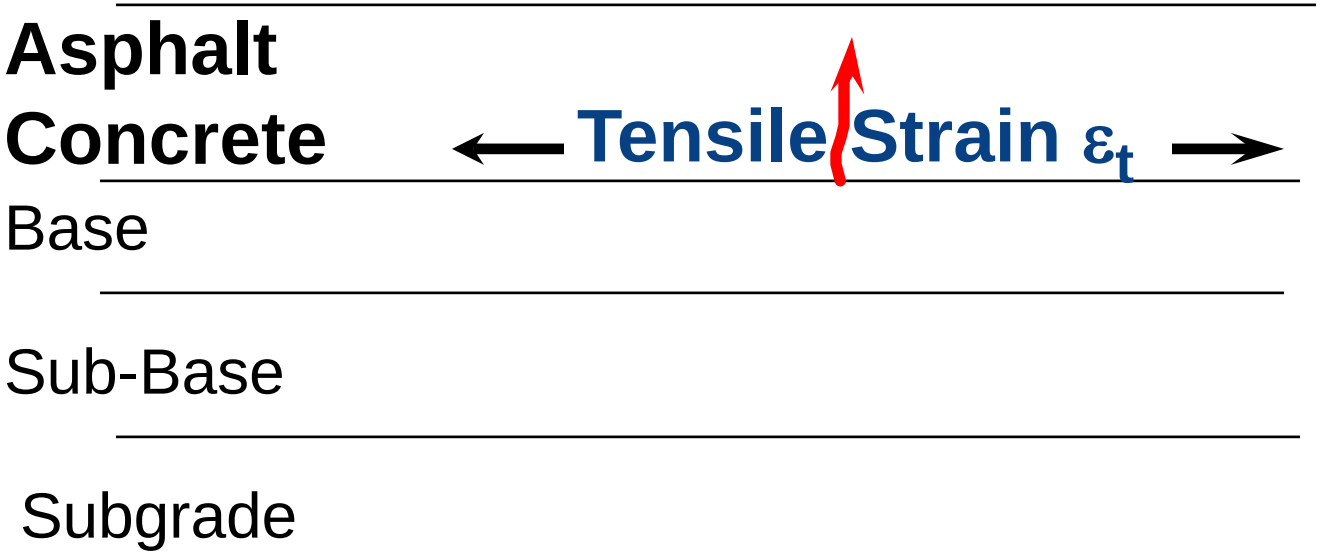
- May also be reflective cracking from:
  - Underlying cracked asphalt pavement
  - Concrete pavement joints
  - Shrinkage cracks in cement treated base or FDR-C

Fatigue Cracking

At ***moderate*** temperatures, tensile strains under loading at ***bottom of asphalt***



Only where there are **heavy trucks and buses** Only in the **wheelpaths**



Initial Wheel Path Cracking

- May start as either transverse or longitudinal
- Only in the wheelpaths!

Cracks Connect: Alligator Cracking

- Transverse and longitudinal cracks then connect to form “alligator” pattern
- Only in the wheelpaths!

Fatigue Cracking in Wheel Paths

- Cracks into smaller pieces
- Cracked pieces become looser leading to potholes

Better Use of PCI in Pavement Management

- **Most current PMSs**
  - Treatments are recommended based on PCI without considering distress type
  - Treatment selection based on default performance data
  - Costs are also default unless updated
- **What are easy steps to improve PMS?**

- **Recommended Steps**
- Identify heavy vehicle routes and flag them in PMS or in excel download
- Identify last treatment and treatment date for each segment (guess if you have to)
- Download the condition data for each segment in last survey
- Call CCPIC, we will identify the age-related and fatigue cracking variables and show you how to prioritize the segments for preservation (seals) and rehabilitation (overlay, remove & replace, FDR)
- No charge

Variables in the PCI

- **Fatigue cracking and potholes caused by *heavy vehicle loads*:**
  - Alligator cracking
  - Potholes
- **Cracking caused by *aging:***
  - Block cracking
  - Joint reflections
  - Longitudinal and transverse cracking

- **Other distresses in PCI:**
  - Low ride quality
  - Bleeding
  - Bumps and sags
  - Corrugations
  - Depressions
  - Edge cracking
  - Lane/shoulder drop-off
  - Patching and utility cut patching
  - Polished aggregate
  - Rutting
  - Shoving
  - Slippage cracking
  - Swelling
  - Weathering and raveling

Outreach to PMS Software Providers and Consultants

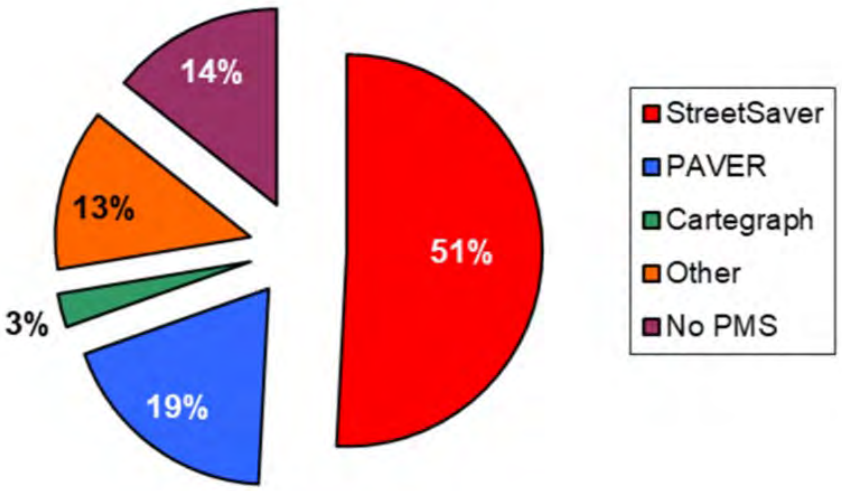


Figure B.4 PMS Software Used By Cities And Counties

- Over the next 9 months CCPIC will be reaching out to consultants and PMS software providers in the state to discuss these steps and how they can help their clients make better decisions
- If you are using a consultant or software provider, please let us know who so we can contact them
- No charge

Update on use of RAP in local government mixes

What is RAP?

- **Reclaimed Asphalt Pavement**
  - Millings from existing pavement
    - Streets and highways
    - Parking lots
  - Plant wasted material
  - Can include many mix designs, patches, or be primarily from one existing road
  - Conventional, rubberized and polymer binders
- **Aged**
  - Amount of oxidation depends on age, climate, depth below surface, air void content (air permeability)

Cost-Effectiveness

- **Asphalt binder**:
  - about $800/ton
  - Valero Benicia refinery (40% of California asphalt) shut down in April, tanks have been pumped out
  - Expect variable performance from increased imports
- **Virgin aggregate**:
  - about $40/ton
- **RAP**:
  - about $40/ton

Material	%	cost/ton	mat cost
virgin asphalt binder	5.0%	$600	$30
virgin agg	95.0%	$40	$38
RAP (95% agg 5% binder)	0.0%	$40	$0
Total material cost	**100.0%**		**$68**

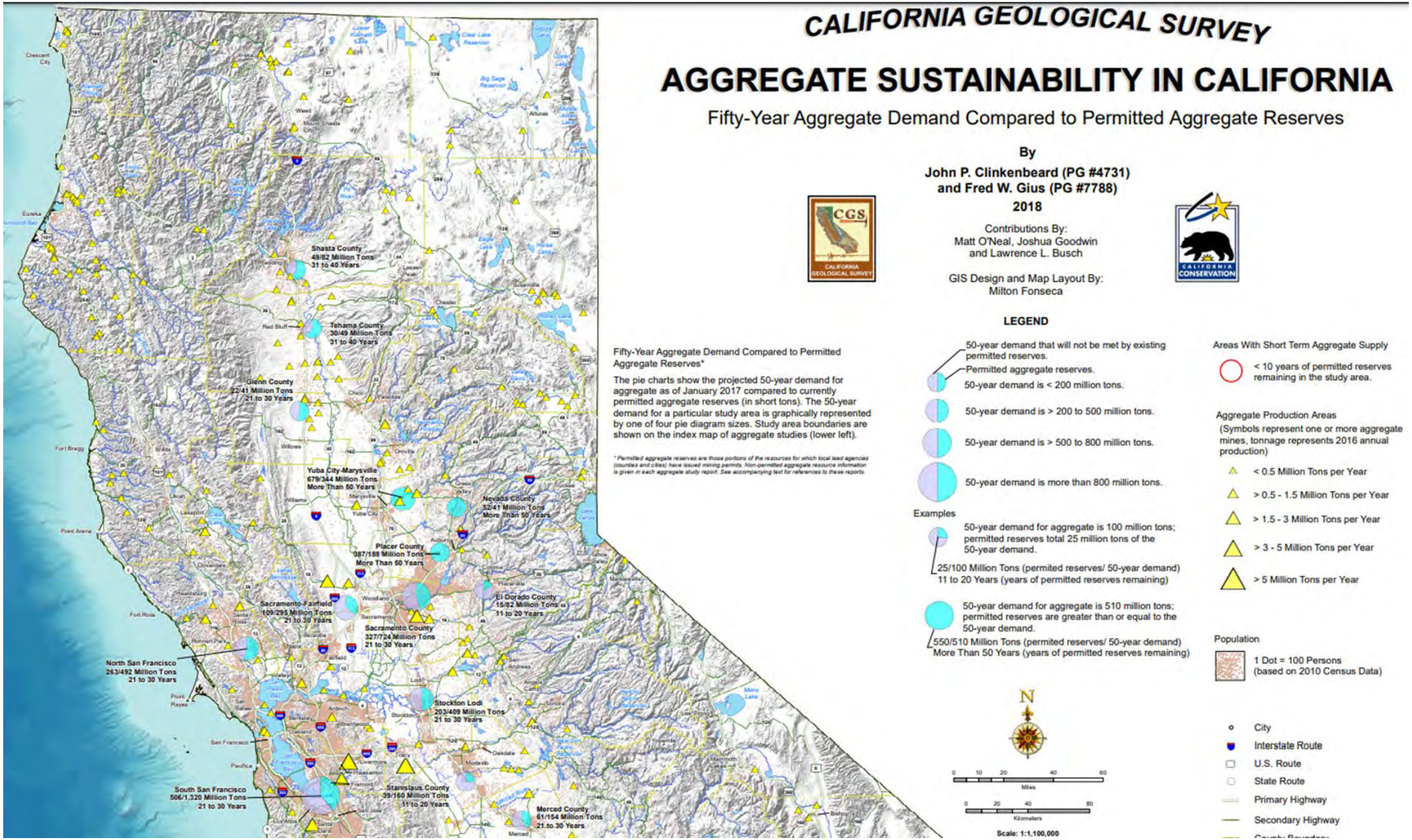
Material	%	cost/ton	mat cost
virgin asphalt binder	4.3%	$600	$26
virgin agg	80.8%	$40	$32
RAP (95% agg 5% binder)	15.0%	$40	$6
Total material cost	**100.0%**		**$64**

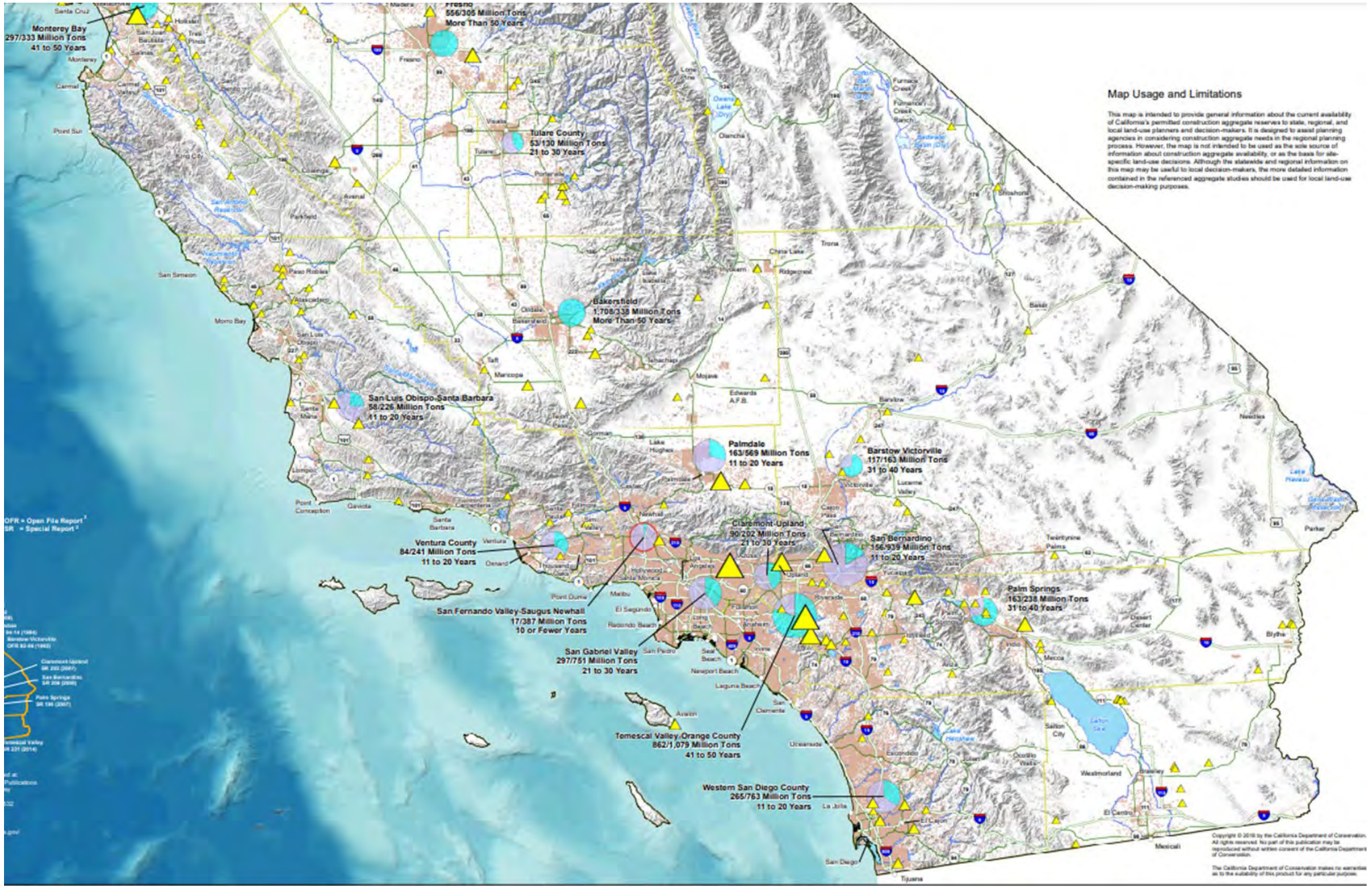
Material	%	cost/ton	mat cost
virgin asphalt binder	3.8%	$600	$23
virgin agg	71.3%	$40	$29
RAP (95% agg 5% binder)	25.0%	$40	$10
Total material cost	**100.0%**		**$61**

Material	%	cost/ton	mat cost
virgin asphalt binder	3.0%	$600	$18
virgin agg	57.0%	$40	$23
RAP (95% agg 5% binder)	40.0%	$40	$16
Total material cost	**100.0%**		**$57**

Finite Resource Conservation

- Aggregate supplies are limited in many parts of the state
- Existing permitted quarries have limited supplies left
  - Only Placer, Nevada, Sutter/Yuba, Fresno and Bakersfield areas have 50-year demand currently permitted
  - Some areas will run out by 2035 or sooner (San Diego County, Los Angeles County (San Fernando/Saugus/Newhall, Palmdale), San Bernardino County, Ventura County)
- Starting new quarries is difficult
  - Typical time for permit process is about 10 years
  - About 50% probability that will be successful after 10 years
- Importing aggregate
  - Increases costs
  - Increases environmental impacts


CALIFORNIA GEOLOGICAL SURVEY
AGGREGATE SUSTAINABILITY IN CALIFORNIA
Fifty-Year Aggregate Demand Compared to Permitted Aggregate Reserves
By
John P. Clinkenbeard (PG #4731)
and Fred W. Gius (PG #7788)
2018
Contributions By:
Matt O'Neal, Joshua Goodwin
and Lawrence L. Busch
GIS Design and Map Layout By:
Milton Fonseca
CGS
CALIFORNIA GEOLOGICAL SURVEY
CALIFORNIA CONSERVATION
Shasta County
49/82 Million Tons
31 to 40 Years
Tehama County
30/49 Million Tons
31 to 40 Years
Glenn County
22/41 Million Tons
21 to 30 Years
Yuba City-Marysville
679/344 Million Tons
More Than 50 Years
Nevada County
52/41 Million Tons
More Than 50 Years
Placer County
387/188 Million Tons
More Than 50 Years
El Dorado County
15/82 Million Tons
11 to 20 Years
Sacramento-Fairfield
109/295 Million Tons
21 to 30 Years
Sacramento County
327/724 Million Tons
21 to 30 Years
North San Francisco
263/492 Million Tons
21 to 30 Years
Stockton Lodi
203/409 Million Tons
21 to 30 Years
South San Francisco
506/1,320 Million Tons
21 to 30 Years
Stanislaus County
39/160 Million Tons
11 to 20 Years
Merced County
61/154 Million Tons
21 to 30 Years
Fifty-Year Aggregate Demand Compared to Permitted Aggregate Reserves*
The pie charts show the projected 50-year demand for aggregate as of January 2017 compared to currently permitted aggregate reserves (in short tons). The 50-year demand for a particular study area is graphically represented by one of four pie diagram sizes. Study area boundaries are shown on the index map of aggregate studies (lower left).
* Permitted aggregate reserves are those portions of the resources for which local lead agencies (counties and cities) have issued mining permits. Non-permitted aggregate resource information is given in each aggregate study report. See accompanying text for references to these reports.
LEGEND
50-year demand that will not be met by existing permitted reserves.
Permitted aggregate reserves.
50-year demand is < 200 million tons.
50-year demand is > 200 to 500 million tons.
50-year demand is > 500 to 800 million tons.
50-year demand is more than 800 million tons.
Examples
50-year demand for aggregate is 100 million tons; permitted reserves total 25 million tons of the 50-year demand.
25/100 Million Tons (permited reserves/ 50-year demand)
11 to 20 Years (years of permitted reserves remaining)
50-year demand for aggregate is 510 million tons; permitted reserves are greater than or equal to the 50-year demand.
550/510 Million Tons (permited reserves/ 50-year demand)
More Than 50 Years (years of permitted reserves remaining)
Areas With Short Term Aggregate Supply
< 10 years of permitted reserves remaining in the study area.
Aggregate Production Areas
(Symbols represent one or more aggregate mines, tonnage represents 2016 annual production)
< 0.5 Million Tons per Year
> 0.5 - 1.5 Million Tons per Year
> 1.5 - 3 Million Tons per Year
> 3 - 5 Million Tons per Year
> 5 Million Tons per Year
Population
1 Dot = 100 Persons
(based on 2010 Census Data)
N
0 10 20 40 60
Miles
0 20 40 80
Kilometers
Scale: 1:1,100,000
City
Interstate Route
U.S. Route
State Route
Primary Highway
Secondary Highway


Monterey Bay
297/333 Million Tons
41 to 50 Years
Fresno
556/305 Million Tons
More Than 50 Years
Tulare County
53/130 Million Tons
21 to 30 Years
Bakersfield
1,708/338 Million Tons
More Than 50 Years
San Luis Obispo-Santa Barbara
58/226 Million Tons
11 to 20 Years
Palmdale
163/569 Million Tons
11 to 20 Years
Barstow Victorville
117/163 Million Tons
31 to 40 Years
Claremont-Upland
90/202 Million Tons
21 to 30 Years
San Bernardino
156/939 Million Tons
11 to 20 Years
Ventura County
84/241 Million Tons
11 to 20 Years
San Fernando Valley-Saugus Newhall
17/387 Million Tons
10 or Fewer Years
San Gabriel Valley
297/751 Million Tons
21 to 30 Years
Palm Springs
163/238 Million Tons
31 to 40 Years
Temescal Valley-Orange County
862/1,079 Million Tons
41 to 50 Years
Western San Diego County
265/763 Million Tons
11 to 20 Years
OFR = Open File Report
SR = Special Report
Map Usage and Limitations
This map is intended to provide general information about the current availability of California's permitted construction aggregate reserves to state, regional, and local land-use planners and decision-makers. It is designed to assist planning agencies in considering construction aggregate needs in the regional planning process. However, the map is not intended to be used as the sole source of information about construction aggregate availability, or as the basis for site-specific land-use decisions. Although the statewide and regional information on this map may be useful to local decision-makers, the more detailed information contained in the referenced aggregate studies should be used for local land-use decision-making purposes.
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The California Department of Conservation makes no warranties as to the suitability of this product for any particular purpose.

Caltrans Standard Specifications
39-2.02B(2) Type A Hot Mix Asphalt Mix Design

- **"For Type A HMA mixtures using RAP, the maximum allowed binder replacement is 25.0 percent in the upper 0.2 foot exclusive of OGFC and 40.0 percent below. The binder replacement is calculated as a percentage of the approved JMF target asphalt binder content. For RAP substitution of 15 percent or less, the grade of the virgin binder must be the specified grade of asphalt binder for Type A HMA.**

- **For RAP substitution greater than 15 percent and not exceeding 25 percent, the grade of the virgin binder must be the specified grade of asphalt binder for Type A HMA with the upper and lower temperature classification reduced by 6 degrees C. Hamburg wheel track requirements are based on the grade of asphalt binder specified for Type A HMA."**

2024 Greenbook Standard Specifications
203-6.3.1 General

- **"For asphalt concrete with 20 to 25 percent reclaimed asphalt, the grade of the virgin binder must be the specified grade of asphalt binder for the asphalt concrete with the upper and lower temperature classification reduced by 6 degrees C."**

- **This allows up to 19% RAP without any adjustment in virgin binder!**

- **Should state "greater than 15 percent and not exceeding 25 percent". Recommend for inclusion in Special Provisions.**

- **No limit on binder replacement. Recommend inclusion of Caltrans limitations in Special Provisions.**

CCPIC Recommendations?

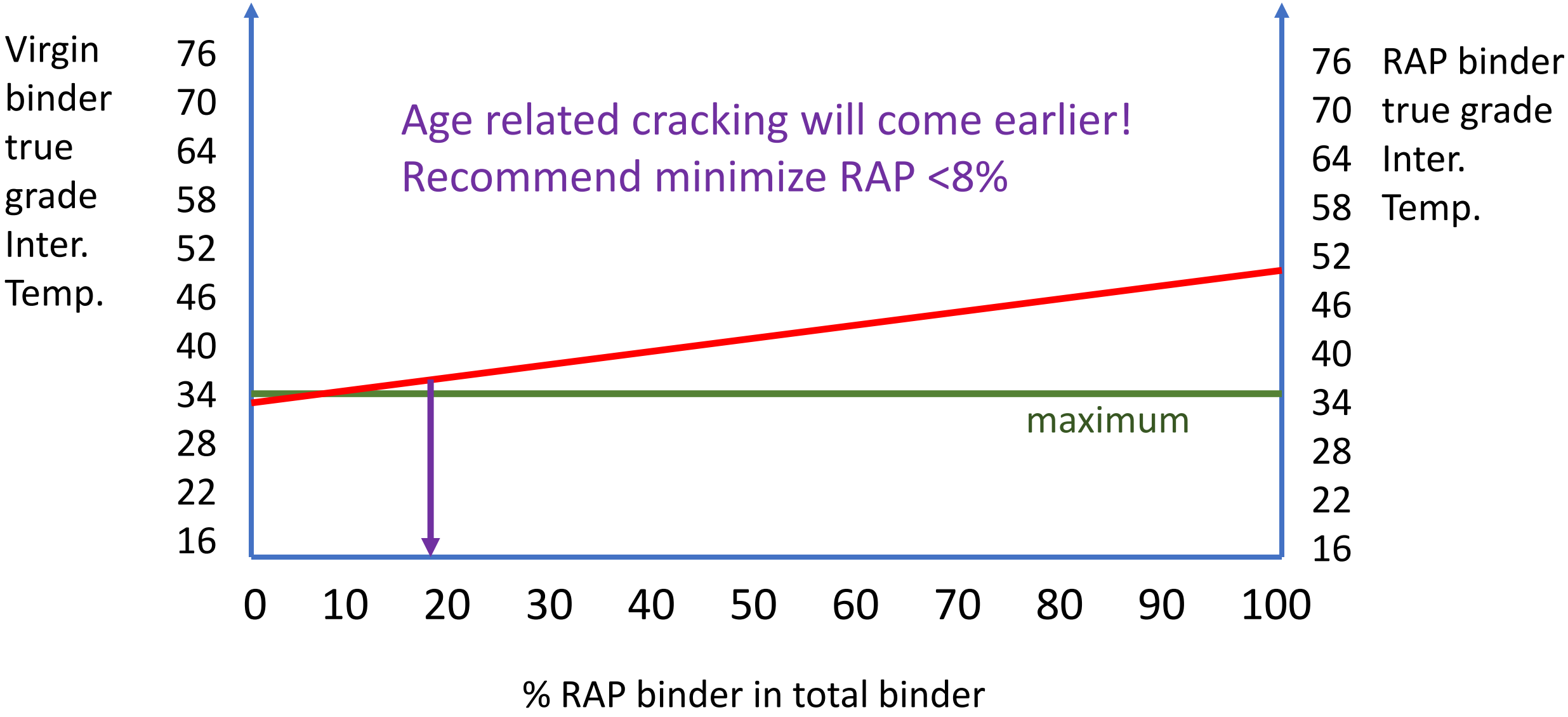
- **For age-related cracking affecting all asphalt pavements everywhere want more and softer binder, but without causing rutting**
- If using climate region PG asphalt, limit <8% RAP
- Better to go to 16 to 25% RAP and reduce virgin PG binder grade
  - PG58-22 + 25% RAP, becomes PG64-16, better than PG64-10 +15% RAP
  - This approach is in Caltrans current specifications
  - Also in CCPIC asphalt specifications
    - CCPIC Superpave specs include specs for residential and arterial streets

CCPIC HMA Superpave specs downloadable at CCPIC website:

- Caltrans format
- Greenbook format

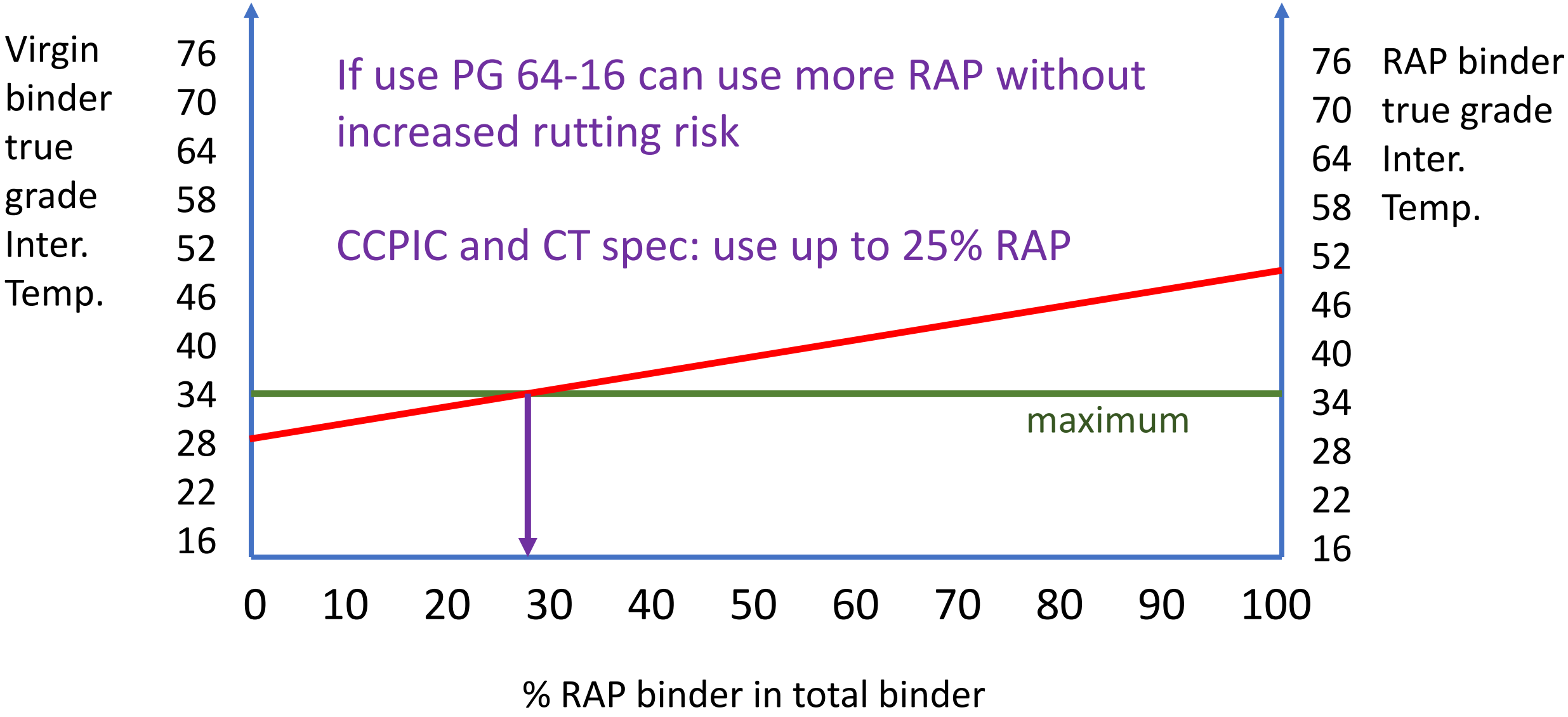
Blended Binder PG Grading: Intermediate Temperature

PG 70-10 requires maximum 34°C; what if use 19% RAP?



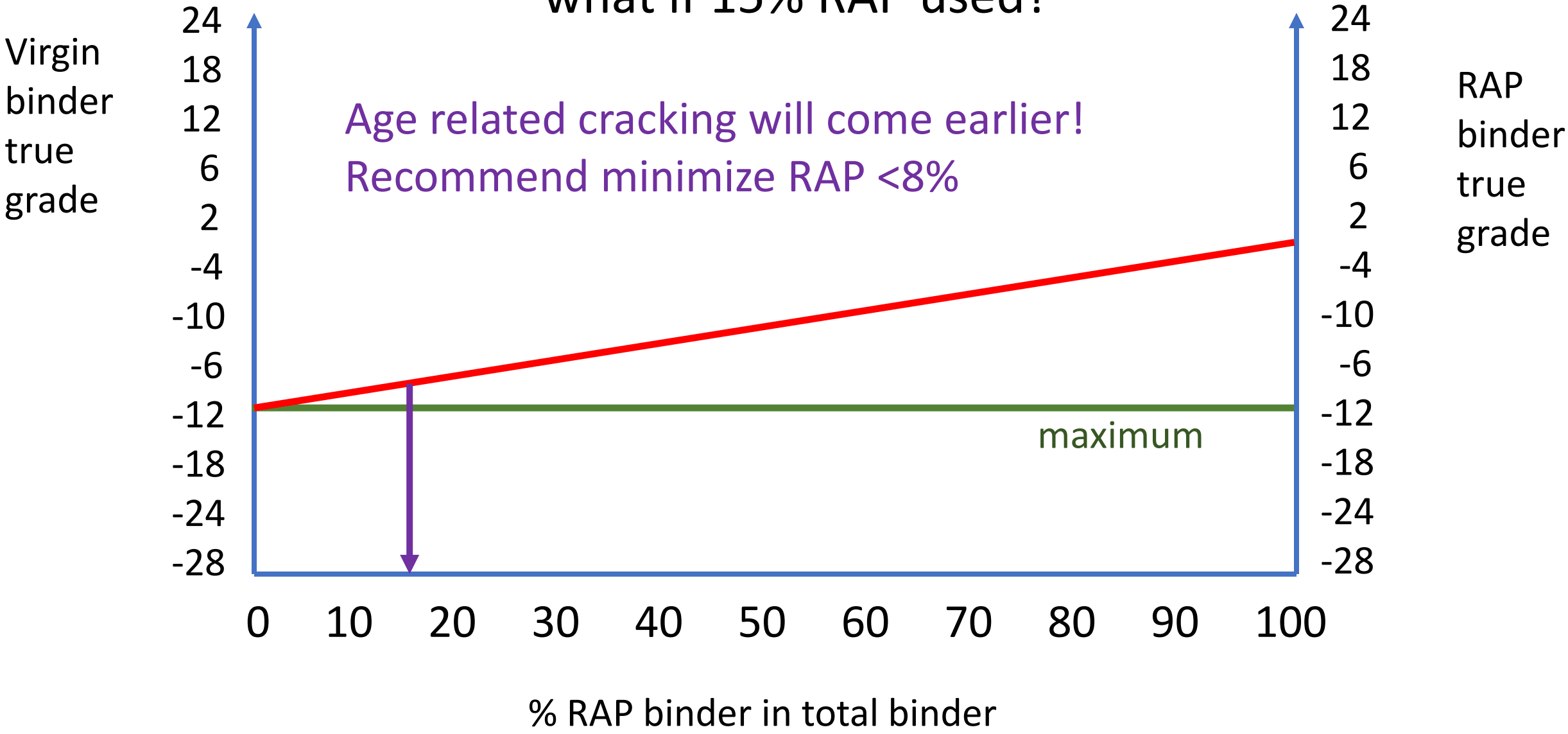
Blended Binder PG Grading: Intermediate Temperature

PG 70-10 requires maximum 34°C; how much RAP if PG 64-16 used?



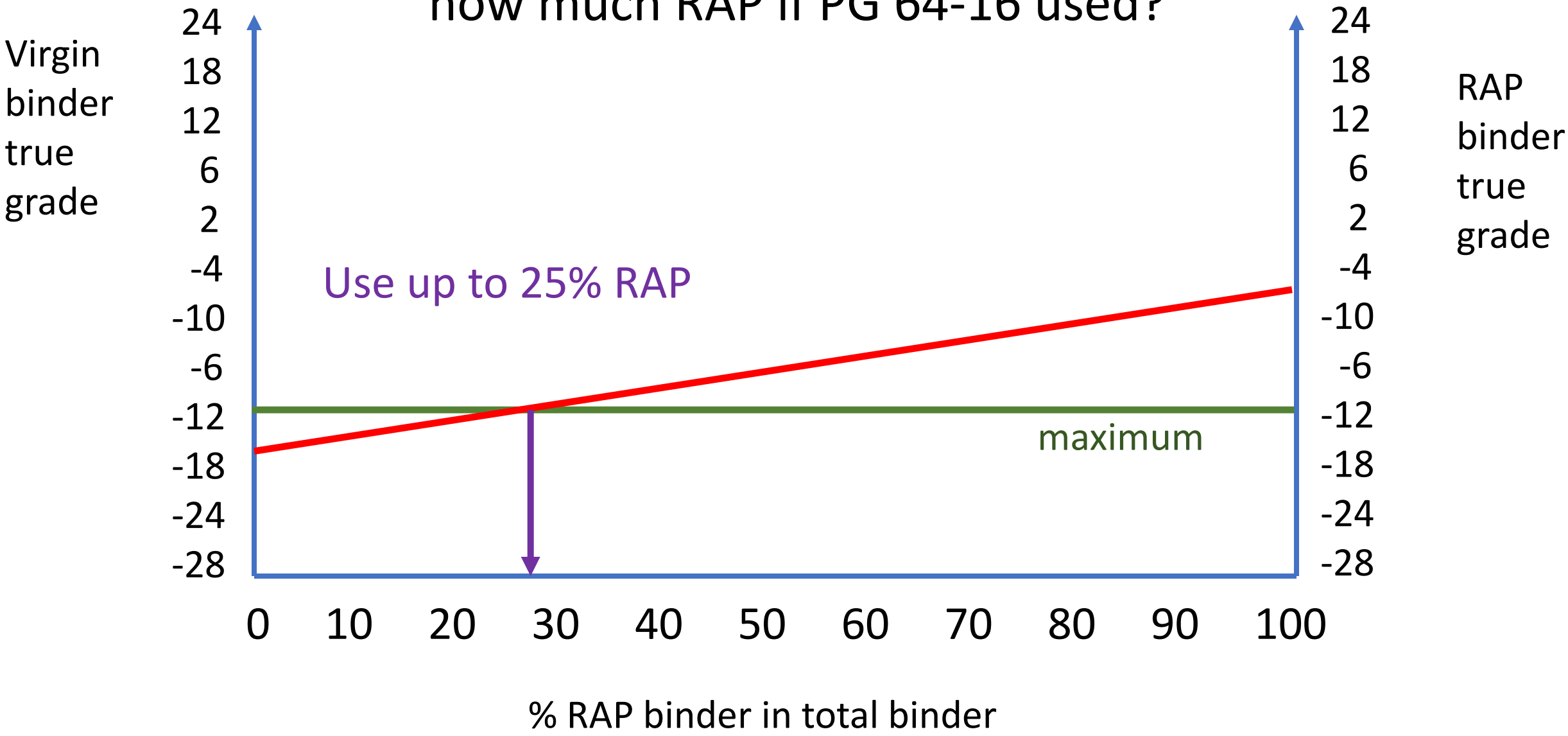
Blended Binder PG Grading: Low Temperature

PG 70-10 requires maximum -10°C for critical property (m, S); what if 15% RAP used?



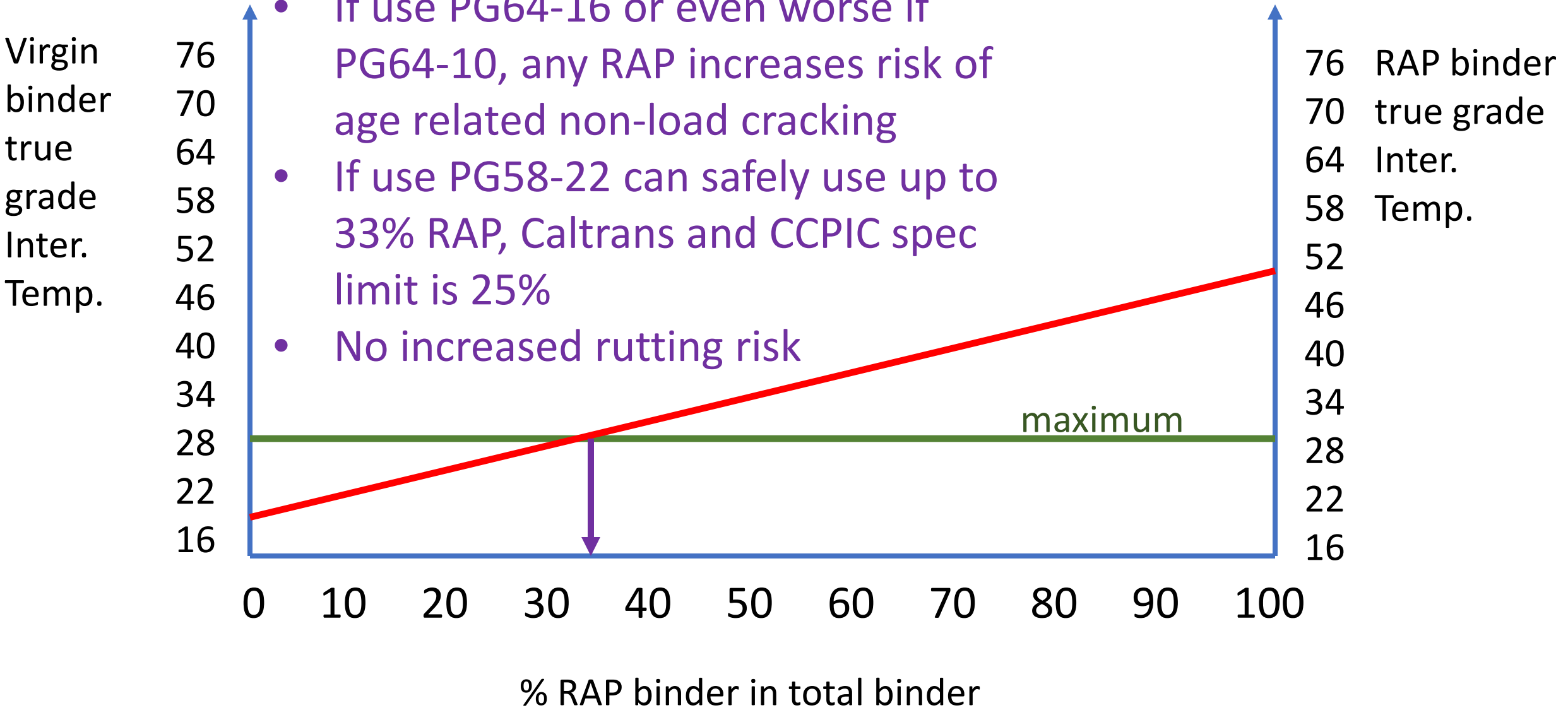
Blended Binder PG Grading: Low Temperature

PG 70-10 requires maximum -10°C for critical property (m, S); how much RAP if PG 64-16 used?



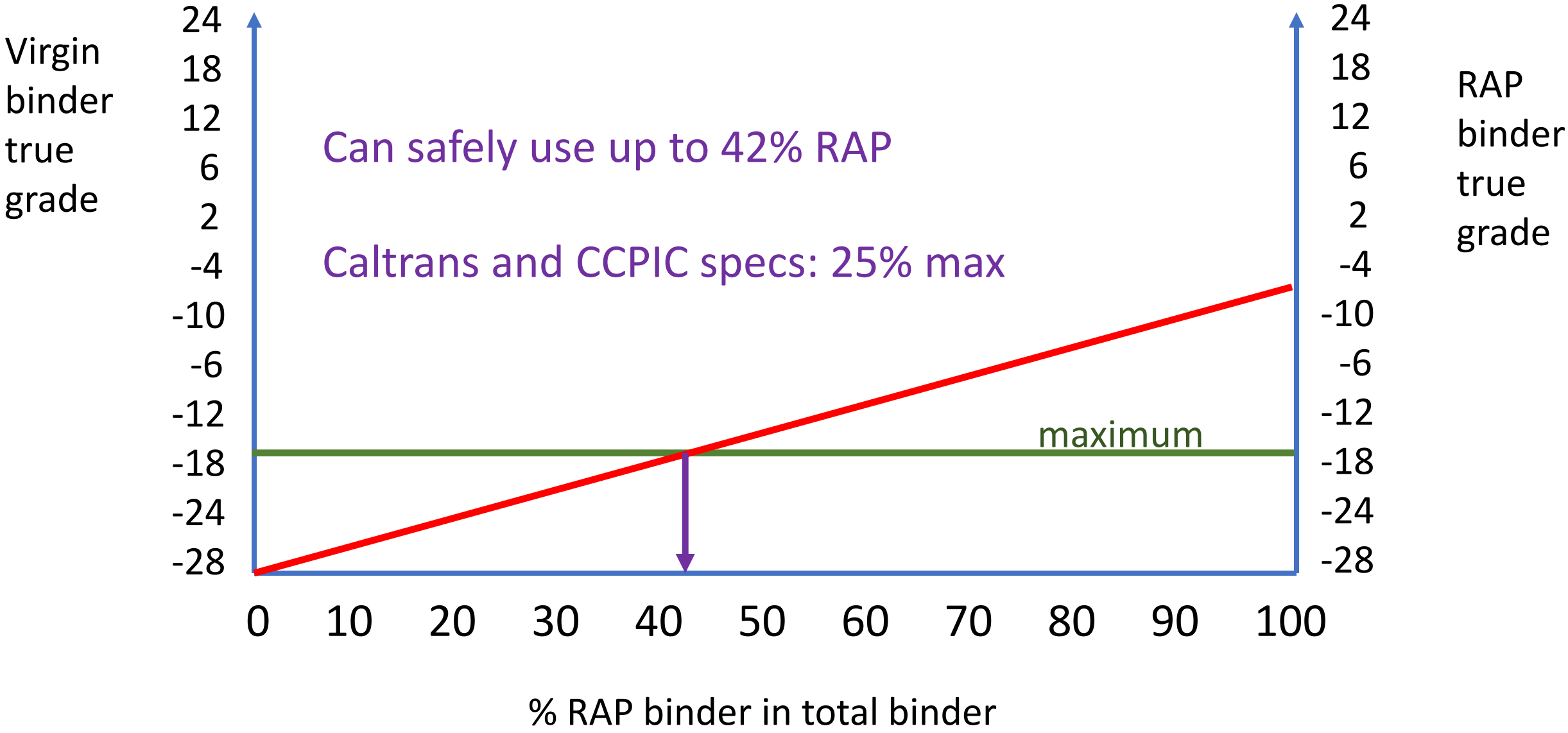
Blended Binder PG Grading: Intermediate Temperature

PG 64-16 requires maximum 28°C; how much RAP if PG 58-22 used?



Blended Binder PG Grading: Low Temperature

PG 64-16 requires maximum -16°C for critical property (m, S); how much RAP if PG 58-22 used?



Contact us if questions about RAP and binder grade in the asphalt you are buying

- We can walk through your specs with you and look at your recent asphalt Job Mix Formulas with you

New HMA with fine dry rubber mixes (RHMA-D)

1. Recycled tire rubber (RTR) has been successfully used for fabrication of rubberized asphalt mixes RHMA-G and RHMA-O in California for over two decades
2. In 2024, around 40% of Caltrans asphalt mix tonnage was rubberized, mainly RHMA-G and RHMA-O, allowing recycling of around 2.3 million tires... the remaining 60% was standard HMA containing no RTR
3. Why not bring the benefits of the RTR to the standard HMA?

Our goal:

Use RTR to improve the mechanical performance of standard HMA…

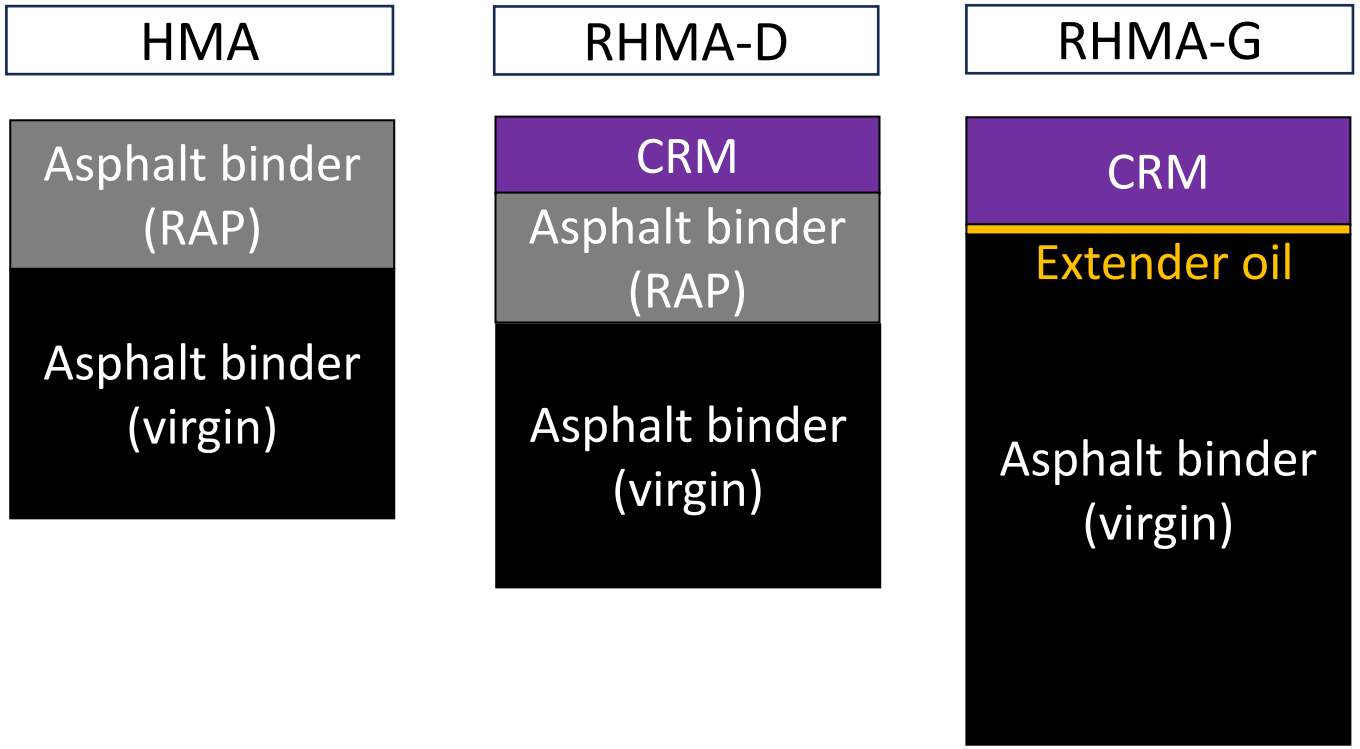
- …without increasing mixing and compaction temperatures
- …without challenging compactability
- …without significantly increasing initial cost
- …without substantially altering the original mix design

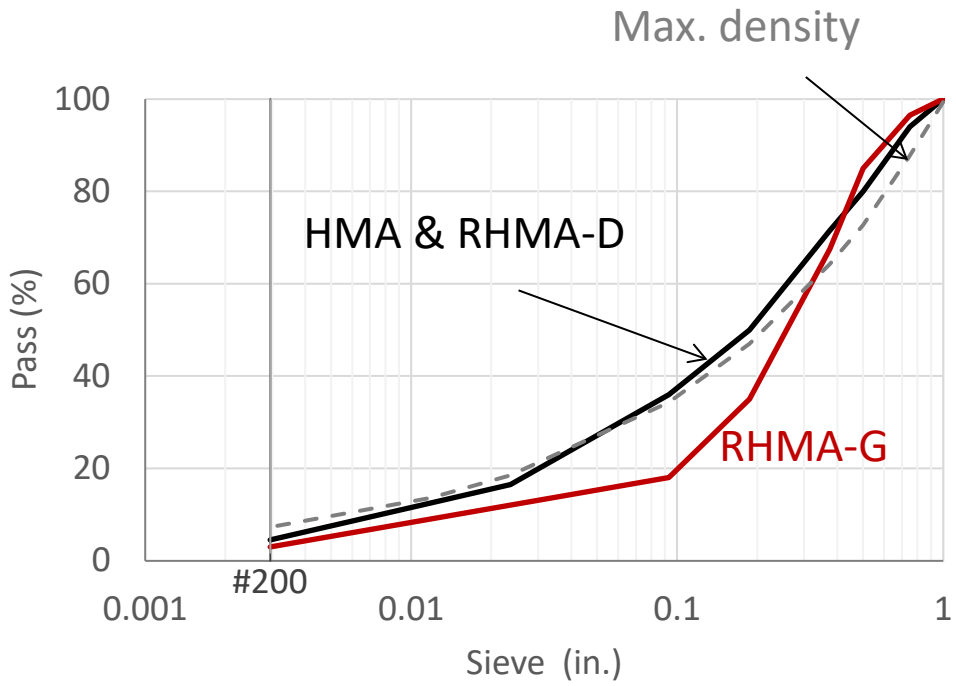
Standard HMA with RTR = RHMA-D

What is RHMA-D?

RHMA-D = Standard HMA with RTR

- Total binder content comparable to standard HMA
- The % of rubber may be any, typically at or above 10% total binder
- Dense gradation as standard HMA





What is RHMA-D?

RHMA-D fields of application:

- Intermediate layer in any road
- Surface layer in streets and county roads where RHMA-G is not feasible because of cost, availability, lack of personnel experience, perceived risk, etc.

What is CRM, ECRM, and TB?

Waste Tires

Mechanical shredding

CRM

- Crumb Rubber Modifier (CRM), also known as Ground Tire Rubber (GTR)
- Passing #8 for Caltrans RHMA-G/O
- Current shredding technology allows finer particles

ECRM

- Engineered CRM
- Several patented processes
- Most processes involve heating, blending with hot asphalt or other oils ~300°F, cooling and powder coating

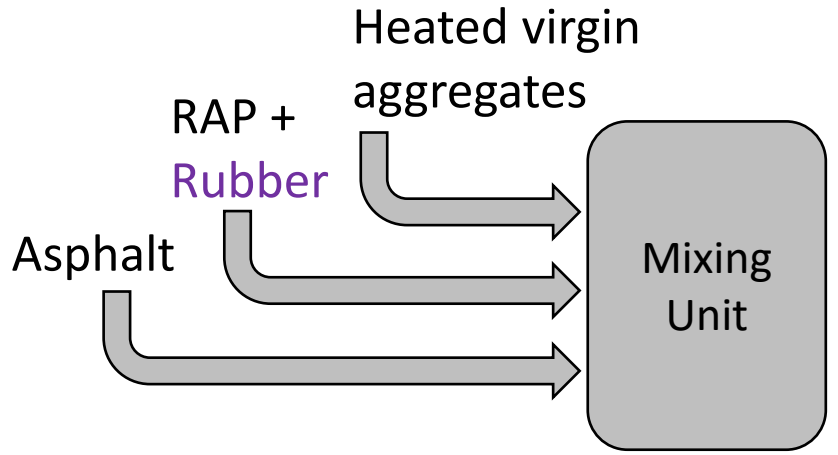
TB

- Terminal blend rubber
- Several patented processes
- Most processes involve heating, blending with hot asphalt ~600°F, and shearing
- The process results in rubber devulcanization
- Particles are micrometer size

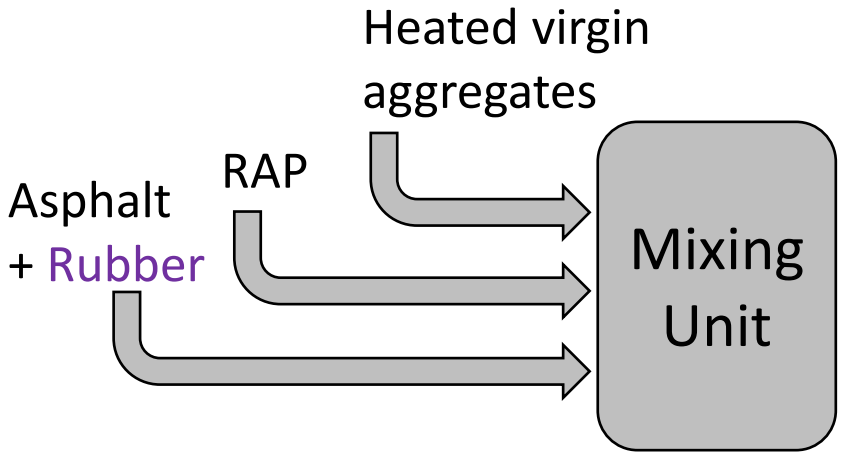
Dry Process versus Wet Process

- Dry process:
  - The rubber is added the same as RAP
  - Not standardized in California
  - Typical process for ECRM
- Wet process:
  - The rubber is blended with the asphalt binder
  - Different variants:
    - ✓ Terminal blend
    - ✓ High viscosity (Caltrans RHMA-G/O)
      - ❖ CRM #8
      - ❖ At least 45 minutes interaction time
      - ❖ ~400°F
    - ✓ Advanced wet
      - ❖ CRM #40
      - ❖ No interaction time
      - ❖ ~325°F (same as HMA with plain binder)
      - ❖ No extender oil

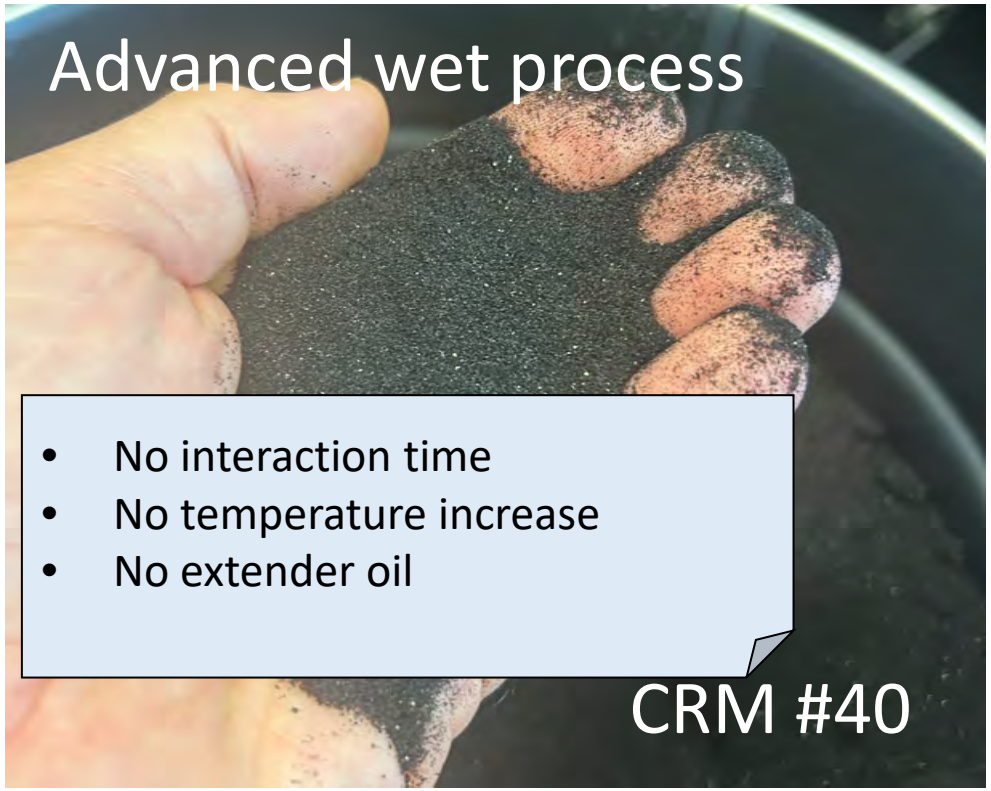
Dry Process



Wet Process



Dry Process versus Wet Process

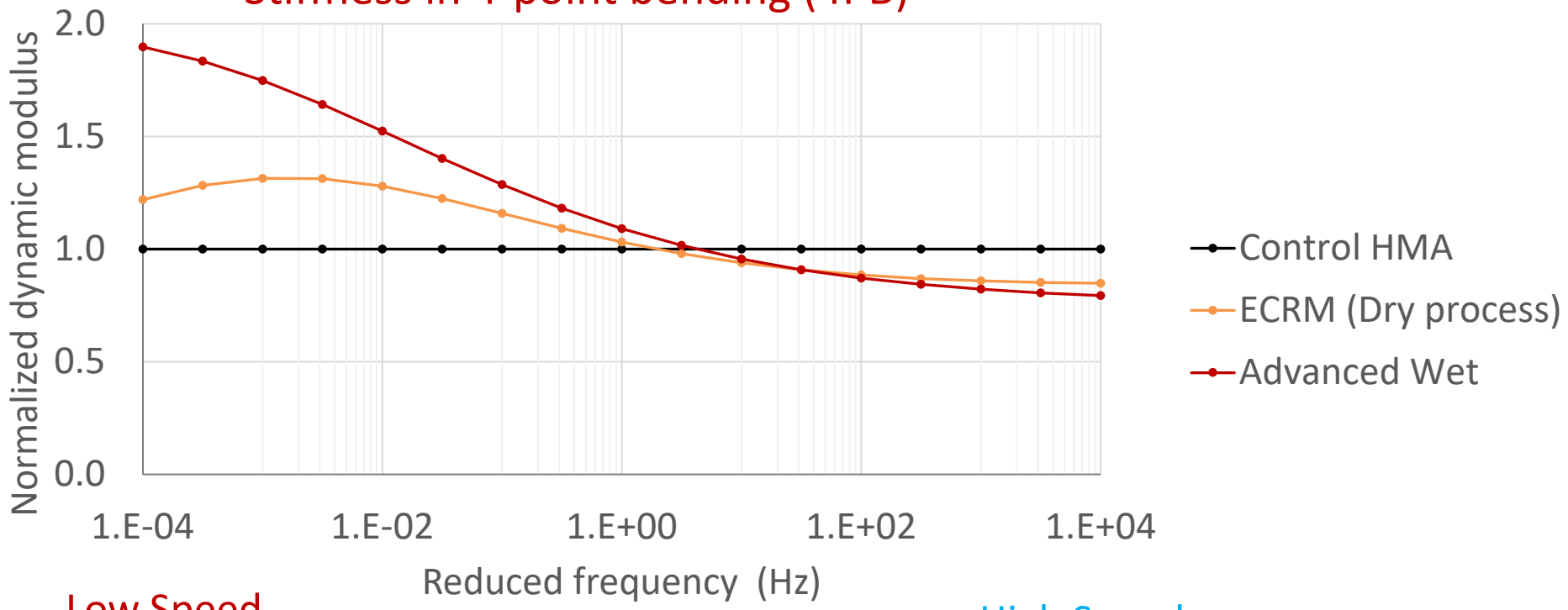


Initial Laboratory Study: RHMA-D has better properties than control HMA

Higher modulus at high temperature means less rutting

Lower modulus at low temperature means less cracking

Stiffness in 4-point bending (4PB)

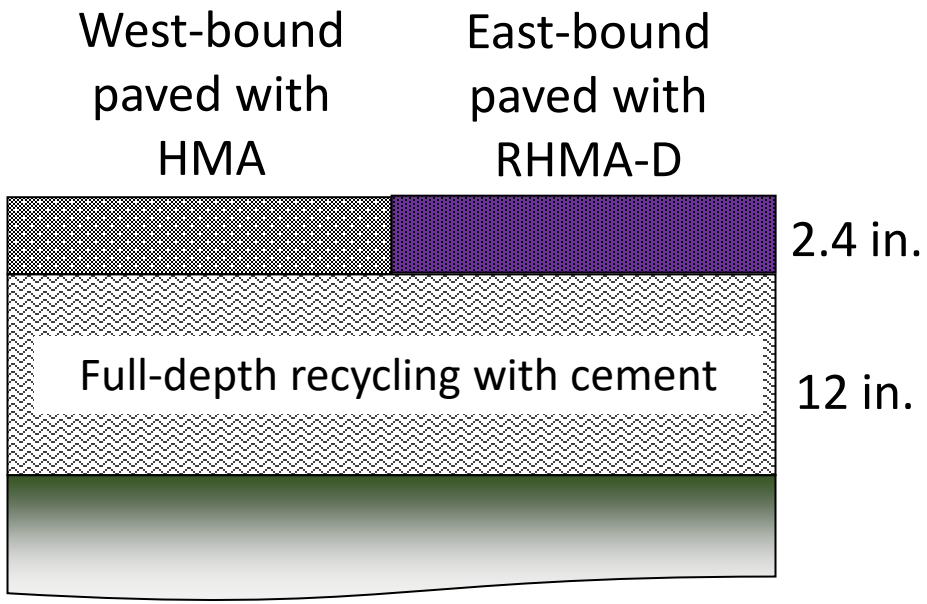


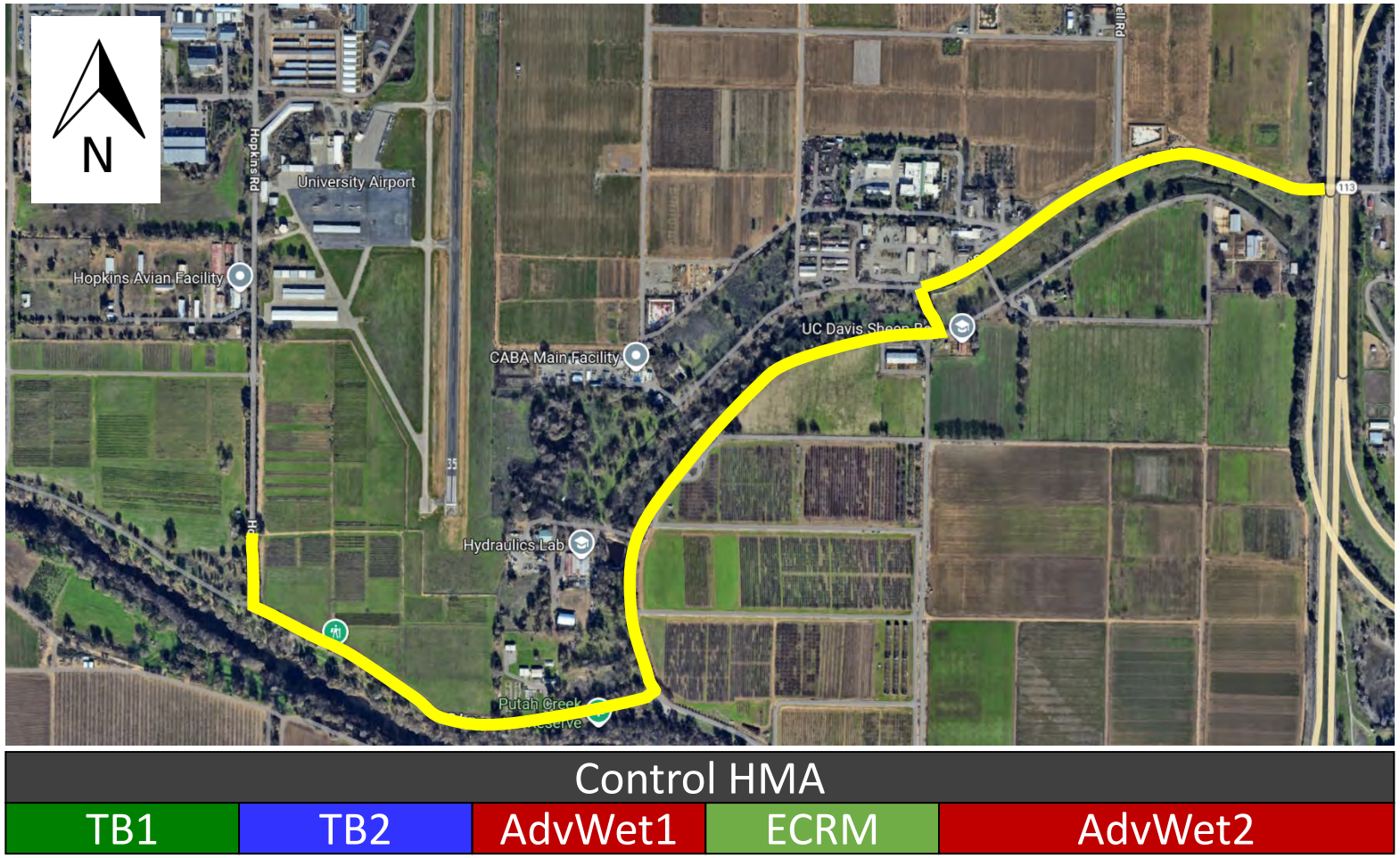
Low Speed / High Temp.

High Speed / Low Temp.

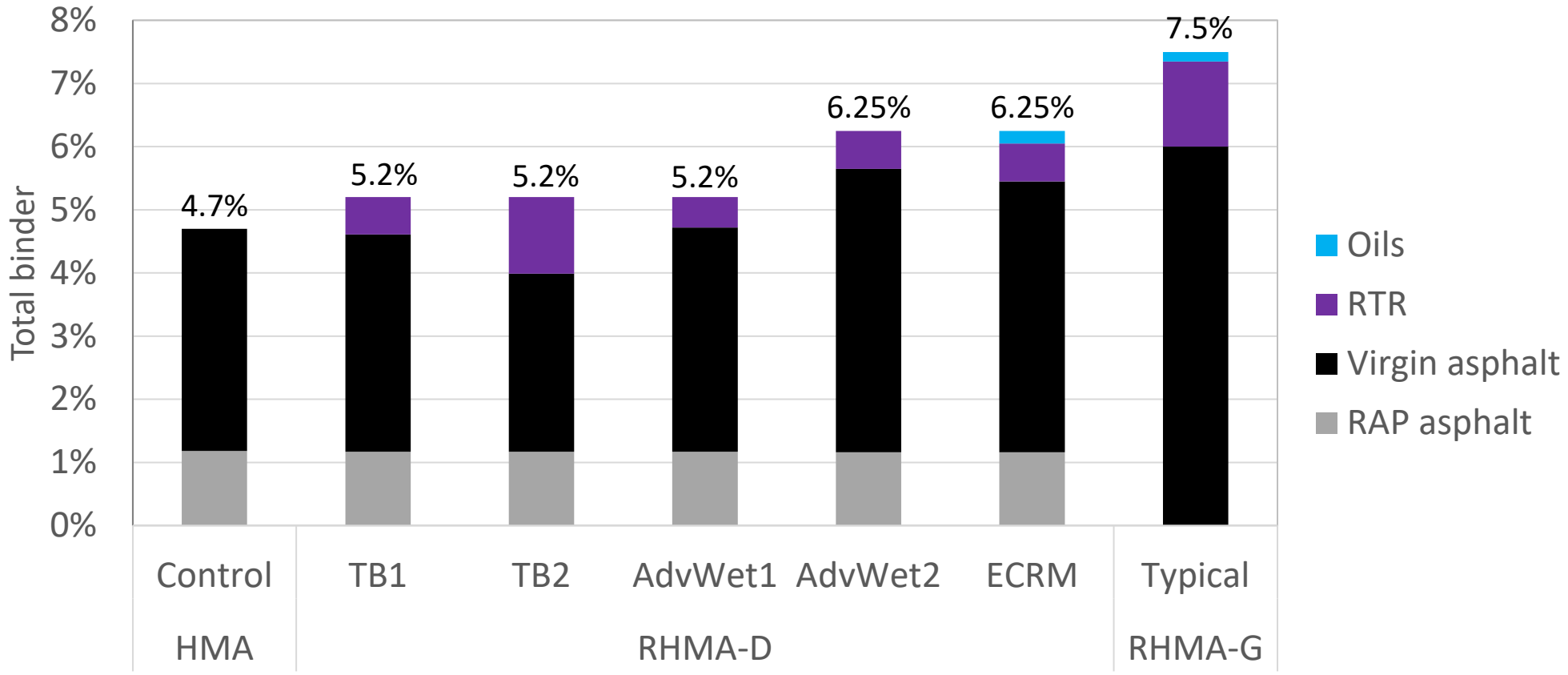
Levee Road Project

- The Levee Road is a 1.7-mile pavement rehabilitation/reconstruction at UC Davis campus
- Three technologies evaluated:
  - Terminal blend (TB)
  - Engineered CRM (ECRM)
  - Advanced Wet (AdvWet) process





- Binder content of RHMA-D mixes determined following a Balanced Mix Design (BMD) approach



	Control HMA	TB1	TB2	AdvWet1	AdvWet2	ECRM	RHMA-G
RTR versus total binder	0	11%	23%	9%	10%	10%	18%

Main Outcomes of Levee Road Project: Constructability

- Fabrication and placement of RHMA-D do not differ from standard HMA produced with plain binder:
  - RHMA-D mixes were mixed and placed at the same temperatures as the Control HMA
  - Plant and paving personnel did not observe any noticeable rubber odor, as typically associated with RHMA-G fabrication and placement
  - Paving machine operator and roller operators reported very positive impressions regarding the compactability of all RHMA-D mixes
  - In-place densities achieved in the field were same or higher than those of the Control HMA

Some testimonies:

"Much easier to work with than RHMA-G"

"Same or easier to compact than HMA"

"Far less smoke and smell than RHMA-G"

"Working with conventional RHMA-G typically leaves a rubber taste in the mouth and a strong odor on skin and clothing, whereas the RHMA-D mixes produced none of these effects or very slight ones"

RTR incorporation at the asphalt plant

- Terminal blend (TB1 & TB2): the rubber processing happens at refinery/terminal (off-site)
  - Delivered as finished liquid binders and handled like plain binder: same tanks, piping, and metering
  - No agitation equipment, no extender oil, and no interaction time required at the plant
- Advanced wet (AdvWet1 & AdvWet2): rubber blending at the plant, simplified
  - CRM #40 blended with the plain PG 58-22 binder using the plant's existing rubber blending equipment at 350°F (much lower than RHMA-G 375–425°F)
  - Simpler binder blending process: no extender oil and no minimum interaction time (vs. 45 minutes minimum for RHMA-G)
  - Binder viscosity roughly half that of RHMA-G asphalt rubber binder: no pumping or metering issues with existing plant infrastructure
- ECRM (dry process): the rubber product is handled like RAP
  - Pre-blended with the RAP (80 lb per ton of RAP) and fed through the plant's RAP feeder
  - No interaction tank or binder-system modifications: feasible at any plant with a RAP feeder

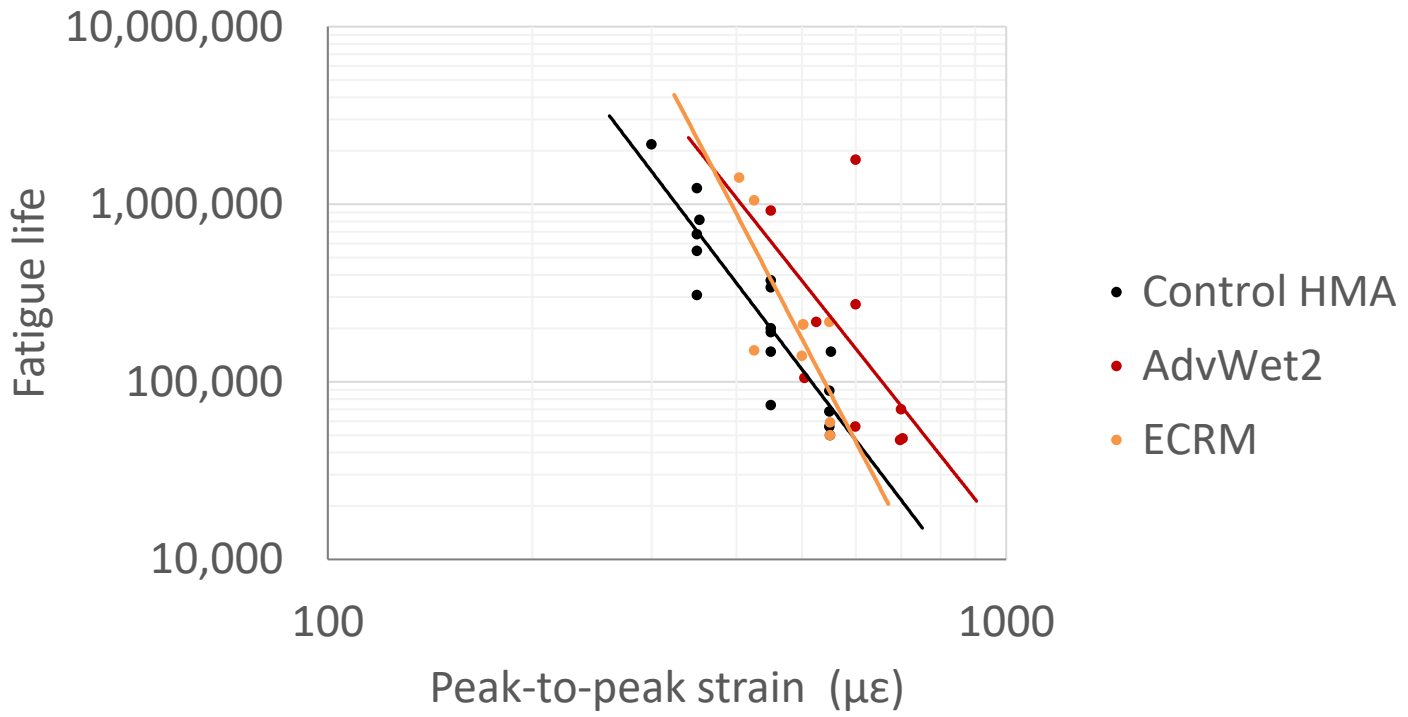
Main Outcomes of Levee Road Project: Constructability

Paving operations and in-place density

- Same paving operations as the Control HMA: bottom-dump trucks and windrow, pickup machine, paver, and rollers
- Same temperatures as conventional HMA, with no notable differences from the Control HMA:
  - ~325°F at plant discharge, 300–315°F at the windrow, and 260–290°F behind the paver
- In-place densities well above the Caltrans 91% minimum for all mixes:
  - Control HMA: 94.5% (5.5% air voids)
  - Four of the five RHMA-D mixes: 94.7% to 97.2%, exceeding the Control HMA
  - AdvWet1: 93.3%, related to its low binder content (next slide)
  - No compaction rebound between breakdown, intermediate, and finish windows.

Increased cracking resistance without compromising rutting resistance

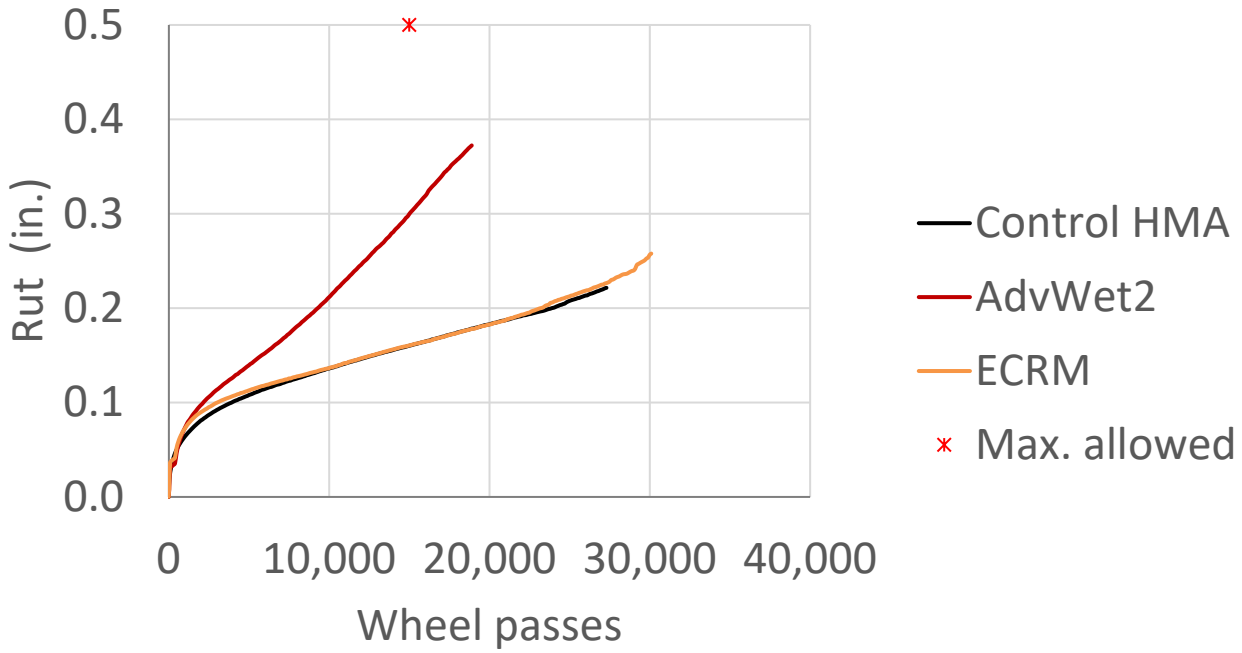
Fatigue cracking resistance in 4PB



- Fatigue lives of AdvWet2 and ECRM are approximately 3-5 times that of the Control HMA

Increased cracking resistance without compromising rutting resistance

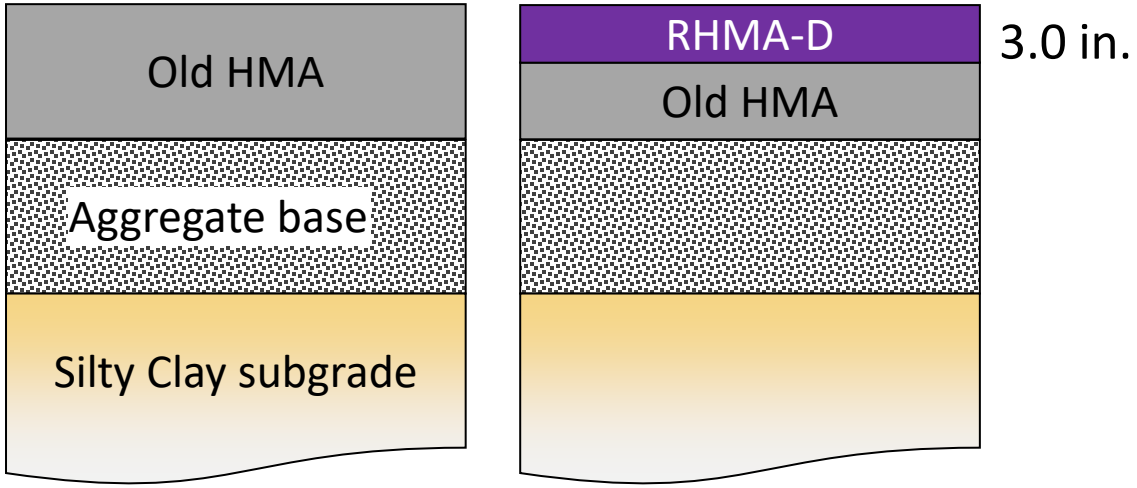
Rutting resistance in the Hamburg Wheel Tracking test



- The RTR addition allows improving cracking resistance without compromising rutting resistance

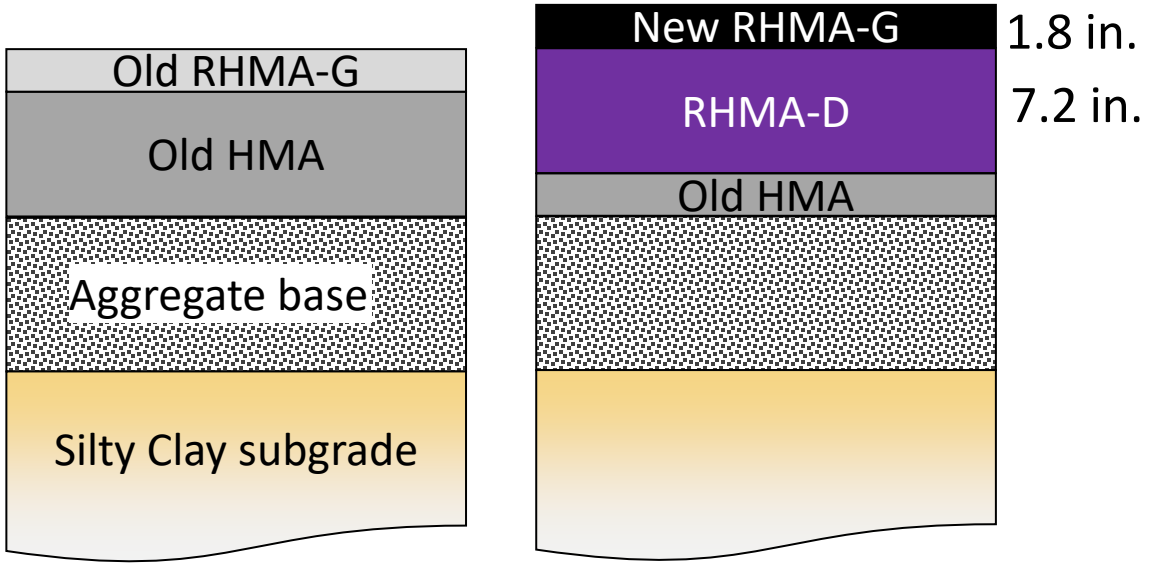
- Two case studies: Surface and intermediate layer

Case Study 1: Surface layer



20-year analysis period
TI = 8.5 (0.62 million ESALs)

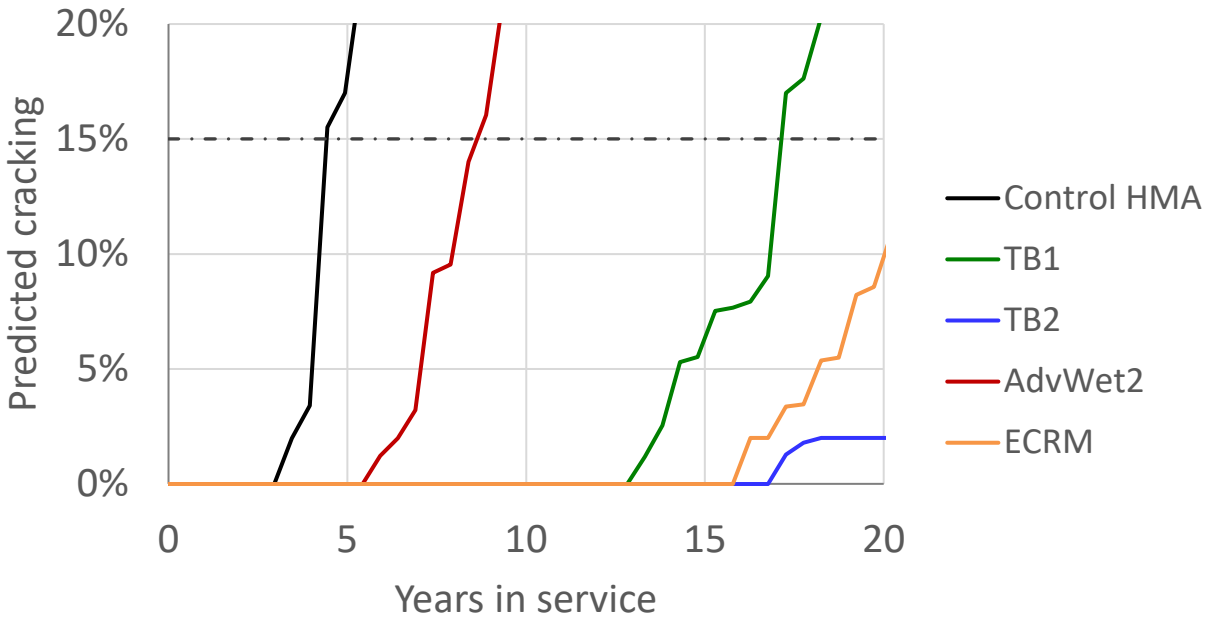
Case Study 2: Intermediate layer



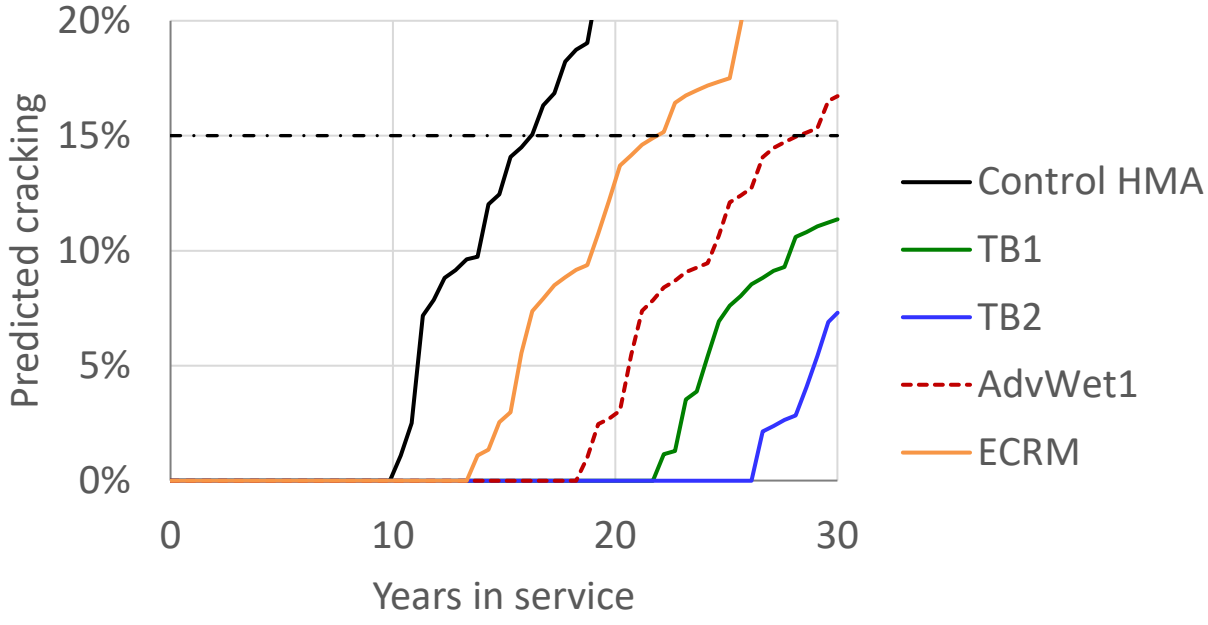
40-year analysis period
TI = 11 (5.4 million ESALs)

- Two case studies: Surface and intermediate layer

Case Study 1: Surface layer



Case Study 2: Intermediate layer

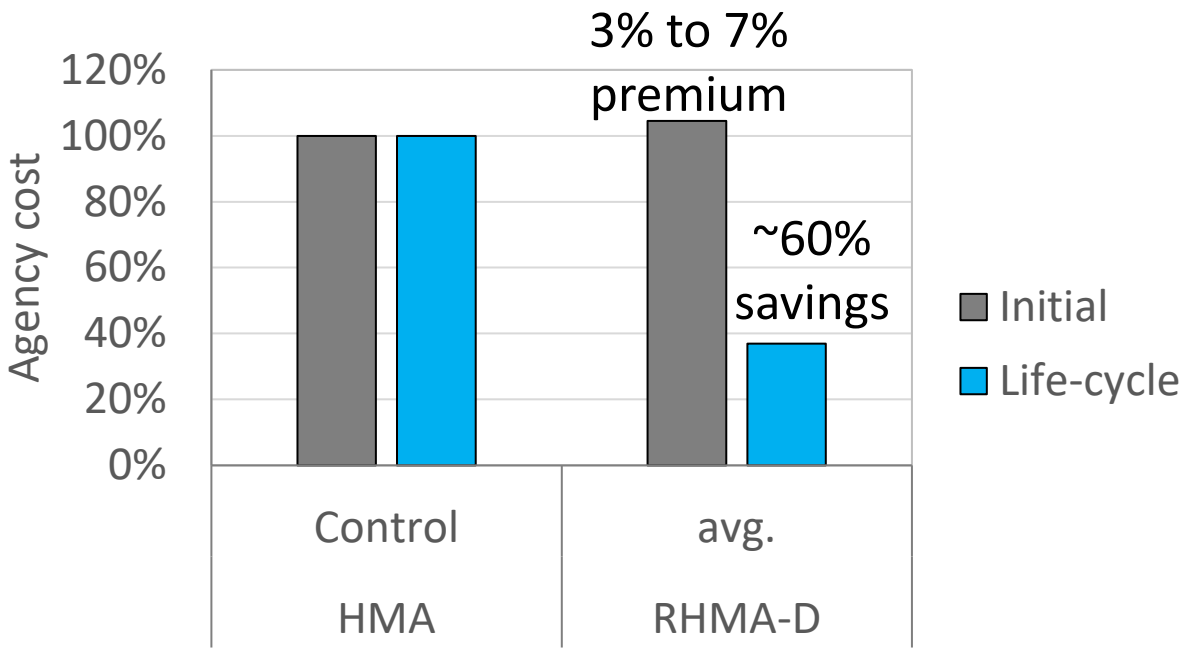


- The RHMA-D mixes improved the Control HMA performance as surface and as intermediate layer

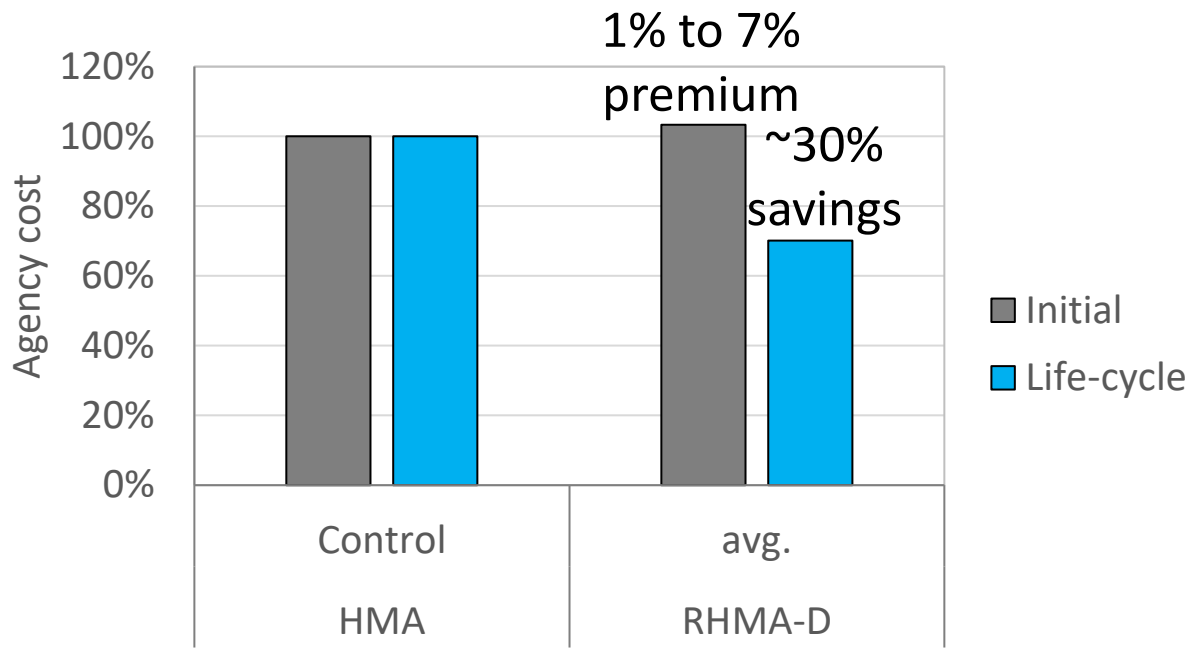
Main Outcomes of Levee Road Project: Life-cycle benefits

- Two case studies: Surface and intermediate layer

Case Study 1: Surface layer



Case Study 2: Intermediate layer



- Small increase in initial cost (up to 7%)
- Considerable life-cycle savings because of improved performance
- GWP savings (lower life-cycle emissions) are comparable to cost savings

Updates on Caltrans/industry towards asphalt Balanced Mix Design (BMD)

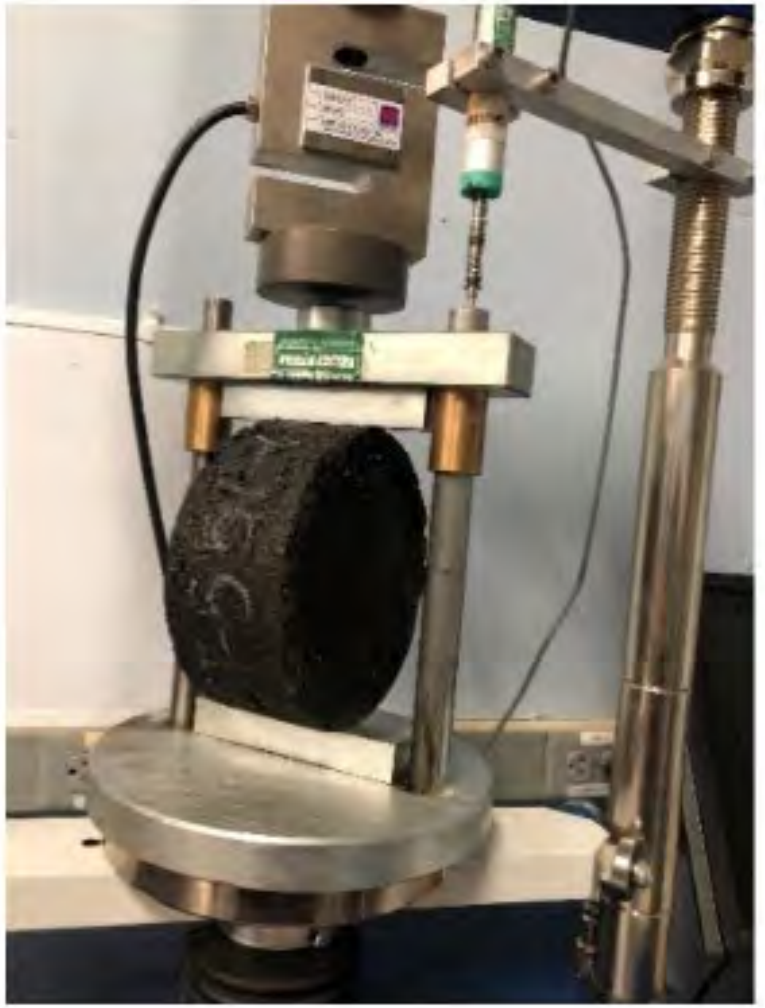
What is Balanced Mix Design?

- How have we been design asphalt mixes:
  - Hveem (developed 1950s): produces mixes with outstanding rutting resistance, poor cracking resistance; still used in SoCal Greenbook
  - Superpave (developed 1990s): produces mixes with excellent rutting resistance, incentives contractors to minimized binder content, no check on rutting or cracking performance; used by Caltrans since 2015; CCPIC version on website (higher binder contents for non-truck routes)
- Balanced Mix Design
  - Use simple performance related tests for rutting and cracking to achieve low risk of rutting and reduced risk of cracking compared to Superpave (current Caltrans) and especially compared to Hveem (Greenbook)

Potential Future Test in Specs: IDEAL-CT

- **Uses simple load frame**
- **Superpave compacted test specimen**
- **Run at 25°C (77°F)**
  - No temperature cabinet needed for testing
- **Run under two aging conditions:**
  - Plant sampled
  - Plant sampled + 20 hours at 100°C (212°F) in the oven (medium term oven aging [MTOA])
- **Gives two results from one test:**
  - Strength correlated to stiffness
  - IDEAL-CT index related to age-related cracking

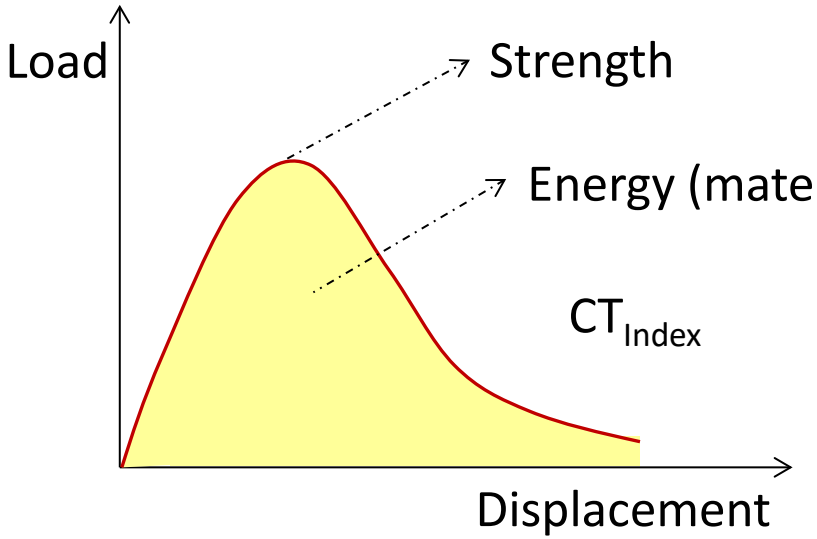
Image: UCPRC, https://escholarship.org/uc/item/52d1d1q5



Main Outcomes of Levee Road Project: Improved mechanical performance

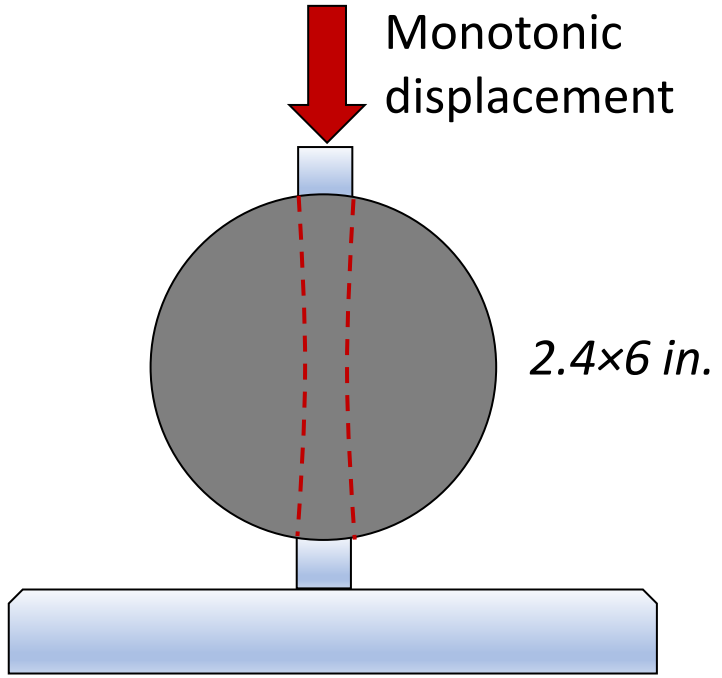
Increased toughness

IDEAL Cracking Tolerant test



Testing conditions:

- 77°F



Updates on 6ppd-q, coho salmon, and rubberized mixes

What are we talking about?

- 6ppd-q is a chemical used in tires to keep them from oxidizing (like age related cracking in pavement)
  - Tire industry is searching for a replacement chemical
  - Have exemption from state toxicology department in the meanwhile
- In last 5 years have identified that it is toxic to salmon and steelhead
  - The biggest concern is coho salmon who are sensitive (die, can't reproduce) at 10 parts/million, compared to chinook, steelhead at about 40 ppm
- How much comes from pavement versus tire wear?
  - No one knows
  - UCPRC/CalRecycle contract to test pavement materials and tire rubber in the laboratory starting this fall, results due in late 2028
- A Caltrans D5 (SLO) employee alerted NMF and there is a potential ban
  - Caltrans and CalRecycle discussing with NMF

- One-lane mile of pavement over 20 years:
  - Comparison of conservative estimate of potential rubber loss from pavement
  - Rubber loss from vehicles using the pavement

Pavement				
Analysis period	20	years		
	RHMA-G		RHMA-O	
Replacement time	20	years	15	years
rubber over analysis period	11.33	tons	20.71	tons
% available to leach	1%		10%	
available to leach over analysis period	**0.113**	**tons**	**2.071**	**tons**

- One-lane mile of pavement over 20 years:
  - Comparison of conservative estimate of potential rubber loss from pavement
  - Rubber loss from vehicles using the pavement

Low volume county road

Vehicles	all vehicle rubber assumed available to leach			
			Vehicle traffic (from calculations page)	
car tires total	0.561	tons	**1,000**	Average Annual Daily Traffic/lane 1 direction
trucks tires total	0.281	tons	5.0%	% 2-axle trucks
All vehicles total	**0.842**	**tons**	5.0%	% 3-axle trucks
			5.0%	% 4-axle trucks
			5.0%	% 5-axle trucks

Boulevard (P Street Sacramento)

Vehicles	all vehicle rubber assumed available to leach			
			Vehicle traffic (from calculations page)	
car tires total	3.241	tons	**5,000**	Average Annual Daily Traffic/lane 1 direction
trucks tires total	0.697	tons	2.5%	% 2-axle trucks
All vehicles total	**3.939**	**tons**	2.5%	% 3-axle trucks
			2.5%	% 4-axle trucks
			0.0%	% 5-axle trucks

Summary of potential actions

- New CCPIC online self-paced pavement training classes and upcoming live web classes
  - Take a look, contact us if questions
- New CCPIC asphalt pavement design catalog based on Caltrans CalME
  - Download it, Consultants contact us for questions
- Update on improving decision making in PMS
  - Agencies and Consultants, please contact us to discuss recommendations
- Update on use of RAP in local government mixes
  - Don’t use more than 8% RAP, or go to 15 to 25% with step-down binder
  - Contact us if questions and to review specifications etc
- New HMA with fine dry rubber mixes (RHMA-D)
  - Contact us if interested in participating in test sections
- Caltrans “balanced mix design”
- Update on 6ppd-q
  - No action now

Questions?

- Presentations, seminars at your place, with neighbors:
  - Upcoming: Monterey County (Oct 15), Solano County (Nov 19), City of El Cajon (Dec), City of San Marcos (Dec)
  - Monterey and Solano will cover basics, PMS use, compaction, gravel roads
- **John Harvey**: jtharvey@ucdavis.edu
- **Erik Updyke:** eupdyke@ucdavis.edu
- Get on CCPIC update list:

CCPIC update list

Other information

- UCPRC assembling a working group with USGS, Oregon and other interested parties
- It has been identified that open graded asphalt reduces stormwater pollution and is used as a BMP by Caltrans and others
  - RHMA-O lasts longer than regular open graded (UCPRC research)

- More information to come as it develops