
COLD RECYCLING CONSTRUCTION TRAINING

JUNE 10TH, 2026



Housekeeping



- Please type your name, district, and unit in the chat so we can have a record of attendees
- Questions in the chat box will be monitored and answered at the end of the webinar.
- Register on CT Learns to add to your training record.

PRESENTERS - CALTRANS



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Soil Stabilization & Pavement Recycling Specialist
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PRESENTATION OUTLINE

- **Caltrans' Cold Recycling Program and an Overview of Cold Recycling Processes**
- **Available Test Methods and Mix Design Overview**
- **Specification Overview and Emphasis on Key Items**
- **Contractor Perspective - Observations, Challenges, and Solutions for Cold Recycling Pavements**
- **Questions and Answers**





Caltrans' Cold Recycling Program and an Overview of the Cold Recycling Processes

Joseph Hammack
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California Department of Transportation (Caltrans)

OFFICE OF PAVEMENT RECYCLING AND JOB ORDER CONTRACTING STAFF

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Pavement Engineering

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RESOURCES



Office of Pavement Recycling & Job Order Contracting

To create a more sustainable and resilient pavement that respects the environment, and protects the health and safety of the people of California and its workers.

The Office of Pavement Recycling and Job Order Contracts is responsible with working with Districts and various stakeholders on prioritizing Pavement Recycling under appropriate pavement applications, which includes Partial Depth Recycling, Full Depth Recycling, and Cold Central Plant Recycling. The benefits would include lower capital costs, lower global warming potential, reduced material to the landfills, aligning with Caltrans goal for sustainability.

The Office also assists Districts in implementing Job Order Contracting (JOC), which is a project delivery method utilized to deliver projects comprised of numerous, non-complex, commonly encountered, and repetitive tasks whose scope is narrow. The benefits would include time savings and reduce procurement support costs for the Department.



Office Chief
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Office of Pavement Recycling & Job Order Contracting

- ▶ Pavement Recycling
- ▶ Job Order Contracting

Office of Pavement Recycling & Job Order Contracting Quicklinks

- Guide for Partial and Full Depth Pavement Recycling in California

Cold Recycling Resources

- ▶ 2022/2023 In-Place Recycling Webinar Series
 - ▶ Part I: Project Selection & Development of the In-Place Recycling (IPR) Industry (October 2022)
 - ▶ [Project Selection & Development of the In-Place Recycling \(IPR\) Industry Presentation Slides](#)
 - ▶ [Project Selection & Development of the In-Place Recycling \(IPR\) Industry Video Recording](#)
 - ▶ Part II: Partial Depth Recycling (March 2023)
 - ▶ [Partial Depth Recycling Presentation Slides](#)
 - ▶ [Partial Depth Recycling Video Recording](#)
 - ▶ Part III: Full Depth Recycling (June 2023)
 - ▶ [Full Depth Recycling Presentation Slides](#)
 - ▶ [Full Depth Recycling Video Recording](#)
 - ▶ Part IV: Cold Central Plant Recycling (September 2023)
 - ▶ [Cold Central Plant Recycling Presentation Slides](#)
 - ▶ [Cold Central Plant Recycling Video Recording](#)
 - ▶ Part V: Inverted Cold Recycled Pavements (September 2024)
 - ▶ [Inverted Cold Recycled Pavements Presentation Slides](#)
 - ▶ [Inverted Cold Recycled Pavements Video Recording](#)
 - ▶ Part VI: Mix Design and QC for In Place Recycling (May 2025)
 - ▶ [Mix Design and QC for In Place Recycling Presentation Slides](#)
 - ▶ [Mix Design and QC for In Place Recycling Video Recording](#)
 - ▶ Part VII: Implementation (October 2025)
 - ▶ [Implementation Presentation Slides](#)
- ▶ 2020 Introduction to Cold Recycling Webinar
 - ▶ [CR Training Presentation Slides](#)
 - ▶ [CR Training Day I Video Recording](#)
 - ▶ [CR Training Day II Video Recording](#)
- ▶ [Site Investigation Guide](#)
- ▶ [Highway Design Manual: Chapter 630 Flexible Pavement](#)
- ▶ [Caltrans PavEM Portal Website](#)
- ▶ [Guide for Partial Depth and Full Depth Recycling In California](#)

<https://maintenance.onramp.dot.ca.gov/asphaltpaves/pavement-recycling-pr>

RESOURCES - AVAILABLE CALIFORNIA TEST METHODS

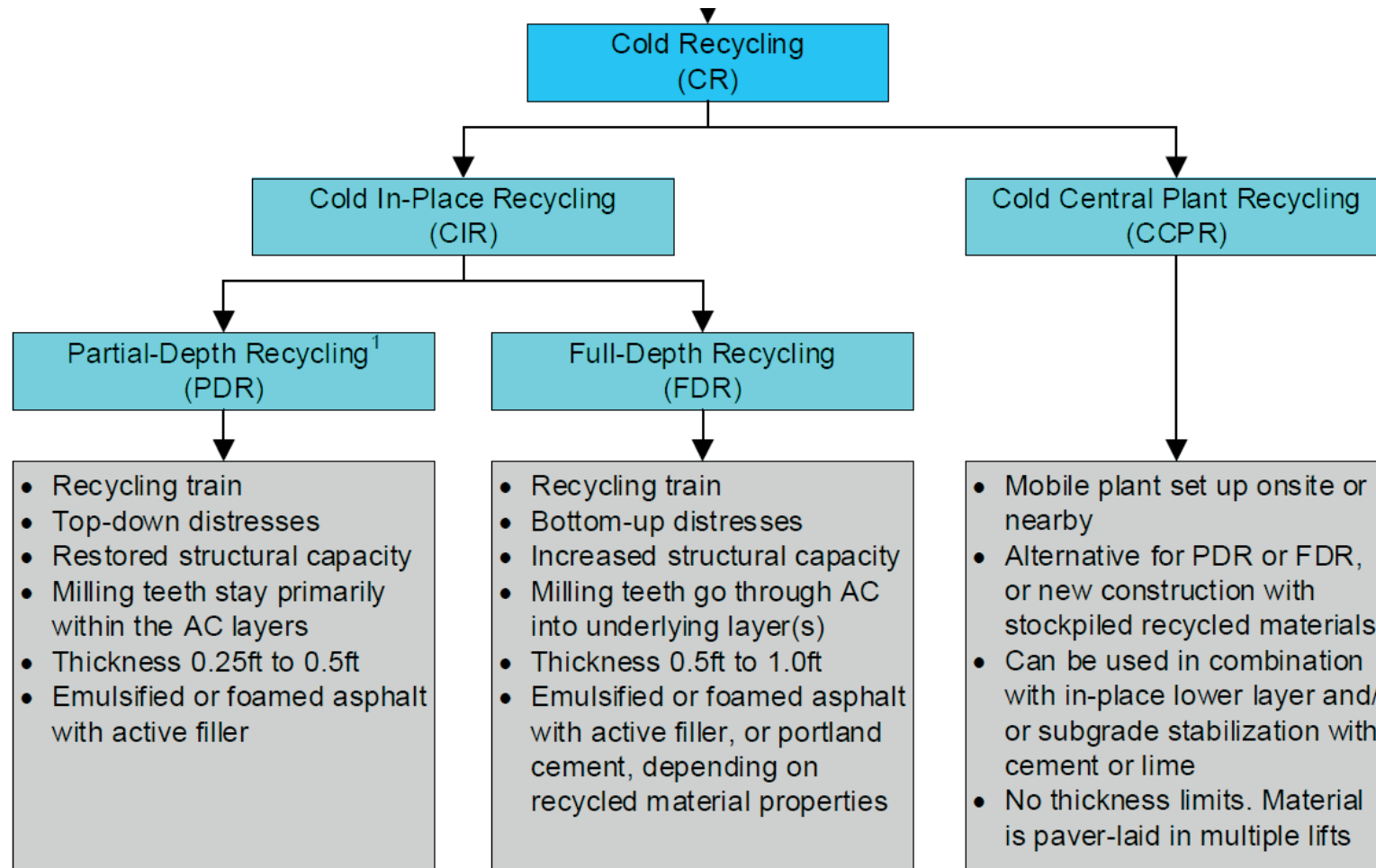
- CT 313: Method of Test for Mixture Design and Testing of Full Depth Recycling of Asphalt Pavements Using Foamed Asphalt and Additives
- CT 314: Method of Test for Determination of the Target Cement Content for In-Place Full-Depth Recycling of Asphalt Pavements Using Cement
- CT 315: Method of Test for Mixture Design and Testing of Partial Depth Recycling (PDR) of Asphalt Pavements Using Bituminous Recycling Agents and Additives
- CT 316: Method of Test for Mixture Design and Testing of Cold Central Plant Recycling (CCPR) of Asphalt Pavements Using Bituminous Recycling Agents and Additives
- CT 372: Method of Test for Resistance of Cold Recycled Pavement Materials to Moisture-Induced Damage

INDEPENDENT ASSURANCE (IA) CERTIFICATIONS



- Caltrans IA can certify labs for recycling related test methods.
- Contact:
IA.Service.Request@dot.ca.gov

WHAT IS COLD RECYCLING IN CALTRANS?



SUSTAINABLE BENEFITS OF COLD RECYCLING

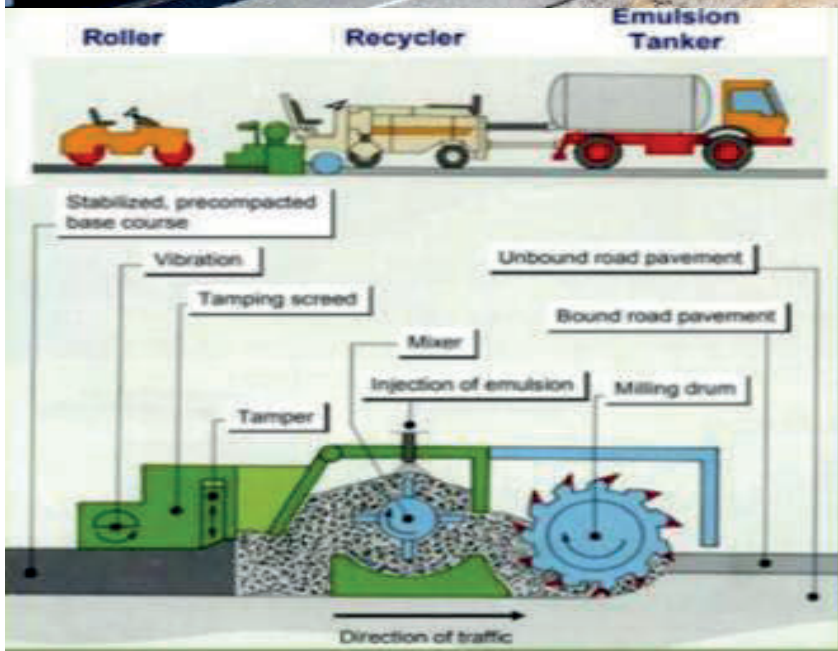
- Safety – Less construction traffic in work zone.
 - Less trucking operations, shorter construction time, less traffic disruption.
- Requires less new materials since the pavement is recycled.
 - According to the 2026 California Geological Survey, by the Department of Conservation, California is running out of available permitted aggregate mining space.
 - Some regions have 50 years or less of available aggregate reserves. Others, less than 10 years.
 - Cold recycling utilizes existing aggregates in asphalt pavement and base.
- Removes distresses and restores or enhances structural capacity.
- Constructed under traffic.
- Recycled roads can be recycled again.

STEPS IN COLD RECYCLING STRATEGIES

Cold Recycling strategies (PDR, FDR, CCPR) generally involve the following steps:

1. Cold-planning or pulverizing the existing pavement from edge of pavement to edge of pavement
2. Mixing with a recycling agent, stabilizing agent, water, and if required, supplemental aggregates
3. Compacting the mixed material back on the traveled way
4. Overlay with new HMA surface layer

PARTIAL DEPTH RECYCLING (PDR)



- Top-down distresses within the asphalt layers
- Remove existing Rubber Hot Mix Asphalt (RHMA) > 25% or chip-seals.
- Recycle top 0.25 to 0.5 ft from EP to EP
 - Milling teeth stay in the AC layer keeping about 2.5 inches of the existing AC thickness to support the train.
- Production rate is 1 to 2 lane miles per day
- PDR-Emulsified Asphalt, PDR-Foamed Asphalt
- New surfacing is required with 0.15 to 0.2 ft. of HMA or RHMA-G overlay.
- PDR can be done on Class 1,2, and 3 roads, depending on funding program.

PDR CONSTRUCTION PROCESS – RECYCLING TRAIN



Single Unit

- Recycling unit pulverizes, mixes, and treats the millings in one machine
- Shorter train length = better maneuverability
- Less control over gradation than Multi Unit

Multi Unit

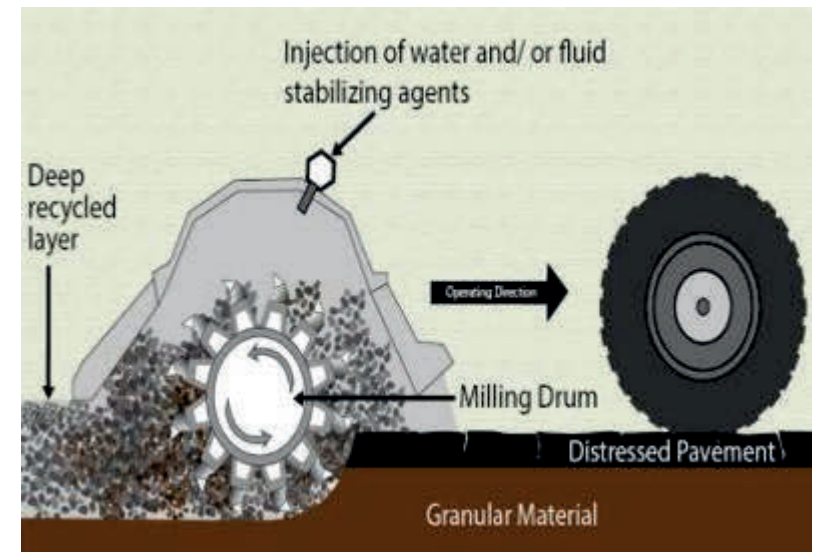
- A separate milling machine feeds millings into the recycling unit
- Longer train length = less maneuverability
- Better control on gradation and proportioning

SR 247 - PDR VIDEO



FULL DEPTH RECYCLING (FDR)

- Rehabilitation to address bottom-up distresses from the underlying layers.
- Recycles top 0.5 to 1.0 ft (typically 0.65 foot to 1 foot)
 - Milling teeth go through AC layers into the underlying base.
- 1 to 2 lane miles per day depending on recycling train
 - Wheel Driven – Pictured
 - Track Driven – PDR Single unit train
- FDR-No Stabilizer, FDR-Foamed Asphalt, FDR-Cement.
- New HMA or RHMA-G overlay is required, thick enough for a 20-year design.
- FDR can be used on Class 1, 2, and 3 routes.



FULL DEPTH RECYCLING (FDR) – FOAMED ASPHALT VS CEMENT

- **FDR with foamed asphalt** is selected for good quality materials
 - Recycled blend is primarily asphalt and underlying base – Gravels according to the Unified Soil Classification System (USCS)
 - Low plasticity materials
 - If combined materials fines content (Passing #200 sieve) exceed 15%, consider cement.
- **FDR with cement** is selected for more marginal materials.
 - Thin asphalt over subgrade, or marginal base material
 - FDR-C on high plasticity materials ($PI > 20$) is not recommended.
 - More cement $\neq$ Better Pavement, increases risk of shrinkage cracking
- Know what you're recycling. Site investigation to see what materials are out on grade.
- The more information of existing structure you can communicate to the contractor in bid documents, the better.



CHULA VISTA FDR VIDEO



COLD CENTRAL PLANT RECYCLING (CCPR)



- A maintenance or rehabilitation process where materials are milled to the required depth, transported to a nearby cold central plant, processed to a specified gradation, treated with recycling agents, transported back to the road, and then laid with a paver.
- Can be used for both partial- and full-depth recycling, as well as new construction with recycled materials.
- Multiple layers can be placed.
- CCPR-Emulsified Asphalt, CCPR-Foamed Asphalt
- Stabilization of the underlying layers and/or subgrade can be included as part of the rehabilitation process to increase structural capacity without increasing grade height.

COLD CENTRAL PLANT RECYCLING (CCPR) – RECYCLING UNIT



CCPR – PROCESSING AT THE PLANT

■ Milling

- RAP sources can vary, but typically some RAP is directly sourced from the project

■ Stockpile Management

- Ensures homogenous stockpile
- Avoid contamination
- Bins can be used
- Plant operators and loaders manage the treated material, compact within 2 hours of production, sooner is better.



CONSTRUCTION PROCESSES - PLACEMENT – PDR AND CCPR

- Standard paving crew and equipment
 - Plan for Material Swell
 - Air Voids ~ 9% to 15%
 - Do Not Heat Screed
 - Loose Thickness – Approx. 1.25" to 1.5" per 1" compacted



PDR Belt Fed



PDR Windrow



CCPR End Dump

CONSTRUCTION PROCESSES – PLACEMENT - FDR



Wheel Driven Recycling Train

- Recycled material left in place
- Utilizes grader to shape material
- More common



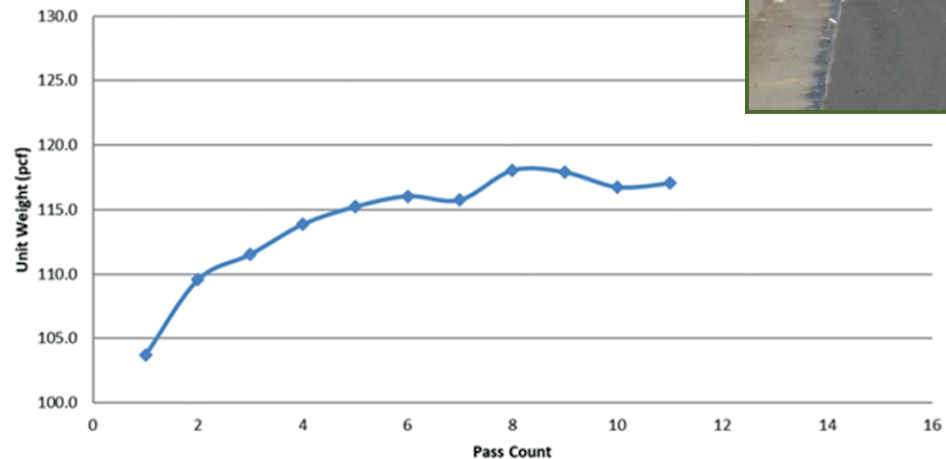
Track Driven Recycling Train

- Same as PDR – Single Unit Train
- Recycled material is fed into a paver and uniformly laid.
No grader

CONSTRUCTION PROCESS – COMPACTION – PDR AND CCPR

- Break-Over curve for density
 - On test strip and minimum 1 per day
 - Density changes with materials and environment
 - Relative compaction – 98% to 102%
- Minimum 10-ton Steel Drum and 25-ton Pneumatic rollers

CIR Test Strip



CONSTRUCTION PROCESS –COMPACTION - FDR



Initial Compaction



Final Grading



Final Compaction

- CT 216 – Relative compaction is used for Density Target
 - On test strip and minimum 2 per day.
 - Density changes with materials and environment
- 98% relative compaction for FDR-FA, 95% relative compaction for FDR-C
 - On test strip and 1 per lot
- Plan for material Swell
 - Estimated 7-10%

CONSTRUCTION PROCESS - FOG SEAL & SAND – PDR/FDR/CCPR

- After the end of the shift, the asphaltic emulsion and sand cover is applied.
 - Wait until fog seal breaks to place sand so it is tacky.
- Open to traffic after sand is placed. Road is open during curing process
- Contractor is responsible to maintain surface and repair any damage caused by Traffic
- For PDR-EA and CCPR-EA – Supplemental compaction prior to HMA Overlay
 - Will be removed in 2026 standard specifications
- For FDR-C – Microcracking before overlay



CONSTRUCTION PROCESS – MICROCRACKING (FDR-C ONLY)

- Prior to Asphalt Overlay
- Shrinkage crack mitigation (not prevention)
 - Induces a network of fine microcacks
 - 48 to 56 hours after final compaction
 - Up to 2 to 3 single passes with a 12-ton smooth drum vibrating roller
 - Maximum vibration traveling 2 to 3 mph



CONSTRUCTION PROCESS – ASPHALT SURFACE COURSE

- Quality Control and visual inspection are critical!
 - Visual Inspection is part of acceptance
 - No segregation, raveling, or loose material
 - Uniform texture and minimal variance
- PDR and CCPR have smoothness requirements
- HMA is placed
 - PDR/CCPR - within 15 days with conditions for moisture
 - FDR – within 7 days



THANK YOU!



Joseph Hammack

Transportation Engineer

HQ Division of Maintenance

California Department of Transportation
(Caltrans)



PRESENTATION OUTLINE

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- Available Test Methods and Mix Design Overview
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Section 30 — Recycled Pavement

CALTRANS 2025 STANDARD SPECIFICATIONS

Specification Overview · Subsections 30-1 through 30-6

Anthony Silva

Cold Recycling Construction Training · June 10, 2026

SECTION 30 AT A GLANCE

One General section, plus one section per recycling method

Section	Method	In one line	Test method
30-1	General	Shared rules: submittals, QC plan, mix design, payment	Applies to all
30-2	FDR — No Stabilizer (FDR-N)	Pulverize to ≤12", no binder, regrade & recompact	Gradation / density
30-3	FDR — Foamed Asphalt (FDR-FA)	Pulverize + foamed asphalt stabilizer, in place	CT 313
30-4	FDR — Cement (FDR-C)	Pulverize + cement → stiff, bound base course	CT 314 (UCS)
30-5	Partial Depth Recycling (PDR)	Recycle within the asphalt layer, ~3–5" (formerly CIR)	CT 315
30-6	Cold Central Plant Recycling (CCPR)	RAP mixed at a nearby plant, hauled back & paved	CT 316

Read it by depth and binder: PDR stays in the asphalt · FDR goes full depth into the base · CCPR is plant-based.

30-I GENERAL

Common requirements for all recycled-pavement methods

All methods

- Sets the shared rules that apply across every recycling method in Section 30
- Submittals: contractor Quality Control plan due at least 20 days before work starts
- Mix design and asphaltic-emulsion submittals reviewed and approved before production
- Preoperation meeting locks acceptance testing, reporting timeframes, and dispute process
- Defines shared materials (asphaltic emulsion, water) and measurement / payment



30-2 FDR — NO STABILIZER

Full Depth Recycling with no stabilizing binder (FDR-N)

No strength test

- Pulverize existing asphalt plus part of the granular base to a maximum 12-inch depth
- Purely mechanical — no binder; regrade and recompact, then HMA overlay
- Optional additives (aggregate base, lime, cement, kiln dust, fly ash) only if the blend needs them
- Best for moderate-to-low volume roads; most cost-effective where digouts run 20%+ by area
- Traffic runs on the untreated surface during work → 24-hour pilot-car control required



30-3 FDR — FOAMED ASPHALT

CT 313

Full Depth Recycling stabilized with foamed asphalt (FDR-FA)

- Pulverize asphalt + base to $\leq 12''$ and stabilize in place with foamed paving-grade asphalt
- Cement often added at a low % for early-opening strength
- Foaming quality controlled by expansion ratio and half-life; binder must be silicone / anti-foam free
- Mix design and acceptance by Indirect Tensile Strength — CT 313
- Current targets: Wet ITS 31.5 psi and Dry ITS 45 psi (major update from the 2013 procedure)



30-4 FDR — CEMENT

Full Depth Recycling stabilized with Portland cement (FDR-C)

CT 314

- Pulverize full asphalt + part of the underlying layer with a small % cement → stiff, bound base
- Acceptance by 7-day Unconfined Compressive Strength; target 300–450 psi (reduced) — CT 314
- ICS (Initial Consumption of Stabilizer) test sets the minimum cement to stabilize the mix
- Stronger ≠ better: too high invites shrinkage / reflective cracking → micro-crack at 46–56 hrs
- Cold-weather limits: don't start below 40°F; no work if freezing is expected within 7 days



30-5 PARTIAL DEPTH RECYCLING

CT 315

Recycling within the asphalt layer (PDR; historically CIR)

- Recycles within the existing asphalt — about 3–5" (0.25–0.40 ft) — the technique long called CIR
- Binder routes: emulsified (EA), foamed (FA), or engineered emulsion (EE); cement as an additive
- CT 315 dropped the Marshall stability requirement for EA mixes → Indirect Tensile Strength only
- Specimens fabricated in the gyratory compactor; targets Wet ITS 31.5 psi and Dry ITS 45 psi
- Intelligent Compaction is mandatory on in-place PDR



30-6 COLD CENTRAL PLANT RECYCLING

CT 316

RAP processed at a nearby cold central plant, then placed (CCPR)

- RAP is milled, hauled to a nearby cold central plant, mixed, hauled back, and paved — not in place
- Stabilized with foamed asphalt or emulsion plus cement and water in a pugmill / mixing chamber
- Use it for tight process control, imported RAP from stockpiles, or when jobsite space is limited
- Multiple lifts possible; can add structural capacity without raising the profile grade
- Mix design and acceptance by CT 316 (aligned to PDR); advancing through pilots into the standard

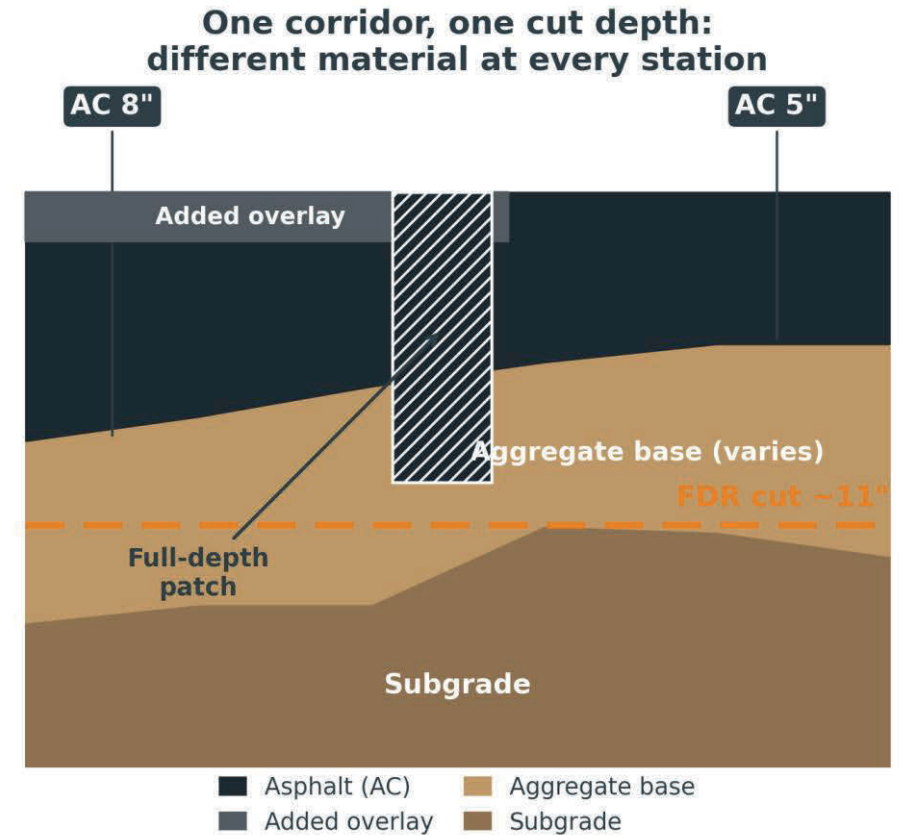


SAMPLING DRIVES THE MIX DESIGN

Why representative field sampling comes before any recycled mix design

- In cold recycling the existing road is the aggregate source. There is no quarry spec to fall back on, so the mix design is only as good as the samples that represent the road.
- Non-representative samples push binder content, gradation, and strength targets off-target. The cost shows up later as raveling, cracking, or failed acceptance.
- Cores, test pits, and milled material define layer thickness, RAP gradation, and every material that ends up in the blend.
- Sample density should track how much the road changes. Add coverage where age, traffic, drainage, and past repairs vary.
- 30-I approves the mix design and emulsion submittals before production. Representative sampling is what makes that submittal defensible.

Sampling first



KEY ITEMS TO REMEMBER

1

Depth tells you the method

PDR stays in the asphalt · FDR goes full depth into the base · CCPR is done at a plant.

2

The binder picks the test

Foam → CT 313 · Cement → CT 314 (UCS) · PDR → CT 315 · CCPR → CT 316. FDR-N has no strength test.

3

One ITS line for asphalt-bound mixes

FDR-FA and PDR both target Wet ITS 31.5 psi and Dry ITS 45 psi, on gyratory-compacted specimens.

4

30-I governs all of them

QC plan, mix design, and material submittals are approved before any machine turns.

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COLD RECYCLING CONSTRUCTION SPECIFICATIONS

June 10, 2026

Raguparan Thangavelautham

Senior Transportation Engineer

HQ Division of Construction

California Department of Transportation (Caltrans)



AVAILABLE COLD RECYCLING SPECIFICATIONS

STANDARD SPECIFICATIONS

STATE OF CALIFORNIA
CALIFORNIA STATE TRANSPORTATION AGENCY
DEPARTMENT OF TRANSPORTATION

2025 Edition

PUBLISHED BY
DEPARTMENT OF TRANSPORTATION



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Section 30 Recycled Pavement

- 30-1 General
- 30-2 Full Depth Recycling – No Stabilizer
- 30-3 Full Depth Recycling – Foamed Asphalt
- 30-4 Full Depth Recycling – Cement
- 30-5 Partial Depth Recycling (PDR)
- 30-6 Cold Central Plant Recycling

PARTIAL DEPTH RECYCLING (PDR) (SECTION 30-5)



Submittals:

- Submit the following 20 days before start work
 - Quality Control Plan (QCP)
 - Mix design
 - Contingency plan

QUALITY CONTROL (QC) PLAN SUBMITTAL REQUIREMENTS - PDR



- Submit QC Plan before starting PDR production
- Engineer reviews QC Plan within 5 business days of submittal
- Do not start PDR production until the Engineer authorizes the QC Plan
- Submit a QC Plan Supplement at least **3 business days** before implementing any changes
- Do not implement any QC Plan changes without the Engineer's authorization

 Refer to Section 30-5.01C(2) for detailed QC Plan requirements

QUALITY CONTROL REPORTING - PDR



Daily QC Report Requirements

- Submit one consolidated daily report for all completed lots
- Include production, material usage, process control, and quality control testing information
- Update reports within **24 hours** of receiving test results
- Submit daily production quantities and material usage during PDR activities

 Refer to Section 30-5.01C(5) for detailed reporting requirements.

QUALITY ASSURANCE - PDR



Quality Assurance

- Quality Control
- Department Acceptance
- Dispute Resolution

 Refer to Section 30-5.01D for detailed Quality Control requirements

OVERALL QUALITY CONTROL REQUIREMENT - PDR



Quality Control Plan

- Submit and maintain an approved QC Plan.
- **Define Procedures**
 - Process control
 - Sampling and testing
 - Reporting & Corrective actions
- **Quality Control Activities**
 - Monitor production and material application rates.
 - Document process adjustments and corrective actions
 - Perform required QC sampling and testing.
 - Stop work and notify the Engineer when suspension limits are exceeded

JIT (JUST-IN-TIME) TRAINING



- Must be completed within **14 days** before work starts
- Submit the training materials at least **7 days** before the training
- **Covers**
 - Equipment calibration
 - Mixing process
 - QC testing procedures
- **Aligns**
 - Prime contractor
 - Recycling Subcontractor
 - Inspectors
 - Equipment Operators
 - Lab personnel

TEST STRIP

■ Test Strip Requirements

- Construct on the **first day of PDR activities**
- Located within the pavement area to receive PDR
- **Single lane width** Minimum length: **1,056 feet**

■ Demonstrate the Following

- Ability of proposed equipment, materials, and processes to produce and place the PDR mixture
- Effect of varying:
 - Cold-planing machine forward speed
 - Drum rotation rate

 Refer to Section 30-5.01D(2)(d) for the details of the test strip specifications

PARTIAL DEPTH RECYCLING (PDR) TEST STRIP REPORT
Contractor's Establishment of Break Over Density

Pg. 1 of 1
JOB # 4737-REC

PROJECT INFORMATION

CONTRACT NUMBER 08-1L8604	CO/ROUTE Hwy 2-Wrightwood CA	CONTRACTOR Sully Miller	JMF NUMBER 21-0702	DATE 8/25/2021
Start Loc.: 00+00	End Loc.: 10+00	Lane No.: 1	Dir. (E,W,N,S): W	Offset from C/L: 8'

Note: Use 24-hour clock throughout form.

WEATHER

☒ Clear	☐ Partly Cloudy	☐ Cloudy	☐ Rain	☐ Breezy	☐ Windy
Ambient Temp °F 72	Time 8:00	Surface Temp °F 80	Time 8:00		

CIR RECYCLING EQUIPMENT

Cold Milling or Planing Equipment:	Self-propelled?	☒ Yes	☐ No
	Minimum 12-foot cutter that can remove pavement to specified depths?	☒ Yes	☐ No
	Effect of varying forward speed and drum rotation of cold planing machine on the CIR mixture consistency:	X	
	Ski devices for longitudinal profile?	☒ Yes	☐ No
Mixing and Proportioning Equipment:	Automatic depth & cross slope controls capable of maintaining the cutting depth to within 0.25-inch of the specified depth?	☒ Yes	☐ No
	Homogeneous mix?	☒ Yes	☐ No
	Material Plant Quality Program Calibrated? Cert Date: 4/6/2021 Exp. Date: 10/6/2021	☒ Yes	☐ No
Pugmill:	Milled pavement material delivered to the mixing chamber controlled by weight?	☒ Yes	☐ No
	Determination of optimum rate of emulsified recycling agent: 3.0 % recycling agent (Cement) 0.5 % water 2.0 %	☒ Yes	☐ No
	Delivery amount of recycling agent and recycling additive being controlled?	☒ Yes	☐ No
Water Storage and Supply Equipment:	Supplemental water source independent from the recycle train?	☒ Yes	☐ No
	Supplemental water interlocked with the RAP weighing device or microprocessor?	☒ Yes	☐ No
Spreading Equipment:	Paver in compliance with Section 39-1.03B of the Standard Specifications?	☒ Yes	☐ No
	Pavers loading equipment picking up and depositing CIR mixture without waste?	☒ Yes	☐ No
	Ski devices for longitudinal profile?	☒ Yes	☐ No
Compacting Equipment:	Compacting equipment in compliance with Sections 39-1.03B and 39-1.03B(3)?	☒ Yes	☐ No
	Pneumatic-tired roller weigh at least 25 tons? Minimum 5.5 foot wide?	☒ Yes	☐ No
	One double drum vibratory steel-wheeled roller weighing at least 10 tons? Minimum 5.5 foot wide?	☒ Yes	☐ No
	Finish roller? Type:	☐ Yes	☒ No
Each roller have working water spray and scraper systems?		☒ Yes	☐ No

COMPACTION ROLLING PATTERN MAXIMUM DENSITY DETERMINATION

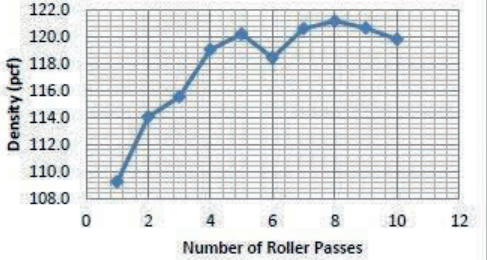
Roller Pass No.	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Pass 6	Pass 7	Pass 8	Pass 9	Pass 10
Type of Roller	SD/Vibe	SD/Vibe	SD/Vibe	RTR	RTR	RTR	RTR	RTR	RTR	RTR
Density (pcf)	107.9	113.4	115.3	119.7	120.0	118.4	121.0	121.3	120.4	120.9
Density (pcf)	110.6	114.7	115.8	118.4	120.4	118.5	120.2	121.0	120.9	118.7
Ave. Dens. (pcf)	109.3	114.1	115.6	119.1	120.2	118.5	120.6	121.2	120.7	119.8

Roller Pass No.	Pass 11	Pass 12	Pass 13	Pass 14
Type of Roller				
Density (pcf)				
Density (pcf)				
Ave. Dens. (pcf)				

Maximum Density **121.2** pcf

Compaction and Sieve Data on CIR Placement Report

Lot No. **Test Strip**



TEST STRIP - CONTINUED

Demonstrate the Following -Continued

- Establish application rates for:
 - Asphalt, Cement, Water
- Determine rolling pattern needed to reach the **break-over point**
- Establish application rates for
 - Asphaltic Emulsion & Sand Cover
- The Engineer will evaluate the test strip & Authorize

 Refer to Section 30-5.01D(2)(d) for the details of the test strip specifications

Pg. 1 of 1

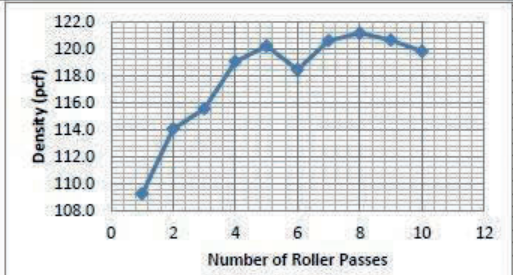
JOB # 4737-REC


PARTIAL DEPTH RECYCLING (PDR) TEST STRIP REPORT
 Contractor's Establishment of Break Over Density

PROJECT INFORMATION										
CONTRACT NUMBER 08-1L6604		COIRTE Hwy 2-Wrightwood CA		CONTRACTOR Sully Miller		JMF NUMBER 21-0702		DATE 8/25/2021		
Start Loc.: 00+00		End Loc.: 10+00		Lane No.: 1		Dir. (E,W,N,S): W		Offset from C/L: 8'		
Note: Use 24-hour clock throughout form										
WEATHER										
☒ Clear		☐ Partly Cloudy		☐ Cloudy		☐ Rain		☐ Breezy		
Ambient Temp °F 72		Time 8:00		Surface Temp °F 80		Time 8:00				
CIR RECYCLING EQUIPMENT										
Cold Milling or Planing Equipment:	Self-propelled?								☒ Yes	☐ No
	Minimum 12-foot cutter that can remove pavement to specified depths?								☒ Yes	☐ No
	Effect of varying forward speed and drum rotation of cold planing machine on the CIR mixture consistency:								☒ X	
	Ski devices for longitudinal profile?								☒ Yes	☐ No
Mixing and Proportioning Equipment:	Automatic depth & cross slope controls capable of maintaining the cutting depth to within 0.25-inch of the specified depth?								☒ Yes	☐ No
	Homogeneous mix?								☒ Yes	☐ No
	Material Plant Quality Program Calibrated? Cert Date: 4/6/2021 Exp. Date: 10/6/2021								☒ Yes	☐ No
Pugmill:	Milled pavement material delivered to the mixing chamber controlled by weight?								☒ Yes	☐ No
	Determination of optimum rate of emulsified recycling agent: 3.0 % recycling agent (Cement) 0.5 % water 2.0 %									
Water Storage and Supply Equipment:	Delivery amount of recycling agent and recycling additive being controlled?								☒ Yes	☐ No
	Supplemental water source independent from the recycle train?								☒ Yes	☐ No
Spreading Equipment:	Supplemental water interlocked with the RAP weighing device or microprocessor?								☒ Yes	☐ No
	Paver in compliance with Section 39-1.03B of the Standard Specifications?								☒ Yes	☐ No
	Pavers loading equipment picking up and depositing CIR mixture without waste?								☒ Yes	☐ No
Compacting Equipment:	Ski devices for longitudinal profile?								☒ Yes	☐ No
	Compacting equipment in compliance with Sections 39-1.03B and 39-1.03B(3)?								☒ Yes	☐ No
	Pneumatic-tired roller weigh at least 25 tons? Minimum 5.5 foot wide?								☒ Yes	☐ No
	One double drum vibratory steel-wheeled roller weighing at least 10 tons? Minimum 5.5 foot wide?								☒ Yes	☐ No
	Finish roller? Type:								☐ Yes	☒ No
	Each roller have working water spray and scraper systems?								☒ Yes	☐ No
COMPACTION ROLLING PATTERN MAXIMUM DENSITY DETERMINATION										
Roller Pass No.	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Pass 6	Pass 7	Pass 8	Pass 9	Pass 10
Type of Roller	SD/Vibe	SD/Vibe	SD/Vibe	RTR	RTR	RTR	RTR	RTR	RTR	RTR
Density (pcf)	107.9	113.4	115.3	119.7	120.0	118.4	121.0	121.3	120.4	120.9
Density (pcf)	110.6	114.7	115.8	118.4	120.4	118.5	120.2	121.0	120.9	118.7
Ave. Dens. (pcf)	109.3	114.1	115.6	119.1	120.2	118.5	120.6	121.2	120.7	119.8
Roller Pass No.	Pass 11	Pass 12	Pass 13	Pass 14						
Type of Roller										
Density (pcf)										
Density (pcf)										
Ave. Dens. (pcf)										

Maximum Density 121.2 pcf

Compaction and Sieve Data on CIR Placement Report
 Lot No. Test Strip



Number of Roller Passes	Density (pcf)
1	108.0
2	114.1
3	115.6
4	119.1
5	120.2
6	118.5
7	120.6
8	121.2
9	120.7
10	119.8

QC TESTING & NONCOMPLIANCE - PDR

- Perform QC sampling and testing at the required frequencies
- Monitor compliance with specification requirements and QC Plan limits.
- Stop PDR operations and notify the Engineer when suspension limits are exceeded
- Correct noncompliant work before resuming production

 Refer to Section 30-5.01D(2)(e)(ii)

PDR Quality Testing Frequencies

Quality characteristic	Test method	Minimum sampling and testing frequency	Location of sampling
Water sulfates ^a (max, ppm)	California Test 417	1 per source	Source
Water chlorides ^a (max, ppm)	California Test 422	1 per source	Source
Asphalt expansion and half-life for PDR-FA	Visual inspection	Each tanker truck	Recycling equipment
Maximum wet gradation (% passing)	AASHTO T 27	Test strip and 2 per lot	Recycled mat
1-1/4"			
Wet gradation (% passing) Sieve size: 1-1/4" 1" 3/4" No. 4	AASHTO T 27	Test strip and every 3rd lot	
Dry gradation ^b (% passing) Sieve size: 1-1/4" 1" 3/4" No. 4 No. 30 No. 200	AASHTO T 27	1 per day and prior to the introduction of recycling agent	
Indirect dry tensile strength (psi)	California Test 372	Every other lot	
Indirect wet tensile strength (min, psi) ^c	California Test 372	Every other lot	

^aOnly required for new asphalt surface courses

MATERIAL SAMPLING & TESTING - PDR

- Sample and test recycling agents and asphaltic emulsion
- Use an authorized laboratory
- Provide samples to the Engineer for acceptance testing

 Refer to Section 30-5.01D(2)(e)(ii)

PDR Quality Testing Frequencies

Quality characteristic	Test method	Minimum sampling and testing frequency	Location of sampling
Water sulfates ^a (max, ppm)	California Test 417	1 per source	Source
Water chlorides ^a (max, ppm)	California Test 422	1 per source	Source
Asphalt expansion and half-life for PDR-FA	Visual inspection	Each tanker truck	Recycling equipment
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Dry gradation ^b (% passing) Sieve size: 1-1/4" 1" 3/4" No. 4 No. 30 No. 200	AASHTO T 27	1 per day and prior to the introduction of recycling agent	
Indirect dry tensile strength (psi)	California Test 372	Every other lot	
Indirect wet tensile strength (min, psi) ^c	California Test 372	Every other lot	

^aOnly required for new material sources

MATERIAL QUALITY CHARACTERISTICS - PDR

- **Material Quality Characteristics Requirements**
 - Gradation
 - Density and Relative Compaction
 - Indirect Tensile Strength (ITS)
 - Thickness
 - Asphalt Expansion and Half-Life (PDR-FA)

 Refer to Section 30-5.02B

30-5.02B Material Quality Characteristics During Production

Material quality characteristics during production must comply with the following requirements as shown in the following table:

PDR Quality Characteristic Requirements		
Quality characteristic	Test method	Requirement
Asphalt expansion and half-life for PDR-FA	Visual inspection	Foaming
Maximum wet gradation (% passing) Sieve size: 1-1/4"	AASHTO T 27	100
Wet gradation (% passing) Sieve size: 1-1/4" 1" 3/4" No. 4	AASHTO T 27	100 98 Report only Report only
Dry gradation (% passing) Sieve size: 1-1/4" 1" 3/4" No. 4 No. 30 No. 200	AASHTO T 27	Report only
Relative compaction (min, %) ^a	California Test 231 or California Test 375	98–102
In-place wet density (g/cc)	California Test 375, Part 4	Report only
Thickness (inch) ^b Each core Average thickness of cores	Core measurements	±0.75 inch of the thickness shown ≥ thickness shown
Indirect dry tensile strength (psi)	California Test 372	Report only
Indirect wet tensile strength (min, psi)	California Test 372	Report only

^aThe average of lot test locations must be between 98 to 102 percent with no individual test less than 95 to 105 percent. Use California Test 375 for 4 inches or less and California Test 231 for greater than 4 inches.

^bCoring must be done after any smoothness correction. Take 4- or 6-inch core from one random location per lot as determined by the Engineer. Coring at more than one location per lot is change order work. Perform coring and measure core depth in the presence of the Engineer. If core retrieval is not achieved, you may submit depth measurements, taken in the presence of the Engineer. This process will be done after supplemental compaction for PDR-EA.

SMOOTHNESS REQUIREMENTS - PDR

■ Surface Smoothness

- Monitor smoothness during cold-planing operations.
- Stop work and notify the Engineer when smoothness limits are exceeded.
- Verify final smoothness before HMA overlay.
- Correct deficient areas before opening to traffic.

 Refer to Section 30-5.01D(2)(e)(ii)(F)



DEPARTMENT ACCEPTANCE – PDR

■ Visual Inspection

- Surface uniformity
- No segregation, raveling, rutting, humps, depressions, roller marks, or loose material

■ Smoothness Requirements

- $MRI \leq 90$ in/mi per 0.1-mile section
- Localized roughness ≤ 240 in/mi
- Straightedge compliance

■ Material Acceptance

- Asphalt binder meets Section 92 requirements
- Asphaltic emulsion meets Section 94 requirements
- Compliance with Quality Characteristic per

30-5.01D(3) Department Acceptance

The Engineer samples materials for testing under California Test 125

PDR acceptance is based on:

1. Visual inspection for:
 - 1.1. Segregation, raveling, rutting, humps, depressions, roller marks, and loose material.
 - 1.2. Uniform surface texture throughout the work limits.
2. Compliance with smoothness requirements on the PDR surface of:
 - 2.1. MRI of 90 in/mi or less for each 0.1-mile section.
 - 2.2. Areas of localized roughness no greater than 240 in/mi.
 - 2.3. Areas that require PDR surface smoothness determined using a 12-foot straightedge. The PDR surface must not vary from the lower edge of the straightedge by more than:
 - 2.3.1. 0.02 foot when the straightedge is laid parallel with the centerline
 - 2.3.2. 0.03 foot when the straight edge is laid perpendicular to the centerline and extends from edge to edge of a traffic lane
3. Asphalt acceptance is based on the Department's sampling and testing for compliance with the requirements for the quality characteristic in section 92 table "PG Asphalt Binder" for the performance grade of asphalt used
4. Asphaltic emulsion acceptance is based on the Department's sampling and testing for compliance with the requirements shown in the following table:

Asphaltic Emulsion Requirements

Quality characteristic	Test method	Requirements	
		Minimum	Maximum
Test on emulsion:			
Sieve test (max, %)	AASHTO T 59	--	0.1
Residue by evaporation (min, %)	AASHTO T 59	28.5 ^a	--
Test on residue by evaporation:			
Penetration, at 25 °C (mm)	AASHTO T 49	40	90

^aResidue requirement is based on 1:1 dilution ratio of asphaltic emulsion and water.

 Refer to Section 30-5.01D(3), Department Acceptance, for detailed requirements.

DEPARTMENT ACCEPTANCE - CONTINUED (PDR)

- **Compliance with Material Quality Characteristic**
 - Gradation
 - Indirect Wet Tensile Strength (ITS)
 - Relative Compaction
 - PDR Thickness
- **Noncompliance**
 - Stop PDR activities when directed by the Engineer.
 - Identify and implement corrective actions.
 - Reprocess, remedy, or replace noncompliant work.
- Obtain **Engineer authorization** before resuming work

Quality characteristic	PDR Quality	
	Test method	Requirement
Maximum wet gradation (% passing) Sieve size: 1-1/4"	AASHTO T 27	100
Wet gradation (% passing) Sieve size: 1-1/4" 1" 3/4" No. 4	AASHTO T 27	100 98 Report only Report only
Dry gradation (% passing) Sieve size: 1-1/4" 1" 3/4" No. 4 No. 30 No. 200	AASHTO T 27	Report only
Indirect wet tensile strength (min, psi)	California Test 372	Report only
Relative compaction (min, %) ^a	California Test 231 or California Test 375	98–102
Thickness (inch) ^b : Each core Average thickness of cores	Core measurements	±0.75 inch of the thickness shown ≥ thickness shown

 Refer to Section 30-5.01D(3), Department Acceptance, for detailed acceptance criteria

MATERIALS PLANT QUALITY PROGRAM (MPQP)

CALIBRATION OF PDR EQUIPMENT



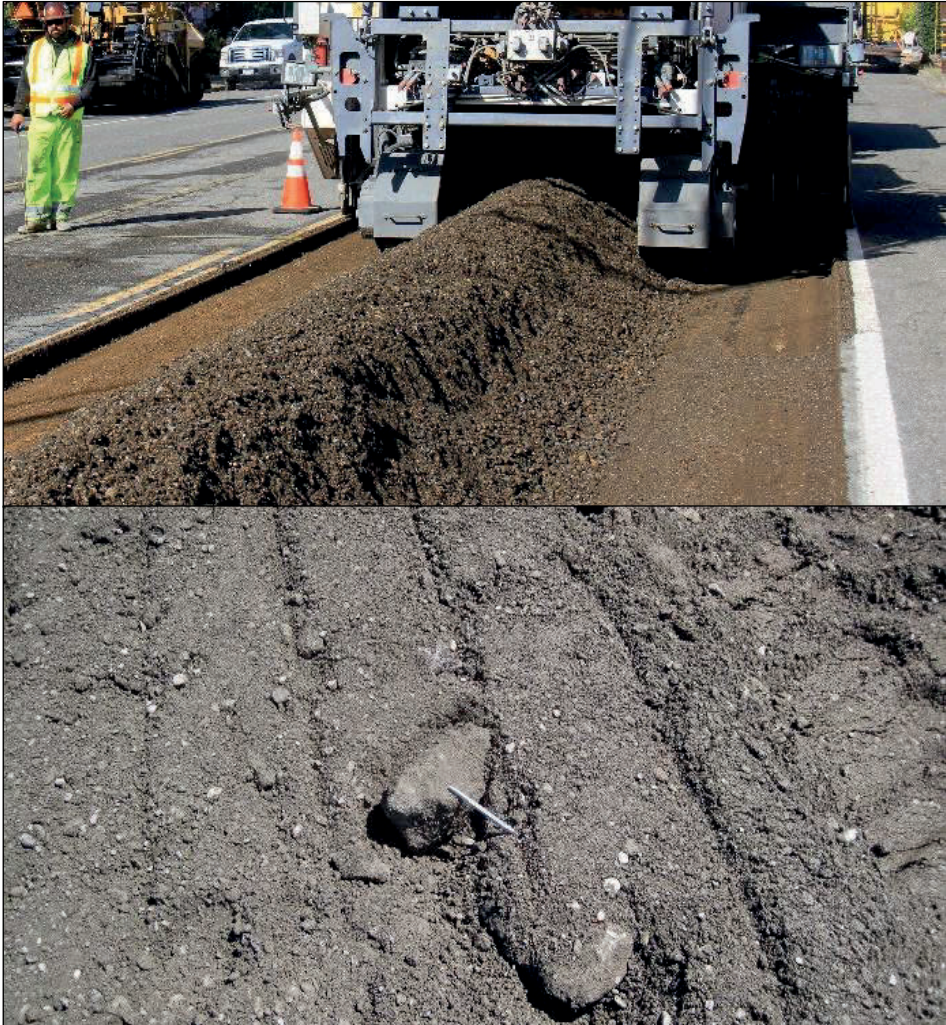
- Aggregate Weigh Belt
- Cement Spreader
- Mass Flow Meter – Recycling Agent
- Depth Control System
- Distance Measurement System

INSPECTION AND TESTING

- Testing alone is **not enough**
- Visual inspection identifies:
 - Segregation
 - Raveling
 - Non-uniform mixing



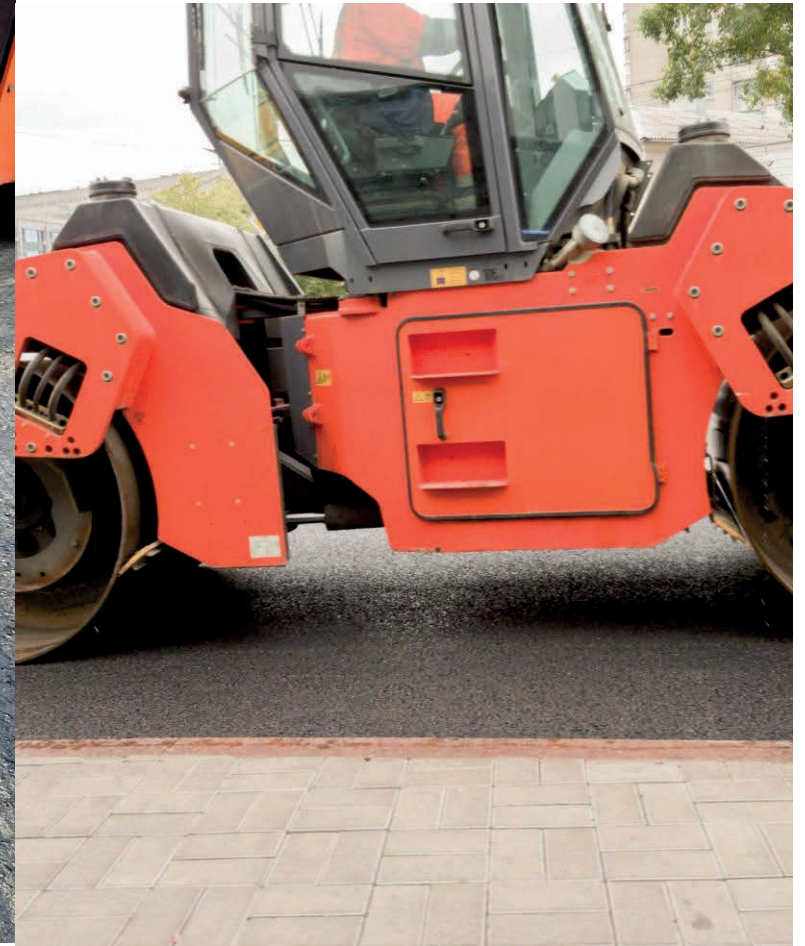
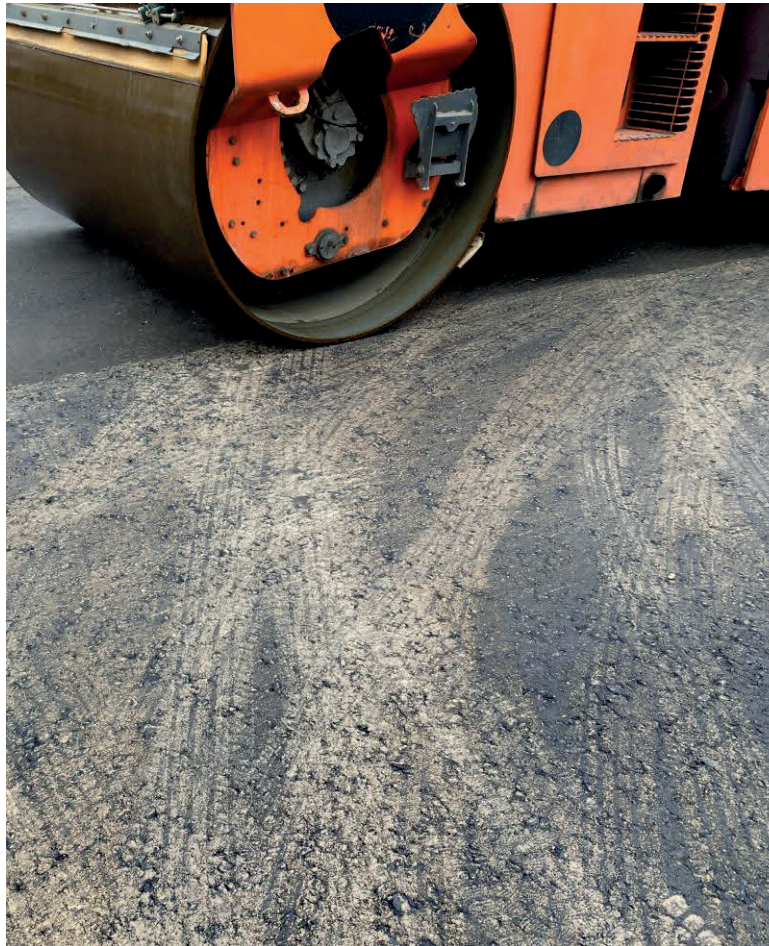
MATERIAL SIZING & GRADATION



- **Control During Pulverizing:**
 - Avoid oversized particles
 - Ensure uniform mix
- **Issues:**
 - Large chunks → weak spots
 - Non-uniform mix → inconsistent strength
- **Adjustment needed:**
 - Machine settings
 - Screening if required
 - Reduce recycling train speed

COMPACTION TIMING (CR LAYERS)

- **Max allowed:** 2 hours
- **Preferred:** within 1 hour
- Why critical?
 - Delays → moisture loss → poor density
 - Leads to:
 - Weak layer
 - Cracking
 - Reduced life
- 📌 Field tip:
- Monitor time from **pulverizing** → **compaction completion**



COMPACTION WATER CONTROL

Target: ~2% above optimum moisture

- **Problems:**

- Too dry → low density
- Too wet → instability and rutting

- **Field practice:**

- Maintain **consistent surface moisture**
- Monitor continuously during rolling



FIELD LAB IMPORTANCE

Critical for:

- Moisture testing
- Density checks
- Sample curing
- Prompt sample compaction for representative results

Key points:

- Must be **certified lab**
- Time-sensitive → delays affect accuracy



EMULSION & SAND COVER TIMING

Apply Emulsion To:

- Damp surface (no standing water)

Apply Sand Cover:

- Typically, 30–45 minutes after emulsion

Factors Affecting timing:

- Temperature
- Wind
- Time of day

Too early or late = poor bonding or tracking issues



OPENING TO TRAFFIC

Steps to Take

- Apply emulsion
- Apply sand cover
- Place temporary painted traffic stripes and pavement markings



MAINTAIN, CURE, AND PROTECT THE SURFACE

Important:

- Protect the surface from:
 - Tire damage
 - Raveling
- Maintain the surface Immediately repair any damage or defects before opening to traffic



HMA CAP PLACEMENT TIMING

Place within **15** days after PDR construction completed

Check:

- Moisture condition
- Surface integrity

Risks of delay:

- Moisture loss
- Surface damage
- Reduced bonding



HMA CAP PLACEMENT TIMING

Do not place HMA until one of the following conditions is met

- Three days and moisture measured at mid-depth of the PDR pavement is 2.0 percent or less
- Ten days without rainfall
- Four days without rainfall and no change in measured moisture content of the PDR pavement within a 24-hour period



THANK YOU



Raguparan Thangavelautham

Senior Transportation Engineer

HQ Division of Construction

California Department of Transportation (Caltrans)



PRESENTATION OUTLINE

- Caltrans' Cold Recycling Program and an Overview of Cold Recycling Processes
- Available Test Methods and Mix Design Overview
- Specification Overview and Emphasis on Key Items
- Contractor Perspective - Observations, Challenges, and Solutions for Cold Recycling Projects
- Questions and Answers



Contractor Perspective on Cold Recycling Projects

Mike Concannon, P.E.



Contractors rely on the same information that Owners rely on

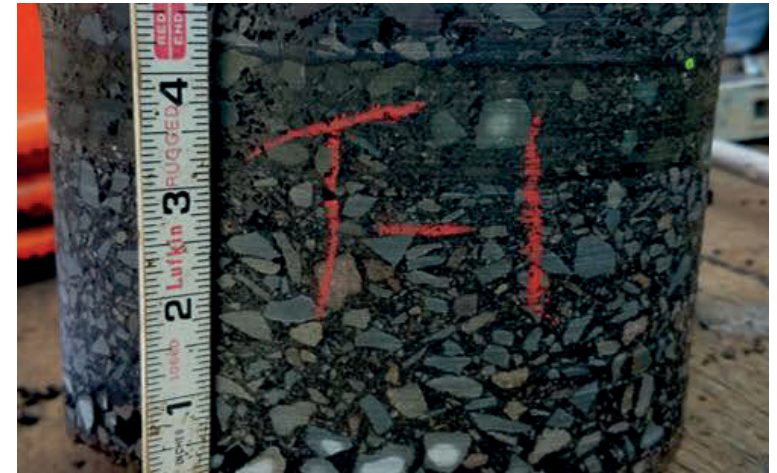
- Pavement investigation, historical data gathering and traffic analysis
- Appropriate design based on existing conditions
- Mix design/job mix formula on all projects
- Just In Time Training (JITT)
 - Include Inspector, Contractor, Engineer, QC
- Partnering, industry working with agencies



Sampling and Mix Design

Sampling - Several Key Objectives

- Verifying Existing Conditions
 - Subgrade Stability
 - Adequate Pavement Thickness
 - Presence of Paving Fabric
- Obtain Representative Sample
 - Space Sampling Throughout Project Area
 - Identify if Multiple Mix Designs are Appropriate



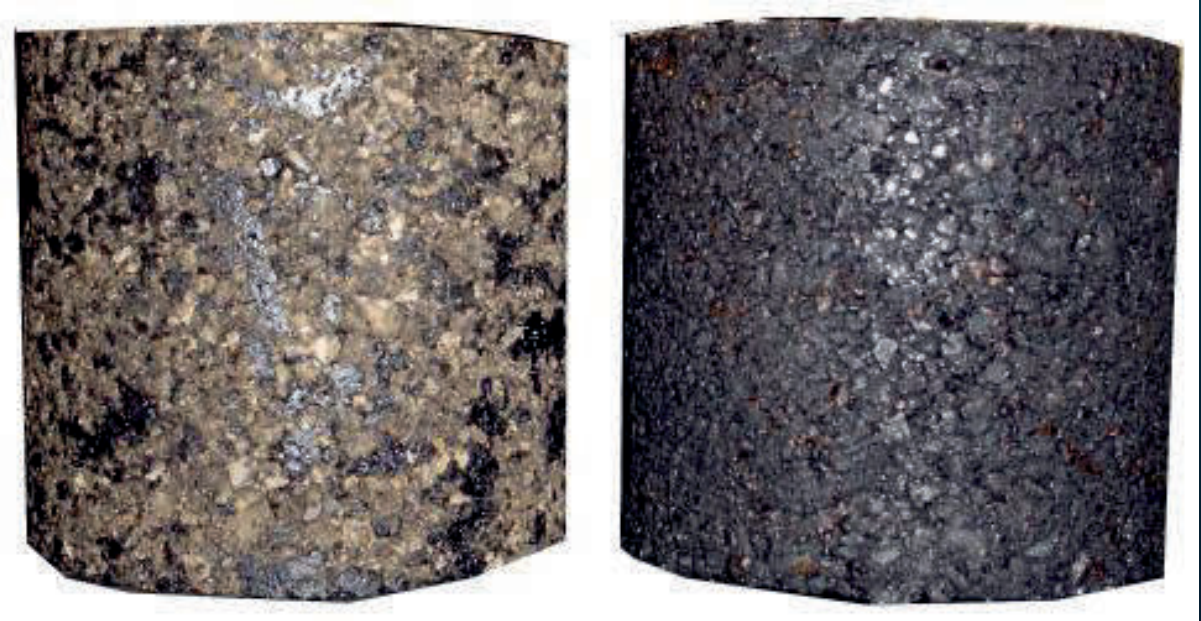
Sampling & Mix Design

- Mix Design Objectives
 - Identify Optimum Binder Content
 - Determine Necessity of Additives
 - Lime or Cement
 - Determine Necessity of Supplemental Aggregate
- Ensure Material Compatibility w/ Proposed Recycling Method
 - RHMA, Oil-Treated Sand, Fines Content etc. can affect Mix Design



Emulsion Vs Foam

- Emulsion has better bituminous coating than foam
 - Often will outperform foam under direct traffic
- Emulsion is safer than Foam
 - Emulsion is run at 80 to 140 degrees F
 - Asphalt in Foam must be minimum ~350 degrees F
- Foam is less dependent on environmental conditions
- Emulsion generally has a longer initial curing time
- Current research indicates both show similar long term strengths



Quality Control



- Gradation Testing
- Recycling Agent – pass/fail
- Strength Testing (Indirect Tensile Strength)
- Compaction Testing Throughout Construction

Quality Control

Maintain and Protect PDR/CCPR/FDR Surface

- Expect some raveling in cross-traffic, high shear areas
- Curing from the top down – Surface damage can spread quickly
- Follow established contingency plan for repairs and maintenance

Place Overlay within 15 days of PDR/CCPR Completion or 7 days of FDR Completion



Contingency Plan Content

- Imbalance of Recycling Agent/Additives
- Non-uniform PDR/CCPR/FDR Material
- Recycling/Stabilizing Agent Instability or Failure
- Paving Equipment Issues
- Rough PDR/CCPR/FDR Surface
- Compaction Challenges
- Raveling (Minor and Major)
- Dimpling/Denting
- Recycled Mix Instability



Raveling – What Do We Do?

- Raveling is a common occurrence – while it must be addressed, it is not an immediate sign of general PDR failure

Raveling		
Cause	Preventative Action	Repair
Insufficient Early Strength	Maintain Traffic Closure Longer	Sweep and Fog Seal or Re-recycle
Insufficient Recycling Agent	Increase Recycling Agent	Re-recycle Affected Area
Insufficient Cement	Increase Cement (Maintain 2:1 Ratio)	Re-recycle or Limit Traffic
Too Much Cement	Reduce Cement or Increase Recycling Agent	Re-recycle or Limit Traffic



Unsuitable/Inconsistent Material

- Subgrade Failures
 - FDR – increase depth of treatment
 - PDR – digouts after PDR construction
 - CCPR – digouts using CCPR material
- Recycling Material Variation
 - Multiple Mix Designs if Identified at Sampling
 - Recycling Agent Adjustments



Equipment Failures

- Contingency Plan should Specify Actions Based on Equipment
 - Cement Spreading Eq.
 - Milling Equipment
 - Recycler/Pulverizer
 - Pugmill/Crushing Unit
 - Recycling Agent Tanker
 - Paver/Pickup Machine
 - Motorgrader
 - Compaction Equipment
 - Fog Seal/Sand Spreading Eq.



Compaction and Other QC Challenges

Compaction should be based on DAILY break-over curve (minimum) for PDR and FDR

- Compaction potential changes with temperature, material sizing, etc.

Recycling Agent must be monitored every load

- FA – Foaming Test
- EA – Sieve Test

Gradation Challenges – Slow down recycling operation

FDR-C – grading and compaction timing is absolutely critical for strength development



Environmental Conditions

Mother Nature doesn't read the Specifications

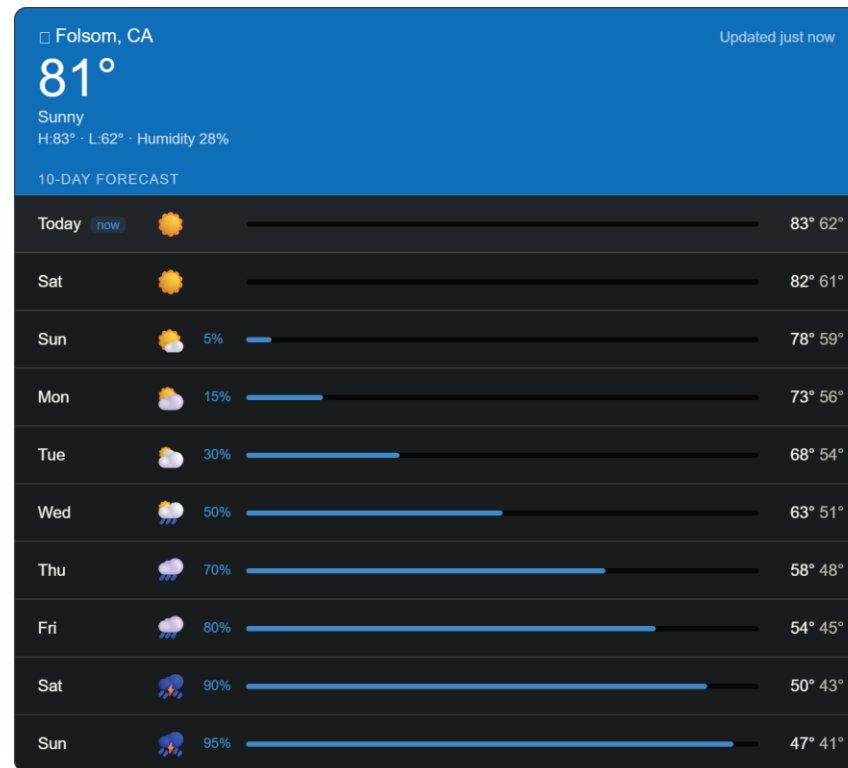
All recycled products must cure

- PDR and CCPR cure more effectively in hot temperature and sunlight
- FDR-C requires moisture

Make educated, engineering-based decisions when weather doesn't cooperate

Adjustments to standard operating procedures may be necessary

- Increased traffic limitations
- Modifications to mix designs
- Adjustment of curing timelines



Thank You

Mike Concannon, P.E.
Senior Pavement Engineer
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02-4G120 – TRI 36 – PDR IN 2015



April 2012 – Before PDR



May 2018 – 3 year after PDR



August 2025 – 10 Year after PDR

Questions?



Thank you for attending today's training!
Slides will be sent to the group and also
uploaded on our Onramp page.

**[https://maintenance.onramp.dot.ca.gov/
asphaltpaves/pavement-recycling-pr](https://maintenance.onramp.dot.ca.gov/asphaltpaves/pavement-recycling-pr)**

If you haven't already, please register for the
course on CT learns so you can have a record
in your training history.

Reporting Code: G256000726