Sustainable Engineering Technologies in Pavement Infrastructure

“The Roads to our Future are Paved with Recycled Materials”

CEAC and Public Works Officers Institute
March 29th, 2018

James Emerson, APM
With more than **150 agencies** indicating they have employed one or more recycling techniques such as the use of Cold-In-place Recycling (CIR), Cold Central Plant Recycling (CCPR) and Full Depth Reclamation. These techniques are reported to have **cost savings up to 50%** when compared to older remove and replace.

A conservative estimate of 50 percent of all eligible California streets that could utilize recycling technologies indicates California agencies can save as much as **$823 million** a year, that is **41 percent**.
SHC Section 2030(c)-(f) specifies additional project elements that will be incorporated into RMRA funded projects by cities and counties to the extent possible and cost effective, and where feasible (as deemed by cities and counties). These elements are:

• Technologies and material recycling techniques that lower greenhouse gas emissions and reduce the cost of maintaining local streets and roads through material choice and construction method.
Tax Payer Friendly Topics

• Cold Central Plant Recycling (CCPR)
• Cold In-Place Recycling (CIR)
• Full Depth Rehabilitation (FDR)
Applications for Pavements

Caltrans Specifications:
24-2: Lime Stabilized Soil
24-3: Cement Stabilized Soil
24-4: Cement Treated Base
30-2: Pulverized Roadbed
30-3: FDR with Foamed Asphalt
30-4: FDR with Cement
30-9: Cold in-Place Recycling

2015 Greenbook:
301-3.1 Soil Cement
301-3.3: Cement Treated Base
301-3.4: Cement Stabilized Pulverized Base
301-3.5: Lime Treated Soil
Typical Performance Curve

Preservation (fog seal / rap slurry seal / rap micro-surfacing, rap chip seal / rap cape seal): $0.05-0.80/sf

Resurface (thin overlays, ARHM, 2-4 layer systems): $1.45-$2.50/sf

Reconstruction:
- Older: $5-$11/sf
- Sustainable (CCPR w/ Soil Stabilization): $3-$5/sf
- FDR $1.50-$2.50/sf

Rehabilitation:
- Older (R&R): $3-$5/sf
- Sustainable (CIR/CCPR): $2-$3/sf
Reclaimed Asphalt Pavement (RAP)

• The Need
  • Increasingly difficult to open new pits
  • Some of the best aggregates are in our roads
What We Know

• Asphalt is the number two recycled product in the world after water!
• Valuable RAP material in Hot Mix Asphalt, 600 million tons recycled in 2012.
• Used when and where feasible…

• How do we expand on the value?

Cost Effect:

Shrinking budgets equal fewer asphalt overlay projects
Useable in pavement preservation and rehabilitation
Many cases out performs native aggregates
Central Plant Recycling
Cold In-place Recycling
Full Depth Reclamation
Natural Black Aggregates
How much is your asphalt worth?
The local streets/roads owned and maintained by the Bay Area’s 9 counties and 101 cities include nearly 43,000 lane-miles of pavement. 43,000 x 5,280 L.F. = 227,040,000 L.F. @ 12’ wide (avg.) = 2,724,480,000 S.F. @ 33’(4”) @ 148 lbs./c.f. = 133,063,603,200 lbs asphalt
133,063,200 lbs. = 66,531,801.60 Tons
66,531,801.60 tons @ $45.00 per ton = $2,993,931,072.00
Add curbs and gutters, sidewalks, storm drains, traffic signs, signals and lights needed for functioning roadways — that’s a big network.
To replace this network would cost something on the order of $40 billion or more.
Cold Central Plant Recycling (CCPR)

Clean Rap = New Pavement:

- Stockpiled RAP and kept clean
- Crushed RAP to specific gradation
- Mixed with engineered emulsion or foamed asphalt per mix design in a central plant close to project
- Transported to lay down area
- Paved as a recycled asphalt mix
- Compacted to specified density
- Readied for surface treatment
- Reduced carbon footprint
- Reduced truck traffic
- Reuse agency asphalt assets

From RAP

New Pavement
MILL, STOCKPILE AND RECYCLE YOUR OWN ASPHALT
Black Gold $20.00-$35/ton
RECYCLE YOUR ASPHALT ON-SITE

California Air Resource Board Compliant
2017 PROJECT PROFILE:
SAN MATEO EXPO CENTER PARKING LOT REHABILITATION
800,000 square feet

VALUE ENGINEERING – ENVIRONMENTAL AND ECONOMIC BENEFITS:

• ELIMINATED (approx.) 3,800 trucks of export and 4,100 loads of import = 7,900 Trucks off the road coming and going on new streets
• REDUCED Construction Schedule by half, 30 day construction deadline
• REDUCED Community Impact of the project
• ELIMINATED Constructability Issues, inherent to the site (Bay Muds)
• ADDRESSED the Long-Term Performance of the Pavement
• REDUCTION of Green- House gas emissions
• REDUCED Cost of the project by more than 40%
• Older Remove and Replace 5.5 million dollars
• Sustainable Value Engineering 2.9 million dollars
• $2,600,000.00 SAVINGS

CCPR/FDR ALTERNATIVE TO REMOVE AND REPLACE DESIGN
“Sustainable Pavement” with 2.6 million dollars saved
Yosemite National Park “Value Engineered”
Los Angeles County Road Improvement Project
Cold Central Plant Recycling (CCPR) with Soil Stabilization

- **Urban Residential Streets:**
  - Project is located near City of Inglewood
- **Length:** 7 lane miles
- **Area:** 471,600 sf
- **Pavement Condition Index:**
  - 46 (Poor)
- **Treatment Strategies:**
  - Reconstruction
    - 1½” of ARHM
    - 3” of CCPRACP
    - 6” of Soil Stabilization
- **Cost Savings** *(1.1M Cost Saving)*
  - Older R&R Reconstruction: $2.05M ($4.34/sf)
  - Sustainable Reconstruction: $971K ($2.06/sf)
Comparison of Pavement Sections
LA County Project

Aggregates Base

- Asphalt Overlay
- AB
- Subgrade Prep.

AC

CCPR/ Cement Soil Stabilization, Thin A/C Overlay

- AC
- CCPR-AC
- Cement Stabilized Foundation

Utilities?

Total G.E. = 1.2’

Total G.E. = 1.6’

$1,000,000.00 Cost savings when compared to R&R
Cold In-place Recycling (CIR)

Distressed Pavement = New Pavement Using A Train of Equipment that:

• **Mills** deteriorated pavement for reuse of existing agency assets into Reclaimed Asphalt Pavement (RAP)
• **Crushes** RAP to specified gradation requirements
• **Mixes** with engineered recycling agent per mix design
• **Re-Paves** recycled mix in-place
• **Compacts** to specified density
• **Ready** for surface treatment
• **Small** carbon footprint
• **Reduce** truck traffic
• **Reduce** construction time
• **Reduce** public inconvenience

Eliminates Cracks
When to Utilize Asphalt Recycling

- Anywhere mill and fill is considered
  - Adequate existing pavement thickness
    - 2.5 inches minimum in existing asphalt thickness, recycle up to a depth of 5-inches
- Will handle all cracking distress provided not sub-grade or base related
- Where surface maintenance is no longer effective
- When you are doing more than 20% dig-outs
- Where safety is a concern
- When life cycle costs dictate
- When you need to stretch your budget

Avg. PCI = 47
Where to Utilize Asphalt Recycling?

Caltrans

Highways
Virtually No Traffic Limitations

Airports

City of Oakley

City Streets

Contra Costa County
Caltrans Approved Asphalt Recycling Plant Meets Caltrans Calibration Requirements

Return belts
Crusher
Screen Decks
Mass Flow Meter
New Mix
Pug Mill
County of Santa Barbara, Hollister Road

Traffic Flowing

Driveways open
City of Napa, Freeway Drive 2011
Sonoma County, Adobe Road 2011
Since 2011 more than 500 miles of asphalt assets have been Cold In-place Recycled (CIR) Just in the bay area alone!
## Project Costs Analysis

### Cold In Place Recycling Costs (as bid)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quant.</th>
<th>Unit Price</th>
<th>Total</th>
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<tbody>
<tr>
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<tr>
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<td>Cement Additive</td>
<td>Ton</td>
<td>57</td>
<td>$260.00</td>
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<td><strong>Total</strong></td>
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<td>$279,488</td>
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Cost per Sq. Ft. $0.82

Cost per Sq. Yd. $7.35

### HMA Project Alternative (estimated)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quant.</th>
<th>Unit Price</th>
<th>Total</th>
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<td>Remove and Replace</td>
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<td>3/8 Leveling Course (.10 ft.)</td>
<td>Ton</td>
<td>2,565</td>
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<td>1/2&quot; HMA (.15 ft.)</td>
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Cost per Sq. Ft. $2.34

Cost per Sq. Yd. $21.05

Project Cost savings using CIR is approximately $118,000 per lane mile over HMA approach.
Cost savings $300,320.00 When compared to older remove and replace
8,744 tons of asphalt removed and repaved in-place
840 fewer trucks used utilizing CIR, compared to a mill and fill operation
Cut 30% off the project schedule
1,649 fewer barrels of oil used
Life cycle cost benefits
79.6% fewer carbon emissions utilizing CIR compared to mill and fill operation
Angeles Forest Highway – Before

PCI = 47
Angeles Forest Highway - After

PCI = 100
## Sustainable Economic-Benefits

<table>
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<tr>
<th>ENERGY USAGE, GREENHOUSE GAS EMISSIONS, LANDFILL REDUCTION, AND COST SAVINGS FOR SUSTAINABLE PAVEMENT TREATMENTS (1)</th>
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<tbody>
<tr>
<td>NUMBER OF PROJECTS COMPLETED</td>
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<tr>
<td>COLD IN-PLACE RECYCLING</td>
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<td>COLD CENTRAL PLANT RECYCLING</td>
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<td>SUBGRADE STABILIZATION</td>
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<td>PAVEMENT PRESERVATION</td>
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<td>REDUCTION IN GHG EMISSIONS (% or metric tons) (2)</td>
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<td>LANDFILL REDUCTION (CY)</td>
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<td>COST SAVINGS (%)</td>
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<td>$16,736,000</td>
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<td>$31,723,000</td>
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</table>

690,000 TIRES WERE ELIMINATED FROM LANDFILLS BY INCORPORATES TIRE PARTICLES INTO THE ASPHALT HOT MIX

(APPROX. 1,000 TIRES / 1 LANE-MILE / 1-INCH ARHM OVERLAY)


18,000 metric tons of CO2E reduced ≈ 3,800 passenger vehicles removed from roads*

* Based on latest updated of the average fuel economy and the emissions factor for the combustion of gasoline as of August 25, 2015. The emissions factor for passenger vehicles is 5.2 tons/vehicle/year. (www.epa.gov)
Full Depth Rehabilitation
WHAT IS FDR?

Full Depth Rehabilitation

FDR is a process in which the existing asphalt surface is removed by milling or pulverized in-place and blended with the underlying base, sub-base, and/or subgrade materials, mixed with Portland Cement, and compacted to provide a new stabilized base that is high strength, non-plastic, and less permeable. A new surface course is then applied, which completes the FDR process, providing a new pavement structure using Recycled materials from the failed pavement.
FDR SHOULD BE USED WHEN:

• SERIOUSLY DAMAGED PAVEMENT
• BASE OR SUB-BASE FAILURE
• POOR SOIL CONDITIONS, EXPANSIVE
• THERE IS PATCHING OVER 15%-20% OF PROJECT
• TRAFFIC LOADING EXCEEDS DESIGN
DAY 1

MILL OR PULVERIZE PAVEMENT

-100% pass 2-inch sieve
-min 90% pass 1.5-inch sieve
-min of 55% passing No. 4 sieve
DAY 1
GRADE ROAD

RE-ESTABLISH NEW GRADE:
• Allows for New AC Section
• Re-Establish Crown and Drainage
• Allows for Temporary Traffic
• Observe conditions for instability
DAY 2

APPLY CEMENT

On-board controls provide metered cement application rate

Determine application rate as 90% of the max
SPREAD RATE CONFIRMATION

• Confirm spread rate by Pan Testing

• Cross check with Certified Truck Tags

1’ x 3’ pan
DAY 2

MIX and HYDRATE

Mixer attached to water truck hydrates cement to a prescribed moisture content
Residential Street FDR: Community Access
DAY 2
GRADING SUPPORT

Pull material away from edges

Pull material from around manholes & structures
DAY 2

UTILITIES

General Contractor to provide a dedicated utility locator crew
DAY 2

COMPACTION

Compact FDR section to 95% relative compaction

Specialized compactors 12 to 18 inches
DAY 2

FINISH GRADE

Finish roll for tight surface
DAY 3

FINISH

Place CCPR or HMA on FDR surface
ENVIRONMENTAL & ECONOMIC BENEFITS

FDR VS. REMOVE/REPLACE (50,000 square feet, 12-in Deep)

- **Number of Trucks Required**
  - FDR Process: 120 Loads Export
  - Remove/Replace Process: 146 Loads of Aggregate Import
  - 4 Loads of Cement

- **Material Required (Tons)**
  - FDR Process: 3,650 Tons New Aggregate
  - Remove/Replace Process: 108 Tons of Cement

- **Diesel Fuel Consumed (Gal)**
  - FDR Process: 3,920 Gallons
  - Remove/Replace Process: 480 Gallons

Colors:
- Red: Remove/Replace Process
- Blue: FDR Process
- Green: Specific material or activity
 ENVIRONMENTAL SAVINGS

1 Cement Truck =

40 Gravel Trucks
PERFORMANCE BENEFITS: CREATES AN “INVERTED PAVEMENT”
Eight Years Later

Tale of Two Cities

10" FDR with 4" asphalt overlay

Dig outs, remove and replace, patching
PROJECT PROFILE BENEFITS

Bancroft Avenue, San Leandro

2-lane Major Collector, 136,000 square feet
4” AC over 12” FDR using 5% cement

$7.36/sft. – Older Remove and Replace Pavement Cost
$4.05/sft. - FDR Cost (45% COST SAVINGS)
CALTRANS DESIGN GUIDELINES

A standardized structural value is given to the stabilized base:

Caltrans Design Equation:

\[ G_f = 0.9 + \left( \frac{UCCS}{1000} \right) \quad UCCS \text{ in } psi \]

Minimum Unconfined Strength = 300 psi
Maximum Unconfined Strength = 600 psi
Minimum Thickness = 8 inches
Maximum Thickness = 18 inches
Awards with Sustainable Methods

- 2009 City of Santa Ana Delhi & Willard  ARRA/Roads & Bridges National CIR
- 2010 APWA City of Moreno Valley Eucalyptus Avenue CIR
- 2010 City of Beverly Hills ARRA/Roads & Bridges National CIR
- 2011 Los Angeles County Angeles Forest Highway ARRA/Roads & Bridges CIR
- 2012 California Chip Seal Innovative Cape Seal Project of the Year 2012, Escondido Canyon Road
- 2012 ASCE Los Angeles County Sustainability Angeles Forest Highway
- 2013 Los Angeles County Green Leadership Award Sustainability Treatments for County Roads
- 2013 Los Angeles County 27th Annual Productivity and Quality Award
- 2013 Los Angeles County Compass Blueprint Award Design CIR
- 2014 City of Glendale League of Cities Central Avenue CCPR
- 2014 Butte County Ord Ferry Road League of Cities CCPR, FDR
- 2014 Los Angeles County League of Cities Outstanding Local Streets Sinaloa ET AL RAP Cape Seal
- 2014 County of San Bernardino League of Cities (Finalists) CCPR, Cement stabilization
- 2014 Los Angeles County League of Cities (Finalists) Del Amo Blvd.
- 2014 City of Irvine League of Cities (Finalists) RAP slurry project
- 2014 Sonoma County League of Cities (Finalists) Doran Beach Road FDR
- 2014 City of Thousand Oaks League of Cities (Nomination) Norwegian Grade FDR
- 2014 Palm Desert APWA Project of the year Inland Empire Branch CIR Route 111 (N. Palm Canyon Drive)
- 2014 City of Hanford APWA Project of the Year Central Valley Branch 12th Street Widening FDR
- 2015 Los Angeles County ARRA/Roads and Bridges Lennox Roads project CCPR, Cement Stabilization
- 2015 Los Angeles League of Cities Outstanding Streets Willowbrook Community CCPR, Cement Stabilization
- 2016 City of Oakley Main Street project 3” CIR APWA Northern California Chapter
- 2016 League of Cities/CEAC Outstanding Street & Road project FHWA & LA County Angeles Forest Highway
- 2015 FHWA FP2 City of Los Angeles James B. Sorenson Award Excellence in Pavement Preservation
- 2017 Santa Barbara County APWA award of the year Hollister CIR project
- 2017 Imperial County Salton City CCPR/Cement overall State winner CEAC/League of cities
NOW WE FINALLY HAVE SB-1

• WHAT WILL YOU DO WITH YOUR SHARE OF THE FUNDING?

• DOUBLE YOUR RETURN BY RECYCLING YOUR ASSETS!
Summary - Benefits of Recycling and Reclamation

- Shorter Construction Periods with Reduction in User Delays
- Improved Pavement and Structural Section Properties
- Mitigates Reflective Cracking
- 20 Plus Years Performance Expectations
- Cost Savings Over Traditional Rehabilitation Methods
- **Sustainable Development** “.... Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”
  - Reduces the consumption of natural resources
  - Reduce energy consumption
  - Reduces truck traffic
  - Reduce greenhouse gas emissions, pollution
Questions?

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