WELCOME TO FMG
LEADERS IN
COLD-IN-PLACE RECYCLING

A Graniterock Division

COLD IN-PLACE RECYCLING

Dennis McElroy – CIR Operations Manager  Cell: 408-639-8063
Overview

- CIR with Foamed Asphalt and How it works
- Benefits Sample Project
- Order of Work
- QC / QA

“It is a beautiful thing when the Green Solution is also the most cost effective one.”

Michael J. Murdter, P.E., Director County of Santa Clara Roads and Airports Department
What is Cold In-Place Recycling?

Existing pavement layers are pulverized, mixed with additives and repaved in place without the application of heat.
Producing foamed Asphalt

Foamed asphalt is produced by foaming standard road-grade oil.

In the process, small amounts of water and air are injected into the hot oil at high pressure, which results in the oil foaming and expanding to around 20 times its original volume.

The oil is then injected into a mixer via injection nozzles.
CIR- FA (How it works)

Aggregate sizing accomplished by:
- Down cutting Milling Drum
- Forward Speed
- Condition of existing pavement
CIR-FA Material Structure

- **Bitumen (Oil)**
  - PG 64-10 at +/- 350 deg F
  - ADD Water = Foam
  - Average Oil percentages: 2% - 2.5%

- **Cement**
  - Portland Type II
  - Range: 1% - 1.25%
Properties of BSM (bitumen-stabilized material)

- Easy workability is a distinctive feature of BSM mix
- Open to traffic immediately after completion
- BSM mixes do not involve coating of the aggregate but homogeneous mixing of the asphalt binder and aggregate.
Windrow of CIR Material to Paving Machine
- Rear Conveyor Delivery of CIR Material to Paving Machine
BENEFITS
Completed Projects – Over 35 Million Square Feet and Counting

- Foster City
  - Baffin Street
  - Gull Ave

- Redwood City
  - East Bayshore Parkway

- Santa Clara County
  - Santa Teresa Ave.
  - Condit Rd.
  - Half Rd.
  - Lawrence Expressway
  - Hellyer Ave

- City of San Jose
  - Monterey Rd.
  - STP 2010
  - 2013 Street Resurfacing Project
  - 2014 Street Resurfacing Project
  - 2015 Road Rehabilitation Project
  - 2016 Road Rehabilitation Project

- City of Gilroy
  - E. Luchessa Ave
  - Rossi Lane

- Alameda County
  - Resurfacing of Various Roadways
  - Grant Ave
  - Crow Canyon Rd

- City of Morgan Hill
  - Condit Rd.
  - Railroad Ave

- City of Santa Cruz
  - Laurel Street
  - Western Drive
  - River St.
  - Front Street
  - Soquel Ave.

- City of Newark
  - Mowry Ave

- Marin County
  - Idylberry rd
  - Tiburon and Point Reyes Station
  - Point Reyes Petaluma Rd
  - Sir Francis Drake Blvd

- County of Sacramento

- East Bay Regional Parks District
  - Carquinez Bay Trail

- City of Hayward
  - 14 City Streets
  - 2015 Neighborhood Block Grant Project
  - Industrial Blvd
  - FY 16 Pavement Rehab Project

- City of Sunnyvale
  - Mathilda Ave.
  - Evelyn Ave.

- City of Fremont
  - Paseo Padre Parkway

- City of Daly City
  - Callan Blvd
  - 2015 Pavement Rehab Project

- Stanford University
  - Campus Loop Drive

- Monterey County
  - River Road
In excess of 100 million square metres have meanwhile been recycled in numerous countries around the world using foamed bitumen as a binding agent.
The Australians and Kiwis even went so far as to develop a structural design procedure specifically for cold-foam
Benefits of CIR –FA
(In-Place Construction Activities)

- **Environmental:**
  - Reducing or eliminating disposal of old distressed pavement materials.
  - “Zero Waste” approach to pavement rehabilitation by full use of the materials in the existing pavement.

- Haulage of waste materials and new material is drastically reduced or totally eliminated, and as a result overall energy consumption and greenhouse emissions are significantly reduced.
“Pavement Projects: The City is wrapping up a number of major road paving projects. Park Avenue, Kennedy Drive and Monterey Drive have been reconstructed using an innovative pavement recycling approach called “Cold In-place Recycling” (CIR). CIR is considered the most environmental-friendly and cost-effective method among the various in-place pavement recycling techniques. In the CIR process, a portion of the existing asphalt is milled off, and the reclaimed material is mixed with recycling agents then spread and compacted to produce a base layer for the final new pavement. The environmental benefits of CIR over traditional paving includes an estimated 62% savings in aggregate consumption, and a net savings in gas emissions, including 52% less carbon dioxide, 54% less nitric oxide/nitrogen dioxide, and 61% less sulfur dioxide.”

- Jamie Goldstein (City Manager)
Benefits of CIR –FA

- **Structural:**
  - Significantly controls or eliminates the occurrence of reflective cracking on new asphalt overlays.
  - Pavement surface irregularities and cracks can be effectively interrupted. A damaged asphalt concrete layer can be converted into a homogenous and stronger layer through CIR-FA.

- **Short cure time:** 2-3 days before final a wear course can be placed.
  - The CIR-FA layer acts as a temporary wear course while curing.
Benefits of CIR –FA

- **Safety:**
  - CIR construction can proceed as fast as 1 – 2 lane miles per day, thus decreasing the inconvenience to the public or owner and exposure of workers.
  - Fewer haul trucks enter and leave the project site result in improved traffic safety.
  - CIR is performed in a single 12.5ft pass, 1 lane width, and operates within a single lane closure.
Benefits of CIR –FA

**Construction:**
- Shorter construction time reduces project cost while benefits the road user with reduced traffic disruption.
- Cross section profile, crowns, and cross slope drainage can be manipulated in the right application.
- Opportunity to improve smoothness

CIR- FA can be completed at night.
Benefits of CIR – FA

- **Economic:**
  - Reduced material buy
  - Reduced haul cost
  - Reduced haul damage
  - Reduced traffic congestion
  - Reduced project duration
  - More value

- Combined translates into an average cost savings of 15% - 30%
Example: Monterey Rd., San Jose - 2011

- **Quantity:**
  - 638,040 Sf

- **Conventional R&R**
  - 3” Mill
  - 6” Digouts
  - 1” HMA Leveling Course / 2” R-HMA Overlay
  - Total: $2,540,470.00

- **Cold In-Place Recycling**
  - 2” Wedge Cut
  - Minimal 6” Digouts (Areas innaccessbible)
  - 4” CIR – EAM (Foam)
  - 2” RHMA Overlay
  - Total: $2,122,400.00

**NET SAVINGS:** 16% or $418,070.00
Monterey Rd., San Jose

- Existing Pavement Conditions
  - Alligator Cracked Surface
  - Years of patching
  - Raveling/Potholes
  - Aged Oxidized Pavement
  - Type II Slurry Seal
  - Areas of Petro mat

- Benefits
  - Elimination of costs for 780 truckloads of importing and off haul costs of over 15,600 tons of aggregates to and from landfill and/or asphalt plant or quarry.
  - Conventional R&R method would have taken approximately 18 days, whereas the CIR method took only 9 days.
Monterey Rd., San Jose - 3/22/2016
Marin County – Project Example 2015

- Sir Francis Drake Blvd – Marin County
- 2 lane Rural Road
- 420,000 sf @ $1.50 SF for CIR
- Recycled in 6 days
- 8 – 10 hr work window

- Fatigue Cracking, Oxidized Pavement, Potholes, etc.
- 6” CIR (Fog Line to Fog Line)
- Fog Seal w/ Temp Striping
- Final HMA Overlay (2”) placed immediately

Before

After -- Final CIR Surface
Marin County – Project Example
Marin County – Project Example
Specific Project Savings - Examples

- **City of Foster City:** Bid as an alternate with 23% Base Repairs
  - Total Savings of $100,078 or 23%

- **City of Redwood City:** Value Engineering Project with 33% 6” Base Repairs
  - Total Savings of $38,144 or 30%

- **Alameda County:** Value Engineering Project
  - Total Savings of $550,000 or 31%
Design Section Examples
When to Consider CIR?

- When Base Repairs are over 25% of the total surface area
- Thick overlay sections are needed
- Anywhere mill and fill is considered
- Where surface maintenance is no longer effective
CIR-FA Section Examples

- **CIR-FA Depth:** 2” minimum – 6” maximum  ---  AC or AB or AC/AB Blends are all ok to recycle.
  - Eliminating the potential for reflective cracking = lowers costs in the long run on your Pavement Maintenance System
  - Smoothness Improvements

**BEFORE:**

- Distressed AC Pavement, fatigue, cracking
- Base Material (AB)
- Subgrade

**AFTER CIR-FA:**

- New thin overlay with CIR-FA Section eliminates reflective cracking
- Base Material (AB)
- Subgrade

- HMA overlay with CIR-FA Section. CIR-FA rehabilitating entire existing AC section.
- HMA overlay with CIR-FA Section. CIR-FA rehabilitating entire existing AC section and has included a portion of the AB section.
Example CIR-FA Design Sections

**EXAMPLE CIR-EAM SECTIONS**

- **Chip seal**
- **3" CIR**
- **R-value 10**
- **1.600 ESALs TI = 4.0**
  - "minimum" section

- **Chip seal**
- **4" CIR**
- **R-value 12**
- **8,900 ESALs TI = 5.7**
  - Rural Thin

- **2" AC**
- **3" CIR**
- **3" AB**
- **R-value 10**
- **87,000 ESALs TI = 6.7**
  - Rural / Collector

- **2" AB**
- **6" CIR**
- **R-value 10**
- **620,000 ESALs TI = 8.5**
  - Arterial

AC = asphalt surface course  CIR = CIR w/ foamed asphalt  ESAL = Equivalent Single Axle Load (18,000 lb)
“AASHTO ’93 is the preferred method for foamed asphalt CIR section design. Considerable research is available recommending structural coefficients of 0.30 to 0.35 per inch of foamed asphalt. AASHTO ‘93 allows more flexibility in selecting desired reliability and estimating variability, allowing more designs to be more carefully tailored to each situation and taking full advantage of the proven strength of the material.”

“The Caltrans Design Method can be used, but tends to be conservative because of the limited information available to establish a gravel factor for foamed asphalt. Available information suggests a gravel factor of 1.7 is reasonable, and that higher values may be appropriate.”
CIPR Structural Section Design:

For design purposes, it was assumed that the untreated RAP would be as strong as Class II aggregate base. To determine the Gravel Equivalent ($G_E$) and Gravel Factor$^3$ ($G_f$), a straight-line ratio of tensile strengths was used. Using average worst-case tensile strengths$^6$, and using the formula $G_{fcipr} = (\text{Treated ITS})/(\text{Untreated ITS}) + 0.1$, resulted in a $G_{fcipr}$ of 1.8. Because this was the first project in the State of California to use this process, a conservative approach was taken and the $G_f$ was maximized at 1.4 which is equivalent to Asphalt treated base material. Based on Caltrans current HDM design guidelines the project required a $G_E$ of 2.54’. This required the following structural section:
Order of Work
**CIR - The Process (Order of Work)**

- Similar to typical road reconstruction prep:
  1. Lower all existing utilities +/- 3” below CIR depth
  2. Wedge Cut / Conforms
     - Trim outside edge of roadway before CIR.
CIR - The Process

- During CIR Activities
  - Single Lane Closure
  - Spread Portland Type II Cement (50 – 100 ft)
  - Pulverize/Process /Place Existing Materials
    - 12.5’ (fixed) Down Cutting Drum
CIR – The Process

Water Truck with Paver
CIR – The Process

- Material is compacted to a minimum of 98% using two (2) 12-ton, steel drum vibratory rollers.
- A 25-ton pneumatic (rubber tire) roller is used to finish the surface and prepare it for traffic.
CIR - The Process

- Apply Fog Seal (SS1 cut 50/50), Temp Striping, Sand Blotter to treated Surface
- Reconstructed Roadway is ready to surface in 2-3 days after initial cure period
- No Deflection or Rutting, No Supplemental Compaction
39.7 COLD IN PLACE RECYCLING – (EAM) EXPANDED ASPHALT METHOD

This item of work shall consist of recycling existing pavement into a new roadway base course suitable for roadway use. Included in the work are miller design, QA/QC, milling, job site equipment, permitting, added materials, placing, compacting, curing, and any other items as necessary to meet these specifications.

Cold In-Place Recycling (CIR) material shall not be exposed to traffic for more than an hour (1) hour.

39.7.1 Minimum Qualifications for Cold In-Place Recycling Expanded Asphalt Method (CIR-EAM) Contractor

The Contractor directly responsible for providing the cold in place recycling activities shall provide the minimum qualifications for the Engineer’s approval prior to being awarded the project. The minimum qualifications shall include:

- At least two (2) years’ experience providing cold in-place recycling services
- A list of five (5) or more successful cold in-place recycling projects with a list of references, including contact information
- The names of a cold in-place expert with a minimum of five (5) years’ experience providing QA/QC services on cold in-place recycling projects. This individual shall oversee quality control data throughout the project.

39.7.2 Mix Design

A minimum of 14 days prior to starting the Cold In Place Recycling the Contractor will take samples of the existing pavement, prepare, and submit a mix design for the Engineer’s approval. The mix design shall be prepared by a lab certified to perform the tests specified.

The design submittal must include the following information:

- Cold in Place Recycling CIR equipment and method proposed
- Gradation (ASTM D1174, AASHTO M12)
- Bitumen Grade
- Bitumen Emulsion
- Bitumen Source
- Water Content
- Cement Content
- Coarse Aggregate
- Fine Aggregate
- Any other additive or emulsifiers
Questions and Answers

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  - Email: dmcelroy@graniterock.com

- **Ed Schwartz**
  - CIR QC Manager
  - Phone: 209-743-9883
  - Email: ed@fmgcoinc.com

A Graniterock Division
References:


5. Full Depth Reclamation Using Foamed Asphalt, Caltrans Division of Maintenance, June 2012.

Appendix A – Mix Design Procedure
Mix Design Sampling

- Cores and Test Pits
  - A combination of cores and test pits are used to gather material that represents the layers found in the roadway.
- Cores: Verify Existing Section
- Test Pits: Sample Collection
- It is important to sample AC, AB, and SG as well as verify layer thickness and condition.
The Foaming properties of the bitumen to be used must be verified prior to construction.

- This is checked by adding varying percentages of water to a stream of hot bitumen measuring the resulting expansion and half life.

- Expansion = Volume change measured in ratio

- Half Life = The measure of time required for the foamed bitumen to reach half its max volume.
Mix Design – Blend and Proportion

- The collected material is brought back to the lab, and re-proportioned to meet the needs of the project.
- Example: Existing conditions = 2” AC over 8” AB
- Project calls for 4” CIR
- 50% AC 50% AB proportion is required to represent anticipated field conditions
- Four total bulk samples must be prepared one for each point.
Mix Design – Foam and Compact

- Four points are prepared from 1% to 3% bitumen and 1% Type II Portland Cement
- A typical bitumen span is 1.75%, 2.0%, 2.25%, 2.50%
- Six, 4-inch diameter briquettes are compacted using marshal compaction methods (75 Blows per side)
- 3 are used for dry strength testing
- 3 are used for soaked strength testing
- Typical acceptance criteria = 235 kpa (wet)
Final Report Should include:

- Proportioning of materials used in the mix design
- Lowest percentage of additives required to meet the design strength
- CA Test method 216 Maximum wet density
- Coarse dry gradation 1.5” through #4
- Expansion ratio and half-life of bitumen
- Minimum temperature of bitumen to achieve required foaming properties
Appendix A – QA/QC Procedures
The Project is Divided into lots of 3,000 square yards
- 3,000 SY x 9' = 27,000 SF
- Pass Width = 12.5'
- 27,000sf/12.5’ width = 2,160 LF per lot
Project Testing and Inspection

- Typical Production rates range from 70,000 sf to 150,000 sf per shift
- A production shift of 150K sf per shift will create approximately six lots, producing 12 bulk samples per shift
  - The laboratories close proximity to the job site is a must for proper turn around of tests
For each lot, collect 2 bulk samples to perform the following lab tests:

- Indirect tensile strength test (min 6 briquettes)
  - 3 dry, 3 soaked
- Coarse Sieve Analysis 1.5” - #4
- Compaction Curve
- 10 Nuclear Density Tests*

*pay factor attached
Laboratory Compaction Curve

- California Test Method 216 is the preferred compaction method for CIR Material

- Why?
  - Most agencies are familiar with the test method
  - Quick turn around time
  - No moisture bias required
Nuclear Density Testing

- We test compaction using a standard nuclear density gauge set to Marshall mode.
- A typical cold foam specification will call for 98% - 105% compaction per CTM 216.
Grain Size Analysis

- A grain size analysis is performed on each lot recycled
- A typical requirement is:
  - 100% Passing the 1.5” Screen
  - 90% passing the 0.75” Screen
- The 3 main things that contribute to materials gradation:
  - Rate of Recycle
  - Condition of the teeth on the Pulverizing Drum
  - Condition/Strength of the existing material
Strength Determination

- An indirect tensile strength test is performed on the recycled material.
- 6, 2.5” x 4” briquettes are fabricated using Marshall Compaction Methods.
- All briquettes are cured for 72 hrs @ 40 C.
- After the curing period all 6 briquettes are tested for tensile strength.
- 3 briquettes are tested dry.
- 3 briquettes are soaked for 24 hrs.
- Soaked strengths are typically the acceptance criteria.
There are a few issues to be aware of when performing the indirect tensile strength test

- Samples should be compacted within 2 hrs. of initial mixing
- Moisture content at time of compaction is critical
During the recycling process the following information is recorded by our QA/QC Tech:

- Depth of Recycle
- Expansion and half-life of bitumen
- Rate of Recycle
- Visual gradation
- Free Oil
- Moisture Content
- Bitumen Content
- Bitumen Temperature
- Cement Spread Rate
Final Reporting Should Include:

- Location and size of each lot
- Test Results from each lot
- Total quantities of additives used per lot
- Length, width and depth of the recycled layer
- Temperature of materials during processing
- Other General findings
Questions and Answers

- **Dennis McElroy**
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- **Ed Schwartz**
  - CIR QC Manager
  - Phone: 209-743-9883
  - Email: ed@fmgcoinc.com
Bid Item Example
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<th>Unit of Measure</th>
<th>Item Description</th>
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<td>HMA LEVELING</td>
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<td>TN</td>
<td>4” THICK PAVEMENT REPAIR</td>
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<td>SQ. FT</td>
<td>COLD-IN-PLACE</td>
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<td>13,400</td>
<td>LF</td>
<td>6” AC WEDGE CUT AT LIP OF GUTTER PAN</td>
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<td>955</td>
<td>LF</td>
<td>15” AC WEDGE CUT AT STREET CONFORM</td>
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<td>RAISE EXISTING MANHOLE FRAME AND COVER TO GRADE</td>
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<td>39</td>
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**TOTAL**

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<td>Adjust Water Valve Box to Grade</td>
<td>EA</td>
<td>29</td>
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<td>Adjust Sanitary Sewer Manhole Frame &amp; Cover to Grade (Removable Item)</td>
<td>EA</td>
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<td>9</td>
<td>Sanitary Sewer Cleanout Frame &amp; Cover to Grade (Removable Item)</td>
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<td>Adjust Storm Drain Manhole Frame &amp; Cover to Grade</td>
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<td>11</td>
<td>Adjust Storm Drain Inlet Grade to Grade</td>
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<td>Adj Monument Box &amp; Cover to Grade</td>
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<tr>
<td>15</td>
<td>Concrete Curb</td>
<td>LF</td>
<td>57</td>
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<tr>
<td>16</td>
<td>Remove and Replace Concrete Curb and Gutter</td>
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<td>247</td>
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</tr>
<tr>
<td>17</td>
<td>Remove and Replace Concrete Sidewalk</td>
<td>SF</td>
<td>720</td>
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<tr>
<td>18</td>
<td>Remove and Replace Curb Ramp (Various Cases)</td>
<td>EA</td>
<td>21</td>
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</tr>
<tr>
<td>19</td>
<td>Concrete Spandrel</td>
<td>SF</td>
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<td>20</td>
<td>Concrete Valley Gutter</td>
<td>SF</td>
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<tr>
<td>21</td>
<td>Subgrade Preparation</td>
<td>SY</td>
<td>315</td>
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</tr>
<tr>
<td>22</td>
<td>Excavation (Removable Item)</td>
<td>CY</td>
<td>14</td>
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<tr>
<td>23</td>
<td>Eucalyptus Tree Removal</td>
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<td>24</td>
<td>Clearing &amp; Grubbling</td>
<td>SF</td>
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<td>Wedge Grinding Asphalt or Concrete Pavement</td>
<td>LF</td>
<td>9,848</td>
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<tr>
<td>26</td>
<td>Conform Grinding Asphalt or Concrete Pavement</td>
<td>LF</td>
<td>427</td>
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<tr>
<td>27</td>
<td>Cold Milling Asphalt Pavement (3-Inch Depth)</td>
<td>SY</td>
<td>1,153</td>
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<td>Hot Mix Asphalt Pavement (2 Inches)</td>
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<td>$15,470</td>
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<tr>
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<td>Hot Mix Asphalt Pavement (3 Inches)</td>
<td>TON</td>
<td>214</td>
<td>5</td>
<td>$1,070</td>
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<tr>
<td>31</td>
<td>Hot Mix Asphalt Sidewalk (3” AC over 4” AB)</td>
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<td>Road Widening (6” AC over 6” AB)</td>
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<td>3,328</td>
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<td>Cold-In-Place Recycling (2 Inches)</td>
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<td>Cold-In-Place Recycling (3 Inches)</td>
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<td>Crack Sealing</td>
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<td>36</td>
<td>Thermoplastic Traffic Stripe – Detail 2</td>
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<td>Thermoplastic Traffic Stripe – Detail 9</td>
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<td>Thermoplastic Traffic Stripe – Detail 22</td>
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<td>Thermoplastic Continental Crosswalk (White or Yellow)</td>
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<td>Thermoplastic Pavement Markings (Arrows, Words, and Numerals, White or Yellow)</td>
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<td>48</td>
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<td>Install Delineations and Object Markers</td>
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<td>5</td>
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<tr>
<td>51</td>
<td>AC Dike</td>
<td>LF</td>
<td>1,648</td>
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<td>$8,240</td>
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Base Bid Subtotal: $158,525