2016 ARIZONA PAVEMENTS/MATERIALS CONFERENCE
NOVEMBER 16-17, 2016
PHOENIX, ARIZONA

Soil Stabilization & Full Depth Reclamation
Sustainable Engineering Designs
Marco A. Estrada
Pavement Recycling Systems
TYPICAL PERFORMANCE CURVE

Preservation (fog seal / slurry seal / chip seal / cape seal): $0.05-0.80/sf

Resurface (thin overlay / 2 or 3-layered system): $1.00-$2.50/sf

Reconstruction:
- Conventional: $6-$12/sf
- Sustainable (CCPR w/ Soil Stabilization): $3-$5/sf

Rehabilitation:
- Conventional (R&R): $3-$5/sf
- Sustainable (CIR/CCPR): $2-$3/sf
Unstable Subgrade Remediation
SUSTAINABLE ENGINEERING TECHNOLOGIES

- Soil Stabilization
  - Remediation of Unstable Subgrade or Base
  - New Construction Structural Design Applications

- Full-Depth Reclamation
  - Asphalt Pulverization with Cement for Base Modification
  - Thicker asphalt pavement structural sections

- Benefits of Soil Stabilization & Full-Depth Reclamation
  - Structural Pavement Design
  - Lower Costs
  - Reduced Environmental Impacts
  - Reduced Community & Utility Impacts
THE PROBLEM: POOR QUALITY “UNSUITABLE” SOILS & BASES

- Exhibit Poor Pavement Support
  Low R-values & Unconfined Compressive Strength

- Typically Moisture Sensitive
  Expansion Potential & Swell Pressure

- Constructability Issues
  “Pumping - Poor Workability Not Readily Compactable

Typical Poor Quality Soil
Remediation of Unstable Subgrade
- Scarify, aerate, & re-compact
- Remove unstable, pumping soil and replace with geotextile fabrics and base

Structural Design Applications
- Remove low R-value soil and replace with base
- Thicker asphalt pavement structural sections
- Interlayer grid systems
THE SOLUTION: SOIL STABILIZATION & FDR

- Quicklime/Hydrated Lime Slurry
- Portland Cement
- Asphalt Emulsion
Critical Element: Selection of Soil Stabilization Reagents for the Spectrum of Soil Types

Expansive

Quicklime/Lime Slurry

Non-Expansive

Cement

Asphalt Emulsion

Combination of Reagents
CRITICAL ELEMENTS DESIGN

- Pavement Structural Design: Increase load-bearing....structural improvements
  - Increased R-value, compressive strength, CBR, Structural Number, etc.

- Base/Subgrade distress including subgrade instability...pumping or yielding foundation

- Subgrade instability generally controls depth of design section
SUBGRADE STABILITY CAN CONTROL DEPTH OF STABILIZED SECTION
## Structural Equivalency: Pavement Section Design

<table>
<thead>
<tr>
<th>CLS Soil Cement or Lime Treated Subgrade</th>
<th>CTB</th>
<th>7-Day Break (CS)</th>
<th>Compressive Strength (psi)</th>
<th>Modulus - $10^6$ psi, ECTB or ECLS</th>
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<tbody>
<tr>
<td>.17</td>
<td></td>
<td>200</td>
<td>5.0</td>
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<td>.18</td>
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<td>300</td>
<td>5.5</td>
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<td>.20</td>
<td>.24</td>
<td>500</td>
<td>6.5</td>
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<td>.21</td>
<td>.26</td>
<td>600</td>
<td>7.0</td>
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<td>.23</td>
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SURFACING AND BASE COEFFICIENTS

<table>
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<tr>
<th>Material</th>
<th>Maximum Coefficient</th>
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<tbody>
<tr>
<td>Asphaltic Concrete (3/4&quot; or 1/2&quot; Mix; Virgin or Recycled)</td>
<td>.44 - $a_1$</td>
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<tr>
<td>Cement Treated or Bituminous Treated Base</td>
<td>.28 - $a_2$</td>
</tr>
<tr>
<td>Cement or Lime Treated Subgrade</td>
<td>.23 - $a_2$</td>
</tr>
<tr>
<td>Aggregate Base</td>
<td>.14 - $a_2$</td>
</tr>
<tr>
<td>Aggregate Subbase</td>
<td>.11 - $a_3$</td>
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</table>
Continental Ranch
Parcel 12 A+B Reconstruction
34,295 SY

- Remove/replace ramp
- New ramp

<table>
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<tr>
<th>Existing</th>
<th>Future</th>
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<tbody>
<tr>
<td>2'' AC</td>
<td>3'' AC</td>
</tr>
<tr>
<td>4'' AB</td>
<td>6'' Cement</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Treatment</td>
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</table>

Lat: 32.367007 Long: -111.119484
CITY OF TUCSON
2016 ROAD REHABILITATION PROJECT

- Distressed Pavement Existing Section
  *Typical 2” to 3” Asphalt over 8” Aggregate Base Course*

- Full Depth Reclamation
  *Pulverize and Blend existing pavement materials to 12”*

- Sustainable Engineering Design
  *Cement Stabilization 5% cement at 7” depth*
Project Phasing
Arterial Street FDR: Community Access
Residential Street: Traffic Control
Residential Street: Community Access
Access to the local residents
Same day Residential Street:
Cement stable, access to local traffic
Minimizes export of construction materials
Reduces import of virgin aggregate base
1 TRUCK LOAD OF CEMENT ELIMINATES
40 TRUCK LOADS OF EXPORT & IMPORT
CITY-WIDE RESIDENTIAL STREETS REPAIR
2 MILLION SQUARE FEET CEMENT TREAT
ENERGY & TIME SAVINGS COMPARISON

- Excavate & Export (8”)...... 49,630 cy or 4,727 trucks
- Import (8”)............. 90,450 tons of base or 5,025 trucks
- Cement Treatment (8” 5% Cement)....... 4,355 tons of cement or 168 trucks
- Eliminated over 9,500 trucks from the job (58:1 ratio)
- Equipment days to complete R & R...................... 100
- Equipment days to complete treatment.......... 70
- Reduced construction time by 30%. 
# SUSTAINABLE TREATMENTS - BENEFITS

**ENERGY USAGE, GREENHOUSE GAS EMISSIONS, LANDFILL REDUCTION, AND COST SAVINGS FOR SUSTAINABLE PAVEMENT TREATMENTS**

<table>
<thead>
<tr>
<th>NUMBER OF PROJECTS COMPLETED</th>
<th>COLD IN-PLACE RECYCLING</th>
<th>COLD CENTRAL PLANT RECYCLING</th>
<th>SUBGRADE STABILIZATION</th>
<th>PAVEMENT PRESERVATION</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projects</strong></td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>25</td>
<td>51</td>
</tr>
<tr>
<td><strong>Reduction in Energy Consumption (% or kWh)</strong></td>
<td>77%</td>
<td>77%</td>
<td>97%</td>
<td>80%</td>
<td>81%</td>
</tr>
<tr>
<td><strong>Reduction in GHG Emissions (% or metric tons)</strong></td>
<td>79%</td>
<td>79%</td>
<td>97%</td>
<td>86%</td>
<td>85%</td>
</tr>
<tr>
<td><strong>Landfill Reduction (CY)</strong></td>
<td>28,000</td>
<td>16,000</td>
<td>96,000</td>
<td>121,000</td>
<td>261,000</td>
</tr>
<tr>
<td><strong>Cost Savings (%)</strong></td>
<td>45%</td>
<td>21%</td>
<td>74%</td>
<td>43%</td>
<td>47%</td>
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<tr>
<td><strong>Cost Savings ($)</strong></td>
<td>$4,804,000</td>
<td>$1,018,000</td>
<td>$9,165,000</td>
<td>$16,736,000</td>
<td>$31,723,000</td>
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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](http://www.epa.gov))
Urban Residential Streets:
Project is located City of Inglewood

Length: 7 lane miles

Area: 471,600 sf

Pavement Condition Index:
- 56 (Poor)

Treatment Strategies:
- Reconstruction
  - 1½” of ARHM
  - 3” of CCPRACCP
  - 6” of Soil Stabilization

Cost Savings: ($1.1M Cost Saving)
- Conventional Reconstruction: $2.05M ($4.34/sf)
- Sustainable Reconstruction: $971K ($2.06/sf)
PCI Comparison
Sustainable Approach vs. Worst First

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<tr>
<th></th>
<th>Sustainable Approach</th>
<th>Worst First Approach (Projected)</th>
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</thead>
<tbody>
<tr>
<td>Square footage to be treated</td>
<td>145MSF</td>
<td>45MSF</td>
</tr>
<tr>
<td>Roads rated Good-Excellent</td>
<td>52%</td>
<td>42%</td>
</tr>
<tr>
<td>Roads rated Poor &amp; Failed</td>
<td>14%</td>
<td>17%</td>
</tr>
<tr>
<td>Overall Network PCI</td>
<td>71</td>
<td>66</td>
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Almost 25% increase
Almost 20% decrease
Almost 10% increase
Recycles Soil & Minimizes cost versus Export/Import Practices Savings of 30 to 50 percent

Time savings of up to 50%

Reduces Carbon Footprint – Trucking 40:1

Minimizes Distress on Existing Roadway Infrastructure

All weather access.....reduced schedule impacts

Increases Structural Number Without Excavation

- Significant Increases in R Value and Strength
- Coefficients= 0.23 to 0.28
Engineered Approach: Design and Training

Local Contractor expertise and higher capacity equipment...FDR sections of 18” in one lift

Increased partnership efforts between Agency & Contractors
- Industry & Agency task groups working on specifications
- Joint Committees working on specifications

Guidelines & Specifications available
- MAG
- Local agencies
- Pavement & Geotechnical Engineers
Questions?

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marcoestrada@pavementrecycling.com