Illinois Tollway Update on RCA Recycling and Applications

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National Concrete Consortium, Minneapolis
Today’s Agenda

- Overview of the Illinois Tollway’s capital program
- Tollway specifications & options for RCA
- Summary of experiences and cost savings to date
- Future use for RCA
About the Illinois Tollway

292-mile system comprised of five tollways

Opened in 1958 as a bypass around Chicago to connect Indiana and Wisconsin

Carries more than 1.5 million vehicles per day

User-fee system
• Only customers who use the Tollway pay for the Tollway
• No state or federal tax dollars used for maintenance and operations
Congestion-Relief Program (2004 to 2016)

12-year, $5.8 billion program

Accomplishments

• Converted system to open road tolling
• Completed long-awaited south extension of the Veterans Memorial Tollway (I-355) into Will County
• Rebuilt/restored majority of the system
• Added lanes to reduce congestion
Move Illinois Program

**TAKE CARE OF EXISTING SYSTEM NEEDS**

- JANE ADDAMS MEMORIAL TOLLWAY
  - $2.5 billion

- ELGIN O’HARE WESTERN ACCESS
  - $3.4 billion

- I-294/I-57 INTERCHANGE
  - $719 million

**ILLINOIS ROUTE 53/120 PROJECT**

**OTHER EMERGING PROJECTS**
Tollway Objective is to Rebuild in the Greenest and Cleanest Way Possible

Goal to recycle 100 percent of the original pavements and structures back into the new pavements

• Recycled asphalt pavement (RAP)
• Recycled concrete aggregate (RCA)
• Existing subbase aggregates

Improve sustainability further using as many waste products as possible

• Fly ash/slag in Portland Cement Concrete (PCC)
• Roof shingles in asphalt
• Ground tires in asphalt
How the Tollway Specifies RCA Production

On-site or off-site processing

Rubblelization
How Rubblization Was Engineered at the Tollway

• In 1998 a U of I research project placed two 2 mile sections of full depth asphalt over a 14” rubblized concrete base on I-88 EB with no underdrains

• Varied thickness shoulders (6” to 10”) were rubblized

• Stiffer base allowed for only an 8” asphalt pavement that still remains with no distress below the top lift. Only the top 2” of surface course has been replaced.

• Asphalt shoulders are being rebuilt with underdrains due to frost heaving
Rubblization

- Approximately 30 median miles of interstate highway concrete pavement has been rubblized on the Tollway and compacted as a base under new perpetual asphalt pavements

- 27.9 miles on one project alone – Reagan Memorial Tollway (I-88) rebuild & widen phase I project in 2005

- Phase II completed in 2016
On-Site Processing for Porous Granular Embankment (PGE) Subbase – Mobile

• Processing RCA as a PGE (6-inch maximum) aggregate was initiated by IDOT to construct 12-inch minimum thickness bases (3-inch dense graded cap over 9-inch PGE)

• On initial Tollway reconstruction projects mobile processors followed the excavation process down the road

• Too much subbase/subgrade contamination and segregation resulted
On-Site Processing for Porous Granular Embankment (PGE) Subbase – Stationary

• Today, with stricter control on gradation, the processors are typically kept at stationary locations on-site to produce larger piles of PGE at multiple locations along the reconstructed corridor

• Tollway PGE maximum particle size is reduced to 5 inches to allow for thinner bases where stiffer subgrades exist
Off-Site Processing for Porous Granular Embankment (PGE) Subbase – Stationary

• When the base design requires a 9-inch or greater layer of PGE, then the IDOT-certified off-site RCA processing sites are sometimes used

• These sites commonly blend up to 50 percent of the RCA with clumps of asphalt
On-Site Processing for Washed Porous Granular Subbase - Stationary

- RCA has been processed on-site as a washed 1 ½-inch aggregate to use as a drainable base as thin as 6 inches under new concrete pavements with stiff subgrades

- To protect the subgrade soils from rain water stability issues, chemical stabilization of subgrade is critical before placement
Summary of RCA Subbase Options

• **With less stable subgrades, heavier loads and ample room for profile adjustment**
  • A 12” Subgrade Aggregate (3” RAP milling cap over a 9” PGE using a 6” RCA) is typically used

• **With stiffer subgrades and less room for profile adjustment**
  • A 9” Subgrade Aggregate (3” RAP milling cap over a 6” PGE using a 5” RCA ) is typically used

• **With stabilized/stiffer subgrades and little room for profile adjustment**
  • A 6” to 8” Porous Granular Subbase (denser graded washed RCA with 1 ½” maximum aggregate size) is used. No capping stone required.
Experiences with RCA unbound bases

• Only 1 sediment issue when RCA PGE was used

• Segregation and soil contamination was too common when only moving mobile crushers were used for PGE production

• No settlement or erosion issues to date
Other RCA Options

• RCA may be used as a pre-saturated coarse aggregate in concrete for new PCC pavements if chloride content is suitable
  • Not yet used because of base stone demands
  • With pavement design controlling criteria revisions more applications to new pavement concrete may be coming

• RCA 6” PGE stone commonly used to mechanically stabilize small areas of soft/wet subgrades with soil undercuts

• Specifications are being developed to allow for dense-graded 1 ½-inch RCA to be used for compacted cement-treated bases and for unbound subbase aggregates under cement-treated bases where underdrains will not exist
Weighted Cost Savings Replacing Virgin Subbase Aggregate with Rubblization

Extra quantities without rubblization (27.9 miles of four-lane I-88 rebuilt with full-depth asphalt in 2005)
- Excavation (14 inches PCC removal + undercuts) – 584,841 cubic yards (cu yd)
- 12 inches subgrade aggregate + undercut backfill – 818,400 cu yd
  2 inches of HMA added w/ weaker nonrubblized base – 45,830 tons

Cost to reconstruct with virgin aggregate base
- Excavation/disposal – 584,841 cu yd x $12.00/ cu yd = $7,018,092
- Virgin aggregate and backfill – 551,056 cu yd x $20.00/ cu yd = $11,021,120
- Extra asphalt – 45,830 tons x $50.00/ton = $ 2,291,500
- **Total cost = $20,330,712**
Weighted Cost Savings Replacing Virgin Subbase Aggregate with Rubblization

Quantities to reconstruct 27.9 miles of I-88 with PCC rubblized bases
- PCC mainline area = 808,850 square yards (sq yd)
- PCC shoulder area = 517,664 sq yd
- Mainline rubblization bid price = $1.816/sq yd (weighted average)
- Shoulder rubblization bid price = $0.682/sq yd (weighted average)

Costs to reconstruct with rubblized bases
- Mainline rubblization = $1.816 x 808,850 sq yd = $1,468,872
- Shoulder rubblization = $0.682 x 517,664 sq yd = $353,047
- **Total $1,821,919**
Weighted Cost Savings Replacing Virgin Subbase Aggregate with Rubblization

Total savings based on 2005 dollar value
- $20,330,712 for total reconstruction
- $-1,821,918 for rubblization
- $18,508,794 for total savings

Total savings normalized to 2015 dollar value using ENR construction cost indices between 2005 and 2015 that indicate a ratio of 1.32
- $18,508,794 x 1.32 = $24,431,608 total savings based on 2015 dollar value

Material cost savings of on-site RCA processing rather than virgin stone purchase = $6 per ton (2015 dollar)
• Total 3,721,300 tons of PCC pavement material has been recycled as base stone
• 3,721,300 tons x $6/ton (2015 dollar) = $22,327,800 savings

Elimination of disposal costs of excavated PCC = $6 per ton savings
• 3,721,300 tons of PCC x $3/ton (2015 dollar) = $11,163,900 savings

Elimination of haul costs of virgin aggregate from pit to site = $7.50 per ton
• 3,721,300 tons x $7.50/ton (2015 dollar) = $27,909,750 savings
Total Capital Program Cost Savings Thru 2016 by Using RCA Based on the 2015 Dollar Value

Rubblization savings = $24,431,608

RCA as unbound aggregate savings

- Material savings = $22,327,800
- Disposal savings = $11,163,900
- Haul cost savings = $27,909,750
  Total $61,401,450

Total savings from recycling PCC pavements with reconstructed roadways since 2005 = $85,833,058
Next Large Corridor Reconstruction Project – Central Tri-State Tollway (I-294)

• 22 median miles of reconstructed expressway

• Widened in each direction from 4 lanes to 5 lanes with a median flex lane added

• Minimal traffic impact required
Engineering / Research Initiatives Being Applied

• Intelligent compaction of all earthwork / bases

• Re-engineered CRC pavements
  • All to be built with internally cured ternary concrete
  • Built thinner with less steel
  • Built on porous or dense graded granular subbases (RCA the option for both)
  • Built on RCCTB for higher modulus (RCA the option)
New Option for RCA Coming

• **Roller Compacted Cement Treated Bases (RCCTB)**
  • Numerous lab trial mix designs prepared
  • Field demo of two mixes performed
  • Sustainable aggregates to be used

Presented by Steve Gillen on September 20, 2017
Roller Compacted Cement Treated Base (RCCTB) Demo – Initial Blends by STATE Testing

Mix #1 - Vulcan’s Virgin CM-10 (Crushed RCA can be similar)

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Coarse #1</th>
<th>Coarse #2</th>
<th>Fine #1</th>
<th>Fine #2</th>
<th>Combined</th>
<th>Spec % Passing</th>
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<tr>
<td>019CM10</td>
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<td>97.0</td>
<td>86</td>
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<td>100</td>
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<tr>
<td>1-1/2”</td>
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<td>100.0</td>
<td>97.0</td>
<td>86</td>
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<tr>
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<td>97.0</td>
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<td>86</td>
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<td>100</td>
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<tr>
<td>1/2”</td>
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<td>100.0</td>
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<td>86</td>
<td>78.0</td>
<td>100</td>
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<tr>
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<td>97.0</td>
<td>86</td>
<td>78.0</td>
<td>100</td>
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<td>78.0</td>
<td>100</td>
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<tr>
<td>% of agr.</td>
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<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>100.0%</td>
<td>0.0%</td>
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Presented by Steve Gillen, July 7, 2017
Roller Compacted Cement Treated Base (RCCTB) Demo – Initial Blends by STATE Testing

Mix #2 - Vulcan’s Virgin CA-6 & FA-5 by-product
Compaction Results for Mix #1 (CM-10)

6" Thick
- ~7.25" laydown
- ~6" compacted
- With screed vibration

Modified Proctor
- Maximum dry density
  - 139.1 pcf
- Optimum moisture
  - 6.6%

<table>
<thead>
<tr>
<th>Pass</th>
<th>Density (pcf)</th>
<th>Water (HD)</th>
<th>% Moisture (WD)</th>
<th>% Dens (PASS)</th>
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<td>1</td>
<td>136.9</td>
<td>146.7</td>
<td>7.2</td>
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<tr>
<td>2</td>
<td>139.2</td>
<td>149.8</td>
<td>7.6</td>
<td>100.1%</td>
</tr>
<tr>
<td>3</td>
<td>141.2</td>
<td>152.7</td>
<td>8.2</td>
<td>101.5%</td>
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</table>
Compaction Results for Mix #2 (CA-6/FA-5)

4" Thick
- ~5" laydown
- ~4" compacted
- With screed vibration

Modified Proctor
- Maximum dry density
  - 141.4 pcf
- Optimum moisture
  - 5.7%

<table>
<thead>
<tr>
<th>PASS</th>
<th>DD</th>
<th>WD</th>
<th>% MOIST</th>
<th>% DENSITY</th>
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<tr>
<td>SCR/VIBE 0</td>
<td>110.5</td>
<td>116.7</td>
<td>5.6</td>
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<tr>
<td>VIBE 1</td>
<td>130.6</td>
<td>138.1</td>
<td>5.8</td>
<td>92.4%</td>
</tr>
<tr>
<td>VIBE 2</td>
<td>135.8</td>
<td>143.9</td>
<td>6.0</td>
<td>96.0%</td>
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<tr>
<td>VIBE 3</td>
<td>139.4</td>
<td>147.7</td>
<td>5.9</td>
<td>98.6%</td>
</tr>
<tr>
<td>VIBE 4</td>
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<td>150.2</td>
<td>6.0</td>
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<tr>
<td>VIBE 5</td>
<td>143.3</td>
<td>151.7</td>
<td>5.9</td>
<td>101.3%</td>
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<tr>
<td>VIBE 6</td>
<td>143.1</td>
<td>151.6</td>
<td>5.9</td>
<td>101.2%</td>
</tr>
<tr>
<td>VIBE 7</td>
<td>142.6</td>
<td>151.2</td>
<td>6.0</td>
<td>100.8%</td>
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# Compressive Strength Results

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<th>4 Day (psi)</th>
<th>7 Day (psi)</th>
<th>14 Day (psi)</th>
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<tbody>
<tr>
<td>#1 (CM-10)</td>
<td>1275</td>
<td>1489</td>
<td>1659</td>
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<tr>
<td>#2 (CA-6/FA-05)</td>
<td>1099</td>
<td>1186</td>
<td>1430</td>
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Aggregate Options for RCCTB

Coarse aggregate
- Virgin
  - CA 6, CA 7, CA 9, CA 10, or CA 11
  - Class D quality or better
- Recycled
  - Category 1 or 2 coarse FRAP without expansive aggregate blended with an FA 5
  - Recycled concrete aggregate (RCA)
    - As a single CA 10
    - Or as a blended CA 6 / FA 5

Fine aggregate
- FA 5 only (crushing by product)

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing</th>
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</tr>
<tr>
<td>¾ in.</td>
<td>82-100</td>
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<tr>
<td>½ in.</td>
<td>76-100</td>
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<tr>
<td>⅜ in.</td>
<td>70-98</td>
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<tr>
<td># 4</td>
<td>55-80</td>
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<td># 8</td>
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<td># 40</td>
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<td>5-25</td>
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<tr>
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Required combined gradation
THANK YOU