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

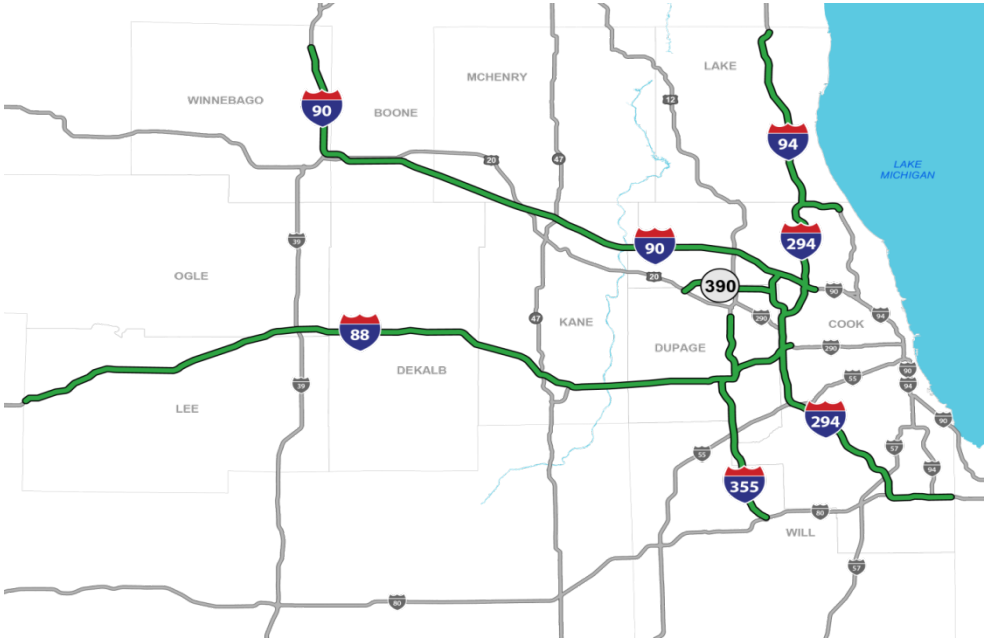
292-mile system comprised of five tollways

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



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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

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Move Illinois Program

TAKE CARE OF EXISTING SYSTEM NEEDS

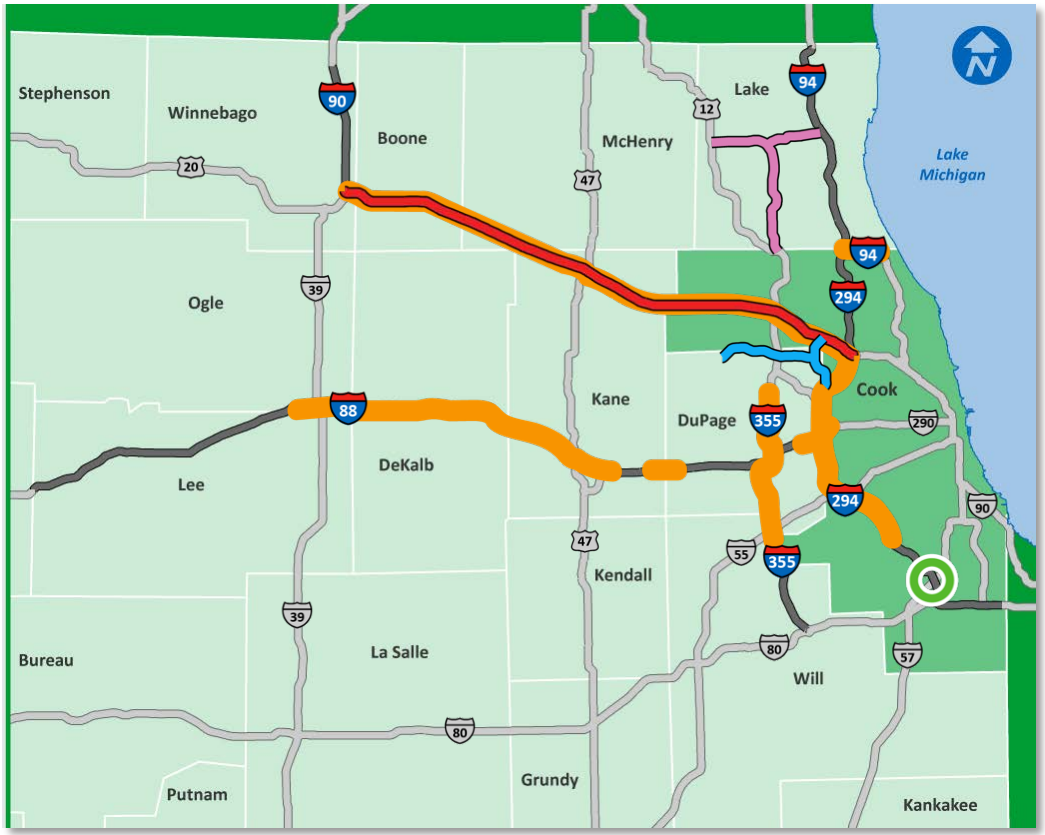
JANE ADDAMS MEMORIAL TOLLWAY
$2.5 billion

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

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How the Tollway Specifies RCA Production

On-site or off-site processing

Rubblization

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

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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

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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

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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

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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

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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.

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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**

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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**

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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**

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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

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Cost Savings to Recycle PCC Pavement as Base Aggregates (RCA) vs Using Virgin Stone (2008 thru 2016)

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

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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

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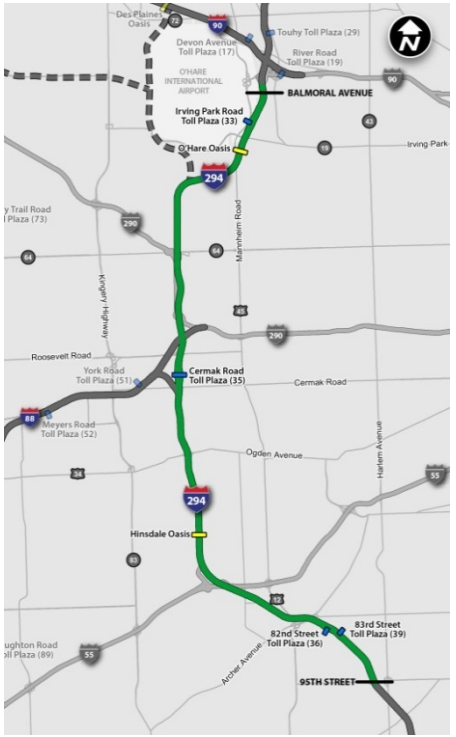
Next Large Corridor Reconstruction Project – Central Tri-State Tollway (I-294)

- 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)

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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

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Roller Compacted Cement Treated Base (RCCTB) Demo – Initial Blends by STATE Testing

Illinois Tollway CTB Combined Gradation Review

	Coarse #1	Coarse #2	Fine #1	Fine #2	Combined	Spec % Passing	
Sieve	019CM10					Lower	Upper
1-1/2"	100				100		
1"	100.0				100	100	100
3/4"	97.0				97	82	100
1/2"	86				86	76	100
3/8"	78.0				78	70	98
#4	61.0				61	55	80
#8	45				45	40	60
#16	32				32	25	45
#30	23				23	18	38
#40	20				20	13	33
#100	14				14	5	25
#200	12				12.0	0	20
						Max	1"
						NMAS	3/4"
% of aggr.	100.0%	0.0%	0.0%	0.0%	100.0%		

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

Roller Compacted Cement Treated Base (RCCTB) Demo – Initial Blends by STATE Testing

Illinois Tollway CTB Combined Gradation Review

	Coarse #1	Coarse #2	Fine #1	Fine #2	Combined	Spec % Passing	
Sieve	042CA06		013FA05			Lower	Upper
1"	100		100		100	100	100
3/4"	94		100		96	82	100
1/2"	76		100		83	76	100
3/8"	66.0		100		76	70	98
#4	48.0		99		63	55	80
#8	35		79		48	40	60
#16	27		53		35	25	45
#30	22		39		27	18	38
#40	20		29		23	13	33
#100	16		24		18	5	25
#200	14.3		20.6		16.2	0	20
						Max NMAS	1" 3/4"
% of aggr.	70.0%	0.0%	30.0%	0.0%	100.0%		

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%

	PASS	DD	WD	% MOIST	% DENSITY
SCR/VIBE	0	116.4	124.0	6.6	83.7%
VIBE	1	136.9	146.7	7.2	98.4%
VIBE	2	139.2	149.8	7.6	100.1%
STATIC	3	141.2	152.7	8.2	101.5%

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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%

	PASS	DD	WD	% MOIST	% DENSITY
SCR/VIBE	0	110.5	116.7	5.6	78.1%
VIBE	1	130.6	138.1	5.8	92.4%
VIBE	2	135.8	143.9	6.0	96.0%
VIBE	3	139.4	147.7	5.9	98.6%
VIBE	4	141.7	150.2	6.0	100.2%
VIBE	5	143.3	151.7	5.9	101.3%
VIBE	6	143.1	151.6	5.9	101.2%
VIBE	7	142.6	151.2	6.0	100.8%

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Compressive Strength Results

Mix #	4 Day (psi)	7 Day (psi)	14 Day (psi)
# 1 (CM-10)	1275	1489	1659
#2 (CA-6/FA-05)	1099	1186	1430

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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)

Sieve Size	% Passing
1 in.	100
¾ in.	82-100
½ in.	76-100
⅜ in.	70-98
# 4	55-80
# 8	40-60
# 16	25-45
# 30	18-38
# 40	13-33
#100	5-25
#200	0-20

Required combined gradation

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THANK YOU