Concrete with Recycled Concrete Aggregate: A Texas Case Study

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TC 4.1 Road Pavements

Argentina

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- Motivation
- Approach
- Performance
- Key Outcomes

U.S. Department of Transportation
Federal Highway Administration

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Project Motivation

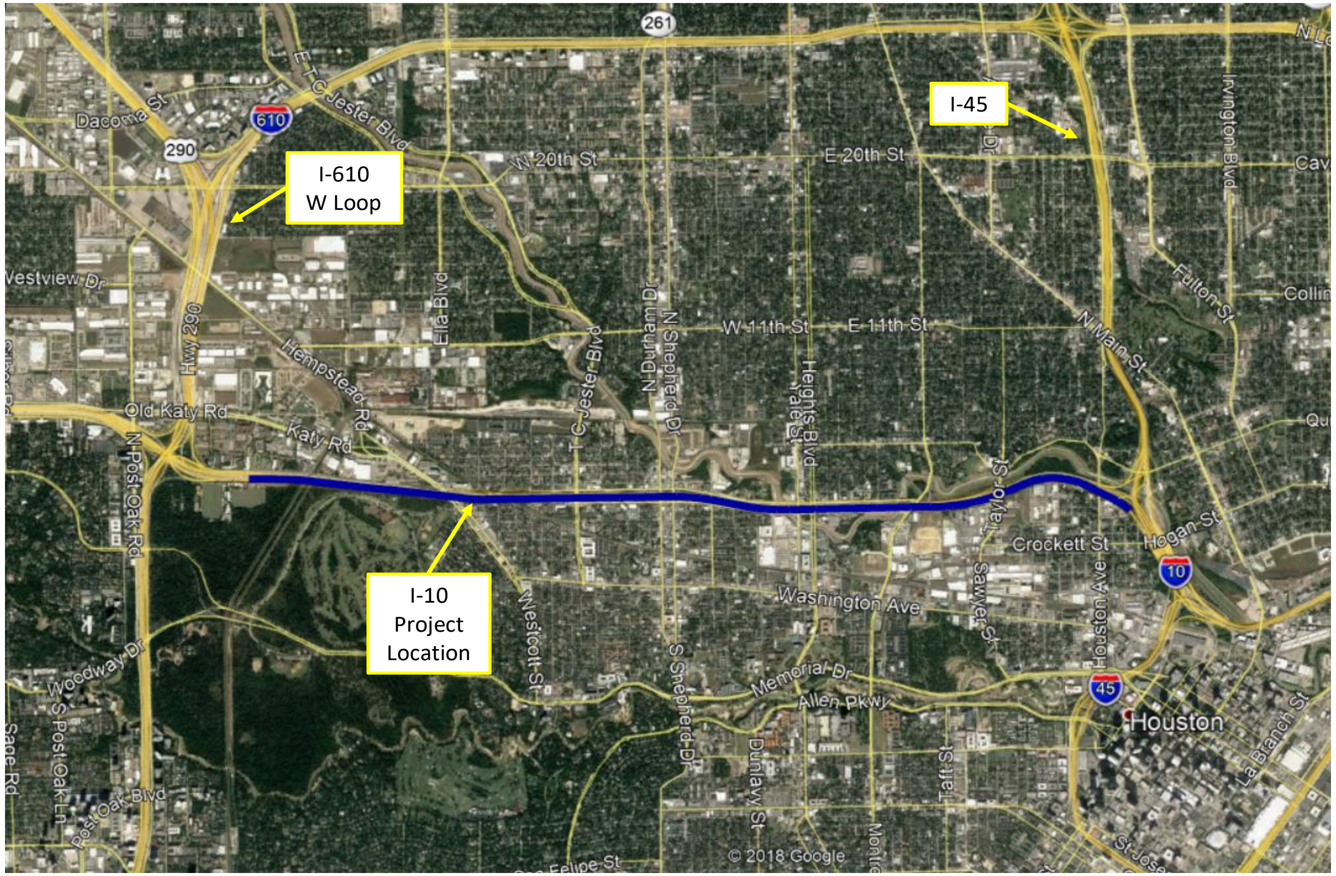
Texas in 1990s…

- Lack of local available aggregate
- Increase costs virgin materials
- Performance issues with virgin aggregates

Image: Pixabay; circle added.

Approach: Continuously Reinforced Concrete Pavement (CRCP) with Recycle Concrete Aggregate

- 1995 Reconstruct 5.8 mi of I-10
- 100% RCA in CRCP
  - Coarse
  - Fine
- 1st in USA



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Pavement Sections

Typical Section 1

- 14-inch CRCP over 3-inch asphalt-stabilized base
- 6 inch lime-treated subgrade
- 14-inch tied concrete shoulder (CRCP)
- Double mat longitudinal reinforcement
- 3/4th Project Length

Typical Section 2

- 11-inch CRCP overlay on 1-inch asphalt stabilized base
- over existing CRCP
- 11-inch tied concrete shoulder (CRCP)
- Single mat longitudinal reinforcement
- 1/4th Project Length

Concrete Mixture

- 6-sack (564 lbs/yd^3) concrete mix
- RCA conformed to same aggregate specifications
- Controlled moisture RCA stockpile with sprinkler
- RCA fines limited to 20 percent

Material	Property	Test Method	RCA Test Result
Coarse Aggregate	Specific gravity	ASTM C127	2.45 - 2.48
	Mortar content	- [1]	~ 30%
	Water absorption	ASTM C127	3.9 - 4.1%
	Sodium soundness loss	ASTM C88	1 - 9%
	Magnesium soundness loss	ASTM C88	1 - 4%
	LA abrasion	ASTM C131	32 - 38%
	Thermal coefficient	- [1]	16 - 26 με/°C
	Freeze-thaw loss	Tex-433C	11.5%
	Alkali-silica reactivity	ASTM C1260	0.023%
Fine Aggregate	Specific gravity	ASTM C128	2.37
	Water absorption	ASTM C128	7.9%
	Angularity	NAA Method	38.6%

Performance Testing

Sustainability
Rating Systems
(e.g., INVEST)

Performance
Testing
↓
Life-Cycle Assessment
(LCA)

Performance
Testing
↓
Life-Cycle Cost
Analysis
(LCCA)

Image Source: FHWA/APTech

LCA ≠ LCCA

- Life-cycle cost analysis (LCCA) evaluates life-cycle economic impacts
- Life-cycle assessment (LCA) quantifies life-cycle potential environmental impacts

[LCA and LCCA One Pagers]

Images: FHWA

Life Cycle Assessment - Quantifies Environmental Impacts

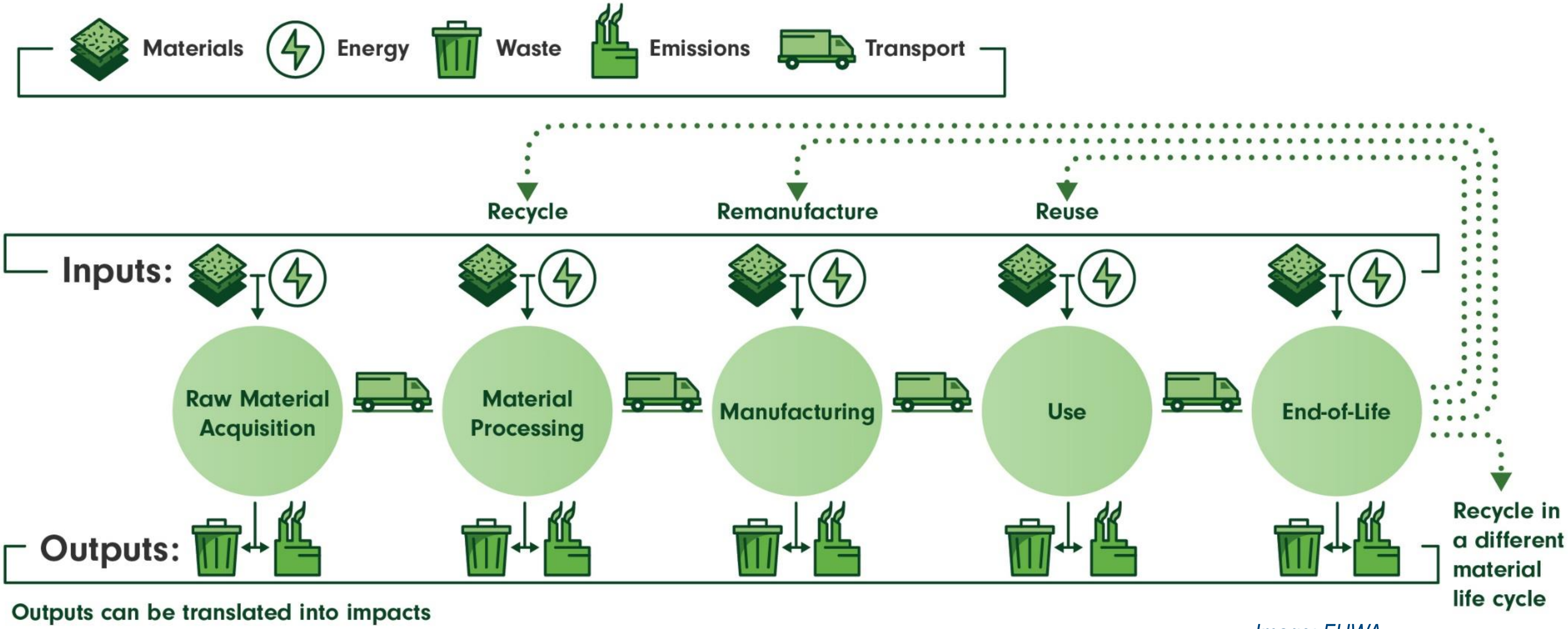


Image: FHWA

Plastic vs. Paper

Images: Pixabay

Post Construction In-Situ Concrete Properties

In-situ Property	Method	Avg.	Range
Compressive strength, 28-day	-	4,615 lb/in^2	4,260 – 5,270 lb/in^2
Indirect tensile strength, 28-day	-	486 lb/in^2	415 – 535 lb/in^2
Modulus of elasticity	-	2.58 x 10^6 lb/in^2	-
Coefficient of thermal expansion	Tex-428-A	-	4.7 – 5.3 με/°F
Chloride content	Tex-617J	1436 ppm	-
Sulfate content	Tex-620J	0.04 lb/yd^3	-
Density	-	2.24	2.19 – 2.36
Water absorption	ASTM C642	10.86%	-
Permeability	ASTM C1202	466 Coulomb	366 – 628 Coulomb

Sustainability Performance

Year	No. of Spalls	No. of Punchouts	No. of PCC Patches[1]	Avg. IRI (in/mi)
2011	9	4	1	115
2012	1	3	3	119
2013	1	0	0	119
2014	3	4	5	113
2015	2	7	1	120
2016	8	5	1	116

- Outperforming CRCP with local virgin aggregate

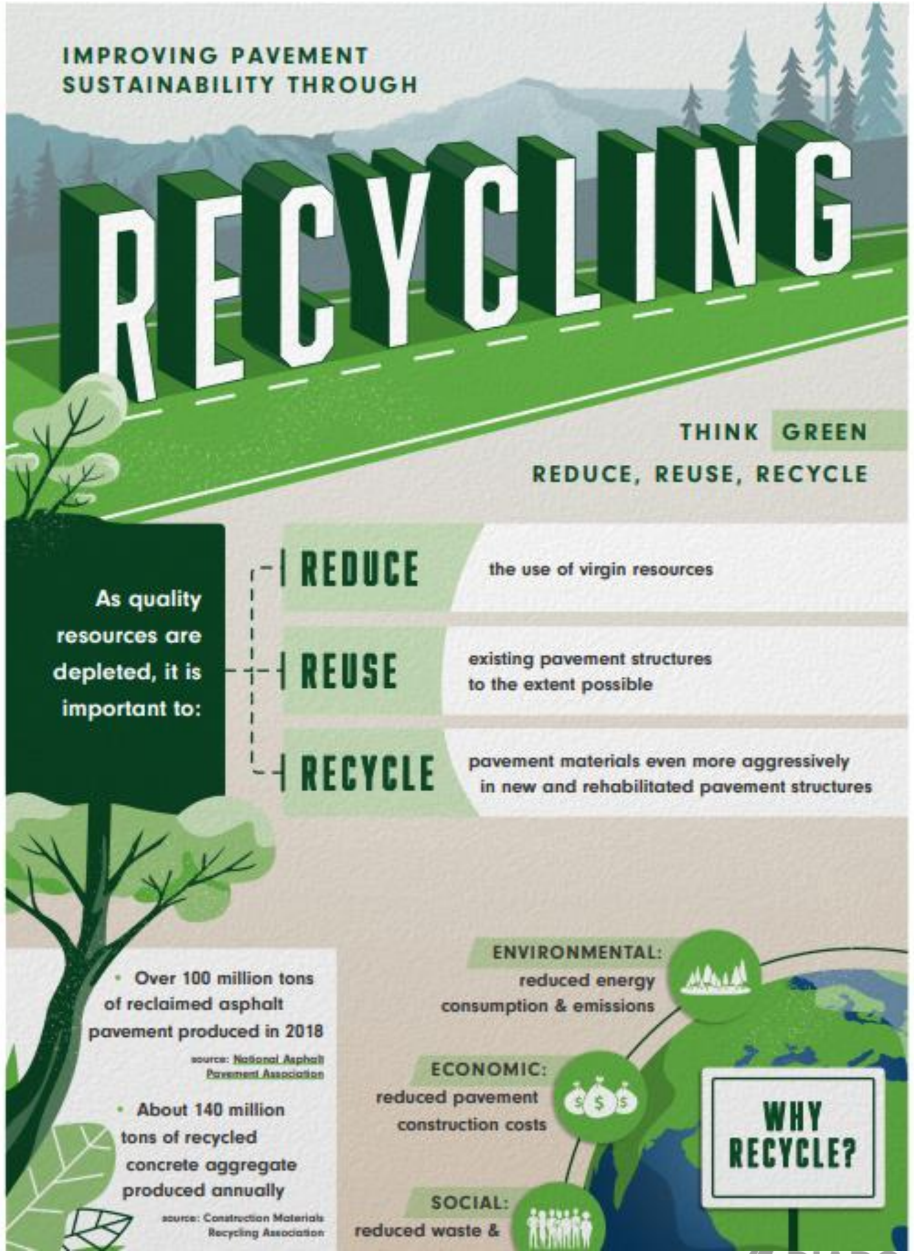
Approximate Savings:

- $1.4M
- 207,750 tons Virgin Aggregate
- 1,268,387 CO_2eq Global Warming Potential

Key Outcomes

- 100% RCA CRCP
  - Performed 10+ years of service
  - Limit fines 20%
  - RCA moisture control
- RCA Sustainability Benefits
  - Reduced Costs (landfill and virgin materials)
  - Reduced Depletion of virgin materials
  - Reduced Global Warming Potential
- Important to Quantify Sustainability Benefits

Image: FHWA



SUSTAINABLE PAVEMENTS PROGRAM

https://www.fhwa.dot.gov/pavement/sustainability

Vision and Mission

Advance the knowledge and practice of designing, constructing, and maintaining more sustainable pavement through:

- Stakeholder engagement
- Education
- Development of guidance and tools

Sustainable Pavement Program Resources



Images: FHWA

Education	Research	Deployment
Pavement LCA Framework	LCA fit in transportation decision-making	LCAPave Tool
Webinars	EPDs in Green Public Procurement	Pilot projects with State DOTs
Tech briefs, one-pagers	LCA of recycled plastics in pavements	Mobile Pavement Technologies Centers
Technical articles	LCA of ground tire rubber in pavements	Informing pre-engineering with ICE Tool

https://www.fhwa.dot.gov/pavement/sustainability

Thank you for your attention!

PIARC Secretary General

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