

<b>1. Report No.</b> FHWA-HIF-15-002		<b>2. Government Accession No.</b>		<b>3. Recipient's Catalog No.</b>	
<b>4. Title and Subtitle</b>  Towards Sustainable Pavement Systems: A Reference Document				<b>5. Report Date</b> January 2015	
				<b>6. Performing Organization Code</b>	
				<b>8. Performing Organization Report No.</b>	
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<b>9. Performing Organization Name and Address</b>  Applied Pavement Technology, Inc. 115 West Main Street, Suite 400 Urbana, IL 61801				<b>11. Contract or Grant No.</b> DTFH61-10-D-00042-T-12001	
				<b>13. Type of Report and Period Covered</b>  Final May 2012 – January 2015	
<b>12. Sponsoring Agency Name and Address</b>  Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC 20590				<b>14. Sponsoring Agency Code</b>	
<b>15. Supplementary Notes</b>  FHWA Contracting Officer's Representative: Gina Ahlstrom					
<b>16. Abstract</b>  All stakeholders in the pavement community—from owner/agencies to designers, and from material suppliers to contractors and consultants—are embracing the need to adopt more sustainable practices in all aspects of their work, and are continually seeking the latest technical information and guidance available to help improve those practices. This reference document has been prepared to provide guidance to the pavement community on sustainability considerations in pavement systems, drawing from and synthesizing the large and diverse body of knowledge that exists on pavement sustainability. As such, it provides the currently available knowledge and information for designing, constructing, and maintaining pavement structures more sustainably, and has been structured so that it can adapt to new findings and new information as sustainability considerations continue to develop and evolve. Key information is presented on pavement sustainability concepts, sustainable materials for paving applications, design of sustainable pavements, sustainable pavement construction practices, use phase considerations, sustainable maintenance and preservation practices, sustainable end-of-life considerations, pavement sustainability and livable communities, and assessment of pavement sustainability.  It is important to recognize that there is no universal definition of a "sustainable" pavement. Sustainability is very much context sensitive in that each project is unique, with specific needs depending on the location, climate, available materials, facility type, and required level of service, as well as on the overall goals of the organization. In essence, sustainability is very much a system characteristic, and pavements represent but one small part of the transportation infrastructure system; consequently, any improvements to the sustainability characteristics of pavement systems cannot be done in isolation from the transportation infrastructure system or from other systems with which pavements interact.					
<b>17. Key Words</b> Sustainability, sustainable pavements, environment, society, economics, asphalt, concrete, materials, design, construction, use phase, maintenance, rehabilitation, recycling, life cycle assessment, life cycle costing, rating systems			<b>18. Distribution Statement</b> No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.		
<b>19. Security Classify. (of this report)</b>  Unclassified		<b>20. Security Classify. (of this page)</b>  Unclassified		<b>21. No of Pages</b>  456	<b>22. Price</b>

<b>SI* (MODERN METRIC) CONVERSION FACTORS</b>				
<b>APPROXIMATE CONVERSIONS TO SI UNITS</b>				
<b>Symbol</b>	<b>When You Know</b>	<b>Multiply By</b>	<b>To Find</b>	<b>Symbol</b>
<b>LENGTH</b>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	645.2	square millimeters	mm <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yard	0.836	square meters	m <sup>2</sup>
ac	acres	0.405	hectares	ha
mi <sup>2</sup>	square miles	2.59	square kilometers	km <sup>2</sup>
<b>VOLUME</b>				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>
NOTE: volumes greater than 1000 L shall be shown in m <sup>3</sup>				
<b>MASS</b>				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
<b>TEMPERATURE (exact degrees)</b>				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
<b>ILLUMINATION</b>				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m <sup>2</sup>	cd/m <sup>2</sup>
<b>FORCE and PRESSURE or STRESS</b>				
lbf	poundforce	4.45	newtons	N
lbf/in <sup>2</sup>	poundforce per square inch	6.89	kilopascals	kPa
<b>APPROXIMATE CONVERSIONS FROM SI UNITS</b>				
<b>Symbol</b>	<b>When You Know</b>	<b>Multiply By</b>	<b>To Find</b>	<b>Symbol</b>
<b>LENGTH</b>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<b>AREA</b>				
mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
ha	hectares	2.47	acres	ac
km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
<b>VOLUME</b>				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m <sup>3</sup>	cubic meters	35.314	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b>MASS</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
<b>TEMPERATURE (exact degrees)</b>				
°C	Celsius	1.8C+32	Fahrenheit	°F
<b>ILLUMINATION</b>				
lx	lux	0.0929	foot-candles	fc
cd/m <sup>2</sup>	candela/m <sup>2</sup>	0.2919	foot-Lamberts	fl
<b>FORCE and PRESSURE or STRESS</b>				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in <sup>2</sup>

\*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

## TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY</b> .....	ES-1
<b>CHAPTER 1. INTRODUCTION</b> .....	1-1
<b>Background</b> .....	1-1
<b>What is Sustainability?</b> .....	1-2
<b>Importance of Sustainability in Pavement Engineering</b> .....	1-3
<b>About This Document</b> .....	1-4
<u>Scope</u> .....	1-5
<u>Target Audience</u> .....	1-6
<u>Document Overview</u> .....	1-6
<b>References</b> .....	1-7
<b>CHAPTER 2. CONCEPTS OF PAVEMENT SUSTAINABILITY</b> .....	2-1
<b>Sustainability Defined</b> .....	2-1
<u>The Sustainability Continuum</u> .....	2-2
<u>Sustainable Best Practices</u> .....	2-2
<u>Sustainability is Context Sensitive</u> .....	2-2
<b>Importance of a Sustainability Definition</b> .....	2-3
<u>Integrating Sustainability into a System</u> .....	2-3
<b>Context: The Role of Pavements in Sustainability</b> .....	2-3
<u>Beyond Greenhouse Gas</u> .....	2-4
<u>The Role of Pavements</u> .....	2-5
<b>The Pavement Life Cycle</b> .....	2-5
<u>Materials Production</u> .....	2-7
<u>Pavement Design</u> .....	2-7
<u>Construction</u> .....	2-7
<u>Use</u> .....	2-8
<u>Maintenance and Preservation</u> .....	2-8
<u>End-of-Life</u> .....	2-8
<b>Measuring Sustainability</b> .....	2-8
<u>Performance Assessment</u> .....	2-8
<u>Life-Cycle Cost Analysis</u> .....	2-9
<u>Life-Cycle Assessment</u> .....	2-9
<u>Rating Systems</u> .....	2-10
<u>Integrating Measurement Systems</u> .....	2-10
<u>Reasons to Measure Sustainability</u> .....	2-11
<b>Trade-off Considerations</b> .....	2-12
<u>Priorities and Values of the Organization or Project</u> .....	2-13
<u>Risk</u> .....	2-13
<b>Summary</b> .....	2-14
<b>References</b> .....	2-14
<b>CHAPTER 3. MATERIALS CONSIDERATIONS TO IMPROVE PAVEMENT SUSTAINABILITY</b> .....	3-1
<b>Introduction</b> .....	3-1
<u>Materials and Consideration of the Life Cycle</u> .....	3-1
<u>Chapter Overview</u> .....	3-2

<b>Aggregate Materials</b> .....	3-3
<u>Introduction</u> .....	3-3
<u>Strategies for Improving Sustainability</u> .....	3-9
<u>Issues/Future Directions/Emerging Technologies</u> .....	3-14
<b>Asphalt Materials and Mixtures</b> .....	3-15
<u>Introduction</u> .....	3-15
<u>Strategies for Improving Sustainability</u> .....	3-32
<u>Future Directions/Emerging Technologies</u> .....	3-35
<b>Hydraulic Cement Materials</b> .....	3-35
<u>Introduction</u> .....	3-36
<u>Strategies for Improving Sustainability</u> .....	3-57
<u>Future Issues/Emerging Technologies</u> .....	3-62
<u>Other Concrete Mixtures</u> .....	3-63
<b>Other Materials</b> .....	3-64
<u>Steel</u> .....	3-64
<u>Reinforcing Fibers</u> .....	3-65
<u>Interlocking Concrete Pavers</u> .....	3-65
<u>Geosynthetics</u> .....	3-66
<u>Soil Modifiers/Stabilizers</u> .....	3-66
<u>Major Issues</u> .....	3-67
<u>Strategies for Improving Sustainability</u> .....	3-68
<b>Concluding Remarks</b> .....	3-69
<b>References</b> .....	3-70

## CHAPTER 4. PAVEMENT AND REHABILITATION DESIGN TO IMPROVE SUSTAINABILITY .....

<b>Introduction</b> .....	4-1
<u>Pavement Design Considerations</u> .....	4-2
<u>Consideration of Payback Time</u> .....	4-5
<u>Mechanistic-Empirical Design Methods</u> .....	4-6
<b>Process for Consideration of Sustainability in Pavement Design</b> .....	4-7
<u>Design Objectives</u> .....	4-7
<u>Alternative Pavement or Rehabilitation Types</u> .....	4-9
<u>Layer and Material Type Selection</u> .....	4-20
<u>Drainage</u> .....	4-21
<u>Construction Quality Specifications</u> .....	4-21
<u>Construction Process and Traffic Management</u> .....	4-23
<u>Consideration of Future Maintenance and Rehabilitation</u> .....	4-23
<b>Sample Sustainable Design Strategies</b> .....	4-23
<u>Longer Life Pavement</u> .....	4-23
<u>Design for Local Materials or Low Impact Transportation</u> .....	4-26
<u>Accelerated Construction</u> .....	4-26
<u>Single-Lane Rehabilitation</u> .....	4-26
<u>Consideration of Use Phase in Design</u> .....	4-27
<b>Major Issues and Trade-offs in Designing More Sustainable Pavements</b> .....	4-27
<b>Future Directions and Emerging Technologies</b> .....	4-27
<b>Concluding Remarks</b> .....	4-32
<b>References</b> .....	4-32

<b>CHAPTER 5. CONSTRUCTION CONSIDERATIONS TO IMPROVE PAVEMENT SUSTAINABILITY</b> .....	5-1
<b>Introduction</b> .....	5-1
<b>Sustainability of Pavement Construction Operations: General Issues</b> .....	5-1
<u>Construction-Related Energy Consumption and Emissions</u> .....	5-1
<u>Impact of Construction on Surrounding Areas</u> .....	5-3
<u>Economics of Construction Practices, Including User Costs</u> .....	5-6
<u>Quality and Performance of Constructed Pavement System</u> .....	5-9
<b>Strategies to Improve Sustainability of General Pavement Construction Operations</b> .....	5-9
<u>Strategies to Reduce Construction-Related Energy Consumption and Emissions</u> .....	5-11
<u>Strategies to Reduce Impact of Construction on Surrounding Area</u> .....	5-14
<u>Evaluation of Sustainable Contracting Alternatives for Environmental Considerations</u> .....	5-18
<b>Strategies for Improving Sustainability of Asphalt Pavement Construction Practices</b> .....	5-18
<u>Placement and Laydown</u> .....	5-20
<u>Construction Quality Assurance</u> .....	5-25
<u>Improving Sustainability through the Use of Innovative and Emerging Technologies</u> .....	5-26
<b>Strategies for Improving the Sustainability of Concrete Pavement Construction Practices</b> .....	5-28
<u>Site Prep Work</u> .....	5-29
<u>Proportioning Concrete Mixtures – Impacts on Sustainable Construction Practices</u> .....	5-31
<u>Concrete Hauling and Placement</u> .....	5-32
<u>Finishing, Texturing, Jointing, and Curing</u> .....	5-34
<u>Improving Sustainability through the Use of Innovative and Emerging Technologies</u> .....	5-36
<b>Concluding Remarks</b> .....	5-38
<b>References</b> .....	5-38
<b>CHAPTER 6. USE-PHASE CONSIDERATIONS</b> .....	6-1
<b>Introduction</b> .....	6-1
<b>Vehicle Fuel Consumption and Pavement Characteristics</b> .....	6-3
<u>Background</u> .....	6-3
<u>Strategies for Improving Sustainability</u> .....	6-17
<u>Future Directions and Emerging Trends</u> .....	6-18
<b>Tire-Pavement Noise</b> .....	6-19
<u>Background</u> .....	6-19
<u>Strategies for Improving Sustainability</u> .....	6-31
<u>Future Directions and Emerging Trends</u> .....	6-31
<b>Addressing Stormwater Runoff through Pavement Permeable Surfaces</b> .....	6-32
<u>Background</u> .....	6-32
<u>Strategies for Improving Sustainability</u> .....	6-37
<u>Future Directions and Emerging Trends</u> .....	6-38

<b>Pavement Thermal Performance and Contribution to Urban and Global Climate</b> .....	6-38
<u>Pavement Properties Affecting Thermal Performance</u> .....	6-38
<u>Urban and Global Warming Effects</u> .....	6-40
<u>Pavement Type and Thermal Performance</u> .....	6-47
<u>Other Strategies to Reduce Pavement Temperatures</u> .....	6-54
<u>Strategies for Improving Sustainability</u> .....	6-54
<u>Future Directions and Emerging Trends</u> .....	6-54
<b>Artificial Lighting</b> .....	6-58
<u>Background</u> .....	6-58
<u>Future Directions and Emerging Trends</u> .....	6-60
<u>Strategies for Improving Sustainability</u> .....	6-60
<b>Safety</b> .....	6-62
<b>Concluding Remarks</b> .....	6-64
<b>References</b> .....	6-67

## CHAPTER 7. MAINTENANCE AND PRESERVATION TREATMENTS TO IMPROVE SUSTAINABILITY .....

<b>Introduction</b> .....	7-1
<b>Pavement Preservation and Sustainability</b> .....	7-2
<u>Pavement Management Systems and Pavement Preservation</u> .....	7-2
<u>Integrating PMS and Pavement Preservation</u> .....	7-2
<u>General Pavement Preservation Strategies for Improving Sustainability</u> .....	7-3
<u>Preservation Treatment Selection</u> .....	7-5
<b>Asphalt-Surfaced Pavement Maintenance and Preservation Treatments</b> ..	7-9
<u>Introduction</u> .....	7-9
<u>Crack Filling/Sealing</u> .....	7-9
<u>Asphalt Patching</u> .....	7-14
<u>Fog Seals/Rejuvenators</u> .....	7-15
<u>Chip Seals</u> .....	7-16
<u>Slurry Seals</u> .....	7-17
<u>Microsurfacing</u> .....	7-17
<u>Ultra-Thin and Thin Asphalt Concrete Overlays</u> .....	7-19
<u>Hot In-Place Recycling (HIR)</u> .....	7-20
<u>Cold In-Place Recycling (CIR)</u> .....	7-22
<u>Ultra-Thin Bonded Wearing Course</u> .....	7-23
<u>Bonded Concrete Overlays</u> .....	7-24
<u>Energy Use and Emissions for Asphalt-Surfaced Pavement Treatments</u> ..	7-25
<u>Strategies for Improving Sustainability</u> .....	7-27
<u>Future Opportunities</u> .....	7-28
<b>Concrete-Surfaced Pavement Maintenance and Preservation Treatments</b> ..	7-28
<u>Introduction</u> .....	7-28
<u>Joint Resealing/Crack Sealing</u> .....	7-31
<u>Slab Stabilization/Slab Jacking</u> .....	7-33
<u>Diamond Grinding/Grooving</u> .....	7-34
<u>Partial-Depth Repairs</u> .....	7-36
<u>Full-Depth Repairs</u> .....	7-37
<u>Dowel Bar Retrofitting</u> .....	7-38
<u>Cross Stitching</u> .....	7-39

<u>Retrofitted Edge Drains</u> .....	7-39
<u>Ultra-Thin Wearing Course</u> .....	7-40
<u>Bonded Concrete Overlays</u> .....	7-40
<u>Energy Use and Emissions for Concrete-Surfaced Pavement Treatments</u> .....	7-41
<u>Strategies for Improving Sustainability</u> .....	7-43
<u>Future Opportunities</u> .....	7-43
<b>Concluding Remarks</b> .....	7-44
<b>References</b> .....	7-45
<b>CHAPTER 8. END-OF-LIFE CONSIDERATIONS</b> .....	8-1
<b>Introduction</b> .....	8-1
<u>Recycling and Reuse Statistics of Pavements</u> .....	8-1
<u>Economic and Environmental Considerations of EOL Options</u> .....	8-2
<u>Closed-Loop or Zero-Waste Thinking for Pavement Systems</u> .....	8-4
<b>EOL Considerations for Asphalt Pavements</b> .....	8-7
<u>Central Plant Recycling</u> .....	8-8
<u>Full-Depth Reclamation (FDR)</u> .....	8-10
<u>Strategies for Improving Sustainability</u> .....	8-15
<u>Future Directions and Emerging Technologies</u> .....	8-17
<b>EOL Considerations for Concrete Pavements</b> .....	8-17
<u>Introduction</u> .....	8-17
<u>Concrete Recycling</u> .....	8-20
<u>Concrete Pavement Reuse</u> .....	8-24
<u>Strategies for Improving Sustainability</u> .....	8-25
<u>Future Directions/Emerging Technologies</u> .....	8-30
<b>Concluding Remarks</b> .....	8-32
<b>References</b> .....	8-32
<b>CHAPTER 9. PAVEMENT SUSTAINABILITY WITHIN LARGER SYSTEMS</b> .....	9-1
<b>Introduction</b> .....	9-1
<b>Larger System Goals and Metrics</b> .....	9-1
<u>Sustainable Communities</u> .....	9-1
<u>Ecosystems</u> .....	9-3
<b>Strategies for Improving Sustainability</b> .....	9-4
<u>Aesthetics</u> .....	9-4
<u>Historical and Cultural Identity</u> .....	9-6
<u>Utility Cuts</u> .....	9-8
<u>Odor, Soot, and Particulate Matter</u> .....	9-11
<u>Allowable Hours of Construction</u> .....	9-11
<u>Strategies for Improving Sustainability</u> .....	9-12
<b>Future Directions/Emerging Technologies</b> .....	9-12
<b>Concluding Remarks</b> .....	9-13
<b>References</b> .....	9-14
<b>CHAPTER 10. ASSESSING PAVEMENT SUSTAINABILITY</b> .....	10-1
<b>Introduction</b> .....	10-1
<b>Life-Cycle Cost Analysis (LCCA)</b> .....	10-1
<u>Background</u> .....	10-1

<u>Key Issues in LCCA</u> .....	10-2
<u>Use of LCCA in Various Pavement Delivery Approaches</u> .....	10-6
<u>Available LCCA Tools</u> .....	10-7
<u>Examples</u> .....	10-8
<b>Life-Cycle Assessment (LCA)</b> .....	10-8
<u>Purpose of an LCA</u> .....	10-8
<u>The LCA Process</u> .....	10-9
<u>Types of LCA Studies</u> .....	10-12
<u>Most Pavement LCAs are Process Based and “Attributional”</u> .....	10-12
<u>Available Tools</u> .....	10-12
<u>Key Issues</u> .....	10-13
<u>Example Studies</u> .....	10-14
<u>Methodological Framework in Greater Detail</u> .....	10-15
<u>What Lies Ahead: Environmental Product Declarations</u> .....	10-15
<u>An Example of an Important Methodological Element: Allocation</u> .....	10-16
<b>Sustainability Rating Systems</b> .....	10-20
<u>Background</u> .....	10-20
<u>Rating Systems in Context</u> .....	10-21
<u>Potential Industry Impacts of Rating Systems</u> .....	10-21
<b>Rating Systems Relevant to Pavements</b> .....	10-21
<u>INVEST (Infrastructure Voluntary Evaluation Sustainability Tool)</u> .....	10-22
<u>Greenroads®</u> .....	10-22
<u>Envision™</u> .....	10-23
<u>GreenLITES</u> .....	10-23
<u>Leadership in Energy and Environmental Design (LEED®)</u> .....	10-23
<b>Use of Assessment Methods</b> .....	10-34
<u>Use Depends on Owner/Agency and Project Priorities</u> .....	10-34
<u>Application at Various Levels</u> .....	10-34
<u>Level of Standardization</u> .....	10-35
<b>Concluding Remarks</b> .....	10-35
<b>References</b> .....	10-36
<b>CHAPTER 11. CONCLUDING REMARKS</b> .....	11-1
<b>Review of Technologies, Innovations, and Trends</b> .....	11-1
<b>Implementation: The Next Step</b> .....	11-3

## GLOSSARY



## LIST OF FIGURES

Figure 1-1.	GHG emissions by economic sector in the U.S. (EPA 2013).....	1-1
Figure 1-2.	Basic components of a typical pavement system.....	1-5
Figure 2-1.	Pavement life-cycle phases (UCPRC 2010) .....	2-6
Figure 3-1.	Typical volumes of aggregate in dense-graded asphalt concrete and in dense-graded hydraulic cement concrete (asphalt concrete: summary of mixture designs by authors; concrete: Tayabji, Smith, and Van Dam 2010).....	3-5
Figure 3-2.	Coarse aggregates: rounded gravel (left) and crushed stone (right) (Kosmatka and Wilson 2011) .....	3-5
Figure 3-3.	Primary energy and global warming potential from aggregate production per kg, at quarry (adapted from Wang et al. 2012) .....	3-7
Figure 3-4.	Schematics illustrating straight-run distillation of asphalt within a complex refinery (Asphalt Institute and Eurobitume 2011) .....	3-17
Figure 3-5.	Estimated tons of WMA usage by industry sector 2009-2011 (Hansen and Copeland 2013).....	3-24
Figure 3-6.	RAP use in the U.S., 2009 through 2011 (adapted from Hansen and Copeland 2013).....	3-26
Figure 3-7.	Typical volumetric distribution of hydraulic paste (cement, water, air) and aggregates in paving concrete (Taylor et al. 2006).....	3-36
Figure 3-8.	Steps in the modern dry-process manufacture of portland cement (Kosmatka and Wilson 2011).....	3-39
Figure 3-9.	U.S. fly ash production, use (U.S. short tons), and utilization rate from 1966 to 2011 (ACAA 2013b) .....	3-44
Figure 3-10.	U.S. slag cement shipments from 1996 to 2007 (adapted from SCA 2007).....	3-46
Figure 3-11.	Schematic of mixer truck washout water recycling for concrete batch plant mix water (Taylor et al. 2006) .....	3-51
Figure 3-12.	Polished slab of concrete viewed through stereomicroscope. Dark circles are entrained air voids distributed throughout the grey hydrated cement paste (Courtesy of Karl Peterson, University of Toronto). .....	3-53
Figure 4-1.	Example of payback time analysis considering only the material production and construction phases of three different pavement design lives (Santero, Harvey, and Horvath 2011).....	4-5
Figure 4-2.	Overall process for considering sustainability in pavement design.....	4-8
Figure 4-3.	Cross sections of various asphalt pavement types (not to scale) .....	4-10
Figure 4-4.	Cross sections of rehabilitated asphalt pavement structures (not to scale).....	4-12
Figure 4-5.	Cross sections of concrete pavement structure types (not to scale).....	4-13
Figure 4-6.	Cross sections of rehabilitated concrete pavement structures (not to scale).....	4-15
Figure 4-7.	Cross section of asphalt-surfaced composite pavement.....	4-16
Figure 4-8.	Cross section of two-lift concrete pavement.....	4-17
Figure 4-9.	Cross section of semi-rigid pavement.....	4-18
Figure 4-10.	Cross sections of pervious concrete pavement, porous asphalt pavement, and permeable interlocking concrete pavement.....	4-19
Figure 4-11.	Perpetual pavement cross section .....	4-25

Figure 4-12.	Example of CRCP longer life design.....	4-26
Figure 5-1.	EPA non-road diesel engine limits for construction vehicles with two different ranges of rated power illustrating tightening of the emission limits (adapted from EPA 2013a) .....	5-4
Figure 5-2.	Impact of construction-related traffic delay: (a) addition emissions, (b) additional energy consumption for normal traffic and traffic delay scenarios for work zone lengths of 1.9 mi (four 8-hr nighttime closures avoiding morning and evening peak hours), 3.8 mi (two 16-hr night and daytime closures avoiding evening peak hours), and 7.6 mi (32-hr closure) .....	5-8
Figure 5-3.	Generalized asphalt pavement construction processes and associated fuel factors (fuel factor source: Skolnik, Brooks, and Oman 2013) .....	5-19
Figure 5-4.	Effect of compaction on predicted bottom-up fatigue life for two-layer beam specimens in mixture using a AR4000c binder (binder type used in several western highway agencies prior to Superpave) and at different air void and binder content levels (after Harvey et al. 2004).....	5-23
Figure 5-5.	Bulk specific gravity profile of one test lane (Leng 2011) .....	5-26
Figure 5-6.	Spray paver on the left and material transfer device on the right used in the overlay construction in Illinois (Al-Qadi et al. 2012).....	5-28
Figure 5-7.	Generalized concrete pavement construction processes and associated fuel factors (fuel factor source: Skolnik, Brooks, and Oman 2013) .....	5-29
Figure 6-1.	Pavement characteristics and influences on use-phase objectives.....	6-1
Figure 6-2.	Pavement texture and wavelength (Sandberg 1997).....	6-7
Figure 6-3.	Energy savings in MJ and equivalent gallons of gasoline for a medium-to-high-volume route over 10-year analysis period for preservation treatment versus leaving the pavement rough (Wang et al. 2012).....	6-8
Figure 6-4.	Estimate of light vehicle noise due to tire-pavement noise, powertrain noise, and aerodynamic noise at cruise speed (Rasmussen et al. 2008).....	6-22
Figure 6-5.	Close Proximity (CPX) test trailer (Bendtsen and Thomsen 2008).....	6-23
Figure 6-6.	On-Board Sound Intensity (OBSI) setup (photo courtesy of John Harvey). ....	6-23
Figure 6-7.	Controlled vehicle pass-by levels at 25 ft (7.6 m) versus OBSI level for the SRTT at all test sites and speeds—normalized data (Donavan and Lodico 2009). ..	6-24
Figure 6-8.	Noise-generation mechanisms on dry pavement (Olek, Weiss, and Garcia-Villarreal 2004).....	6-26
Figure 6-9.	Example plot of one-third octave frequency content for several asphalt mixtures and influence of tire-pavement noise mechanisms (Ongel et al. 2008).....	6-26
Figure 6-10.	Normalized distributions of OBSI noise levels for conventional concrete pavement textures (Rasmussen et al. 2012).....	6-28
Figure 6-11a.	Frequency content of OBSI measured at 60 mi/hr (97 km/hr) for pretreatment (PreCDG), conventional diamond grinding (CDG) and NGCS (GnG in the figure) for a California test section, Yolo 113-PM R0.5/R2.5 (Guada et al. 2013) .....	6-29
Figure 6.11b.	Conventional diamond-ground surface showing “fins” that are eventually removed by traffic (Guada et al. 2013) .....	6-29
Figure 6.11c.	Conventional diamond-ground surface with the Next Generation Concrete Surface showing definition of “land area” between grooves (Guada et al. 2013)..	6-29

Figure 6-12a.	Frequency content of OBSI measured at 35 mi/hr (56 km/hr) for Caltrans open-graded asphalt mixtures with typical 0.375 inch (9.5 mm) and #4 (4.75 mm) maximum aggregate sizes (Wu et al. 2013).....	6-30
Figure 6.12b.	Examples of residual specimens after Cantabro testing for raveling of the same OGFC mixtures (Wu et al. 2013). (Each original specimen had a diameter of 4 inches (100 mm) .....	6-30
Figure 6-13.	Pervious concrete (left, courtesy John Kevern) and porous asphalt (right, courtesy National Asphalt Pavement Association).....	6-33
Figure 6-14.	Permeable interlocking concrete pavers (courtesy Interlocking Concrete Pavement Institute) .....	6-34
Figure 6-15.	Vegetated pavement.(photo courtesy of Tom Van Dam) .....	6-34
Figure 6-16.	Heat flow and the basic thermal model for day and night (NCPTC/ NCAT 2013) .....	6-39
Figure 6-17.	Heat islands for various areas of development (EPA 2003) .....	6-40
Figure 6-18.	Average June horizontal flat plate solar radiation map of the U.S. (NREL 2012) .	6-42
Figure 6-19.	Illustration of the main drivers of climate change (Cubasch et al. 2013).....	6-45
Figure 6-20.	Surface temperature and albedo for selected types of pavements in Phoenix, Arizona (Cambridge Systematics 2005) .....	6-47
Figure 6-21.	Effect of albedo on pavement surface temperature in Davis, California (16:00 9 July 2012) (Li et al. 2013) .....	6-48
Figure 6-22.	Near-surface air temperatures of different pavements measured 2 inches (50 mm) above the surface (Li 2012) .....	6-49
Figure 6-23.	Heat flux from pavement surfaces for 1 full day during July 2012 (Li et al. 2013)..	6-50
Figure 6-24.	Typical pavement solar reflectance of conventional asphalt and concrete pavements over time (EPA 2008) .....	6-52
Figure 6-25.	Diamond ground concrete pavement surface.....	6-53
Figure 6-26.	Pavement reflective differences (FHWA 2012) .....	6-59
Figure 6-27.	Fatality and fatality rates, 2002 – 2011 (NHTSA 2013).....	6-62
Figure 6-28.	Crash costs by crash factor (Miller and Zaloshnja 2009) .....	6-63
Figure 7-1.	Illustration of the impact of pavement preservation. ....	7-2
Figure 7-2.	Steps in integrating PMS and pavement preservation (adapted from Zimmerman and Peshkin 2003) .....	7-3
Figure 7-3.	Effect of overlay interval on agency, user and total GHG (CO <sub>2</sub> e) emissions (Lidicker et al. 2012).....	7-4
Figure 7-4.	Process of selecting the preferred preservation treatment (adapted from Peshkin et al. 2011).....	7-6
Figure 7-5.	Installation of hot-applied sealant.....	7-9
Figure 7-6.	Full-depth asphalt patch.....	7-14
Figure 7-7.	Fog seal application .....	7-15
Figure 7-8.	Chip seal construction.....	7-16
Figure 7-9.	Slurry seal application.....	7-17
Figure 7-10.	Ultra-thin asphalt overlay .....	7-19
Figure 7-11.	Hot in-place recycling with application of overlay (Kandhal and Mallick 1997) ..	7-21

Figure 7-12.	Cold in-place recycling (photo courtesy of D. Matthews).....	7-22
Figure 7-13.	Short panels for bonded concrete overlay.....	7-24
Figure 7-14.	Typical sequence of concrete-surfaced pavement treatments as part of CPR (ACPA 2006) .....	7-31
Figure 7-15.	Joint sealing .....	7-32
Figure 7-16.	Surface texture produced by diamond grinding (courtesy ACPA).....	7-34
Figure 7-17.	Diamond grooving operation .....	7-35
Figure 7-18.	Partial-depth repair.....	7-36
Figure 7-19.	Full-depth repair.....	7-37
Figure 7-20.	Placement of dowel bars in a dowel bar retrofitting operation.....	7-38
Figure 7-21.	Bonded concrete overlay construction (courtesy ACPA).....	7-40
Figure 7-22.	Details for the high-traffic case study of the material production phase showing the energy consumption for different LCI data sets (Wang et al. 2012).....	7-42
Figure 8-1.	Recycling and reuse statistics of asphalt and concrete materials (data compiled from Hansen and Copeland (2013) for RAP and Wilburn and Goonan (1998) and USGS (2000) for RCA) .....	8-2
Figure 8.2.	Environmental cost determinants for pavement EOL considerations (adapted from Horvath 2004) .....	8-3
Figure 8-3.	An illustration of EOL allocation rules potentially applicable for pavements (cut-off method, 50/50 method, and substitution method) .....	8-7
Figure 8-4.	Optimal performance levels based on (a) total cost and (b) GHG emissions (Aurangzeb and Al-Qadi 2014) .....	8-9
Figure 8-5.	Full depth reclamation train (courtesy of John Harvey).....	8-11
Figure 8-6.	Example effect of type of crusher on RCA particle size distribution. ....	8-28
Figure 8-7.	Carbon sequestration by fine RCA in laboratory column studies (Gardner, Leipold, and Peyranere 2006).....	8-29
Figure 8-8.	On-site concrete recycling operation .....	8-30
Figure 8-9	Recycling existing concrete pavement in place (photo courtesy of Jim Grove).....	8-31
Figure 9-1.	Zion Park Blvd. in Utah (SR 9) with a chip seal surfacing that uses local red volcanic cinders to match the aesthetics of the surrounding environment and to be consistent with historical road surfacing (photo courtesy of Steve Muench)....	9-5
Figure 9-2.	Brick crosswalk in Charlotte, NC implemented as part of an intersection improvement (Hughes, Chappell, and Chen 2006).....	9-5
Figure 9-3.	Vehicular interlocking concrete pavers being placed in a pedestrian-friendly downtown area in Houghton, MI. Note the use of colored concrete for the pavers to provide a visual offset for the cross walk (photo courtesy of Thomas Van Dam).....	9-6
Figure 9-4.	Old cobblestone pavement preserved and still in use on East Republican St., Seattle, WA (photo courtesy of Steve Muench) .....	9-7
Figure 9-5.	Lombard Street in San Francisco during construction in 1922 (FoundSF 2013)....	9-7
Figure 9-6.	Lombard Street as it looks today with its brick pavement, kept for historical and cultural reasons (Wikipedia, public domain) .....	9-8

Figure 9-7.	Poor quality patch in an existing concrete pavement (photo courtesy of Steve Muench) .....	9-8
Figure 9-8.	Illustration of how existing concrete pavers can be removed to repair a gas line (a), and then the bedding recompactd (b), joint sand reapplied (c), and the final product which shows little sign of disturbance (d) (ICPI 2009).....	9-9
Figure 9-9.	Removal of French hexagonal modular pavement to access utility (Larrod, Sedran, and Balay 2012) .....	9-10
Figure 9-10.	A utility cut in Rome, Italy shown with the excavation open and sampietrini (individual rounded black basalt stones) removed. Upon completion the cut is filled and sampietrini reinstalled (photo courtesy of Steve Muench) .....	9-10
Figure 10-1.	Example projected life-cycle cost stream diagram (FHWA 2002).....	10-2
Figure 10-2.	Probabilistic analysis of two design alternatives (Walls and Smith 1998).....	10-5
Figure 10-3.	Life-cycle assessment framework (ISO 2006a) .....	10-10
Figure 10-4.	Data types relevant to a typical LCA .....	10-10
Figure 10-5.	Sample EPD for a concrete mix design (courtesy of Central Concrete Supply Company) .....	10-16
Figure 10-6.	Example of economic allocation for a multi-output process .....	10-18
Figure 10-7.	Assessing sustainabilty with LCCA, LCA, and rating systems on different levels .....	10-34

## LIST OF TABLES

Table 3-1.	Summary of estimated national average freight movement fuel efficiency (diesel) of freight transportation modes (2009 data) (Kruse, Protopapas, and Olson 2012)...	3-8
Table 3-2.	Approaches for improving aggregate production for pavement sustainability. ...	3-10
Table 3-3.	Approaches for improving pavement sustainability with regard to asphalt materials production .....	3-33
Table 3-4.	Annual energy and CO <sub>2</sub> emissions associated with U.S. cement manufacturing and concrete production (Choate 2003) .....	3-37
Table 3-5.	Chemical composition and select properties of common SCMs (Taylor et al. 2006; Kosmatka, Kerkoff, and Panarese 2002).....	3-42
Table 3-6.	Effects of SCMs on the properties of fresh concrete (Taylor et al. 2006).....	3-42
Table 3-7.	Effects of SCMs on the properties of hardened concrete (Taylor et al. 2006)....	3-43
Table 3-8.	Harmful contaminants, tests methods and limits for grey water to be used in concrete mixtures (Taylor et al. 2006) .....	3-51
Table 3-9.	Effect of recycled water on concrete properties (Taylor et al. 2006).....	3-52
Table 3-10.	Common chemical admixtures used in paving concrete (Taylor et al. 2006) ....	3-52
Table 3-11.	Approaches for improving pavement sustainability with regard to concrete materials production .....	3-58
Table 4-1.	Division of scope between design, maintenance and preservation, and end-of-life chapters.....	4-2
Table 4-2.	Summary of major issues and trade-offs for improving pavement sustainability through design.....	4-28
Table 5-1.	Thresholds of significance for construction operations (AEP 2012) .....	5-4
Table 5-2.	Approaches for improving general sustainability of pavement construction operations .....	5-10
Table 5-3.	GHG emissions reduction scenarios from fossil fuel use (EPA 2009). .....	5-11
Table 5-4.	Operational strategies to reduce emissions incurred due to construction activities (EPA 2007) .....	5-12
Table 5-5.	Alternative fuel use strategies to reduce emissions (EPA 2007).....	5-13
Table 5-6.	Energy efficiency and CO <sub>2</sub> emissions for common equipment used in asphalt pavement construction (compiled from Santero and Horvath [2009a]; Skolnik, Brooks, and Oman [2013]) .....	5-19
Table 5-7.	Approaches for improving sustainability of asphalt pavement construction operations. ....	5-21
Table 5-8.	Best practices to control fumes, emissions, and odors from asphalt mixture plant and paving operations.....	5-22
Table 5-9.	Typical minimum requirements for laydown temperatures as a function of base temperature and lift thicknesses (NCDOT 2012).....	5-24
Table 5-10.	General approaches for improving the sustainability of concrete pavement construction .....	5-30
Table 5-11.	Energy efficiency and CO <sub>2</sub> emissions for typical equipment used for concrete pavement construction (compiled from Santero and Horvath 2009a and Skolnik, Brooks, and Oman 2013) .....	5-32

Table 6-1.	Summary of strategies for improving vehicle use phase fuel consumption and potential trade-offs.....	6-17
Table 6-2.	Decibel changes, energy loss, and loudness (FHWA 2011b) .....	6-20
Table 6-3.	FHWA noise abatement criteria in dBA (hourly A-weighted sound level) (FHWA 2011b).....	6-21
Table 6-4.	Summary of strategies for improving tire-pavement noise and potential trade-offs .....	6-31
Table 6-5.	Summary of strategies to address stormwater runoff issues and potential trade-offs. ....	6-37
Table 6-6.	Summary of considerations to address UHIE issues and potential trade-offs ....	6-56
Table 6-7.	Summary of strategies to address lighting issues and potential trade-offs.....	6-61
Table 7-1.	Pavement maintenance and preservation techniques. ....	7-7
Table 7-2.	Potential use of non-traditional materials and techniques with potential pavement maintenance and preservation application (TRB 2012) .....	7-8
Table 7-3.	Evaluation of sustainability impacts of treatments for asphalt-surfaced pavements...	7-10
Table 7-4.	Energy consumption and GHG emissions data for some typical asphalt-surfaced pavement preservation treatments (Chehovits and Galehouse 2010) ...	7-26
Table 7-5.	Energy consumption and GHG emissions data for new construction and major rehabilitation activities (Chehovits and Galehouse 2010) .....	7-27
Table 7-6.	Comparison between microsurfacing and other treatment alternatives for asphalt-surfaced pavement (Chan et al. 2011) .....	7-27
Table 7-7.	Evaluation of sustainability impacts of treatments for concrete-surfaced pavements.....	7-29
Table 8-1.	Summary of FDR advantages, candidate pavements, and limitations .....	8-12
Table 8-2.	Commonly used test methods in the mixture design of FDR projects.....	8-14
Table 8-3.	Common additives used in FDR projects (recommended additive percentages from ARRA 2001a) .....	8-14
Table 8-4.	Approaches for improving sustainability of asphalt pavement recycling for pavement sustainability .....	8-16
Table 8-5.	Design recommendations for RCA concrete pavements (ACPA 2009) .....	8-24
Table 8-6.	Approaches for improving sustainability of concrete pavement recycling .....	8-26
Table 8-7.	Recommended RCA subbase quality tests and threshold values for various applications (Saeed and Hammons 2008) .....	8-27
Table 9-1.	General strategies to improve pavement sustainability within larger systems....	9-12
Table 10-1.	Typical LCA impact categories.....	10-11
Table 10-2.	Summary of INVEST sustainability criteria and scoring (FHWA 2011) .....	10-24
Table 10-3.	Summary of Greenroads credit categories and scoring (Muench et al. 2011) ..	10-26
Table 10-4.	Summary of ENVISION sustainability criteria and scoring (ISI and Zofnass 2012).....	10-27
Table 10-5.	Summary of GreenLITES sustainability criteria and scoring (NYSDOT 2010) ...	10-29
Table 10-6.	Summary of LEED-ND sustainability criteria and scoring (USGBC 2012; 2013)..	10-33

## ACRONYMS

AADT	Average Annual Daily Traffic
AAR	Alkali-Aggregate Reactivity
AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ACAA	American Coal Ash Association
ACBFS	Air-Cooled Blast Furnace Slag
ACEC	American Council of Engineering Companies
ACI	American Concrete Institute
ACPA	American Concrete Pavement Association
ACR	Alkali-Carbonate Reactivity
AEAs	Air-Entraining Admixtures
AEP	Association of Environmental Professionals
AI	Asphalt Institute
AISC	American Institute of Steel Construction
APT	Accelerated Pavement Testing
APWA	American Public Works Association
ARRA	Asphalt Recycling and Reclaiming Association
ASR	Alkali-Silica Reactivity
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
ATB	Asphalt Stabilized Bases
BCA	Benefit-Cost Analysis
BMP	Best Management Practice
BTS	Bureau of Transportation Statistics
CA4PRS	Construction Analysis for Pavement Rehabilitation Strategies
CAC	Cement Association of Canada
Caltrans	California Department of Transportation
CaCO <sub>3</sub>	Calcium Carbonate/Limestone
CaO	Lime
CARB	California Air Resources Board
CCPR	Cold Central Plant Recycling
CDG	Conventional Diamond Grinding
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CGS	California Geological Society
CH <sub>4</sub>	Methane
CI	Compression Ignition
CIR	Cold In-place Recycling
CKD	Cement-Kiln Dust
CKRC	Cement Kiln Recycling Coalition
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2e</sub>	Carbon Dioxide Equivalent
CP Road Map	Long-Term Plan for Concrete Pavement Research and Technology
CPB	Controlled Pass By
CPR	Concrete Pavement Restoration



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CPX	Close Proximity
CRCP	Continually Reinforced Concrete Pavements
CRM	Crumb Rubber Modifier
CSD	Context-Sensitive Design
C-S-H	Calcium Silicate Hydrate
CTB	Cement Treated Base
CTE	Coefficient of Thermal Expansion and Contraction
dB	Decibels
dBA	Adjusted Decibels
DBB	Design-Bid-Build
DB	Design-Build
DBM	Design-Build-Maintain
DLM	Dynamic Lane Merge
DOT	Department of Transportation
EAPA	European Asphalt Pavement Association
EDC	Every Day Counts
EIO	Economic Input-Output
EIR	Environmental Impact Review
EO	Executive Order
EOL	End-of-Life
EPA	Environmental Protection Agency
EPD	Environmental Product Declaration
ESAL	Equivalent Single-Axle Load
EUAC	Equivalent Uniform Annual Cost
FDR	Full-Depth Reclamation
FDR-FA	Full-Depth Reclamation using Foamed Asphalt
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
GGBFS	Ground Granulated Blast Furnace Slag
GHG	Greenhouse Gas
GPR	Ground Penetrating Radar
GreenLITES	Green Leadership in Transportation and Environmental Sustainability
GSI	Gomaco Smoothness Indicator
GSSI	Geophysical Survey Systems, Inc.
GWP	Global Warming Potential
H <sub>3</sub> PO <sub>4</sub>	Orthophosphoric Acid
HC	Hydrocarbons
HCC	Hydraulic Cement Concrete
HFCs	Hydrofluorocarbons
HIPERPAV	High PERFORMANCE Concrete PAVING
HIR	Hot In-place Recycling
HMA	Hot-Mix Asphalt
HOV	High-Occupancy Vehicle
HRWRA	High-Range Water-Reducing Admixtures
HSIP	Highway Safety Improvement Program
IC	Intelligent compaction
ICPI	Interlocking Concrete Pavement Institute
IEA	International Energy Agency

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INVEST	Infrastructure Voluntary Evaluation Sustainability Tool
IPCC	Intergovernmental Panel on Climate Change
IRI	International Roughness Index
IRT	Infrared Thermography
ISI	Institute for Sustainable Infrastructure
ISO	International Organization for Standardization
ITS	Intelligent Transportation Systems
JPCP	Jointed Plain Concrete Pavement
JRCP	Jointed Reinforced Concrete Pavement
KDOT	Kansas Department of Transportation
LAB	Los Angeles Abrasion
LCA	Life Cycle Assessment
LCB	Lean Concrete Base
LCCA	Life-Cycle Cost Analysis
LCI	Life-Cycle Inventory
LCIA	Life-Cycle Impact Assessment
LED	Light-Emitting Diode
LEED®	Leadership in Energy and Environmental Design
LFATB	Lime and Fly Ash Binder
LNG	Liquefied Natural Gas
LWA	Light Weight Aggregate
MAP-21	Moving Ahead for Progress in the 21st Century Act
MDPDG	AASHTO DARWin-ME™ Mechanistic-Empirical Design Guide
ME	Mechanistic-Empirical
MEPDG	Mechanistic-Empirical Pavement Design Guide
MGGRA	Midwest Greenhouse Gas Reduction Accord
MoDOT	Missouri Department of Transportation
MOVES	Motor Vehicle Emission Simulator
MPD	Mean Profile Depth
MPO	Metropolitan Planning Organizations
MRD	Material-Related Distress
MRWRA	Mid-Range Water Reducing Admixture
MTD	Mean Texture Depth
MTV	Material Transfer Vehicle
NAPA	National Asphalt Pavement Association
NCAT	National Center for Asphalt Technology
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
NCPTC	National Concrete Pavement Technology Center
NDT	Nondestructive Testing
NEPA	National Environmental Policy Act
NGCS	Next Generation Concrete Surface
NHPP	National Highway Performance Program
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NLA	National Lime Association
NMAS	Nominal Maximum Aggregate Size
NMHC	Non-Methane Hydrocarbons
NO <sub>x</sub>	Nitrogen Oxides

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NPC	Net Present Cost
NPS	National Park Service
NPV	Net Present Value
NRCS	Natural Resources Conservation Service
NRMCA	National Ready-Mix Concrete Association
NYSDOT	New York State Department of Transportation
OBSI	On-Board Sound Intensity
OGFC	Open-Graded Friction Course
PAPA	Pennsylvania Asphalt Pavement Association
PCA	Portland Cement Association
PCC	Portland Cement Concrete
PCR	Pavement Condition Rating
PDC	Positive Dust Control
PE-2	Project Emissions Estimator
PFCs	Perfluorocarbons
PG	Performance Grade
PI	Profile Index
PLC	Portland Limestone Cement
PM	Particulate Matter
PM <sub>10</sub>	Fugitive Particulate Matter/Fugitive Dust
PMA	Polymer-Modified Asphalt
PMS	Pavement Management Systems
PPA	Polyphosphoric Acid
PPCPS	Precast Pre-Stressed Concrete Pavement Systems
PWL	Percent within Limits
QA	Quality Assurance
QC	Quality Control
QPPP	Quiet Pavement Pilot Program
QPR	Quieter Pavement Research
RAP	Recycled Asphalt Pavement
RAS	Recycled Asphalt Shingles
RCA	Recycled Concrete Aggregate
RCC	Roller Compacted Concrete
RCC	Roller-Compacted Concrete
RCWM	Recycled, Co-product, or Waste Material
RGGI	Regional Greenhouse Gas Initiative
ROW	Right of Way
RTP	Real-Time Profiler
SAEFL	Swiss Agency for the Environment, Forests and Landscape
SCA	Slag Cement Association
SCM	Supplementary Cementitious Material
SEAM	Sulfur Extended Asphalt Modifier
SETAC	Society of Environmental Toxicology and Chemistry
SF <sub>6</sub>	Sulfur Hexafluoride
SFS	Steel Furnace Slag
SHAs	State Highway Agencies
SHRP	Strategic Highway Research Program
SIT	State Inventory Tool
SLWA	Saturated Lightweight Aggregate

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SMA	Stone Mastic Asphalt
SO <sub>x</sub>	Sulfur Oxides
SPB	Statistical Pass By Method
SPL	Sound Pressure Levels
SRI	Surface Reflectivity Index
SRTT	Standard Reference Test Tire
TCP	Thin Concrete Pavement
TEA-21	Transportation Equity Act for the 21 <sup>st</sup> Century
TiO <sub>2</sub>	Titanium Dioxide
TNM	Traffic Noise Model
TRB	Transportation Research Board
TWh	Terawatt Hours
UCPRC	University of California Pavement Research Center
UHI	Urban Heat Island
UHPC	Ultra-High-Performance Concrete
ULSD	Ultra Low Sulfur Diesel
UNFCCC	United Nations Framework Convention on Climate Change
US DOE	U.S. Department of Energy
USGBC	U.S. Green Building Council
USGS	U.S. Geological Survey
UTW	Ultra-Thin Whitetopping
VMT	Vehicle-Miles Traveled
VOC	Volatile Organic Carbon
WCED	World Commission on Environment and Development
WCI	Western Climate Initiative
WHO	World Health Organization
WMA	Warm-Mix Asphalt
WRAs	Water-Reducing Admixtures