U.S. Department of Transportation
Federal Highway Administration

SUSTAINABLE PAVEMENTS PROGRAM

SUSTAINABILITY RATING SYSTEMS AS APPLIED TO PAVEMENTS

FHWA-HIF-19-079

Sustainability rating systems are being used by some agencies as a way of encouraging more sustainable practices and as a means of communicating the impacts of those practices. Although pavements are not the primary focus of these systems, all are relevant to pavements in some way, as illustrated by case examples of three highlighted sustainability rating systems.

INTRODUCTION

Sustainability rating systems quantify sustainability best practices by associating each practice with a common metric. These rating systems and metrics are voluntary and not regulatory in nature. They are not required by statute or regulation and, therefore, are not independently legally enforceable. Although voluntary, rating systems can be used to encourage sustainability practices beyond the regulatory minimum and help communicate sustainability in a way that is understandable to all stakeholders. Sustainability rating systems address pavements within the context of larger transportation infrastructure systems, with pavements being a component of that infrastructure that can contribute to an overall rating. Presented in this document are three point-based infrastructure/transportation sustainability rating systems (*INVEST*, *Greenroads*, and *Envision*) that are commonly used by owner agencies at the national level to:

- Identify which components of sustainable pavements are addressed by infrastructure/transportation system sustainability rating systems.
- Provide examples of how pavement sustainability can be quantified and encouraged by infrastructure/transportation sustainability rating systems.

SUSTAINABILITY RATING SYSTEMS

A sustainability rating system is essentially a list of sustainability best practices with an associated common metric. This metric, usually points, quantifies each best practice in a common unit. In this way the diverse measurement units of sustainability best practices (e.g., pollutant loading in stormwater runoff, pavement design life, tons of recycled materials used, energy consumed/saved, pedestrian accessibility, ecosystem connectivity, and even the value of art) can all be compared. Rating systems weight best practices by assigning them different point values (usually in relation to their impact on sustainability or priority), which can assist agencies in choosing the most impactful best practices to use given a limited scope or budget. Rating systems usually concentrate on practices that are compatible with current regulations but are above and beyond existing minimum regulatory requirements. Such systems:

- Provide a common metric (points) for the entire range of sustainable solutions.
- Measure sustainability and thus make it manageable.
- Allow for straightforward communication of sustainability goals, efforts, and achievement.
- Provide a reasonable context within which designers, contractors, and material suppliers can be innovative in their solutions.

Motivation to use sustainability rating systems and pursue certification (for those that offer it) varies. In general, motivation starts with the general sustainability goals of the owner, often expressed in strategic plans or officially adopted organizational goals (e.g., from a State Transportation Board, a public-private partnership entity, or a City Council). Rating systems are then used as a vehicle for applying these broadly stated strategies/goals to a specific road project. Their credits can inspire ideas on how to do this, and their use can provide a communications tool and a third-party verification of their efforts.

Three sustainability rating systems (*INVEST*, *Greenroads*, and *Envision*) are briefly summarized below. All of these rating systems have been periodically updated with new versions typically released every few years. This section describes the current rating system versions as of early 2019. Case studies in the next section focus on the application of older versions, but the general findings remain relevant.

INVEST (V1.3, PROJECT DEVELOPMENT PORTION ONLY)

INVEST (Infrastructure Voluntary Evaluation Sustainability Tool) addresses sustainability in roadways from the planning and project development stages through construction, operations, and maintenance (FHWA 2011; Bevan et al. 2012). It is applicable to all U.S. road projects with a focus on State Departments of Transportation (DOTs) and Metropolitan Planning Organizations (MPOs). *INVEST*, developed and owned by the FHWA, has three categories of sustainability practices (systems planning, project development, and operations and maintenance) that can be used independently. This review focuses on the project development portion, which contains nearly all the pavement-related credits. *INVEST* is a self-evaluation tool that uses a point-based approach to quantify sustainability, but there is no independent third-party review.

GREENROADS (V2.0)

Greenroads is a sustainability rating system for roadway design and construction (Muench et al. 2011; Lew, Anderson, and Muench 2016; Anderson et al. 2018). It is a voluntary, point-based system applicable to all U.S. road projects. *Greenroads* is owned and operated by the Greenroads Foundation (a 501 c3 non-profit organization) and was originally developed by the University of Washington in partnership with CH2M Hill (Muench et al 2011). *Greenroads* can be used as a self-evaluation tool, but is primarily designed as a third-party certification program, with Greenroads Foundation serving as the independent third-party reviewer.

ENVISION (V3.0)

Envision is a sustainability rating system for civil infrastructure, with roads being a subset (ISI 2012; ISI 2018). It is a voluntary, point-based system applicable to all civil infrastructure projects. *Envision* is a collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure (ISI), a joint venture of the American Society of Civil Engineers (ASCE), American Council of Engineering Companies (ACEC), and the American Public Works Association (APWA). *Envision* functions as a self-assessment tool as well as an optional third-party verification review performed by contracted entities.

SUSTAINABILITY CONSIDERATIONS RELEVANT TO PAVEMENTS

The FHWA defines what is meant by the term *sustainable pavement* (FHWA 2015). It involves topics throughout the pavement life-cycle including design, construction, use, maintenance/ preservation, and end-of-life. The associated Tech Brief, *Pavement Sustainability*, provides a condensed list of practices (FHWA 2014). Both documents were used to develop Table 1, which identifies pavement sustainability topics and shows how they are addressed by the three rating systems.

Usually, sustainability rating system credits do not address sustainability topics on a one-to-one basis. It is typical that a single rating system credit addresses more than one sustainability topic because either (1) these topics are different expressions of the same sustainability idea, or (2) one generally written rating system credit can be interpreted to address multiple topics. For instance, a credit for using recycled materials in new pavement material may address the following sustainable pavement goals:

- Use recycled/reused material.
- Reduce the amount of virgin high-energy material needed.
- Use in-place reuse/recycling techniques.

It can also be that a broadly defined credit can be interpreted to include a sustainable practice even though that practice is not specifically mentioned. For instance, a credit addressing sustainable procurement practices might be achieved by using specifications that allow for sustainability best practices.

SUSTAINABILITY RATING SYSTEM CASE STUDIES

This section presents a case study from each of the sustainability rating systems and provides the credits and points achieved. Currently, each sustainability rating system used a prior version (*INVEST* v1.1, *Greenroads* v1.5, *Envision* v2.0) than what is current offered. Therefore, this section represents how sustainable pavement practices can be represented in sustainability rating systems, but it may not describe how the *current versions* of these rating systems represent sustainable pavement practices. Generally, over time each rating system has grown to incorporate more practices and a broader definition of sustainability.

GREENROADS: NORTHEAST 120TH STREET EXTENSION, KIRKLAND, WASHINGTON

The City of Kirkland's Northeast 120th Street Extension project was certified by the *Greenroads* (v 1.5) rating system in November 2014 (Muench et al. 2011). The $6.7 million, 24-month duration construction project included the construction of a new 44-ft wide, 880-ft long asphalt pavement, sidewalks, bicycle lanes in each direction, 6 bioretention units, and installation of a 270,000-gal stormwater detention vault. The City used *Greenroads* because of the City's "strong sustainability ethic" (Kirkland mayor Amy Walen quoted in Isaacs 2015), the integration of sustainability into the design/construction did not increase cost, and the resulting pavement was longer-lasting (they achieved a long-lasting pavement credit that was above-and-beyond the City's standard pavement design). Sustainability considerations represented in *Greenroads* were integrated early into the design phase, allowing the project to incorporate a materials management strategy during construction, including onsite reuse and reclamation, recycled pavement materials, as well as a focus on constructability and durability to

Table 1. Pavement sustainability considerations available in sustainability rating systems (data sources: FHWA 2014; FHWA 2015).

Stage	Sustainable Pavement Practices (based on FHWA 2014; FHWA 2015)	*INVEST*[ad] (V1.3)	*Greenroads*[bd] (v2.0)	*Envision*[cd] (V3.0)
Materials	Use recycled/reused material	PD-19, PD-20	MD-1, MD-2	RA1.2
	Using locally-available materials	-	MD-5	-
	Reduce the amount of virgin high-energy material needed (e.g., portland cement, asphalt)	PD-19, PD-20	MD-1, MD-2	RA1.2
	Use alternative fuels/renewable energy to manufacture materials	PD-23	MD-3	RA2.2
	Reduce water use (e.g., recycle concrete washout water)	-	CA-6	RA3.3
Design	Use long-life design	PD-22	MD-6	-
	Incorporate LCCA, LCA, and rating systems into the pavement design process	PD-02	PR-2, PR-6, MD-3	LD3.3
	Use specialty designs to address sustainability issues (e.g., noise, drainage)	PD-24, PD-30, PD-33	EW-8, AL-7	QL1.4, NW2.2
Construction	Use specifications that allow for sustainability best practices	-	CA-8, MD-3, MD-4	RA1.1
	Reduce the negative impacts (e.g., fuel use, emissions, particulate, noise, traffic delays) of construction	PD-26, PD-27	CA-1, CA-5, CA-7	QL1.6
	Optimize/improve efficiency of construction activities	-	CA-7	QL1.6
	Improve construction safety	-	CA-2	QL1.3
	Improve construction quality	PD-28	PR-7, CA-3	-
Use	Improve smoothness, macrotexture, structural response to reduce vehicle fuel use	-	CA-3	-
	Reduce tire-pavement noise	PD-33	AL-7	QL1.4
	Use pavements to influence light levels/pollution	PD-32	AL-7	QL1.5
	Improve safety using pavement characteristics	-	AL-1, AL-2	QL1.2
Maintenance and Preservation	Incorporate sustainability metrics into current asset management systems	-	-	LD2.1
	More intensive use of pavement maintenance/preservation methods to extend pavement surface life	-	-	-
End-of-Life	Use strategies that allow pavements to continue to function without requiring an end-of-life scenario	PD-22	MD-6	-
	Avoid landfilling old pavement materials	PD-29	PR-9	RA1.4
	Use in-place reuse/recycling techniques	PD-19, PD-20	MD-1	RA1.4
	Ensure the highest use of recycled materials	PD-20	MD-2	-

Notes:

a. See the *INVEST* credit listing at https://www.sustainablehighways.org/122/project-development.html.
b. See the *Greenroads* credit listing at: https://www.greenroads.org/files/10418.pdf.
c. See the *Envision* credit listing at: https://www.asce.org/uploadedFiles/Issues_and_Advocacy/Our_Initiatives/Sustainability/Content_Pieces/envision-credit-list.pdf.
d. Column lists the credits within the respective rating systems that address this practice. Sometimes the sustainable pavement practice alone may not earn the full points associated with the credit.

develop a long-life asphalt roadway. This case demonstrates the application of a sustainability rating system to a relatively small local city new roadway project.

Notable pavement sustainability practices included:

- The project team concluded that a change from a 20-year pavement design life to a 40-year design life was more cost effective when the total life-cycle of the pavement was considered.
- 100 percent of the existing hardscape and asphalt parking lot materials (4,063 yd^2) was pulverized and reused as fill and underlying pavement base materials.
- 378 tons of reclaimed asphalt pavement (RAP) was incorporated into the new asphalt pavement (final recycled content of 15.9 percent).
- Project specifications were amended, allowing the use of warm mix asphalt (WMA) for the asphalt roadway (also included 20 percent RAP from other projects).

Table 2 shows the *Greenroads* (v1.5) certification scorecard and identifies credits that were achieved that are relevant to pavement sustainability practices. Out of the 46 points achieved, 23 points (50 percent) were related to pavement sustainability.

INVEST: GEORGE V. VOINOVICH EASTBOUND BRIDGE, CLEVELAND, OHIO

The Ohio Department of Transportation's (ODOT) George V. Voinovich Eastbound Bridge project, used the *INVEST* (v1.1) Project Development module in August 2016 (FHWA 2017; Trumbull-Great Lakes-Ruhlin 2017). ODOT used *INVEST* to measure, track, and improve the sustainability performance of the project. The $273 million design-build project began in 2014 and finished in 2017. The project included the removal of the existing Innerbelt Bridge and construction of a 3,900-ft long, five-lane steel delta-girder bridge, retaining walls, city street improvements, and a bicycle trail. The request for proposals (RFP) for a value-based design-build contract for phase II required the contractor to use *INVEST* throughout the project duration to track sustainability achievements. The value-based design-build process yielded a winning proposal with higher sustainability and lower cost than ODOT had estimated. At the onset of the project and every 6 months thereafter, the project team scored the project using *INVEST* to track progress toward sustainability goals. To ensure that each criterion was addressed at the optimal time, the contractor developed a sustainability schedule intended to overlay the project schedule. The schedule highlighted action items and key dates to ensure that the team made efficient use of time and did not miss windows of opportunity to fulfill *INVEST* criteria. Ultimately, phase II of the George V. Voinovich Bridge project had better economic, social, and environmental outcomes than would otherwise have occurred had the agency not used *INVEST*.

Notable pavement sustainability practices included:

- An existing city street was preserved by milling 2 inches of the asphalt pavement surface and resurfacing, increasing the remaining service life by 2 to 5 years.
- Refurbished elastomeric bearings were used on a portion of the bridge, delaying the need for new materials for 2 to 5 years.
- The use of slag was approved for the concrete mix used for the bridge.
- The project reused 2,338 tons of rebar steel and 13,044 tons of concrete.
- All excavated materials on the job was used as fill within the project limits. No offsite material was imported for fill.
- Reclaimed asphalt pavement (RAP) was used at above 20 percent of the average recycled material content throughout the project.
- The project used ISO 500001 certified cement (cement plant operates an energy

management system). Limestone was blended into the concrete produced for this project, decreasing the cement clinker content and reducing the carbon footprint.

- 100 percent of the demolished old Innerbelt Bridge was reused or recycled. The steel was sent to a recycling facility. The concrete was crushed and used as base material for the project or sent to other projects.

Table 2. Northeast 120th Street extension project scorecard (Greenroads).

Credit Number	Credit Description	Points Possible	Points Achieved	Pavement Related
PR-1	Env. Review Process	NA	yes	-
PR-2	Lifecycle Cost Analysis	NA	yes	X
PR-3	Lifecycle Inventory	NA	yes	X
PR-4	Quality Assurance Plan	NA	yes	X
PR-5	Noise Mitigation Plan	NA	yes	X
PR-6	Waste Mgmt. Plan	NA	yes	X
PR-7	Pollution Prevention Plan	NA	yes	-
PR-8	Low-Impact Development	NA	yes	X
PR-9	Pavement Mgmt. System	NA	yes	X
PR-10	Site Mgmt. System	NA	yes	-
PR-11	Educ. Outreach	NA	yes	-
EW-1	Environmental Mgmt. System	2	-	X
EW-2	Runoff Flow Control	3	-	-
EW-3	Runoff Quality	3	-	-
EW-4	Stormwater Cost Analysis	1	-	-
EW-5	Site Vegetation	3	3	-
EW-6	Habitat Restoration	3	-	-
EW-7	Ecological Connectivity	3	-	-
EW-8	Light Pollution	3	3	-
AE-1	Safety Audit	2	-	-
AE-2	Intelligent Transp. Systems	5	3	-
AE-3	Context-Sensitive Solutions	5	5	-
AE-4	Traffic Emissions Reduction	5	-	-
AE-5	Pedestrian Access	2	2	-
AE-6	Bicycle Access	2	2	-
AE-7	Transit & HOV Access	5	1	-
AE-8	Scenic Views	2	-	-
AE-9	Cultural Outreach	2	-	-
CA-1	Quality Mgmt. System	2	-	X
CA-2	Environmental Training	1	1	X
CA-3	Site Recycling Plan	1	1	X
CA-4	Fossil Fuel Reduction	2	-	X
CA-5	Equipment Emission Reduction	2	-	X
CA-6	Paving Emission Reduction	1	-	X
CA-7	Water Use Tracking	2	2	X
CA-8	Contractor Warranty	3	-	X
MR-1	Lifecycle Assessment	2	-	X
MR-2	Pavement Reuse	5	5	X
MR-3	Earthwork Balance	1	-	-
MR-4	Recycled Materials	5	1	X
MR-5	Regional Materials	5	5	X
MR-6	Energy Efficiency	5	3	-
PT-1	Long-life Pavement	5	5	X
PT-2	Perm. Pavement	3	-	X
PT-3	Warm-Mix Asphalt	3	3	X
PT-4	Cool Pavement	5	-	X
PT-5	Quiet Pavement	3	-	X
PT-6	Pavement Perf. Tracking	1	-	X
CC-1	Work Zone Safety	5	1	-
-	**Total Points**	**113**	**46**	-
-	**Total Points Pavement Related**	**53**	**23**	-

Table 3 shows the *INVEST* (v1.1) certification scorecard and identifies credits that were achieved that are relevant to pavement sustainability practices. Out of the 95 points achieved, 39 points were related to pavement sustainability considerations (41 percent of the achieved points).

Table 3. George V. Voinovich eastbound bridge project scorecard (INVEST).

Credit Number	Credit Description	Points Possible	Points Achieved	Pavement Related
PD01	Economic Analyses	5	5	-
PD02	Life-Cycle Cost Analyses	3	1	X
PD03	Context Sensitive Project Development	5	5	-
PD04	Highway and Traffic Safety	10	8	X
PD05	Educational Outreach	2	2	-
PD06	Tracking Environmental Commitments	5	5	X
PD07	Habitat Restoration	3	3	-
PD08	Stormwater	9	8	-
PD09	Ecological Connectivity	3	3	-
PD10	Pedestrian Access	2	2	-
PD11	Bicycle Access	2	2	-
PD12	Transit & HOV Lane	5	2	-
PD13	Freight Mobility	7	4	-
PD14	ITS for System Operations	5	5	-
PD15	Historical, Archeological, and Cultural Preservation	3	3	-
PD16	Scenic, Natural, or Recreational Qualities	3	3	-
PD17	Energy Efficiency	8	4	-
PD18	Site Vegetation	3	2	-
PD19	Reduce and Reuse Materials	8	8	X
PD20	Recycle Materials	8	2	X
PD21	Earthwork Balance	3	3	-
PD22	Long Life Pavement Design	5	-	X
PD23	Reduce Energy and Emissions in Pavement Materials	3	3	X
PD24	Contractor Warranty	3	-	X
PD25	Construction Environmental Training	1	1	X
PD26	Construction Equipment Emissions	2	2	X
PD27	Construction Noise Mitigation	2	1	X
PD28	Construction Quality Control Plan	5	5	X
PD29	Construction Waste Management	3	3	X
-	**Total Points**	**126**	**95**	-
-	**Total Points Pavement Related**	**58**	**39**	-

ENVISION: I-4 ULTIMATE PROJECT, CENTRAL FLORIDA

The Florida Department of Transportation's (FDOT) I-4 Ultimate Project was certified by the *Envision* (v2.0) rating system in December 2016. The $2.3 billion public-private partnership (PPP) project began in May 2014 and is estimated to be completed in 2021 (certification was achieved in 2017, but construction is not yet complete).

The project consists of reconstructing a 21-mi long section of the general-use travel lanes and adding four additional lanes along the I-4 highway. Other project elements include reconstruction of 15 major interchanges, including the widening of 13 existing bridges, reconstructing 74 bridges, and adding 53 new bridges. The I-4 Mobility Partners used *Envision* to help achieve the Florida Department of Transportation's (FDOT) sustainability goals on a large State DOT PPP freeway project. Notable pavement sustainability practices included:

- Partnered with local workforce development groups (e.g., Goodwill Central Florida, Career Source, and Blue Print) to advertise and adopt the FHWA's on the job training program. The project team plans on graduating 250 on-the-job trainees during the life of the project.
- Reduced the number of lane shifts and phases required during the construction phase to enhance public safety. Implemented the Advanced Lane Closure Alert System to communicate lane closures to commuters, commercial vehicle operators, emergency responders, news media, and FDOT.
- Contacted construction joint venture partners to reuse materials (e.g., fill materials, barriers, sheet piles, sign structures) from nearby projects.
- Designed bridges to withstand sinkhole event opening up to 20 ft in depth due to the high propensity for sinkholes in the area.
- Reused 550,000 yd^2 of existing concrete pavement and 150,000 yd^3 of other concrete items (barriers, curbs and gutter, etc.) as roadway base course, drainage bedding, and fill material.
- Out of the 598,000 tons of milled asphalt pavement surfaces, sent 350,000 tons to the asphalt plant to be used as RAP. The remaining 248,000 tons will be processed and reused onsite as stabilization for road base.
- Locally sourced all of the soil, aggregate, sand, concrete, asphalt, steel, and plant materials.
- Diverted over 98 percent of the waste produced on site (not including hazardous waste) from landfills.

Table 4 shows the *Envision* (v2.0) certification scorecard and identifies credits that were achieved that are relevant to pavement sustainability practices (Lazzara nd). Out of the 392 points achieved, 143 points were related to pavement sustainability considerations (36 percent of the achieved points).

Table 4. I-4 Ultimate project scorecard (Envision).

Credit No.	Credit Description	Points Possible	Points Achieved	Pvmt Related
QL1.1	Improve Community Quality of Life	25	20	-
QL1.2	Stimulate Sustainable Growth and Development	16	16	-
QL1.3	Develop Local Skills and Capabilities	15	15	X
QL2.1	Enhance Public Health and Safety	16	16	X
QL2.2	Minimize Noise & Vibration	11	8	X
QL2.3	Minimize Light Pollution	11	4	-
QL2.4	Improve Community Mobility and Access	14	14	-
QL2.5	Encourage Alternative Mode of Transportation	15	12	-
QL2.6	Improve Site Accessibility, Safety, and Wayfinding	15	15	-
QL3.1	Preserve Historic and Cultural Resources	16	7	-
QL3.2	Preserve Views and Local Character	14	6	-
QL3.3	Enhance Public Space	13	11	-
LD1.1	Provide Effective Leadership and Commitment	17	17	-
LD1.2	Establish a Sustainability Management Systems	14	7	-
LD1.3	Foster Collaboration	15	8	-
LD1.4	Provide for Stakeholder Involvement	14	14	-
LD2.1	Pursue By-Product Synergy Opportunities	15	3	X
LD2.2	Improve Infrastructure Integration	16	16	X
LD3.1	Long-Term Monitoring and Maintenance Plan	10	10	X
LD3.2	Address Conflicting Regulations and Policies	8	-	-
LD3.3	Extend Useful Life	12	12	X
RA1.1	Reduce Net Embodied Energy	18	2	X
RA1.2	Support Sustainable Procurement Practices	9	2	-
RA1.3	Use Recycled Materials	14	11	X
RA1.4	Use Regional Materials	10	10	X
RA1.5	Divert Waste from Landfills	11	11	X
RA1.6	Reduce Excavated Materials Taken Off Site	6	6	-
RA1.7	Provide for Deconstruction and Recycling	12	1	X
RA2.1	Reduce Energy Consumption	18	-	-
RA2.2	Use Renewable Energy	20	-	-
RA2.3	Commission and Monitor Energy Systems	11	-	-
RA3.1	Protect Fresh Water Availability	21	-	-
RA3.2	Reduce Potable Water Consumption	21	-	-
RA3.3	Monitor Water Systems	11	-	-
NW1.1	Preserve Prime Habitat	18	9	-
NW1.2	Protect Wetlands and Surface Water	18	-	-
NW1.3	Preserve Prime Farmland	15	-	-
NW1.4	Avoid Adverse Geology	5	3	-
NW1.5	Preserve Floodplain Functions	14	5	-
NW1.6	Avoid Unsuitable Development on Steep Slopes	6	-	-
NW1.7	Preserve Greenfields	23	10	-
NW2.1	Manage Stormwater	21	-	X
NW2.2	Reduce Pesticide and Fertilizer Impacts	9	1	-
NW2.3	Prevent Surface & Groundwater Contamination	18	18	-
NW3.1	Preserve Species Biodiversity	16	2	-
NW3.2	Control Invasive Species	11	9	-
NW3.3	Restore Disturbed Soils	10	8	-
NW3.4	Maintain Wetland and Surface Water Functions	19	15	-
CR1.1	Reduce GHG Emissions	25	-	X
CR1.2	Reduce Air Pollution Emissions	15	12	X
CR2.1	Assess Climate Threat	15	-	-
CR2.2	Avoid Traps/Vulnerabilities	20	-	-
CR2.3	Prepare for Long-Term Adaptability	20	16	X
CR2.4	Prepare for Short-Term Hazards	21	-	-
CR2.5	Manage Heat Isl. Effects	6	-	X
-	**Total Points**	**809**	**392**	-
-	**Total Pavement-Related Points**	**247**	**143**	-

CONCLUDING REMARKS

The three sustainability rating systems reviewed here include substantial pavement sustainability practices and allow stakeholders of transportation infrastructure projects to measure and communicate these practices as part of an overall sustainability effort. Basic conclusions are:

- **Sustainable pavement practices are well represented in transportation/infrastructure sustainability rating systems**. All three rating systems provide opportunities to apply pavement sustainability considerations for every phase of the pavement lifecycle. About two-thirds of the practices described by FHWA (2015) are addressed by at least one rating system.
- **Sustainable pavement practices can play a substantial role in transportation/infrastructure sustainability rating systems**. From 36 to 50 percent of the total credits achieved by the case studies are related to sustainable pavement practices.
- **Recycling/reuse is a common sustainability practice.** All three sustainability rating systems address components of this idea in multiple pavement life-cycle stages, and all three case study projects achieved points for reusing and recycling existing materials within the project limits in some way.
- **Sustainable pavement practices can play a substantial role in various transportation projects regardless of project type and scale**. The three case studies were on substantially different types of projects (bridge, local new construction road, major corridor upgrade) and all were able to achieve a number of sustainable pavement practices.
- **Some sustainable pavement practices are not credited by rating systems**. About one-third of the sustainable pavement practices documented by FHWA (2015) are not addressed by any rating system.

REFERENCES

Anderson, J. L. et al. 2018. *Greenroads Rating System V2*. Greenroads Foundation, Redmond, WA.

Bevan, T., L. Reid, A. Davis, T. Neuman, K. Penney, S. Seskin, M. VanZerr, J. Anderson, S. Muench, C. Weiland, T. Ramani, J. Zietsman, J. Crossett, C. Crocker, and J. Schulz. 2012. *INVEST: Sustainable Highways Self-Evaluation Tool. Version 1.0.* Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2011. *Sustainable Highways Self-Evaluation Tool: Compendium of System Planning and Processes, Project Delivery and Operations and Maintenance Criteria—Pilot Test Version.* Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2014. (authors: S. Muench and T. Van Dam). *Pavement Sustainability TechBrief.* FHWA-HIF-14-012. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2015. (authors: T. J. Van Dam, J. T. Harvey, S. T. Muench, K. D. Smith, M. B. Snyder, I. L. Al-Qadi, H. Ozer, J. Meijer, P. V. Ram, J. R. Roesler, and A. Kendall). *Towards Sustainable Pavement Systems: A Reference Document*. FHWA-HIF-15-002. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2017. *Case Studies: Ohio DOT – George V. Voinovich Bridge/Cleveland Innerbelt Corridor*. Federal Highway Administration, Washington, DC.

Institute for Sustainable Infrastructure (ISI). 2012. *Envision, Version 2.0. A Rating System for Sustainable Infrastructure*. ISI, Washington, DC.

Institute for Sustainable Infrastructure (ISI). 2018. *Envision Sustainable Infrastructure Framework, Version 3. Guidance Manual.* Institute for Sustainable Infrastructure, Washington, DC.

Isaacs, D. 2015. "Kirkland Street Certified 'Greenest Road in the World.'" *The Auto Reporter*, May 28, 2015. The Auto Reporter, Seattle, WA.

Lazzara, J. no date. *Envision Sustainable Infrastructure Rating System: Credit Documentation*. (credit documentation for I-4 Ultimate project; not publicly available). Institute for Sustainable Infrastructure, Washington, DC.

Lew, J. B., J. L. Anderson, and S. T. Muench. 2016. "Informing Roadway Sustainability Practices Using Greenroads Certified Project Data." *Transportation Research Record 2589*. Transportation Research Board, Washington, DC.

Muench, S. T., J. L. Anderson, J. P. Hatfield, J. R. Koester, and M. Söderlund. 2011. *Greenroads Manual*. Vol. 1.5. University of Washington, Seattle, WA.

Trumbull-Great Lakes-Ruhlin. 2017. *INVEST Report: George V. Voinovich Bridge*. Ohio Department of Transportation, Columbus, OH.

CONTACT

Federal Highway Administration (FHWA)
Office of Preconstruction, Construction, and Pavements Heather Dylla
(Heather.Dylla@dot.gov)

RESEARCHER

This case study was developed by Stephen Muench, University of Washington and prepared under FHWA's Sustainable Pavements Program (DTFH61-15-D-00005). Applied Pavement Technology, Inc. of Urbana, Illinois served as the contractor to FHWA.

DISTRIBUTION

This document is being distributed according to a standard distribution. Direct distribution is being made to the Divisions and Resource Center.

AVAILABILITY

This document may be found at:
https://www.fhwa.dot.gov/pavement

KEY WORDS

concrete pavement, sustainability, blended cements, construction innovations, life-cycle assessment, cost savings

CREDITS

Unless otherwise noted, FHWA is the source for all images in this document.

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation (USDOT) in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document.

The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this report only because they are considered essential to the objective of the document. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

NON-BINDING CONTENTS

The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.

QUALITY ASSURANCE STATEMENT

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

JANUARY 2020
FHWA–HIF–19–079