

Review of Sustainability Rating Systems used for Infrastructure Projects

Caroline M. Clevenger, Ph.D., Mehmet E. Ozbek, Ph.D., and Sherona Simpson

Colorado State University
Fort Collins, Colorado

The construction industry in general and infrastructure projects in particular have significant environmental impacts. Across the building industry, sustainability rating systems have been developed and implemented over the last decade to address and reduce the environmental impacts of vertical projects. During the same period, civil infrastructure projects have not received the same attention with respect to sustainability. Over the last several years, however, several entities have started developing sustainability rating systems applicable to infrastructure projects. In this paper, the authors review and provide a comparison of the six most prominent emerging sustainability rating systems: BE2ST-in-Highways, Envision, GreenLITES, Greenroads, I-LAST and INVEST. The review reveals that many similarities exist between these systems. Specifically each rating system evaluates items related to consumption and management of water, energy, and materials. Differences lie primarily in differences in process and implementation requirements, as well as how weights are assigned among rating criteria. The comparison presented highlights the strengths and weaknesses of various approaches, and motivates future research on sustainable rating systems for infrastructure projects.

Key Words: Infrastructure, Rating Systems, Sustainability, Assessment

Introduction and Purpose

The United Nations (UN) Millennium Ecosystem Assessment acknowledged that over the past 40 years, the current rate of consumption of natural resources does not support renewal to meet the needs of future generations (CEM, 2008). The construction industry accounts for 30% of the energy consumed in the U.S. while contributing 6% of the greenhouse gas emissions in the U.S. (Gambaste, 2005). The industry is becoming more interested in sustainable development (Reeder, 2010). Need, therefore, exists to evaluate and measure the environmental performance of projects. To meet this need, sustainability rating systems have been widely adopted and endorsed by the construction industry. Rating systems allow design teams and constructors to set sustainable priorities while providing stakeholders a method to analyze performance (Reeder, 2010). Rating systems typically measure sustainability efforts using five categories: use of resources; energy; transport; water and waste (CEM, 2008). The use of rating systems, however, has occurred primarily in vertical construction (buildings) and has been slow in coming to horizontal infrastructure works, and the transportation sector in particular (Krekeler, Nelson, Gritsavage, Kolb, & McVoy, 2010).

Research has identified infrastructure projects present significant opportunity to promote sustainability since they are large in scope and typically long in duration. Factors contributing to sustainability of infrastructure projects include: cost, energy consumption, resource requirements, capacity, service quality, safety, impacts on society, and impacts on the environment (Lee, 2011; Martland, 2012). Recently, several systems have been developed or are under development to measure the sustainability of infrastructure projects. These systems employ different methods of determining sustainability emphasizing different sustainable factors (Martland, 2012). The purpose of this paper is to explore and compare six prominent emerging sustainable infrastructure rating systems: BEST-in-Highways, Envision, GreenLITES, Greenroads, I-LAST and Invest. The following section introduces and describes these six infrastructure sustainability rating systems.

Infrastructure Sustainability Rating Systems

BE²ST-In-HighwaysTM

Developed by the Recycled Materials Resource Center (RMRC) based at the College of Engineering at the University of Wisconsin, Building Environmentally and Economically Sustainable Transportation-Infrastructure-Highways (BE²ST-In-Highways) is a sustainability rating system whose main focus is to quantify the sustainability impact of using recycled materials in pavements (Edil, Lee, Benson, & Tinjum, 2010). In scoring projects, the rating system utilizes Pavement Life-Cycle Assessment Tool for Environmental and Economic Effects PaLATE and the Life Cycle Cost Analysis (LCCA) RealCost software program (RMRC, 2012). In addition, it uses Mechanistic-Empirical Pavement Design Guide (MEPDG) to measure service life, Traffic Noise Model LookUp (TNM-Look) to assess traffic noise, and International Roughness Index (IRI) simulation to determine life of pavement (Edil, 2012; Staiano, 2008). Projects are analyzed by comparing a reference design (base design) that has no sustainable features, but fulfills statutory and social requirements to proposed designs that satisfy statutory and social requirements, and incorporate sustainable design features (Edil et al., 2010). By comparing reference to proposed designs, an accurate, transparent, and replicable measurement, which takes into account tradeoffs, can be implemented to evaluate proposed project performance (Edil, 2012).

When implementing this rating system, project teams propose alternate design options to the reference design (Edil et al., 2010). All options are screened in the Mandatory Screening Layer to ensure they conform to statutory and project specific criteria. Design options that pass the Mandatory Screening layer are evaluated in the Judgment Layer. At this layer, projects are evaluated based on nine sub-criteria: Greenhouse Gas Emission, Energy Use, Waste Reduction (including ex situ materials), Waste Reduction (recycling in situ materials), Water Consumption, Hazardous Waste, Life Cycle Cost, Traffic Noise and Social Cost of Carbon Saving (Edil, 2012). Stakeholders have the option to assign weights to each sub-criterion based on their importance and potential to contribute to the project. Weights can be assigned using the Analytical Hierarchy Process (AHP), although this is not mandatory (Lee, 2011). Score percentages are presented in comparison to the reference design and prorated to an equivalent score in accordance with the weight for each sub-criterion. A percentage is calculated by dividing the actual score by maximum possible score according to the following levels: Bronze (50%), Silver (75%) and Gold (90%). The system is applicable to highway projects during the design phase, is entirely web based, and offers third party verification as well as voluntary participation alternatives (RMRC, 2012).

EnvisionTM

Envision, developed by the Zofnass Program for Sustainable Infrastructure based at the Harvard Graduate School of Design and the Institute for Sustainable Infrastructure (ISI), can be used to rate infrastructure works associated with water storage and treatment, energy generation, landscaping, transportation, and information systems (for example broadcast towers) (ISI, 2012). The program encourages the use of life cycle analysis in planning, designing, construction and operation to improve sustainability performance. Design team and owners are recognized for their efforts to incorporate sustainable practices throughout infrastructure project life cycle (ISI, 2012).

Under Envision there are 60 credits distributed under five categories (ISI, 2012): Quality of Life, Leadership, Resource Allocation, Natural World and Climate and Risk. Quality of Life embodies social aspects of sustainability such as appropriateness of project, its holistically effect on the community, and whether it improves the community's mobility or access to facilities. Leadership measures actual performance of stakeholders in areas such as collaboration, management and planning. Resource Allocation applies to the sustainable use materials, water and energy in the project. Quantifying impact in the Natural World Category relates to land issues including: siting of project, understanding, preserving and restoring natural ecosystems. Lastly the Climate and Risk category addresses emissions and resilience, and looks at quantifying the impact of the project as it relates to harmful emissions and longevity. Envision is a two-stage assessment tool: Stage 1 is a Self-Assessment Checklist, and Stage 2 entails Third Party Verification and Public Recognition. Four Envision certifications exist: Acknowledgement of Merit, Silver Award (8% minimum in each category), Gold Award (15% minimum in each category) and Platinum Award (20% minimum in each category) (ISI, 2012).

GreenLITES- Green Leadership in Transportation and Environmental Sustainability

Developed by the New York State Department of Transportation (NYSDOT), GreenLITES assesses project performance in several key areas, while encouraging sustainability best practices. It encourages development with no negative environmental effects and little disruption to society (NYSDOT, 2012). Secondly, it encourages appropriateness of design, the provision of safe multimodal means of transportation and the construction of low cost or no cost maintenance highways (Krekeler et al., 2010). Thirdly, it provides a medium for the dissemination of information as well as funding for research. The system is grounded in the triple bottom line of sustainability: environment, economy, and equity. It includes five point categories: Sustainable Sites, Water Quality, Material and Resources, Energy and Atmosphere, and Innovation. A total of 175 credits exist across these five categories. The system offers transparency in the NYSDOT's operation to state government and other stakeholders, and provides the following award levels: GreenLITES Certified, GreenLITES Silver, GreenLITES Gold and GreenLITES Evergreen awards. GreenLITES is a mandatory tool for the NYSDOT on all highway projects (Krekeler et al., 2010).

Projects are assessed under GreenLITES Design during conceptual and design phases. Stakeholders and project team review the GreenLITES scorecard to determine which items are appropriate to include in the design. The project team next undertakes design while maintaining dialogue with the stakeholders to ensure proposed designs fulfill societal, transportation, and sustainability goals. Once plans, estimates and specifications are complete, the project is reviewed and given one of four awards as appropriate (NYSDOT, 2012).

Additional GreenLITES systems investigate other phases of the projects. GreenLITES Operation addresses issues related to greenhouse gases and water quality (NYSDOT, 2012). It allows sustainable practices to be implemented in every day maintenance activities for infrastructure works. Divisions such as Transportation Maintenance, Traffic, Safety and Mobility, etc. use this rating system as a tool for measuring performance, and to help identify high points and areas of improvement (Krekeler et al., 2010). This system serves as a distribution channel for innovative ideas on best practices. GreenLITES Planning addresses new infrastructure works. The system supports planning of new works in a way that involves all stakeholders, and ensures that projects meet the needs of the community (NYSDOT, 2012). The Planning tool may be used at the local or capital expenditure and solicitation level for long term projects. Finally, NYSDOT is developing a Pilot GreenLITES Regional Assessment Tool to rate projects using the triple bottom line (NYSDOT, 2012).

GreenroadsTM

The Greenroads sustainability rating system was developed by CH2M HILL and the University of Washington in 2009 (Greenroads, 2012). Greenroads stimulates sustainability in highway construction by awarding credits to projects that have successfully incorporated sustainable best practices. It provides a holistic means of considering and evaluating roadway sustainability for new construction, reconstruction and rehabilitation through a quantitative method that informs decision making (Greenroads, 2012). It also addresses operations and maintenance through an Operations and Maintenance Plan, which is evaluated when the project is scored. The system does not apply to day to day maintenance of highways (Greenroads, 2011).

The criteria under the Greenroads sustainable rating system are broken down into two categories: required and voluntary. Each project must meet the 11 project requirements: Environmental Review Process, Lifecycle Cost Analysis, Lifecycle Inventory, Quality Control Plan, Noise Mitigation Plan, Waste Management Plan, Pollution Prevention Plan, Low Impact Development, Pavement Management System, Site Maintenance Plan and Educational Outreach. The majority of required criteria are derivatives of codes or laws; and do not present an additional burden to the project team. In addition, there are six voluntary credit categories. They include: Environment and Water (8 criteria), Access and Equity (9 criteria), Construction Activities (8 criteria), Materials and Resources (6 criteria), Pavement Technologies (6 criteria) and Custom Credits (2 criteria). All criteria are intended to inspire action towards a higher standard of construction sustainability using current technology and tools. After project requirements are fulfilled, voluntary credits are selected, documented, and submitted to Greenroads for a third party review (Greenroads, 2012). Each credit is weighed by Greenroads on a scale of 1-5 depending on its potential to influence the sustainability of projects.

Four awards levels exist for the Greenroads system: Bronze (32-42 voluntary credit points), Silver (43-53 voluntary credit points), Gold (54-63 voluntary credit points) and Evergreen (64 upwards voluntary credit points). The tool

may be used on highways and conceptually on bridges, tunnels and other structures associated with similar works. It is web based and can be used throughout the life cycle of the project (Greenroads, 2012).

I-LAST – Illinois Livable and Sustainable Transportation

The aim of I-LAST is to encourage sustainable practices in highway construction and to evaluate sustainability using simple methods. The system is voluntary, paper based, applicable to highways and employs self-assessment (IDOT & IJSG, 2010). It was developed out of a collaborative effort between the Illinois Department of Transportation (IDOT), the American Consulting Engineers Council (ACEC) and the Illinois Road and Transportation Builders Association (IRTBA). Participation is voluntary and the system consists of a guidebook that allows the project team to review criteria, select which ones are applicable and score them (Knuth & Fortmann, 2011). I-LAST can be used throughout the conceptual phase (Phase I: Planning), design (Phase II: Final Design) and, is also applicable to future construction (Phase III).

Eight major categories exist under this rating system: Planning, Design, Environmental, Water Quality, Transportation, Lighting, Materials and Innovation. In combination, all categories have 153 sustainable criteria which fall into 17 broader criteria headings (IDOT & IJSG, 2010). Certification documentation is not required. Rather, the system employs self-scoring using a hierarchy methodology where 1-3 points are awarded per criteria. There are no calculations, just a yes/no award by the self-evaluator. A maximum of 233 points can be gained across the 153 sustainable best practices. The percentage of points earned is calculated as the ratio of points awarded divided by points achievable (IDOT & IJSG, 2010). Development of an awards system is pending feedback from the users of the rating system.

INVEST-Infrastructure Voluntary Evaluation Sustainability Tool

INVEST was developed by the Federal Highway Administration (FHWA) with the help of CH2M Hill and launched in 2012 (FHWA, 2012b). It was designed to be user friendly and uses a free, web based interface. It is broken down according to the following project phases: systems planning, project development, and operations and maintenance (FHWA, 2012a). The system provides scorecards for Paving, Basic Rural, Basic Urban, Extended Rural, Extended Urban and Custom. Stakeholders are allowed to design a custom, project specific scorecard in situations where a project does not fit into pre-defined scorecards..

Criteria under the INVEST rating system are defined according to sustainable best practices. They fall under one of three headings: project delivery and system planning and processes (17 criteria), project development (20 or 29 criteria depending on whether basic or extended scorecard is used), and operations and maintenance (14 criteria). The criteria in project development are weighted based on their relative sustainable impact. All criteria in Operations and Maintenance and Systems Planning are equally weighted at 15 points each, with the exception of the bonus criteria in Systems Planning, which nets a maximum of 10 points (FHWA, 2012a). The system generates questions that require answers from project administrators. Based on the answers provided, a project is awarded a score for each criterion and an overall score is tallied to rate the entire project. The project is awarded a Bronze, Silver, Gold and Platinum based the overall score. Due to the lack of a third party evaluator, this award serves as unofficial recognition by the FHWA (FHWA, 2012a).

Comparison of the Sustainable Infrastructure Rating Systems

The six rating systems reviewed have similarities and differences. Specifically, all six sustainability rating systems are applicable to the planning and design phases of projects. Only Envision, GreenLITES, Greenroads and INVEST are applicable to the construction phase; and only Envision, GreenLITES and INVEST are applicable to the operations and maintenance phases of a project. I-LAST is currently developing a sub-system applicable to the construction phase. Envision is the only system applicable to many different types of infrastructure projects. The other rating systems are only applicable to highway projects. Tables 1-4 highlight similarities and differences of the six rating systems according to four major categories. Numerous other categories exists but have limited applicability across all of the systems reviewed. It should be noted that the total points achievable for Envision, GreenLITES, Greenroads, I-LAST and INVEST are 708, 290, 118, 233 and 576 respectively. In tables 1-4, the sign “∞” means that the sub-criteria is represented elsewhere in the given system.

Table 1 evaluates the focus of each sustainability system regarding environmental factors when assessing the sustainability of projects. Envision allocated the highest percentage available credits to environmental issues (36%). I-LAST is second at 22% with Greenroads allocating the third highest at 10%. Although the percentage allocated for environmental issues was low for GreenLITES and INVEST, environmental issues were dealt with extensively in terms of policy guidelines in the rating system compared to the other systems.

Table 1: Summary of sub-criteria related to the environment category

SUB-CRITERIA COMPARISON FOR ENVIRONMENTAL CATEGORY													
Rating System	Environmental Management Systems	Site Vegetation/Trees and Plant Communities	Protect Enhance or Restore Wildlife (Habitat Restoration)	Ecological Connectivity	Environmental Training	Improve Air Quality by Improving Traffic Flow	Improving Bicycle and Pedestrian Facilities	Noise Abatement	Integrated Planning Natural Environment	Siting	Biodiversity	Total achievable for Environment	Percentage of system
BE2ST-IN-HWYS	Points determined by project team												
ENVISION	-	∞	∞	∞	∞	∞	∞	∞	∞	156	99	255	36%
GREENLITES	-	∞	∞	∞	-	6	6	4	∞	∞	-	16	6%
GREENROADS	2	3	3	3	1	∞	∞	∞	∞	∞	-	12	10%
I-LAST	-	21	20	∞	-	∞	∞	10	∞	∞	-	51	22%
INVEST	5	3	3	∞	1	15	∞	2	15	∞	-	44	8%

With regard to water quality, both potable and storm water, Table 2 shows that Envision has the highest percentage of related sub-criteria (25%). I-LAST, Greenroads, GreenLITES and INVEST include the following percentages of sub-criteria 15%, 10%, 3% and 2% respectively. Envision and Greenroads were the only systems to track potable water usage during construction. Greenroads was the only system to address the analysis of the cost of handling storm water.

Table 2: Summary of sub-criteria related to the water quality and use category

SUB-CRITERIA COMPARISON FOR WATER QUALITY AND USE CATEGORY										
Rating System	Stormwater Treatment / Management	Reduce runoff and treat stormwater runoff	Runoff Flow Control	Runoff Quality	Stormwater Cost Analysis	Reduce Impervious Areas	Construction Practices to Protect water Quality	Water Tracking	Total achievable for water quality	Percentage of system
BE2ST-IN-HWYS	Points determined by project team									
ENVISION	14	∞	∞	57	-	-	-	106	177	25%
GREENLITES	3	5	∞	∞	-	-	-	-	8	3%
GREENROADS	∞	∞	3	3	1	3	-	2	12	10%
I-LAST	10	∞	∞	∞	-	14	11	-	35	15%
INVEST	9	∞	∞	∞	-	-	-	-	9	2%

Table 3 highlights that the highest percentage sub-criteria allocation for energy was 8 % by Envision and the lowest at 4% by GreenLITES. Greenroads, I-LAST and INVEST all have 7% of related sub-criteria respectively. Common related issues included light pollution, energy consumption and fuels.

Table 3: Summary of sub-criteria related to the energy category

SUB-CRITERIA COMPARISON FOR ENERGY CATEGORY								
Rating System	Energy and Fuels	Energy Efficiency	Reduce Electrical/Energy Consumption	Reduce Petroleum Consumption	Stray Light Reduction	Renewable Energy Consumption	Total achievable for Energy	Percentage of system
BE2ST-IN-HIGHWAYS	Points determined by project team							
ENVISION	∞	21	21	∞	∞	15	57	8%
GREENLITES	∞	∞	3	6	3	-	12	4%
GREENROADS	∞	5	-	-	3	-	8	7%
I-LAST	∞	∞	12	∞	4	∞	16	7%
INVEST	15	11	15	∞	-	∞	41	7%

Table 4 shows the percentage allocation of sub-criteria by each system towards the selection of materials. Greenroads, Envision, I-LAST, INVEST and GreenLITES allocate the following percentage respectively: 19%, 18% 17% 10% and 7%. Significant emphasis was placed on recycling efforts across all systems.

Table 4: Summary of sub-criteria related to the materials category

SUB-CRITERIA COMPARISON FOR MATERIALS CATEGORY											
Rating System	Reuse of Materials	Recycled Content/ Materials	Locally Provided/ Regional Material	Bioengineering Techniques	Hazardous Material Minimization	Life Cycle Assessment	Pavement reuse	Earthwork Balance	Energy Efficiency	Total achievable for Materials	Percentage of system
BE2ST-IN-HWYS	Points determined by project team										
ENVISION	21	57	50	-	-	-	-	-	-	128	18%
GREENLITES	7	2	2	3	6	-	-	-	-	20	7%
GREENROADS	∞	5	5	-	-	2	5	1	5	23	19%
I-LAST	∞	22	6	-	-	-	12	-	-	40	17%
INVEST	∞	31	3	-	-	8	15	∞	-	57	10%

Discussion

While the rating systems share a number of commonalities, they also have unique features. The following discussion highlights the distinctions between systems. INVEST differentiates between levels and type of work and acknowledges that not all sustainability criteria are applicable to all projects and the final score is calculated relative only to applicable criteria as identified attainable by the project team (FHWA, 2012a). INVEST allows project teams to identify which credits are attainable at the beginning of the project and to customize scorecards. It breaks

the criteria of the rating system into a logical sequence and distinguishes between work in rural or urban areas, small scale or large scale work, paving only jobs or custom jobs. I-LAST serves primarily as a guidebook for roadwork project teams. It does not offer awards, and does not tally the points achieved out of 233 possible points (IDOT & IJSG, 2010). Greenroads is a system particularly encouraging of innovation. It awards a maximum of 10 points for innovation (compared to 1-2 points by other systems). It breaks innovation into 2 criteria giving project teams the opportunity to incorporate more than one innovative attribute to each project (Greenroads, 2012). There is also a mechanism for project teams to document their sustainability efforts for inclusion in future versions of Greenroads. Envision incorporates the widest range of infrastructure projects. In addition to roadways, Envision is applicable to water treatment and storage systems, energy generation, landscaping and information systems. This system also requires that a credentialed employee be on the project team and is the only rating system to awards points for leadership (ISI, 2012). BE2ST-in-Highways is unique because it quantifies the sustainable aspects of a project in comparison to a base design. To compare the project against this benchmark, it applies established methods and tools such as Life Cycle Cost Analysis (LCCA) using RealCost software, Life Cycle Assessment (LCA) using PaLATE software, TNM-Look to assess traffic noise, International Roughness Index (IRI) predictions, and Analytical Hierarchy Process (AHP) in the selection of criteria weighting (RMRC, 2012). GreenLITES was developed for domestic use by the NYSDOT to track its sustainability performance. It is applied during the planning and maintenance phases of NYSDOT highway projects, but awards the project a rating based on design intent and specifications (NYSDOT, 2012). While it is attracting some interest from other state DOTs it was not originally intended to be adopted by other DOTs or project teams.

Another potential way systems differ is according to their ease of use. Direct observation and documentation of ease of use is left to future research. The following discussion reports the level of use as documented by the literature. Greenroads has been used to evaluate over 120 projects nationally and internationally (Greenroads, 2012). The majority of use has occurred in the United States. Over 20 projects have been registered in five states and 5-10 projects are pending registration in nine states. Greenroads is also working with several countries to develop and expand the rating system (Greenroads, 2012). GreenLITES has been used to evaluate a total of 221 projects (NYSDOT, 2012). Of the projects evaluated, 39% were not certified, 36% were GreenLITES certified, 16% earned GreenLITES Silver, 5% earned GreenLITES Gold and 5% earned GreenLITES Evergreen. INVEST has been pilot tested on four projects across the U.S. The North Central Texas Council of Governments (NCTCOG) used INVEST's system planning module to evaluate its long term plan Mobility 2035; the Ohio Department of Transportation (ODOT) used the INVEST project development extended scorecard to evaluate the sustainable performance of the Innerbelt Bridge; Utah DOT evaluated its current operations and maintenance program using the INVEST operations and maintenance module, and the INVEST scorecard was used to evaluate the Western Federal Lands Going-to-the-Sun-Road Rehabilitation Project (FHWA, 2012b). BE2ST-in-Highways has been pilot tested on the Baraboo Bypass in Wisconsin (Lee, 2011). Envision has been pilot tested on four Colorado projects; namely the Academy/Woodmen Road interchange in Colorado Springs, Little's Creek in Littleton, Gold Camp Tunnel in Teller County and the Aspen Rio Grande Recycling Project (Hirsch, 2012).

Conclusions

Review of six sustainable rating systems for infrastructure projects reveals that all of the rating systems support sharing, encouragement, and recognition of sustainable best practices. Each system differs however, in how it analyses and evaluates such practices, whether through comparison to a base design, through quantitative methods, through the use of experts in the form of third party validation or through self-assessment. Regardless of analysis method, the objective to analyze and recognize project performance is accomplished according to unique process and implementation requirements of the various rating systems. To what extent sustainability is achieved remains uncertain since consensus does not exist as to the definition of sustainability for highway and infrastructure projects.

Similarities are identified between rating systems for issues related to water, energy, materials and the environment. However, the weights given to each factor vary across systems which have different sustainability objectives. Such objectives differ according to stakeholder and project. Further research is recommended to explore the implications of such similarities and differences in greater detail and to make recommendations about the merits and shortcomings of various sustainable rating systems for infrastructure projects.

References

- CEM. (2008). *Sustainability and the Built Environment* (First ed.). London, England: College of Estate Management
- Edil, T. B., Lee, J., Benson, C. H., & Tinjum, J. M. (2010). Use of BEST In-Highways for Green Highway Construction Rating in Wisconsin *Green Streets and Highways 2010* (pp. 480-494).
- Edil, T. B. (2012). Building Environmentally and Economically Sustainable Transportation-Infrastructure-Highways [WWW document]. URL <http://rmrc.wisc.edu/wp-content/uploads/2012/09/BEST-for-Colorado.pdf>
- FHWA. (2012a). INVEST [WWW document]. URL <https://www.sustainablehighways.org/1/home.html>
- FHWA. (2012b). INVEST- Webcast Launch [WWW document]. URL <http://mp125118.cdn.mediaplatform.com/125118/wc/mp/4000/5592/5599/18858/Archive/default.htm?ivt=%7B6d0eccff-4ff1-bba1-c102-d80de1a4a7f5%7D>
- Gambaste, J. A. (2005). Sustainable Roadway Construction: Energy Consumption and Material Waste Generation of Roadways. *Construction Research Congress 183*.
- Greenroads. (2011). Greenroads Abridged Manual v1.5 [WWW document]. URL <http://www.greenroads.org/366/download-the-manual.html>
- Greenroads. (2012). Greenroads [WWW document]. URL <http://www.greenroads.org/1/home.html>
- IDOT, & IJSG. (2010). I-Last - Illinois Livable and Sustainable Transportation Rating System and Guide [WWW document]. URL <http://www.dot.state.il.us/green/documents/I-LASTGuidebook.pdf>
- ISI. (2012). Institute for Sustainable Infrastructure: Envision Rating System [WWW document]. URL <http://www.sustainableinfrastructure.org/index.cfm>
- Knuth, D., & Fortmann, J. (2011). The Development of I-LAST Illinois—Livable and Sustainable Transportation *Green Streets and Highways 2010* (pp. 495-503).
- Krekeler, P., Nelson, D. A., Gritsavage, J. S., Kolb, E., & McVoy, G. R. (2010). Moving towards Sustainability: New York State Department of Transportation's GreenLITES Story *Green Streets and Highways 2010* (pp. 461-479).
- Lee, J. C., Edil, T. B., Benson, C. H., Tinjum, J. M. . (2011). Evaluation of Variables Affecting Sustainable Highway Design With BE2ST-in-Highways System. *Journal of Transportation Research Board*, 2233.
- Martland, C. D. (2012). *Toward more sustainable infrastructure : project evaluation for planners and engineers*. Hoboken, NJ: Wiley.
- NYSDOT. (2012). New York State Department of Transportation: [WWW document]. URL <https://www.dot.ny.gov/programs/greenlites>
- Reeder, L. (2010). *Guide to green building rating systems : understanding LEED, Green Globes, ENERGY STAR, the National Green Building Standard, and more*. Hoboken, N.J.: Wiley.
- RMRC. (2012). BE2ST-in-Highways™: *BE2ST-in-Highways™ at RMAUPG Annual Meeting* [WWW document]. URL <http://rmrc.wisc.edu/be2st-in-highways/>
- Staiano, M. A. (2008). *Simple Methods for Estimating Highway Noise*. Paper presented at the Transportation Research Board 88th Annual Meeting.