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Final Report

Development of Educational & Professional Training Modules on Green/Sustainability Design & Rating Systems for Neighborhood Development & Transportation

(Project No. 2012-051S)

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ABSTRACT

While the importance of sustainability is well recognized by practicing and academic professionals alike, Civil Engineering curricula do not typically offer courses covering or addressing sustainability design principles and assessment methodologies. To bridge this gap, this report discusses the development and pilot testing of a course on "Sustainability Design and Rating Systems" for upper level undergraduate and master level civil engineering graduate students, which was taught at the University of Alabama at Birmingham (UAB). The course development was the result of close and productive collaboration between one transportation and one environmental engineering faculty member who team-taught the course pilot in the fall semester 2014. This approach can set an example of the benefits of multidisciplinary course instruction that can foster interaction among traditional civil engineering disciplines for the benefit of students. The pilot course focused on sustainable transportation and livable streets, transportation planning and site design for sustainable transportation, sustainability rating systems for neighborhoods and infrastructure, brownfield/greyfield redevelopment options, and sustainability and ethics. The objective was to educate the future engineering workforce about the basic principles of sustainable design and evaluation methods, in an effort to raise awareness and develop expertise on sustainable design options and their associated benefits.

CHAPTER 1: BACKGROUND

Introduction:

Several green rating tools have been developed for transportation and related systems, not dissimilar to ongoing efforts in the building and community development fields. For example, the New York State Department of Transportation developed the GreenLITES (Green Leadership in Transportation and Environmental Sustainability) design program in 2008, based on Leadership in Energy and Environmental Design (LEED). GreenLITES evaluates several aspects of environmental performance, including water and air quality protection, light pollution, stormwater runoff, energy consumption, conformity to natural landscape features, and the disruption of fish or wildlife habitats, and ranks competing projects based on the extent to which they are incorporating sustainability features and protecting the environment. GreenLITES integrates planning and programming decision making to promote a more balanced approach to transportation decision making. Similar tools include Green Roads (Washington State DOT), and STAR (Oregon). ASCE recently unveiled the Envision Tool, which is a sustainability rating tool for various types of infrastructure including transportation and land use.

The LEED for Neighborhood Development (LEED-ND) rating system is a methodology that can be used to evaluate livability and sustainability of developments. LEED-ND is the result of a partnership between the U.S. Green Building Council (USGBC), the Natural Resources Defense Council (NRDC), and the Congress for the New Urbanism (CNU). Conceived in 2002, the rating system integrates principles of smart growth, New Urbanism, and green building infrastructure into the first national standard for green neighborhood development. LEED-ND evaluates not just buildings, but the location of those buildings, the way they relate to each other, and qualities of the public realm that knit them together. An excellent discussion and description of LEED for Neighborhood Development is provided by Welch *et al*. and the Congress for the New Urbanism, Natural Resources Defense Council, and the U.S. Green Building Council [2012].

The LEED-ND program is focused on the sustainability at the scale of neighborhoods and communities. It is a system of rating and certifying green neighborhoods that builds on prior LEED systems. LEED-ND integrates the principles of new urbanism, green building, and smart growth into the first national standard for neighborhood design, expanding LEED's scope beyond individual buildings to a more holistic concern about the context of those buildings.

Unlike other LEED rating systems that focus primarily on green building practices, LEED-ND places emphasis of the site selection, design, and construction elements that bring buildings and infrastructure together in a neighborhood and relate the neighborhood to its landscape as well as its local and regional context. LEED-ND creates a label, as well as guidelines for both decision making and development, to provide an incentive for better location, design, and construction of new residential, commercial, and mixed-use developments [Congress for the New Urbanism, Natural Resources Defense Council, and the U.S. Green Building Council, 2012]. There are 100 possible base points distributed across five major credit categories: sustainable sites; water efficiency; energy and atmosphere; materials and resources, indoor environmental quality, plus an additional six points for innovation in design and an additional four points for regional priority. Buildings can qualify for four levels of certification: Certified (40 – 49 points); Silver (50 – 59

points); Gold (60 – 79 points); and Platinum (more points and higher). All credits are positive whole numbers worth a minimum of one point [Doustmohammadi *et al*., 2013].

Guidelines for methodology implementation became available in 2009. However, widespread use of the methodology lags behind due the lack of systematic training of potential users.

To address this need, this project developed educational resources for introductory training on LEED-ND methodology and other green design for students and practitioners. This training provides an overview and understanding of principals behind LEED-ND evaluation and specific terminology, content and use of the LEED-ND methodology. It distills principles underlying green rating tools for transportation, the commonalities and differences among the tools, their strengths and weaknesses, and guidance on which tools are more appropriate for various functions. Three modules of LEED-ND are introduced focusing on: Smart Location and Linkage (SLL), Neighborhood Pattern and Design (NPD), and Green Infrastructure and Buildings (GIB). The SLL module reviews smart location selection, site design for conservation, brownfields redevelopment options, and flood avoidance of multimodal transportation choices in site development. The NPD module explores issues related to walkability, compact development, mixed-use development options, and designs promoting accessibility for all (walking and biking). The GIB module focuses on elements of certified green buildings, building energy and water efficiency, and storm water, wastewater and solid waste management infrastructure. The modules discuss prerequisites and credits which reward designs and practices promoting sustainability and livability objectives. We also explored other issues as well to give students a broader perspective about sustainability and transportation, etc.

The project opens new avenues for information dissemination on sustainable community design options to transportation professionals, students, researchers and the general public. The education modules developed and pilot-tested in this project are projects to implement sustainability and livability, as well as basic design principles that can be used in developing more sustainable project alternatives for consideration in the future.

This course helps the future workforce become familiar with the subject of green/sustainability design and rating systems, and to use these concepts to make the system sustainable. The course raises the awareness on sustainable design options and their associated benefits. It introduces and contrasts various ratings systems. It is important to educate on both LEED buildings and LEED neighborhoods. As an example, poorly placed green buildings can still have a huge carbon footprint if everyone has to drive there. Our future engineers need to know this. This course can serve as a teaching tool by faculty at other college campuses, and further contribute to raise awareness and help implement sustainable design practices.

Background/Previous Studies:

In October of 2009, the American Society of Civil Engineers (ASCE) adopted the following definition of sustainability: "A set of environmental, economic and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic and social resources" [ASCE, 2009]. This description is consistent with the United Nations (UN) World Commission on

Environment and Development report [United Nations, 1987] that defined sustainable development as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs". These definitions and others offered in the literature, center around three pillars of sustainability namely, economy, environment, and society. This suggests a need to consider a global approach when referring to sustainability that considers economic impacts, the ecological view, and a socio-cultural concept for the coexistence of development and the environment [Pearce and Warford, 1993].

As a result, ASCE established sustainability as one of three strategic priorities for the Society, helping professionals to incorporate sustainability principles into their daily practice. ASCE further recommends that civil engineers, as the stewards of society's infrastructure, must take the lead in applying sustainability to planning, design, and construction [ASCE, undated].

Recently, sustainability and livability have emerged as key priority areas at the national level and new policies have been drafted and introduced to advance sustainability practices and investments. As sustainability is growing in importance to civil engineering and related disciplines, educating the engineering workforce on issues related to sustainable planning, design, and evaluation is becoming more and more an important priority.

Robinson and Sutterer [2003] presented a paper at the 2003 American Society of Engineering Education (ASEE) Annual Conference and Exposition that described their department's experience in integrating sustainability in civil engineering curriculum. The authors concluded that "the initiative to incorporate sustainability into civil engineering courses and curricula may begin in each department with a single faculty or a small group of faculty, but it must begin."

Over the past decade, several Civil Engineering programs have made sincere efforts to expose their students to sustainability concepts and practices. A review of Civil Engineering curricula indicates that several undergraduate Civil Engineering programs have introduced modules related to sustainability within existing courses and others incorporated new courses covering sustainability design principles and assessment methodologies. At the University of Alabama at Birmingham (UAB), sustainability concepts are being developed in course syllabi and integrated into university courses, in conjunction with the Red Mountain Project, conducted in cooperation with UAB's Office of Sustainability in the Facilities Management Department.

A survey was conducted to identify accredited engineering programs at U.S. institutions that incorporate sustainability concepts into engineering curricula [Allen *et al*., 2008; Murphy *et al*., 2009]. The research team contacted the administrative heads of 1,368 engineering departments at 364 U.S. universities and colleges and asked them to complete a questionnaire about the extent to which sustainable engineering was being integrated into their departments' engineering curricula. Their findings indicated that 59 Civil, Architectural, and/or Environmental departments surveyed incorporated sustainability into their curricula.

Bielefeldt [2011] documented the experience of the Department of Civil and Environmental Engineering at the University of Colorado on incorporating a sustainability module into first-year courses for civil and environmental engineering students. She reported survey results on how the students perceived and interacted with introductory sustainability courses. Her results concluded

that a simple course modification can raise the awareness of engineering students about the importance of sustainability.

Aurandt and Butler [2011] described two approaches to incorporating sustainability into the undergraduate engineering curricula and provided a variety of existing course resources that can easily be adopted or adapted by science and engineering faculty. They concluded that core courses required for engineering majors can be redesigned to introduce concepts of sustainability without compromising the original course objectives.

In 1999, a course entitled "Civil Engineering Systems" was introduced as a required course in the undergraduate curriculum at Georgia Institute of Technology in the Department of Civil and Environmental Engineering [Amekudzi and Meyer, 2004]. A systems approach on civil infrastructure and services and sustainability concepts was introduced to students in relationship to planning, design, construction, and operation of civil engineering systems. The novelty of this new course was that it "incorporated not only sustainability into its material, but also adopted a systems perspective on civil-engineered facilities and services" [Amekudzi and Meyer, 2004].

Li and Zhang [2007] noted that the objective of sustainable design for human and industrial systems is to ensure that mankind's use of natural resources and cycles do not lead to diminished quality of life due to losses in future economic opportunities or to adverse impacts on social conditions, human health, and the environment. They further noted that performance-based engineering is a new approach ensuring that a building or other constructed facility achieves the desired performance objectives when subjected to natural or man-made hazards. Additionally, they note (at the time of their publication) that no existing civil and environmental engineering curriculum addresses both issues of sustainability and performance-based engineering. Li and Zhang [2007] proposed a framework to integrate performance-based engineering and sustainability principles in civil and environmental engineering education. Their course has three main sections (modules), as listed below:

1. Introduction to sustainability: definition of sustainability (triple-bottom line), evolution from pollution control to sustainability, existing method for sustainability assessment (life cycle impact assessment, life cycle costing, social and policy analysis).
2. Material flow: life cycle material inventory, source reduction options, recycling options and technologies, and sustainability-oriented material selection.
3. Energy flow: life cycle energy inventory, energy resource options (renewable or non-renewable), impacts of energy consumption, and energy saving technologies.

In higher education institutions, Sherman [2008] noted that the term sustainability was primarily associated with prescribed practices for individuals and campus operations. He notes that for sustainability to fully realize its transformative potential in higher education and society, sustainability must transcend an association with prescribed practices and even specialized areas of study. Sustainability needs to complement and connect avenues across academic disciplines that organize and prioritize teaching and learning on college campuses. As Sherman states "It will transform not only what we do on campus, but also how we think" [Sherman, 2008]. It should be noted that the Accreditation Board for Engineering and Technology (ABET) is requiring sustainability into design later next year.

For better preparing students to tackle real-world problems, Price and Robinson [2015] employed a strategic approach for incorporating sustainable-design principles into the undergraduate curriculum. The plan during the four-year undergraduate curriculum involved creating an awareness of sustainable design in a required freshman-level introduction-to-design course [Price and Robinson, 2015]. This prepares the students to consider sustainability in their civil engineering technical design courses during their academic career. During the fourth year, students apply sustainability concepts in developing and evaluating design solutions in their senior design capstone course. Results are presented related to sustainability/sustainable design in pre-survey and post-survey courses responses.

In a companion paper, Price and Aidon [2013] addressed introducing sustainable design principles in freshman civil engineering design. In this course, a more structured strategy to teaching sustainable design was implemented to incorporate sustainability principles (such as triple-bottom line, life cycle assessment, carbon footprints, etc.) through discussion of concrete as a construction material and case studies of building construction. Pre- and post-surveys were conducted and the beginning and end of the quarter to assess student learning. Their results indicated that there was an increase in student awareness and understanding of sustainable design concepts that were incorporated on a weekly basis throughout the course and how they can be related to civil engineering projects [Price and Aidon, 2013].

Chau [2007] described the rationale for integrating sustainability concepts into an undergraduate civil engineering curriculum in Hong Kong. Incentives for implementation were addressed, and included: development of more awareness of sustainability principles of graduating civil engineering students; providing the means to design and implement required solutions incorporating sustainability concepts; and providing a holistic approach addressing social, political, and life sciences in addition to physical sciences and mathematics to understand the multidimensional aspects of sustainable development in providing solutions to problems. Barriers to implementation include: the inherent requirement of broad knowledge in sustainability issues; a heavy work load already exists in the curricula; and increasing the content by addition of new concepts may require the loss of other essential material in the curricula. However, focus needs to be maintained on problem solving capabilities, decision making, working in multidisciplinary teams, and wider exposure to different engineering aspects [Chau, 2007]. Initial results of stakeholder evaluations suggest that multidisciplinary skills developed during the learning process may contribute significantly to pertinent knowledge on sustainability.

Clevenger *et al*. [2013] note that sustainability rating systems has been developed and implemented during the past decade to address and reduce the environmental impacts of vertical projects. They also note that during the same period of time, civil infrastructure projects have not received the same attention with respect to sustainability. They reviewed and provided a comparison of six emerging sustainability rating systems: BE2ST-in-Highways, Envision, GreenLITES, Greenroads, I-LAST, and INVEST. Their review indicated that many similarities existed between these six sustainability rating systems. Each rating system evaluates items related to consumption and management of water, energy, and materials. Differences were related to process and implementation requirements, as well as weights assigned among the rating criteria [Clevenger *et al*., 2013].

Muench *et al*. [2010] address the use of Greenroads as a proposed sustainability rating system associated with the design and construction of roadways. Greenroads is a performance metric that awards points for approved sustainable choices/practices; it can be used to certify roadways projects based on achieving a list of project requirements and the total points earned. They indicate that such a standard can: allow informed sustainability decisions; provide a quantitative means of sustainability assessment; stimulate improvement and innovation in roadways sustainability; and provide baseline sustainability standards. Greenroads version 1.0 consists of 11 project requirements, 37 voluntary credits (for a total of 108 points), and a customs credits section. Muench *et al*. [2010] note that the direct use of concrete and concrete contractors can earn up to 42 voluntary credit points available (representing 39% of the total points possible).

Toutanji *et al*. [2013] note that "sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about now environmental, economic, and social systems interact to their mutual advantages or disadvantage at various space-based scales of operation". Their study was designed to establish a baseline understanding of the potential of using sustainability performance measures in the Alabama Department of Transportation (ALDOT). Their study indicated that the present status of addressing sustainability in transportation planning was more focused on the effectiveness and efficiency of transportation systems and the resulting environmental impact, and less focused on economic and social impacts [Toutanji *et al*., 2013].

The literature review offers ample evidence of the value of integrating sustainability into Civil Engineering curricula and provides several case studies demonstrating successful interventions. Building on these efforts, our institutions recognized the need to expose Civil Engineering students to sustainability principles and methods through the introduction of new courses into the existing curricula. This final report discusses the development and pilot testing of a new course on "Sustainability Design and Rating Systems" for combined upper level undergraduate and Masters level civil engineering graduate students.

CHAPTER 2: RESEARCH APPROACH

Project Objectives:

This project develops classroom training materials that focus on new paradigms for transportation and community planning that are more sustainable than traditional ones and have noticeable potential societal, health, economic, and environmental benefits and positive impacts. The objective is to educate students and the transportation/sustainability workforce about the basic principles for green/sustainable design and evaluation such as those employed in the Leadership in Energy and Environmental Design (LEED) for Neighborhood Development (LEED-ND) methodology and the Institute for Sustainable Infrastructure's (ISI) rating system, in an effort to raise awareness on sustainable design options and their associated benefits.

Project Methodology:

This project developed educational resources suitable for providing introductory training on the LEED-ND methodology for students and practitioners. This training provides an overview and understanding of the principles behind the LEED-ND evaluation as well as the specific terminology, content and use of the LEED-ND methodology. Examples of practical tools have been demonstrated to show how they can be used to create more sustainable outcomes of decision

making. The project should open new avenues for the dissemination of information on sustainable community design options to transportation professionals, students, researchers and the general public. Research tasks are described below.

Task 1: *Literature Review* A comprehensive review of the relevant literature took place and relevant materials were collected and organized for potential use in subsequent tasks. The review also considered existing LEED training materials and evaluated their potential incorporation into course modules tailored to serve university students.

Task 2: *Development of Instructional Materials, Beta-testing and Evaluation* This task developed instructional materials for a university level course (upper level undergraduate/graduate level). The course was taught at the University of Alabama at Birmingham (UAB) in the fall semester of 2014. After beta-testing at UAB, the course modules will be refined and updated, and further testing and fine tuning will take place at Georgia Tech. The course was intentionally developed in modules to allow for different modules to be incorporated into existing courses and permit easy tailoring of the material for university students versus practitioners and for knowledge expansion versus certification. Additionally, using selected modules, a short course was developed for the benefit of STRIDE's partnering institutions and agencies. The short course is complete with PowerPoint slides and notes, reference listings, and webinar type presentations. Plans are currently underway to provide a webinar outlining the project and course modules under STRIDE.

Task 3: *Technology Transfer* As part of this task, the educational team identified opportunities to disseminate the information collected and synthesized in this study to a wider audience.

Task 4: Reports/*Final Report* A draft final report was prepared and submitted for review, describing project activities and outcomes. A final report has been produced incorporating comments and recommendations by external reviewers.

CHAPTER 3: FINDINGS AND APPLICATIONS

Literature Review

A number of related research studies have been performed addressing sustainable transportation and rating systems. Samberg *et al*. [2011] identify that there is no internationally recognized standard for determining and evaluating sustainable transportation. Mapes and Wolch [2010] note that until 2008, there was no comprehensive system in place to measure the sustainability of new community developments. Many projects tend to focus on features that increase community attractiveness to potential buyers, but fail to address attributes to enhance environmental and socio-economic sustainability [Mapes and Wolch, 2010]. In another study, Litman and Burwell [2006] describe issues related to the sustainable transport definition, and evaluation and implementation of sustainable transportation. Specific issues addressed included the range of sustainability definitions, the range of issues under these definitions, the range of perspectives, criticisms of sustainability analysis, evaluation of sustainability, transportation impacts on sustainability, sustainable transportation decision making, equity, land use, automobile dependency, community livability, human health, and ecological integrity.

Oswald and McNeil [2010] developed a methodology for transportation rating systems and applied the system to transportation investments, specifically urban corridors. Their study sought to develop a methodology for development of green rating systems. Indicators were used in existing LEED and Green Globes rating systems. LEED-New Construction, LEED-Neighborhood Development, and Green Globes were evaluated for their potential relevance to a corridor rating system by: identifying the existing credits/objectives that relate to transportation (for their application specifically to corridors); evaluating the existing rating system to determine already established credits/objectives that could be adjusted or refined to relate specifically to transportation corridors, and categorizing credits based on politics/governmental regulations; land use site selection/location of the corridor, usage-utilization of the corridor by drivers; pedestrians, cyclists, transit riders, etc.; infrastructure/corridor physical components (including lanes, sidewalks, signals, etc.); and construction/actual redevelopment or new development process of a corridor.

Soderlund *et al*. [2008] described a transportation sustainability rating system, Green Roads, to quantify sustainability practices associated with the design and construction of roads. This rating system rewards credits for approved sustainable choices/practices which can be used to certify roadways projects based on the number of total credits earned. Green Roads consists of 54 possible credits in six categories that can be used to achieve certification. The six categories involve sustainable design (10 credits possible), materials and resources (11 credits), stormwater management (8 credits), energy and environmental control (12 credits), construction activities (9 credits), and innovation (4 credits).

Kevern [2011] presented a framework for incorporating sustainable design/thinking as a new civil engineering course along with experiences from the pilot offering of the course. Green building rating systems (focusing primarily on LEED) were used to introduce sustainability concepts in buildings and infrastructure.

Engineering students should become aware of these and other methods that can be used to assess progress toward meeting sustainability goals and objectives. In the conduct of the extensive literature review, various sustainability rating systems were identified; these rating systems are listed on the following page in Table 1.

Table 1. Summary of transportation system and neighborhood-level development sustainability rating systems [adapted from Brodie *et al*., 2013a].

Year	Rating System	Description	Application
Transportation Systems			
2007	**Greenroads** Developed by the University of Washington and CH2MHILL.	Third-party rating system used across the country and abroad. Roadway design and construction projects that meet a set of required criteria are then scored on their sustainable attributes that surpass current standards.	Roadway design and construction
2008	**GreenLITES** Developed by NYSDOT and modeled on USGBC LEED and Greenroads.	Self-certification program used to integrate NYSDOT sustainability principles into choices for all projects and practices. Scoring is based on a set of criteria and certification levels are determined.	All projects and practices at the DOT level
2008	**STARS** Developed by the North American Sustainable Transportation Council based on LEED and Living Building Challenge.	Performance-based system with an emphasis on planning and development. The pilot scoring system evaluates the full life cycle of transportation projects using both required and additional credits.	Planning transportation projects and programming
2009	**Saga Sustainability Database** Developed by the Sustainable Aviation Guidance Alliance.	Comprehensive and searchable catelog of sustainability practices used by airports in an Excel and web database.	Airports
2010	**BE^{4}ST-in-Highways** Developed in part by the University of Wisconsin-Madison.	Software-supported methodology to quantify benefits of sustainable highway construction. Evaluates and rates life cycle performance of highway design and construction projects using mandatory screening.	Life cycle performance of highway design and construction projects
2010	**Greenpave** Developed by the Ontario Ministry of Transportation in Ontario, Canada.	Rating system used by contracters and consultants of the Ministry to promote sustainable pavement design and construction practices..	Pavement projects
2010	**I-LAST** Developed by Illinois DOT and state American Council of Engineering Companies and modeled on GreenLITES.	Performance metric system used to provide a relative rating of sustainable improvements for highway projects. An extensive collection of guidelines and specifications is used for a pre-project and post- project assessment of sustainability.	Highway projects
2012	**INVEST** Developed by the Federal Highway Administration.	Web-based tool to assist transportation agencies meet individual sustainability goals. Rates three phases of projects (i.e. planning, development, operations and maintenance) based on criteria developed.	Life cycle of tranportation projects
2012	**envISIon** In development by Institute for Sustainable Infrastructure.	Self-assessment tool in development to advance improvements in performance and resilience of the wide range of physical infrastructure. Rating is determined by meeting a minimum number of points in each category.	All infrastructure projects
2012	**Green Guides for Roads** In development by the Transportation Association of Canada.	Self-evaluation tool intended to support decision-making based on sustainability objectives.	Roadway and highway projects
	DuboCalc Developed by Dutch Ministry of Infrastructure and Environment.	Quantifies sustainability over the lifecycle of a project so that environmental performance is used as design principle during the bid process of projects.	Transportation infrastructure projects
Neighborhood-Level Development			
2008	**STAR Community Index** Developed by Local Governments for Sustainability USA.	A framework to assess the triple bottom line of sustain-ability for communities through a rating system with online support tools.	Community development
2008	**One Planet Communities** Developed by BioRegional (UK).	Five-step process (including planning and review) to support solutions for sustainable living based on ten basic principles.	Neighborhood-scale development (design, construction, and management)
2008; Updated 2011	**Enterprise Green Communities** Developed by Enterprise Community Partners.	Certification system that guides the development of affordable housing with green practices and accounts for residents well-being.	Development of affordable housing
2009	**LEED-ND** Developed by USGBC LEED.	Evaluates sustainable development based on principles of smart growth, urbanism and sustainable construction using a credits system for certification.	Neighborhood-scale planning and development
2010	**EcoDistricts Initiative** Developed by the Portland Sustainability Institute.	Approach to creating sustainable neighborhoods by removing implementation barriers and establishing a focus on the social component of sustainability.	Neighborhood-scale with focus on engagement and governance
2012	**TOD Rating Systems** Development by Northeastern University and the CTOD.	Quantifies "high-quality" transit –oriented projects and neighborhoods to establish a basis for public sector support in TOD.	Transit-related projects and neighborhoods
2012	**Green Star Communities** Developed by the Green Building Council Australia.	Rating system that uses a framework of guiding principles to evaluate sustainability practices at all stages of development.	All stages of community development (e.g. policy making, implementation, monitoring)

To better understand the rating systems summarized in Table 1, Tables 2 and 3 were developed to compare and contrast the criteria used in each of the rating systems. Tables 2 and 3 consider both transportation and neighborhood-level development systems, based on the same categories of criteria; they further identify similarities and differences among the criteria used to evaluate and quantify the project, program, etc. [Brodie *et al*., 2013a].

Table 2. Criteria comparison of transportation rating systems [adapted from Brodie *et al*., 2013a].

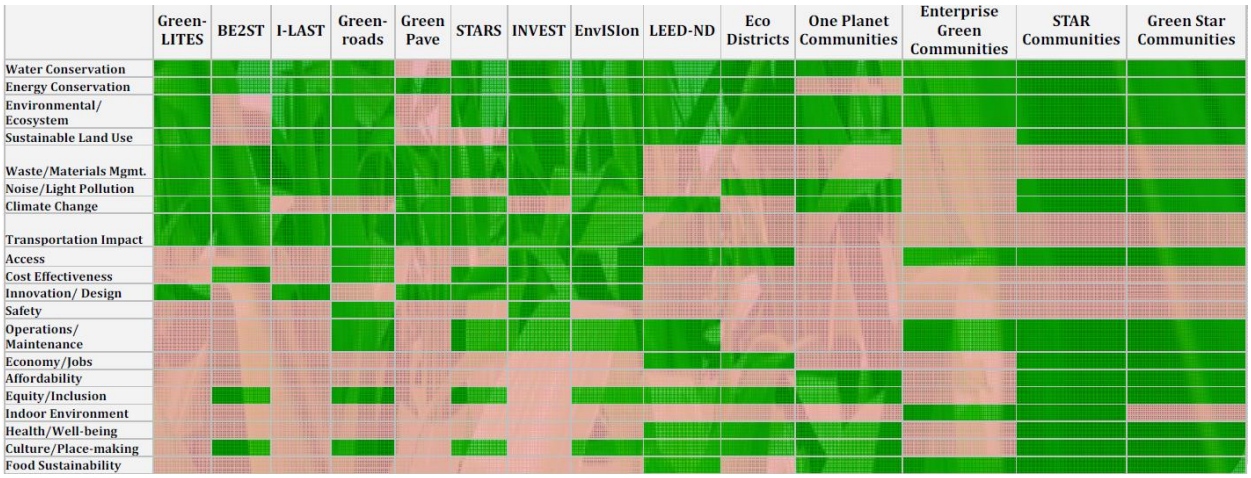
		Transportation							
	Criteria Categories	Greenroads	GreenLITES	STARS	BE^{2}ST	Green Pave	I-LAST	INVEST	EnvISion
Environmental Sustainability	Water Conservation	■	■	■	■		■	■	■
	Energy Conservation	■	■	■	■	■	■	■	■
	Environmental/Ecosystem Protection	■	■	■			■	■	■
	Climate Change		■	■	■	■			■
	Waste and Materials Management	■	■	■	■	■		■	■
	Noise/Light Pollution	■	■		■	■	■	■	■
	Sustainable Land Use	■	■				■	■	■
Economic Sustainability	Innovation/ Design		■	■		■	■	■	■
	Operations and Maintenance	■		■				■	■
	Cost Effectiveness	■		■	■			■	■
	Affordability	■		■	■				■
	Economy/Jobs								
	Transportation Impact	■	■	■	■	■	■	■	■
Social Sustainability	Access	■						■	■
	Safety	■						■	
	Equity/Inclusion	■		■	■				■
	Health/Well-being								
	Culture/Place-making	■		■	■				■
	Food Sustainability								
	Indoor Environment								

Table 3. Criteria comparison for neighborhood-level development rating systems [adapted from Brodie *et al*., 2013a].

		Neighborhood Development					
	Criteria Categories	STAR Communities	OnePlanet Communities	Enterprise Green Communities	LEED-ND	Ecodistricts	Green Star Communities
Environmental Sustainability	Water Conservation	■	■	■	■	■	■
	Energy Conservation	■		■	■	■	■
	Environmental/Ecosystem Protection	■	■	■	■	■	■
	Climate Change	■	■		■		■
	Waste and Materials Management						
	Noise/Light Pollution	■	■			■	■
	Sustainable Land Use	■	■		■	■	■
Economic Sustainability	Innovation/ Design						
	Operations and Maintenance	■		■	■		■
	Cost Effectiveness						
	Affordability	■	■		■	■	■
	Economy/Jobs	■			■	■	■
	Transportation Impact						
Social Sustainability	Access	■		■	■	■	■
	Safety						
	Equity/Inclusion	■	■				■
	Health/Well-being	■	■		■	■	■
	Culture/Place-making	■	■		■	■	■
	Food Sustainability	■	■	■	■		■
	Indoor Environment	■		■			

A condensed listing of selected sustainability rating systems is provided in the poster presentation of Brodie *et al*. [2013b].

Table 4. Summary of criteria in sustainability rating systems [adapted from Brodie *et al*., 2013b].



Development of Course Materials and Teaching of New Course

The materials obtained and collected under Task 1 were critically reviewed, and were used in developing the new upper-level undergraduate/graduate course on "Sustainable Design and Rating Systems". The course provided both transportation and environmental perspectives focusing on principles of sustainable transportation and livable streets, transportation planning and site design for sustainable transportation, transportation sustainability rating systems, brownfield/greyfield redevelopment principles, and sustainable design and ethics. The course was team-taught involving faculty members in transportation engineering and environmental engineering.

Course Scope

The scope of the course revolves around sustainability issues related to transportation and infrastructure. Such issues are of great importance as global concerns about climate change, energy use, environmental impacts, and limits to financial resources for transportation infrastructure require new and different approaches to planning, designing, constructing, operating, and maintaining transportation solutions and systems [CH2M Hill and Good Company, 2009].

The effort resulted in the development of educational resources that focus on new paradigms for transportation and community planning with noticeable societal, health, economic, and environmental benefits. The educational objectives and lectures/modules developed for the course reflect discussions and feedback received from the Southeast Transportation Research Innovation Development and Education Center led by the University of Florida and the Sustainable Smart Cities Research Center at the University of Alabama at Birmingham. The educational resources developed were used as classroom training materials in a newly developed course that aimed at educating undergraduate and first year graduate students about sustainability planning concepts, design options, and rating systems. Students that completed the course were expected to:

1. Understand the role of transportation in sustainable development;
2. Be able to identify planning, and design practices for implementing sustainable transportation systems;
3. Be able to describe and differentiate between sustainable, livable, and smart cities;
4. Be able to describe how brownfield and greyfield redevelopment/revitalization ties in with livable cities principles; and
5. Be able to describe and apply the different rating systems.

The following paragraphs summarize the course development philosophy and delivery approach and share lessons learned.

Approach

Recognizing early on the multidisciplinary nature of sustainability, we formed a team of transportation engineering and environmental engineering faculty members that collaborated closely in the development of educational modules and delivery of the new sustainability course in our institution.

First, we conducted a comprehensive review of the relevant literature and collected and organized relevant materials for potential use in subsequent tasks. These resources helped us formulate an outline for the course content and an extensive working list of references relevant to the topics of interest. While the topic of sustainability is fairly broad, we focused our attention on sustainable transportation, smart location and linkage, neighborhood pattern and design, and green infrastructure and buildings. More specifically, we examined issues related to smart location selection, brownfields redevelopment options, walkability, compact development, mixed-use development options, and designs promoting accessibility for everyone, elements of certified green buildings, building energy and water efficiency, and stormwater, wastewater, and solid waste management infrastructure.

The next step was to develop instructional materials. The course educational materials were intentionally developed in modules to (a) support instructional needs of the new course offering and (b) allow for select modules to be incorporated into existing courses or be used for training seminars to educate practitioners and agencies on issues related to sustainability. Hundreds of PowerPoint slides and notes, reference listings, and webinar-type presentations were developed by module and became available to use as part of the full-length university course offering or as stand-alone modules. Complementing these lectures/modules, guest speakers further addressed sustainability initiatives underway on the UAB campus, and urban hydrology and landscape architecture implemented or a small local community (Mt. Laurel, Alabama) transforming it into a livable/sustainable community by making best use of the site topography. The intent was to develop a range of education modules that fulfills multiple objectives including training of university students and professionals on principles of green design, planning, and/or evaluation methods.

Implementation

A 3-hour semester-long course on “Sustainable Design and Rating Systems” has been developed and delivered on the UAB campus during the fall semester of 2014. A copy of the course syllabus is provided in Appendix I. Appendix II provides additional recommended readings for

the class. The class had 19 enrolled students (8 undergraduate and 11 graduate students). The course was team-taught by Transportation and Environmental Engineering faculty members to address both transportation- and environmental-related aspects of sustainable design.

A series of course modules were introduced focusing on principles of sustainable transportation and livable streets, transportation planning and site design for sustainable transportation, transportation sustainability rating systems, brownfield/greyfield redevelopment principles, and sustainable design and ethics.

The course modules developed for the course included the following:

- Introduction to Sustainability;
- Sustainable Transport;
- Livable Streets;
- Transportation Planning for Sustainability;
- Site Design for Sustainable Transportation;
- Sustainability Rating Systems – FHWA INVEST;
- Sustainability Rating Systems – LEED ND Introduction;
- Sustainability Rating Systems – LEED ND Smart Location and Linkage (SLL);
- Sustainability Rating Systems – LEED ND Neighborhood Pattern and Design (NPD);
- Sustainable Development Rating Systems (I and II)
- Sustainability at the University Campus level;
- Livable, Sustainable, and Smart Cities;
- Megacities;
- Urban Sprawl;
- Brownfield Redevelopment (I and II);
- Greenfield Redevelopment; and
- Urban Hydrology and Landscape Architecture.

The course modules include the lecture materials, allowing instructor/student interactions and discussions. The class time in the course was 75 minutes; the class was offered twice a week during the semester. The course modules/lecture materials are available upon request through the Southeastern Transportation Research, Innovation, Development and Education Center (STRIDE) or from the primary faculty involving in teaching the course: Dr. Robert W. Peters (e-mail address: rwpeters@uab.edu) and Dr. Virginia P. Sisiopiku (e-mail address: vsisiopi@uab.edu). Summaries and objectives of each lecture module can also be provided.

Other sustainability rating systems were also introduced and briefly discussed. Example of rating systems discussed included: GreenLITES, INVEST, Envision, Green Guides for Roads, STAR Community Index, and EcoDistricts Initiative.

The primary course delivery approach involved lectures by the instructors using PowerPoint presentation visual aids. Instructional technology methods (such as use of YouTube video clips, eBooks and other online study resources) were also adopted in the pilot offering in order to keep students engaged throughout the course and offer them unique and exciting learning opportunities. Occasional introduction of relevant short YouTube video clips in the classroom took place that students watched and then answered specific related questions. This technique proved highly

effective as it heightened students' attention, encouraged students' active engagement in classroom discussions, and helped them appreciate the relevance of the course materials. These observations are anecdotal but still consistent with earlier studies that reviewed the impacts of multimedia use on student learning. An example is the work of Berk [2009] who examined the use of video clips in college classrooms and provided a detailed rationale and conceptual framework for the practice.

Interactions between students and professional practitioners were also encouraged through the facilitation of two guest speaker seminars featuring sustainability professionals. Experts suggest that there are multiple advantages of having guest speakers in a class including increasing cultural awareness, promoting social cognition, getting students to listen perspectives of other professionals, and validating the relevance of the class content [Indiana University, 2009]. One invited guest speaker discussed sustainability operations on our university campus, addressing recycling activities, environmental and energy management, alternative transportation initiatives, solar powered electric cars on campus, campus community gardens, etc. The second guest speaker shared information about the redevelopment of a small local community into a livable/sustainable community making best use of the topography of the site. The guest speakers were well received by the class and helped students see how professionals in their field are already using sustainability concepts to benefit peoples' lives and the community in general. Figure 1 below shows the guest presentation provided by Dr. Julie Price, UAB's Coordinator of Sustainability to the class.

Figure 1. Guest presentation by Dr. Julie Price, UAB Coordinator of Sustainability to CE 490/590 Class on "Sustainability Design and Rating Systems"

As part of the class assignments students engaged in literature review and synthesis; individual and group exercises; design activities; and practiced technical writing and communication exercises. The course homework assignments and tests have been provided to STRIDE and are available upon request. In a class project, students worked in teams of three to four to apply Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) principles for evaluation of proposed Community Development Plans or Redevelopment Projects.

The project assignment required teams to:

a. Develop a proposal,

b. Perform analysis, interpret findings, and provide recommendations, and

c. Summarize study and results in a final report and PowerPoint presentation.

Each team conducted an assessment of the principles and resulting LEED-ND scores that would be achieved for the community area plan assigned to them. The selected sites included: Cahaba Heights Community Plan, Calara Comprehensive Plan, Collegeville Neighborhood Development Plan, Fountain Heights Neighborhood Development Plan, and the Highland Park Neighborhood Plan. Each project team (consisting of two graduate and one to two undergraduate students) presented their results in the form of an oral presentation to the class and as a formal technical report. During the presentation sessions, the students went through a peer evaluation exercise rating each one of their peers (except their teammates) on a scale of 1 to 4 on the basis of a. content; b. presentation style, and c. response to questions. They also turned in a form that provided confidential feedback on each teammate's contribution to the project team effort. Overall, the project provided students the opportunity to gain valuable experience in critical review of reports and documents, data gathering and management, use of performance standards to rate sustainability efforts reflected in plans, practicing technical writing, and communication skills, and working in teams.

Evaluation

In terms of class performance, the mean, median, and standard deviation for the quiz were 83.2%, 82.9%, and 8.4%, respectively. The mean, median, and standard deviation for the midterm exam were 87.6%, 88.6%, and 7.3%, respectively. The mean, median, and standard deviation for the final exam were 85.9%, 82.4%, and 6.1%, respectively. The graded class materials included homework assignments, two tests, a final exam, and a class project. The overall class performance resulted in a mean, median, and standard deviation scores of 85.9%, 85.5%, and 5.7%, respectively. These scores indicate that the course content satisfactorily met the course objectives. No course pre-test and post-test was given to the students, but such an approach will be utilized the next time this course is taught.

At the conclusion of the course, students provided feedback and comments regarding the pilot offering through the IDEA survey system. Using this input, the teaching effectiveness was assessed based on: a. Progress on Relevant Objectives, a weighted average of student ratings of the progress they reported on objectives selected as "Important" or "Essential", and b. Overall Ratings, the average student agreement with statements that the teacher and the course were excellent. Seven out of eleven enrolled graduate students and 6 out of 8 undergraduate students provided feedback (68.4% response rate).

Table 5 summarizes student ratings (provided in the IDEA student surveys) of learning on relevant (essential and important) objectives. The feedback from the students is overall very positive with a score of progress toward objectives of 4.8 out of 5.0 reported by graduate and 4.0 out of 5.0 by undergraduate students. As it can be observed, graduate students provided consistently higher ratings than undergraduate students who were less familiar with the course teaching style, and expectations than graduate students and thus more reserved.

Table 5. Student ratings of learning on relevant objectives.

Description of Objective	Importance Rating	Graduate (5-point Scale)	Undergraduate (5-point Scale)
1. Gaining factual knowledge (terminology, classifications, methods,	Essential	4.7	4.2
2. Learning fundamental principles, generalizations, or theories	Essential	4.7	4.2
3. Learning to *apply* course material (to improve thinking, problem solving, and decisions)	Important	4.7	3.8
4. Developing specific skills, competencies, and points of view needed by professionals in the field most closely	Important	4.9	4.2
5. Acquiring skills in working with others as a member of a team	Important	4.7	4.0
6. Developing creative capacities (writing, inventing, designing, performing in art,	Important	4.7	3.3
7. Gaining a broader understanding and appreciation of intellectual/cultural	Minor/None		
8. Developing skill in expressing myself orally	Important	4.7	4.3
9. Learning how to find and use resources for answering questions or solving problems	Important	4.9	4.3
10. Developing a clearer understanding of, and commitment to, personal values	Minor/None		
11. Learning to *analyze* and *critically evaluate* ideas, arguments, and points of view	Important	4.9	3.5
12. Acquiring an interest in learning more by asking my own questions and seeking answers	Important	4.9	4.2
Progress on Relevant Objectives		**4.8**	**4.0**

Table 6 provides a summary evaluation of teaching effectiveness based on the IDEA survey report. It can be seen that students provided excellent ratings in their evaluations of both the teacher and course. These overall ratings serve as another indication of student satisfaction with the course content and delivery and as an expression of their support for the new course offering.

Table 6. Summary evaluation of teaching effectiveness.

	Average (5−point scale)	
	Graduate	**Undergraduate**
A. Progress on Relevant Objectives (See Table 1 for details)	4.8	4.0
Overall Ratings **B. Excellent Teacher**	5.0	4.2
C. Excellent Course	4.6	3.8
D. Average of B and C	4.8	4.0
Summary Evaluation (Average of A and D)	**4.8**	**4.0**

Anecdotal comments provided by students were also positive. One of the evaluations indicated "This was a great class to take. I really liked the format being broken up into two categories taught by two different professors with different specialties. Their knowledge from different disciplines helped me learn." Another student commended: "This class was great. The instructor did a good job bringing her strengths to the class" and "The project schedule was well planned. Content after each class was available immediately."

In summary, the student evaluations were overwhelmingly positive, with more than 83% rating the course as "very good or excellent" and stating that the course met the stated learning objectives and demonstrated substantial effectiveness toward providing students with factual knowledge (terminology, classifications, methods, trends) and teaching them fundamental principles, generalizations, or theories related to the topic of the course.

Observations and lessons learned from the first offering of the course included having more "hands-on" field activities (e.g., field trips, sustainability design assessments, discussion of other sustainability design assessment methodologies, etc.) to further enrich the learning experience in future offerings. The course has long-term value, helping to increase familiarity of sustainability design and rating systems, and should provide scope for new research ideas, and enhance current practices in the field.

CHAPTER 4: CONCLUSIONS, RECOMMENDATIONS, AND SUGGESTED RESEARCH

This research project documented the need for introducing sustainability related courses in the Civil Engineering curricula and the steps taken at our institution to research, develop, and pilot test such a course in fall semester 2014. The new course demonstrated a successful integration of sustainability concepts within a civil engineering curriculum. The pilot course combined knowledge and expertise in transportation and environmental engineering disciplines and fostered a successful interaction between faculty members and students with interests in these fields. This approach addresses best the multidisciplinary nature of sustainability and expands training and

career opportunities for students in civil engineering fields.

The recently introduced "Sustainability Design and Rating Systems" course reviewed planning and design practices for implementing sustainable transportation systems and helped students to better understand and appreciate the role of transportation in sustainable development. Moreover, it introduced and contrasted principles of various sustainability rating systems for transportation and neighborhood development and provided students the opportunity to implement aspects of the LEED-ND rating methodology as part of a group project. Further information regarding the course can be found in the website of the sponsoring University Transportation Center [STRIDE, undated].

Future efforts recommended include further expansion of the topics covered in the class, and adoption of the course materials for teaching the course on-line. Revisions to the course material will include discussions of life cycle analysis and behavior. The course modules could also be used for professional development activities. Venues for presentation of the course materials could also include webinars.

Overall, the work described in this final report builds the foundation for assessment and adoption of sustainable and green urban development and transportation options that would improve quality of life and result in measurable economic benefits. The education modules developed as part of this effort are expected to help traditional and non-traditional students to understand appropriate criteria for selecting projects that meet sustainability and livability priorities, as well as basic design principles that can be used in developing more sustainable project alternatives for consideration in the future. The effort documented in this final report opens new avenues for the dissemination of information on sustainable design options to engineering students while simultaneously supporting training needs of civil engineering professionals, who can benefit from future adoption of developed educational modules into short courses and seminars.

Publications/Presentations Resulting from this Research:

- Sisiopiku, V.P., R.W. Peters, and O. Ramadan, 2015. "Introducing Sustainability Design and Assessment Methods into the Civil Engineering Curriculum", ***Proceedings of the 122nd Annual Conference & Exposition of the American Society of Engineering Education (ASEE)***, Seattle, WA, (June 14–17).
- Ramadan, O., V. Sisiopiku, and R. Peters, 2014. "Sustainability Design and Rating Systems for Transportation: A Synthesis of Practice", Invited poster presentation presented at the 93rd Transportation Research Board (TRB) Meeting, Washington, D.C., (January 12–16).
- Brodie, S., A. Ingles, Z. Colville, A. Amekudzi, R.W. Peters, and V. Sisiopiku, 2013. "Review of Sustainability Rating Systems for Transportation and Neighborhood-Level Developments", Proceedings of the ***Green Streets, Highways and Development 2013: Advancing the Practice,*** ASCE Transportation & Development Institute (T&DI) Conference, Austin, Texas, pp.337–354
- Brodie, S., A. Ingles, Z. Colville, A. Amekudzi, R.W. Peters, and V. Sisiopiku, 2013. "Sustainability Evaluation of Transportation Systems and Neighborhood-Level Development", University Transportation Center (UTC) Conference of the Southeastern Region, Orlando, FL, (April 4–5).

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- Brodie, S., A. Ingles, Z. Colville, A. Amekudzi, R.W. Peters, and V. Sisiopiku, 2013. "Sustainability Evaluation of Transportation Systems and Neighborhood-Level Developments", Invited poster presentation presented at the 92nd Annual Meeting of the Transportation Research Board (TRB) conference, held in Washington, D.C., (January 13–17).

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APPENDICES

Appendix I. Course Syllabus for CE 490/590 (Sustainability Design and Rating Systems).

COURSE SYLLABUS
Fall Semester, 2014
CE 490/590
SUSTAINABILITY DESIGN AND RATING SYSTEMS

Instructor Information:

Instructors:	Robert W. Peters, Ph.D., P.E., and Virginia P. Sisiopiku, Ph.D.
Offices:	210c and 311b Hoehn Engineering Building
Phones:	(205)-934-8434 / (205)-934-9912
E-mail:	rwpeters@uab.edu; vsisiopi@uab.edu
Class Hours:	MW 12:30 p.m. – 1:45 p.m. (3 credit hours) 152 Hoehn Engineering Building
Office Hours:	TTh 4:00 – 5:00 p.m. (Dr. Peters) or by appointment (Drs. Peters and Sisiopiku). Call to confirm appointment.

Course Description:

This is a 3-hour course which addresses LEED-Neighborhood development (ND) principles and other green design applications and rating methodologies. Topics covered focus on sustainable transportation, smart location and linkage, neighborhood pattern and design, and green infrastructure and buildings. The course examines issues related to smart location selection, brownfields redevelopment options, walkability, compact development, mixed-use development options, and designs promoting accessibility for all, elements of certified green buildings, building energy and water efficiency, and stormwater, wastewater, and solid waste management infrastructure.

Recommended Background:

- Introduction to environmental engineering;
- Introduction to transportation engineering;
- Sustainable engineering courses.

Required Texts:

None; course materials will be provided as PowerPoint presentations and class handouts.

Course Goals:

- Learn principles of sustainable transportation, and sustainable transportation planning and design best practices.
- Study sustainability rating systems for transportation and neighborhood development.
- Learn principles regarding livable cities, sustainable cities, and smart cities.
- Be able to describe brownfield and greyfield redevelopment/revitalization activities.
- Be able to describe and differentiate the various rating systems.

Course Objectives:

1. Understand the role of transportation in sustainable development
2. Be able to identify planning, and design practices for implementing sustainable transportation systems
3. Be able to describe and differentiate between sustainable, livable, and smart cities.
4. Be able to describe how brownfield and greyfield redevelopment/ revitalization ties in with livable cities principles.
5. Be able to describe and apply the different rating systems.

Schedule:

First Day of Class:	Monday, August 25, 2014
Last Day of Class:	Wednesday, December 3, 2014
No Class Meeting:	9/1/14- Labor Day
	11/24-28- Thanksgiving
Exams:	10/6/14 and 11/17/14 (tentative)
Presentations:	12/1/14 and 12/3/14
Final Exam:	Monday, December 8, 2014 (10:45 a.m. – 1:15 p.m.)

Course Outline:

1.	Introduction	1 class - VPS
2.	Principles of sustainable transportation and livable streets	2 classes - VPS
3.	Transportation planning and site design for sustainable transportation	2 classes - VPS
4.	Transportation Sustainability Rating Systems	2 classes - VPS
5.	Sustainability rating systems for neighborhoods (LEED ND)	3 classes - VPS
6.	Principles of livable cities, sustainable cities, and smart cities	2 classes - RWP
7.	Brownfield/greyfield redevelopment principles and activities	4 classes - RWP
8.	Rating systems	4 classes - RWP
9.	Sustainable design and ethics	1 class - RWP
10.	Guest Speakers	3 classes - VPS/RWP
11.	Class Presentations	2 classes - VPS/RWP
12.	Exams/Final	3 classes - VPS/RWP

Assignments:

Homework will be due one week after being assigned. There will be two quizzes offered during the semester and a comprehensive final exam. Additionally, there will be a project that will be assigned several weeks into the course, which will be due on Wednesday, November 19th. For the project, you will write up a project report and will make a PowerPoint presentation at the end of the semester to the class.

Grading:

Grading will be determined from the following:

Homework – 10%;
Exams/quizzes – 20% each;
Project – 20%; and
Final Exam – 30%.

Class Expectations:

Attendance and participation in class discussions and activities is expected. Please see the Student Handbook concerning the university's policy on attendance and student conduct. It is your responsibility to obtain any changes to the course syllabus given by the instructor in class.

You are expected to turn in assignments on time. Class participation will also be considered in the evaluation of your grade.

As a consideration to your fellow students, cellular phones, beepers, etc. should be turned off during class so as not to disturb or distract your fellow students.

Academic Misconduct:

It is expected that the results presented on your homework, quizzes, exams, and project will be solely the answers and input provided by the individual student; cheating will not be tolerated. UAB policy states that it "expects all members of its academic community to function according to the highest ethical and professional standards…Academic misconduct undermines the purpose of education. Such behavior is a serious violation of the trust that must exist among faculty and students for a university to nurture intellectual growth and development. Academic misconduct can generally be defined as all acts of dishonesty in an academic or related matter. Academic dishonesty includes, but is not limited to, the following categories of behavior: abetting, cheating, plagiarism, fabrication, misrepresentation."

ABET Course Criteria:

Relationship of Course to Program Objectives: CE Outcome: 1, 3, 5, 6, 7, 11
Correspond to ABET: 3a, 3c, 3e, 3f, 3g, 3k

Design Activities: Some class assignments and examination projects are centered around design problems. Additionally, design activities are required to perform the class project.

Computer Activities: Class assignments may involve the use of the computer and spread sheets in solving the problems.

Laboratory Activities: Class laboratory exercises (homework) and design for class project.

Demonstration of Written Communication Skills: The class project will involve a written report to be handed in by November 19, 2014.

Demonstration of Oral Communication Skills: The class project will involve an oral presentation using PowerPoint format.

Understanding of Ethical, Social, Economic, and Safety Considerations: These are all significant factors related to the design of sustainable, livable, smart cities. Students will be kept aware of current activities involving sustainability/livability principles. Safety is especially important for activities involving urban areas.

ABET Course Orientation: ~ 50% engineering science; and
~ 50% engineering design.

Appendix II. Additional Readings for CE 490/590 Course (Sustainability Design and Rating Systems).

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