Green Building Education and Research at the University of Florida

Charles J. Kibert, Ph.D. and Robert R. Ries, Ph.D.
University of Florida
Gainesville, Florida

In 1991 the M.E. Rinker Sr. School of Building Construction initiated efforts to include green building education and research in its programs. In subsequent years the Powell Center for Construction and Environment was organized as a research, education, and outreach center; the first U.S. Green Building Council (USGBC) student chapter was formed; Rinker Hall became the first green building on the University of Florida campus and the first Gold certified building in Florida; several international conferences and workshops were organized; books and papers on the subject were published; sustainable construction undergraduate and graduate courses were made available; professional groups relative to built environment sustainability were organized; funded research on sustainable construction was obtained; and a significant number of graduate papers, theses, and dissertations were produced by faculty Masters and doctoral students. This paper describes the process of factoring in sustainability as an important issue in construction education, the various courses and programs that were created to address this need, the collateral impacts of this effort at the University of Florida, and the impacts on construction industry in Florida. The lessons learned from this pioneering effort to include sustainability and green building in a construction curriculum provides lessons learned and a potential template for other ASC schools to use in their implementation of green building as an element of instruction.

Key Words: Sustainability, Sustainable Construction, Green Building, USGBC, LEED, Green Globes

Introduction

Construction industry is well-known for its resource and environmental impacts. More than any other human endeavor, the built environment has direct, complex, and long-lasting impacts on the biosphere. In the U.S., the production and manufacture of building components, along with the construction process itself, involves the extraction and movement of 6 billion tons of basic materials annually. Construction industry, representing about 8% of U.S. gross domestic product (GDP), consumes 40% of extracted materials in the U.S. Some estimates suggest that as much as 90% of all materials ever extracted reside in today's buildings and infrastructure. Construction waste is generated at the rate of about 0.5 tons per person each year in the U.S. or about 5-10 lbs per square foot (45-90 kilograms per square meter) of new construction. Waste from renovation occurs at the level of 70-100 lbs per square foot (318-900 kilograms per square meter). The demolition process results in truly enormous quantities of waste with little or no reuse or recycling occurring. Of the approximately 145 million tons of construction and demolition waste generated each year in the U.S., about 92% is demolition waste with the remainder being waste from construction activities. In addition to large quantities of waste resulting from built environment activities, questionable urban planning and development practices also have enormous consequences. Since transportation consumes about 40% of primary energy consumption in the U.S., the distribution of the built environment and the consequent need to rely on automobiles for movement between work, home, school, and shopping results in disproportionate energy consumption, air pollution and the generation of carbon dioxide which contributes to global warming.

To address these issues and also to provide instruction and education about the emerging concept of high-performance green buildings, in 1990 the M.E. Rinker School of Building Construction (the Rinker School) at the

University of Florida began a 15 year process of developing a robust program in *sustainable construction*, that is, how construction industry should respond to the rapidly emerging *sustainable development* imperative, sometimes referred to as *sustainability*. In 1987, the Brundtland Report defined sustainable development as "..meeting the needs of the future without compromising the ability of future generations to meet their need (WCED, 1987). Sustainable construction was defined as "…the design and operation of a healthy, resource-efficient built environment based on ecological principles (Kibert, 1994). The Rinker School program addressing sustainability and sustainable construction has several basic strategies: developing undergraduate instruction, including sustainability topics in existing courses, developing graduate courses and a track in sustainable construction, providing continuing education to industry, organizing and participating in national and international sustainable construction and green building organizations, and developing a research agenda focused on sustainability. These strategies are covered in the following sections.

Sustainable Construction in the Undergraduate Program

The undergraduate program of the Rinker School currently offers two courses to undergraduates: BCN 1582, International Sustainable Development and BCN 4905, High Performance Buildings. In 1996 the Rinker School faculty agreed that undergraduates should also have familiarity with sustainable development and as a result, BCN 1582, International Sustainable Development was created in 1997. BCN 1582 is a mandatory prerequisite course for pre-BCN freshmen and sophomores at the University of Florida. BCN 4905 is a designation for a special topics course that is being used to pilot a new course, in this case, High Performance Buildings. The intent is to transition the latter course into a standard elective offering with the possibility that it could become a mandatory course based on demands from industry and shifts in accreditation policy. Seminars were held for School faculty to make suggestions as to where these topics could also be included as a thread in the wide range of construction courses, much as is the case with estimating and construction safety. For instance, issues of energy conservation and global warming could be addressed in classes covering mechanical and electrical systems while green building materials could be addressed in construction materials and construction techniques courses.

Description of BCN 1582, International Sustainable Development

This course covers the worldwide trend known as sustainable development, which may be described as providing resources and environmental quality for both present and future generations. Sustainable development includes reducing the impacts of the human activities on natural ecosystems and understanding the role these ecosystems have in the economy and on human welfare. It involves understanding the lessons that human society can learn from natural systems and how these lessons can help provide a good quality of life for the planet's population. Many countries around the world have developed policies on sustainable development and a few have either included it in their constitutions or have passed laws requiring its consideration in all activities. Numerous communities worldwide have embraced the notion of sustainability and are implementing Local Agenda 21 to make themselves more self-reliant. Organizations and businesses worldwide are beginning to shift their thinking and behavior using the principles of sustainability. This course covers the fundamental concepts of sustainable development; international, regional and national movements and policies; sustainable community initiatives; and the implementation of sustainable development by various sectors of human activity: agriculture, forestry, manufacturing, construction, government, and higher education. As an integral part of international sustainable development and its practices, a portion of the course also covers the notion of social sustainability, including the impact of consumptive human activities and resulting forms of marginalization, informality, globalization, and homelessness. Understanding the policies and practices of sustainability are understood as fundamental to the long -term survival of the earth. The final 25% of the course addresses the application of sustainability to the built environment. A seminar series was organized and included professionals with national reputations and the resulting book, *Reshaping the Built Environment*, is used as a textbook for this course (Kibert, 1999). A significant number of guest lecturers from various disciplines on campus provide insight into sustainability from a broad range of perspectives.

Description of BCN 4905, High Performance Building

BCN 4905 is a green building class that addresses issues of life cycle sustainable built environment with a focus on construction. The course takes a life cycle viewpoint, including the resources and energy used in producing materials and systems, and constructing, operating, and maintaining the built environment. The course consists of an introduction to sustainability in the built environment covering issues of global environmental significance. This places the activities and processes related to the environmental outcomes of the built environment into a broader context. Fundamental mass and energy flows are examined in order to provide a basic understanding of the implications of material use and energy throughout the life cycle of a building. The approaches and techniques that represent significant opportunities to reduce environmental impact required are examined and discussed. This includes green materials and processes, including construction site operations involving equipment, materials use, waste management, and the impacts on the health and safety of the workforce. The course also examines the green construction process, including commissioning and the impacts of construction on operation, maintenance, and indoor environmental quality. Economic valuation and cost-benefit analysis of high performance buildings and building systems is also addressed. The LEED rating system is covered thoroughly, with key topic areas in LEED linked to in-depth course material throughout the semester. Developing an understanding of the environmental impacts associated with the life cycle of the built environment provides future constructors an understanding of the concepts and framework for environmentally responsible building construction. Students are then able to integrate those concepts in the actual design and construction process in the field.

Sustainable Construction in the Graduate Program

A specialized track in the Masters program was created in 1997 and has evolved to the point that students can obtain specialize in Sustainable Construction. A totally internet delivered version of these graduate courses and the Certificate program are available as part of the School's Masters program in International Construction Management (MICM). The Certificate programs require the student to successfully complete the ICM equivalents of BCN 6585, BCN 6586, BCN 6580, and a 3 semester hour graduate directed research course on a topic of high-performance building. The specialization in Sustainable Construction in the Masters program includes successfully completing these three courses plus a variety of courses on ecological issues, environmental issues, ecological economics, renewable energy systems, ecological design, or urban planning, to name a few.

BCN 6585, Principles of Sustainable Construction, was first offered in 1996 and marked the initiation of a strong graduate track in sustainable construction. Two other graduate courses were developed in 2000 and 2004 to meet growing demand for studies in this discipline. BCN 6586 Construction Ecology covers the links between ecology and the built environment. To address the demand for professionals and students trained in the use of the USGBC LEED building assessment standard, BCN 6580, Green Building Delivery Systems, was created. Each of these courses is described in the following paragraphs.

Description of BCN 6585, Principles of Sustainable Construction

The initial efforts to address the need to consider sustainability in construction occurred in 1995 with the creation of a graduate course, BCN 6585 Principles of Sustainable Construction. The purpose of this course was to consider the environmental impacts of construction and provide instruction about emerging new disciplines such as ecological design, green building materials, healthy buildings, new urbanism, industrial ecology, ecological economics and the ethics associated with these ideas. The course includes a number of hands-o n projects for the students to analyze including Net Zero Energy Buildings, innovative green materials and products, and life cycle costing (LCC) and life cycle assessment (LCA) methods applied to green building projects.

Description of BCN 6586, Construction Ecology

This course has the objective of determining how to apply ecological theory and developments in industrial ecology to create what has often been described as Ecological Design and to consider its application to the built environment. Although Ecological Design or Ecologically Sustainable Design has long been one of the key aspects of sustainable

construction or green building, upon closer examination, contemporary green design approaches lack any true understanding of or incorporation of ecological principles, research, approaches, or key ideas. This course examines the major schools of thought in present day ecology to determine what can be applied either as model or metaphor for green buildings. The new discipline of Industrial Ecology which applies ecology to industrial operations such as manufacturing is examined for approaches that can be applied to Ecological Design. The work of architects attempting to apply ecology in their work is examined to determine the state of environmentally friendly buildings being created using current approaches. Throughout the course subsidiary issues of materials, energy, water, land use, and the integration of the natural and built environments are examined. A workshop that included some of the world's top ecologists, industrial ecologists, architects, and product manufacturers was conducted in 2000 to support this course and the resulting book is now used as a textbook for the course (Kibert et al., 2002). A series of projects including high fly-ash and high blast furnace slag concrete, pervious concrete, rammed earth and compressed earth block, and whole building energy analysis provide challenging and stimulating real world projects for the students.

Description of BCN 6580 Green Building Delivery Systems

The purpose of the course is provide an overview of emerging delivery systems for high performance green buildings and the basis on which their sustainability can be evaluated. The U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) criteria are discussed in detail. LEED for New Construction (LEED-NC) is the main focus of the building assessment portion of the course with LEED for Existing Buildings (LEED-EB) being covered for the sake of comparison. The various categories of LEED-NC such as sustainable sites, energy and atmosphere, water efficiency, materials resources, and indoor environmental quality are covered in detail. Additional topics include construction operations, building commissioning, life cycle costing, life cycle assessment, ecological design, and future directions for green building. Students participate in a simulation of the design and delivery of a green building and produce the required LEED documents for this project. Although not specifically intended for this course, students acquire adequate background to take the USGBC examination to become a LEED Accredited Professional (LEED-AP). Other building assessment systems such as Green Globes are covered and compared to LEED as tools for rating buildings. As was the case with the other graduate courses, a book was written to serve as a textbook to support this course (Kibert, 2008).

Research Programs in Sustainable Construction

The Powell Center for Construction and Environment was created in 1991 and marks the first efforts of the Rinker School to integrate environmental issues into the research programs of the School. The School organized the First International Conference on Sustainable Construction held in Tampa, Florida which also marked the organization of Task Group 16 on Sustainable Construction as part of an international construction networking organization, Conseil International du Batiment (CIB), in Rotterdam, The Netherlands (Kibert, 1994). The Powell Center also organized Green Building Materials '96 held in Gainesville, Florida (Kibert and Bosch, 1996). Members of the Powell Center also started Greening the University of Florida, a campus organization to foster greening of campus operations and curricula and were also instrumental in the formation of a Sustainability Committee appointed by the University President and the Faculty Senate. The Powell Center developed a strong research agenda in the area of building materials, to include reducing construction waste, recycling construction and demolition waste, deconstruction, water recycling and reuse, and rammed earth block and construction. Life cycle assessment (LCA) is an active area of research in the Center, and the research is focused on both methodology and applications. Developing LCA methodology and applications, especially as it pertains to the built environment, is important because the framework can lead to new insights on the environmental impact of the building life cycle. Over 50 Masters students have written their final reports or theses on green building subjects and four doctoral students completed dissertations on green building product economics, LEED costing, indoor air quality optimization, and the building hydrologic cycle and were awarded doctorates. At present eight doctoral students and 15 Masters students are conducting research on sustainable construction topics.

Collateral Effects of Sustainable Construction Efforts

In addition to the research and instructional benefits of the programs in sustainable construction described above there have been several other visible impacts of these efforts at the University of Florida and throughout Florida. The faculty of the School supported the Powell Center's suggestion that the School's new building should exemplify the concept of sustainable construction. The USGBC announced the award of a Gold certification for Rinker Hall, the home of the M.E. Rinker Sr. School of Building Construction at the University of Florida on May 7, 2004. It was rated and certified in accordance with the provisions of LEED-NC 2.1, developed by the USGBC. At the time of the announcement, Rinker Hall was one of only 20 buildings in the U.S. to have been awarded a Gold certification. Rinker Hall is the first University of Florida building designed based on LEED and its success has transformed the University's building program. All future new and renovated buildings on the University of Florida campus must now achieve at least a LEED Silver certification. At present 25 University of Florida buildings are certified or registered with the Library West addition being the second LEED Gold certified building on campus.

Rinker Hall accommodates 450 students on 3 levels in 47,270 square feet of space. The facility has a mix of classrooms, teaching labs, construction labs, administrative offices and student facilities. By using advanced cooling and heating strategies, Rinker Hall uses about one-third the energy of a typical University of Florida classroom building. Organized on a pure north/south solar axis to maximize deep daylighting, the project utilized extensive computer simulation to optimize the balance of natural and artificial lighting systems. From the central public stair and daylight washed atrium to classrooms with large exterior windows, shaped ceiling geometries and deep daylighting louvers, the building is dramatically illuminated by daylight. Exposed circulation structural and mechanical systems assist building construction students in "reading" the building as a whole and understanding how all systems work together. Environmentally 'clean' products and finishes were specified, which, together with minimized moisture carry through, result in dramatically improved indoor air quality. A rigorous Construction Waste Management Plan supporting material resource conservation and recycling were implemented during construction. Over 50% of construction waste materials were recycled through implementation of the Waste Management Plan, which required the contractor to record all construction waste and components re-used, recycled and land-filled. Rinker Hall also has a highly advanced water supply system. Rinker Hall conserves water resources through reduced building water use, building stormwater use, reduced landscape water requirements and full integration with the University's reclaimed water system. Roof captured stormwater is collected and stored in a building catchment tank. This water is then utilized for flushing toilets. Waterless urinals are installed on two floors and remaining fixtures require 20% less water than mandated by building codes. Building wastewater is collected by a University system, which provides initial treatment and then returns the water for site irrigation. Outdoor work areas utilize pervious paving to increase groundwater recharges. Indigenous and low water plantings are used for all site plantings to provide a drought-tolerant, low water use landscape.

Rinker Hall is also used in the instructional mission of the Rinker School. The Rinker School offers the only specialized track in the U.S. in green building in its Masters Degree program and Rinker Hall plays a role by providing a physical example of the principles covered in the classroom. For example, Rinker Hall is designed to be disassembled or deconstructed at the end of its useful life to facilitate reuse and recycling of its components. However, its award winning design and the positive response of the faculty and students who use it mean that it is likely to be in use for a very long time.

In addition to the impacts at the University of Florida, the effects of this shift in thinking also affected the construction professions in Florida. A course called "Build Green and Profit," designed for continuing education of builders and subcontractors, has been delivered to over 5,000 people. A professional education course on the LEED building assessment system, "Learning to LEED," was developed in 2007 and is delivered throughout Florida to include to project teams engaged in specific green building projects. To-date over 2,500 construction professionals have attended the course and many have successfully passed the LEED-AP exam. A significant number of green buildings, green developments, and green residences have been or are now being built in Florida. The Florida Green Building Coalition is an active force in green building in the state and five professional chapters of the USGBC are active in promoting green building (Orlando, Miami, Jacksonville, Tampa, and Gainesville). Construction companies throughout Florida now have graduates of the University of Florida program who have been exposed to high-performance green buildings and are aware of the benefits of sustainable construction. The result is that the industry in Florida is being rapidly transformed by these graduates with the added benefit of positioning their

companies to be partners in green building projects because they are readily qualified to become LEED Accredited Professionals, generally an added advantage for these projects. In addition to these benefits, the construction side of the building industry has been the leader in green building in Florida and are more recently being joined by the design professions.

Summary and Conclusions

The building construction program at the University of Florida began the incorporation of sustainability into its curriculum and research almost 15 years ago and has developed courses and programs that have resulted in students being well versed in the issues of green building, green building standards, low impact construction methods, building health, construction waste reduction, recycling of construction and demolition debris. The result has been that builders in the State of Florida are now aware of the issues of high-performance buildings and have taken the leadership role afforded by the success of the Powell Center and Rinker School in incorporating sustainability and sustainable development into its curriculum. Robust research and continuing education programs insure a continuing exchange of information and technology between academia and industry in Florida. In Florida, with its rapidly growing population, the efficient use of resources and the protection of a good quality of life afforded by a clean, healthy environment are needed to assure the sustainability of construction industry itself. By creating win-win situations in which both the environment and industry profit in the delivery of high-performance green buildings, the Rinker School is helping pave the way for the future, long-term success of the construction industry.

References

Kibert, C.J. (Ed). (1994). *Proceedings of the First International Conference on Sustainable Construction*, Tampa, Florida, 6-9 November 1994.

Kibert, C.J. and Bosch, G. (Eds). 1996. Proceedings *of Green Building Materials '96*, Gainesville, Florida, 5-8 May 1996.

Kibert, C.J. (Ed). (1999). *Reshaping the built environment*. Washington, DC: Island Press

Kibert, C.J., Sendzimir, J. and Guy, G. (Eds). (2002). *Construction Ecology*. London: Spon Press Limited.

Kibert, C. J. (2008). *Sustainable Construction: Green building Design and Delivery*., 2nd Edition, New York: John Wiley & Sons, Inc.

WCED. (1987) Our Common Future. The World Commission on Economic Development. Oxford University Press.