Sustainability in Engineering Design and Construction

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Sustainability in Engineering Design and Construction

This book is dedicated to the students who encouraged the authors to write it so they would be able to learn more about sustainable design and construction and to all of the youth who are interested in preserving the planet for future generations.

This book is also dedicated to Colten Guerra, the 4-year-old great nephew of Dr. Yates, who has a long battle ahead of him fighting cancer.

Dr. Castro-Lacouture dedicates this book to his wife Paula and his children Eva, Matias, and Camilo.

Preface

The purpose of this book is to introduce sustainability and sustainable practices to members of the engineering and construction (E&C) industry and to provide insight into how to design and construct sustainable structures. Information is presented on why sustainable practices are being used, how they are being implemented, and what the potential benefits of their use are for members of E&C firms.

This book is unique because it not only addresses the sustainable aspects of buildings but also covers sustainable practices during engineering design and construction operations for all types of E&C projects. Many books focus on the sustainability certification rating systems used for evaluating buildings after they are complete, and these rating systems are mentioned in this book, but the main focus of this book is on providing information on how to address sustainability in all of the E&C industry sectors during engineering design and construction operations.

The first part of the book, Chapters 1 through 3, provides background information on sustainability, sustainable development practices, corporate social responsibility, supply chain management, early adopters of government sustainability objectives, barriers and drivers for implementing sustainable development practices, sustainability in the construction sector, domestic and foreign environmental regulations, sustainability global reporting initiatives, the social and community impact of projects, the environmental impact of production operations for construction materials, and global environmental management standards.

The first part of the book also includes information on the global treaties influencing the incorporation of sustainable practices into engineering design and construction operations such as the Kyoto Protocol Treaty, Basel Convention, Rio Declaration, and Stockholm Convention. It also presents information on clean development mechanisms, joint implementation practices, carbon sinks, and emissions credits. The environmental laws affecting E&C professionals working in the United States are covered to illustrate their impact on engineering designs and construction operations.

The middle part of the book, Chapters 4 through 10, presents information on sustainable designs; selecting sustainable sites; designing for passive survivability; designing for disassembly; and information on the ISO 14000 standard. It also discusses life-cycle cost assessment models and how to quantify all of the sustainable impacts on construction including the overall costs of materials taking into consideration cradle-to-grave economic and environmental costs. The middle section of the book also provides a summary of the results obtained from a research investigation into how sustainable practices are already being integrated into E&C firms and projects. Information is provided on how sustainability techniques are being used in the E&C industry, and on corporate- and project-level sustainability practices. The last part of the middle section of the book discusses global sustainability trends and implications and provides samples of some of the environmental degradation mitigation strategies being used throughout the world.

The third part of the book, Chapters 11 through 15, covers specific sustainability concepts and processes by including detailed information on sustainable construction materials and processes, heavy construction equipment, and traditional and alternative energy sources. It also provides background information on the Leadership in Energy and Environmental Design (LEED) Green Building Rating System and many other sustainability organizations and certification programs such as the International Green Construction Code, the Building Resource Energy and Environmental Assessment Model (BREEAM), Green Globes, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) comprehensive assessment, Chartered Institute of Building's Sustainability and the Construction Industry in the United Kingdom Building for Environmental and Economic Sustainability (BEES) Stars, Green Advantage, Green Star, Green Guide to Specifications, British Standards Institute BES 6001, Responsible Sources Model, the Sustainable Sites Initiative, Design Quality Indicators, Civil Engineering Environmental Quality Assessment and Award Scheme, Los Alamos National Laboratory Sustainable Design Guide, the World Green Building Council, Green Guides to Specifications, United Nations Environment Programme, the Sustainable Building Alliance, GreenRoads, Green Building National Standard that incorporates NSI/ASHRAE/IES/USGBC Standard 189.1–2104, and others.

The last part of the book, Chapter 16, includes implementation resources developed during a research investigation funded by the Construction Industry Institute and conducted by Research Team 250, called Sustainable Industrial Engineering and Construction. The Research Team 250 members were from E&C firms and government agencies, and their names and affiliations are included in our "Acknowledgments" section. The implementation resources included in this book are a Sustainability Quick Start Guide, two Sustainability Maturity Models, a Sustainability Index Metric, and a Checklist for Evaluating the Sustainability of Construction Jobsite Operations. These implementation resources are used by members of E&C firms to help them implement sustainability programs and to evaluate the sustainability of engineering designs and construction operations. To illustrate how the checklist for evaluating the sustainability of construction jobsite operations is implemented on projects, Appendices D through F include three sample sustainability project execution plans developed using the checklist for actual construction projects located in Arizona, North Carolina, and Pennsylvania.

This book provides information on (1) definitions for sustainability terms, (2) sources for locating global sustainability requirements, (3) current sustainability issues and sustainable designs, (4) environmental laws related to sustainability and their implications, (5) sustainable design, (6) life-cycle cost assessment models, (7) sustainable practices currently being used in the E&C industry, (8) corporate-level sustainability practices, (9) project-level sustainability practices, (10) global sustainability trends and implications, (11) sustainable materials, (12) sustainable heavy construction equipment, (13) traditional and alternative energy sources, (14) the LEED Green Building Rating System, (15) sustainability organizations and certification programs, (16) sustainability implementation resources, and (17) a summary of sustainable engineering design and construction.

The end of each chapter contains a list of key terms, discussion questions, and references. Appendix A includes a list of commonly used acronyms and organizations related to sustainable practices along with their definitions. Other instructional materials and resources are available for educators, including PowerPoint lectures for each chapter, solutions to the discussion questions at the end of each chapter, and sample examination questions. These materials and resources are available at https://www.crcpress.com/product/isbn/9781498733915

The underlying theme of this book is to enhance the use of sustainability practices by providing information on how to incorporate sustainability practices into engineering designs and construction operations in all of the E&C industry sectors. Sustainability practices not only are evaluated after a structure is completed but they also need to be integrated into the designs, materials, processes, and operations used to build structures.

Acknowledgments

Environmental consciousness increased during the last half of the twentieth century, and a resurgence of environmental concern occurred during the beginning of the twenty-first century. One of the major drivers for implementing sustainable practices at the beginning of the twenty-first century was the youth who came of age during this period. They are concerned about the state of the environment, and the environmental consequences they have inherited affecting their world.

It was university engineering and construction students who asked the authors to develop a course on sustainability in engineering design and construction so they could be more informed about their role in improving the environment for future generations. The discussions about sustainability that the authors had with students led to a research investigation on sustainability in the industrial construction sector that contributed to the body of knowledge already available for the building sector. Many aspects of the research were incorporated into lecture materials that the authors used in engineering and construction courses and the final result is this book, which captures for engineering and construction students and industry professionals information that helps them provide sustainable services to clients and improve the environmental aspects of society.

The authors thank the members of the Construction Industry Institute for funding the sustainability research project and acknowledge the contributions of the members of Research Team 250, made up of 14 representatives from construction firms, owner organizations, and government agencies. The Research Team 250 members and the firms they were working for during the research project were as follows:

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sustainable practices in the engineering and construction industry. Their contributions to this book are greatly appreciated by the authors.

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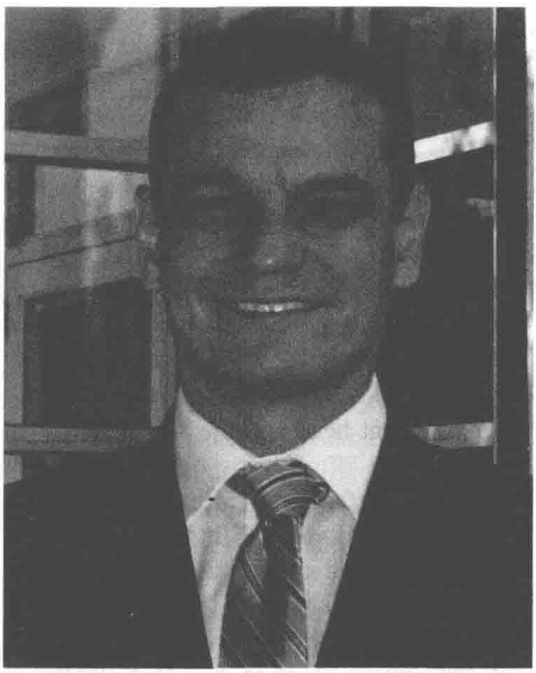
Authors

J. K. Yates, PhD, emeritus professor and currently a civil and construction engineering consultant, is a former dean of the College of Engineering Technology at Ferris State University, Big Rapids, Michigan, which is one of the largest colleges of engineering technology in the United States. She was also formerly the department head and the Joe W. Kimmel Distinguished Professor of Construction Management in the Department of Construction Management in the Kimmel School of Construction Management and Technology at Western Carolina University, Cullowhee, North Carolina. Dr. Yates was previously a professor and department chair in the Department of Construction Management and Engineering at North Dakota State University; in charge of the Construction Engineering and Management focus area in the Civil and Environmental Engineering Department at Ohio University; and program coordinator for the Construction Engineering program in the Civil and Environmental Engineering Department at San Jose State University in California. Dr. Yates was also a professor at New York University Polytechnic School of Engineering (formerly Polytechnic University and Brooklyn Polytechnic) and at Iowa State University, along with being a visiting professor at the University of Colorado for one year.

Dr. Yates earned a Bachelor of Science degree in civil engineering at the University of Washington and a PhD in civil engineering at Texas A&M University, College Station, Texas, with minors in global finance and management, global political science, business analysis, construction science, and archeology/anthropology.

Dr. Yates has worked for several of the top ranked domestic and global engineering and construction firms, as a consultant during legal cases, and on international contracts. Dr. Yates is the author of eight books and numerous refereed journal articles and is a former member of the American Society of Civil Engineers, Project Management Institute, and American Association of Cost Engineers International. Dr. Yates received the Distinguished Professor award from the Construction Industry Institute (CII) in 2010 and from Polytechnic University in 1994, the Associated General Contractor's Outstanding Construction Professor in America in 1997, one of the *Engineering News Records*' "Those Who Made Marks on the Construction Industry" in 1991, and in 2001 one of the principal investigators on a project that received the Ron Brown award for industry/academic collaborations with the Hewlett Packard Foundation. Dr. Yates has traveled for work and pleasure to 25 countries and worked in Bontang, East Kalimantan on the island of Borneo in Indonesia.



Daniel Castro-Lacouture, PhD, PE, is a professor and chair of the School of Building Construction, College of Architecture, Georgia Institute of Technology, Atlanta, Georgia. His overall area of interest consists of defining and deploying evaluation protocols for technology innovations in the built environment, focusing on areas affecting the built environment from both operational and sustainability perspectives. An Excellence in Civil Engineering Education (ExCEEd) Fellow, Georgia Tech Class of 1969 Teaching Fellow, and Colfuturo Scholar, Dr. Castro-Lacouture is a registered professional engineer and associate editor of *Automation in Construction*; he was chair of the American Society of Civil Engineers (ASCE) 2014 Construction Research Congress; and he has worked in construction engineering and management positions in both the public and private sectors.

Dr. Castro-Lacouture has been a member of governing boards and organizations at the local, national, and international levels, such as the Architecture/Construction/Engineering (ACE) Mentor Program of Atlanta, the American Society of Civil Engineers' Construction Institute North Georgia Chapter, the Green Advantage Certification Board, the International Council for Building (CIB) Working Commission W117 on Performance Measurement in Construction, and the International Association for Automation and Robotics in Construction (IAARC). He has taught 26 undergraduate and graduate courses and was corecipient of the best paper award at two international conferences. He earned his bachelor of science degree in civil engineering at the Universidad de Los Andes, Colombia; masters of science degree in construction management at the University of Reading, United Kingdom; and PhD in construction engineering and management at the School of Civil Engineering, Purdue University, West Lafayette, Indiana.

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