

Annie R. Pearce, Yong Han Ahn and HanmiGlobal

Sustainable Buildings and Infrastructure

Paths to the Future

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SUSTAINABLE BUILDINGS AND INFRASTRUCTURE

Paths to the Future

*Annie R. Pearce, Yong Han Ahn
and HanmiGlobal*



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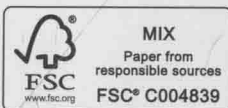
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SUSTAINABLE BUILDINGS AND INFRASTRUCTURE

Construction is one of the biggest industries in the world, providing necessary facilities for human prosperity ranging from the homes in which we live to the highways on which we drive, the power plants that provide energy for our daily activities, and the very infrastructure on which human society is built.

The construction sector, including the building sector, has among the largest potential of any industry to contribute to the reduction of energy and greenhouse gas emissions. This ambitious and comprehensive textbook covers the concept of embedding sustainability across all construction activities. It is aimed at students taking courses in Construction Management and the Built Environment. Written in a lively and engaging style, the book sets out the practical requirements for making the transition to a sustainable construction industry by 2020. Case studies are included throughout, making the book both a core reference and a practical guide.

Annie R. Pearce is an Associate Professor in the Department of Building Construction, Myers-Lawson School of Construction at Virginia Tech specializing in sustainable facilities and infrastructure systems. Her areas of expertise include metrics of sustainability for built facilities, green building materials and systems, cost modeling to support sustainability implementation, and in situ performance of sustainable facility technologies.

Yong Han Ahn is an Assistant Professor in the Department of Construction Management at East Carolina University and a leader of the Sustainable Design and Construction Management (SDCM) research group. Dr. Ahn's research and teaching focuses on motivating students, the construction profession and the wider construction industry to incorporate sustainability into their practices.

HanmiGlobal Co., Ltd. currently a member of the U.S. Green Building Council (USGBC), is a global project and construction management company with a subsidiary in the U.S. (OTAK, Inc.). Being the first company to provide LEED consulting services in the Republic of Korea, they have accumulated experience and capabilities to meet the requirements of the USGBC. HanmiGlobal has been ranked as the 18th largest PM/CM firm of all non-US based firms by the Engineering News Record (ENR).

This book is dedicated to a sustainable future for the built environment
and new ways of thinking for the people who occupy it.

Foreword by Jong Hoon Kim

HanmiGlobal has established environmental standards for high performance buildings and eco-friendly infrastructures. These environmental standards conform to the standards of sustainability we have established. It is our goal to create future construction management practices in our projects that will employ project/sustainable techniques through continuous research and development of new technologies.

Our effort is not only a passive approach to reducing the corporate carbon footprint, but also to proactively participate in the global sustainability business. In moving forward with these issues, our company is interested in preparing a sustainability business which includes: sustainable design management, sustainability knowledge support and sustainability due diligence. We will also undertake research and consulting on Green Buildings and new renewable energy resources.

In order to initiate our vision of sustainable management practices, we have enacted sustainability policies with the joint applications of ISO 14001, LEED (Leadership in Energy and Environmental Design), BEMS (Building Energy Management System), and other global environmental policies. By providing a total solution concept using optimized sustainable guidelines, HanmiGlobal plans to develop into a sustainable PM/CM consultancy, from the design process to construction.

However, is it possible to provide sustainable construction using only pre-established environmental standards and systems provided?

It is more important to establish a workable tool for construction professionals to understand both the administrative and the technical requirements of a sustainable construction project. This book draws attention to the current way of thinking and offers practical approaches to sustainability. In addition, the book will call for contributions concerning sustainability concepts, theories, and case studies to combine better decision making with practical relevance to sustainable developments.

We are pleased to collaborate with Professor Annie Pearce at Virginia Tech and Professor Yong Han Ahn at East Carolina University in order to conduct research about sustainability opportunities throughout the construction lifecycle to establish the best practices in industry standards. We are very satisfied with the outcome of this research and look

forward to seeing the results implemented as a guideline for sustainable project management.

One of the most critical issues in the current construction industry concerns not only green building issues and high efficiency structures, but also the need to form an ecological balance with the environment. We hope this publication provides readers with an overall understanding of sustainable building and practical business cases that will encourage the government, construction experts, and students who are interested in sustainability objectives to present approaches to future projects.

Jong Hoon Kim
Chairman & CEO of HanmiGlobal

Foreword by Norbert Lechner

Sustainability is now widely recognized as a major priority in all sectors of the economy, and the building sector is especially important because it is a major consumer of both materials and energy, with buildings consuming about 50 per cent of the energy in the United States. The consumption of materials not only depletes our physical resources, the process of getting raw materials from the ground into the fabric of a building being constructed requires huge amounts of energy that then becomes embodied in the finished building. The endless depletion of our material and energy resources is certainly not sustainable. However, the greatest threat by far is climate change brought about by global warming. Both the operational and embodied energy required by buildings comes mainly from the burning of fossil fuels which are rapidly increasing the carbon dioxide content of the atmosphere. There is no sector of the economy that is causing climate change as much as the construction sector.

In the process of creating a building, the early decisions have the greatest impact (see Figure F1). Although the actual construction comes late in the process, constructors have critically important knowledge at all points in the design process. Before the first line is drawn, the

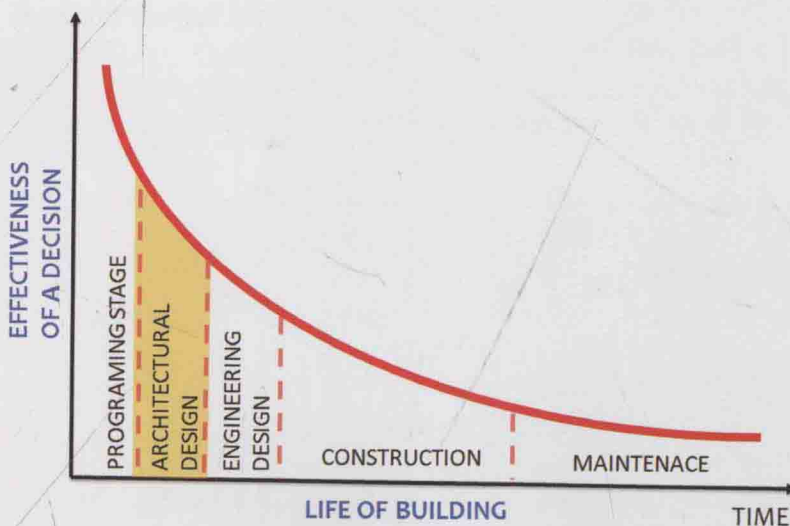


Figure F1 The change in the effectiveness of a decision over the life of a building

architect needs the knowledge of both the engineers and constructors in order to design a sustainable building. However, that knowledge must be integrated by the interchange of ideas by the building professionals. Thus, from the very first step in the building process, it is necessary to use the team approach in order to create high-performance sustainable buildings. Low-performing buildings are not acceptable because they will not create a sustainable future.

This very comprehensive and scholarly book presents the knowledge needed by the constructor for construction to be sustainable, and the numerous case studies anchor this book in reality. It presents the drivers of sustainability, its history, and the required policies and programmes. The book gives an in-depth description of the available green rating systems as well as the opportunities in project delivery and pre-design for the constructor. It also provides information on sustainable design strategies to help the constructor be a more effective member of the design team.

The many opportunities for saving energy and materials during the actual construction process are covered in the book. Since constructors are in an excellent position to help in post-occupancy activities and strategies, the book explains how they can help to maximize energy savings.

Fortunately, there are many immediate benefits to sustainable design, and the book makes it clear that many sustainable practices are good for business. The last chapter lays out the trends for the future of sustainable design and construction, which will only increase with time. Since the world's population and affluence will both keep increasing, there will be a continuing need for not only more buildings but ever more complicated buildings. Building professionals well informed about sustainable design will be in great demand, and this book is a great resource for creating sustainable constructors.

Norbert Lechner, Professor Emeritus, Auburn University

Foreword by Jerry Yudelson, Yudelson Associates

In the past decade, sustainable building construction and operations have taken on increasing importance, as the realization has dawned that buildings contribute, directly and indirectly, to nearly half of global carbon dioxide emissions. Indeed, the entire modern green building movement has shifted to a strong focus on building sustainability, as measured by energy and water use. This is not to diminish the importance of other green building attributes such as land use, material and resource conservation, transport alternatives and indoor environmental quality, but rather to emphasize the need to focus on a broad spectrum of building key performance indicators (Building KPI's).

Sustainable Building and Infrastructure: Paths to the Future addresses the opportunities for the construction industry to work with design, finance and operations to achieve sustainability goals that have global importance. There are goals internal to the process by which buildings are procured, including the important role of Integrated Project Delivery systems, along with the increasing use of Building Information Modeling (BIM) as a design and construction tool for the industry.

In this book, the authors focus on sustainability opportunities in four key areas: pre-design, design, construction, and operations or post-occupancy practices. Each is important in its own right, but equally important is the over-riding need to integrate them into a seamless system, so that the business case for sustainability can rest on a firm foundation of industry practice.

How can this be done in actual practice, when schedules are ever shortened and budgets ever reduced? Perhaps the most fundamental rule is this: begin with the end in mind! If the end is a truly sustainable built environment, then the project will begin with this goal, which will find expression in site selection, the building program and a close alignment of goals with user needs. At the beginning of design, a fundamental best practice is to bring together all stakeholders in a one-day (or longer) eco-charrette, in which the environmental goals begin to find form in alternatives for building form.

During the design process, we find that more architects each year are beginning to realize that "form follows performance" in sustainable buildings. In other words, if zero net energy is a goal and on-site energy production (typically with solar power) will only yield "x" amount of energy, then the design must result in a building energy use no more

than “x.” That in turn, begins to dictate window area ratios, envelope design and so forth.

Equally important are the use of early stage energy modeling and a full range of BIM tools to speed design while resolving conflicts between systems and meeting budget and schedule requirements. During later design stages and into procurement and construction, there will be opportunities to introduce high-performance building products and systems into the project. Then, the “hand off” to occupancy and operations must be accomplished smoothly, through processes such as building commissioning, operator training and similar means. Lastly, there should be a commitment to Post-Occupancy Evaluation that provides a feedback mechanism to design and construction as to how well the sustainable systems actually perform.

The Building Team must adapt quickly to new technologies, products, processes and systems, if it is to be seen as an integral part of the sustainable solution to a growing number of economic, environmental and social issues in the global economy. Indeed, the next big challenge facing the Building Team is not just making the individual building more sustainable, but working to create sustainable cities for a global population that will be three-quarters urban dwellers by 2050. To accomplish this goal, it is vital that tools such as BIM be used not just for building construction documents, but as a complete support system for building sustainability.

I am confident that books such as this will serve a noble purpose in bringing the entire Building Team into a more harmonious relationship with sustainable construction and operations and, in so doing, help to solve significant and pressing global problems facing urban civilization.

Jerry Yudelson, PE, LEED Fellow
Tucson, Arizona
October 2011

Preface

Imagine this: you are given a very important task to complete, one that is too complex to do alone. You must spend millions of dollars to get it done, work closely with people you have never met before, and finish the work with limited time and resources. Every decision will be monitored closely, and you are likely to have less money to complete the project than you need. Now imagine that everyone on your team speaks a different language, has different and sometimes conflicting interests, and uses different tools and techniques to do their part. Imagine further that you may not even be allowed to talk to each other some of the time. Your solution has to remain valid and useful for 30 years, 50 years, or even 100 years or more, although the environment in which it is used and the uses to which it will be put will change dramatically over that time in ways you cannot imagine. Imagine that if you fail to complete your task as assigned, very bad things could happen – people could become ill, be injured or killed. If you make a mistake, the penalties could be staggering.

Feel the pressure? This is the world of modern construction, in all its technical and legal complexity. Now add a whole range of additional challenges: new codes, standards and environmental requirements, a very competitive market with extremely low profit margins, well-informed clients who have new ideas that they aggressively want to implement on their projects, and thousands of components with different attributes and sources in the marketplace. Imagine further that your clients want you to keep track of each of those components, where they came from, and the problems that were created in their manufacture or will be created during and after their service life. You also have to understand how they should work together, connect them all in the right ways, and verify that those connections were made correctly so that the project meets your predictions for performance. Finally, put this all in the context of a world where our actions as a species appear to be leading to runaway changes on a global scale. We don't know what those changes will be, exactly, but we know they will affect the kinds of resources available in the future, the ecological and socio-political conditions in which our buildings must perform, and the expectations of the people who use and rely upon our creations during their life-cycle.

We wrote this book because we recognize the challenges facing the people who create the built environment. As educators and

practitioners, we are acutely aware of the complexity inherent in the construction industry, both technical and otherwise. Even as new technologies emerge to improve the performance of constructed systems, there is evidence to suggest that we do not even use existing technologies as effectively as we could. We have dedicated our lives to try to make things better, and we hope this book will play a role in achieving that outcome.

We want the next generation to inherit a world that has fewer, not more, problems than our generation has had to face. Many of those problems have been caused in large part by the built environment and the legacies of how it has been constructed over time. We see enormous challenges in figuring out how to fix those problems, but we also see enormous potential for change and a whole host of opportunities. Solving the problems that result from our industry will take the contributions of many people working together, but we believe it can be done.

This book is a tool for those who seek to change the architecture, engineering and construction (AEC) industry. It was designed to offer a new way to think about how we create the built environment, along with a sampling of promising technologies and practices, and a look ahead to what the future may hold. The first two chapters provide an introduction to why sustainability is important for stakeholders of the built environment and an overview of the history of past efforts to make our built environment more sustainable. These chapters lay the foundation for understanding both the human and organizational dimensions of the problem, discussed in Chapter 3, and the technological and process dimensions over the building life-cycle, discussed in Chapters 4 to 8. In Chapter 9, we use a detailed case study to illuminate how these dimensions come together in a real project, and we show how decisions can be analysed according to the economic criteria that shape how most organizations operate. Finally, in Chapter 10, we offer our best projection of what the future holds for our industry. Each chapter also has a section on upcoming trends and a set of questions for reflection and discussion. We hope these resources will help our readers consider what is to come as they develop a strategy for sustainability for their own organizations.

We welcome your comments about what this book does well, and how it could be better in future editions. We hope you find it useful both for learning more about built environment sustainability and as a tool for day-to-day practice. Please contact us with your comments and good ideas, and we wish you well in your quest for sustainability.

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Annie R. Pearce and Yong Han Ahn

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