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FORWARD:
Sustainable Construction at the Start of the 21st Century

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INTRODUCTION

This Special Issue of the International Electronic Journal of Construction (IeJC) has Sustainable Construction as its theme. The purpose of this Special Issue is to examine the state of Sustainable Construction one decade after the movement started and, coincidentally, as we enter the 21st Century. The authors of the papers in this volume were all specifically invited to address issues both in their own countries as well as internationally. Each of them is an acknowledged international authority on Sustainable Construction as well as a well-known thinker and doer in their discipline. A review of these papers will reveal that they cover a wide range of current developments and concerns and provide insights from a wide variety of perspectives. Hopefully readers will come away with a far deeper understanding of the progress, current trends, challenges, and obstacles of contemporary Sustainable Construction.

The IeJC is primarily an internet-delivered, electronic journal with an international Editorial Board, and originally developed at the M.E. Rinker School of Building Construction (an academic unit of the College of Design, Construction and Planning of the University of Florida). The Rinker School's history of involvement with Sustainable Construction predates the actual formal movement itself. The Powell Center for Construction and Environment (the Powell Center) was founded in the Rinker School in 1991 for the purpose of helping construction industry, at that time construed in the narrow sense of builders, to address and minimize their obvious impacts. In 1991 we did not clearly understand the full magnitude of materials, energy, and water consumption; the generation rates of construction and demolition waste; nor were the concepts of deconstruction and materials reuse established; nor had the concept of ecological design been articulated. However the Powell Center faculty and staff did intuitively understand the obvious problems of waste and inefficiency. Research projects proposed by the Center began measuring waste generated from new construction and developing and delivering educational programs to inform industry of the problem and potential solutions. The terminology, Sustainable Construction, was originated at the Powell Center in 1992 and the First International Conference on Sustainable Construction, organized by the Powell Center and Task Group 16 (Sustainable Construction) of Conseil International du Batiment (CIB) was held in November 1994 in Tampa, Florida. Earlier in May of the same year CIB Task Group 8 (Building Assessment) held its Buildings and Environment Conference in England. The U.S. Green Building Council (USGBC) held its first conference in Washington, D.C. in March of 1994. Consequently the early 1990s mark the start of what now appears to be a significant and possibly permanent shift in the construction landscape, the advent of Sustainable Construction in its many varied forms. At present dozens of conferences on topics related to Sustainable Construction are held each year. Numerous books, journals, and publications are available and students can now obtain degrees in subjects like ecological design and Sustainable Construction. Research centers on Sustainable Construction have now been organized in several countries. Hundreds of new products that support the goals of Sustainable Construction are entering the marketplace. Universities are teaching dozens of

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courses on Sustainable Construction issues and offering degrees in this and related areas. On the surface, at least, it would appear that Sustainable Construction and other similar efforts are a significant success story and that an irreversible momentum that will eventually encompass all building types is well-established. The actual situation however may not be so upbeat and Sustainable Construction still faces a significant uphill battle to both achieve its desired philosophical and technical ends as well as to become an economic success story. In fact economics, philosophical foundations, and technical solutions are all tightly coupled together and Sustainable Construction can only be achieved if the economic rationale can be successfully articulated.

ESSENTIAL BACKGROUND TO SUSTAINABLE CONSTRUCTION

The international effort to shift construction industry onto a path parallel to the overarching sustainable development movement is only about a decade old. Referred to as *Sustainable Construction*, this effort addresses the entire life cycle of building: their planning, design, construction, operation, modifications, renovation, retrofit, and ultimate disposal. According to a definition proposed by Task Group 16 (Sustainable Construction) of Conseil International du Batiment (CIB), an international construction research networking organization with headquarters in Rotterdam, The Netherlands, Sustainable Construction is "… the creation and operation of a healthy built environment based on resource efficiency and ecological principles." Figure 1 depicts the relationship of the various life cycle stages, required resources, and proposed principles of Sustainable Construction (Kibert, 1994). The basic 'stuff' or resources needed for construction are materials, energy, water, land, and, in the spirit of sustainability, ecological systems. The latter is included because it is becoming ever more apparent that ecosystems can and should be integrated with buildings to provide a wide range of services such as heating, cooling, stormwater uptake, environmental amenity, waste processing, and even food. The timeline for the built environment runs from planning through deconstruction or building disassembly. The principles proposed for Sustainable Construction include: reduce, reuse, and recycle resources; protect nature in all activities; eliminate toxic substances from construction; apply life cycle economics in decision making; and create a quality built environment (aesthetics, durability, maintainability, to name a few quality aspects).

New approaches to decision making are the hallmark of Sustainable Construction. *Life Cycle Assessment* (LCA) is used to compare materials and products to help decide which approaches have the least impact. LCA involves a detailed examination of all the energy, materials, and water consumed and the waste and emissions created in the product life cycle, from resource extraction (mining, logging, harvesting) to material and product manufacture, to final installation in the building. It also includes the impacts of transportation between all these stages. A wide range of tools have been developed for implementing LCA in practice, for example ATHENA (Canada) and BEES (U.S.). *Life Cycle Costing* (LCC) is an economic analysis technique that examines not only the first or capital cost of a project, but also the operational costs, including energy, water, and maintenance costs. Sustainable alternatives, often more expensive in a first cost sense, provide cost saving when all costs are included. Detailed energy analyses and daylighting simulations are being used to achieve greatly reduce energy profiles for the new class of high performance green building resulting from Sustainable Construction. Advanced engineering tools such as *Computational Fluid Dynamics* (CFD) are being employed to help assess difficult to model phenomena such as natural ventilation, chimney effects, and passive heating and cooling. Used primarily for resolving difficult computational problems such as aircraft and spacecraft design, CFD is also being used to create radical building cooling technologies, for example *radiant cooling*. Radiant cooling involves passing cold water through hollow building elements such as wall and floor sections, and the achievement of space cooling by radiation rather than forced convection.

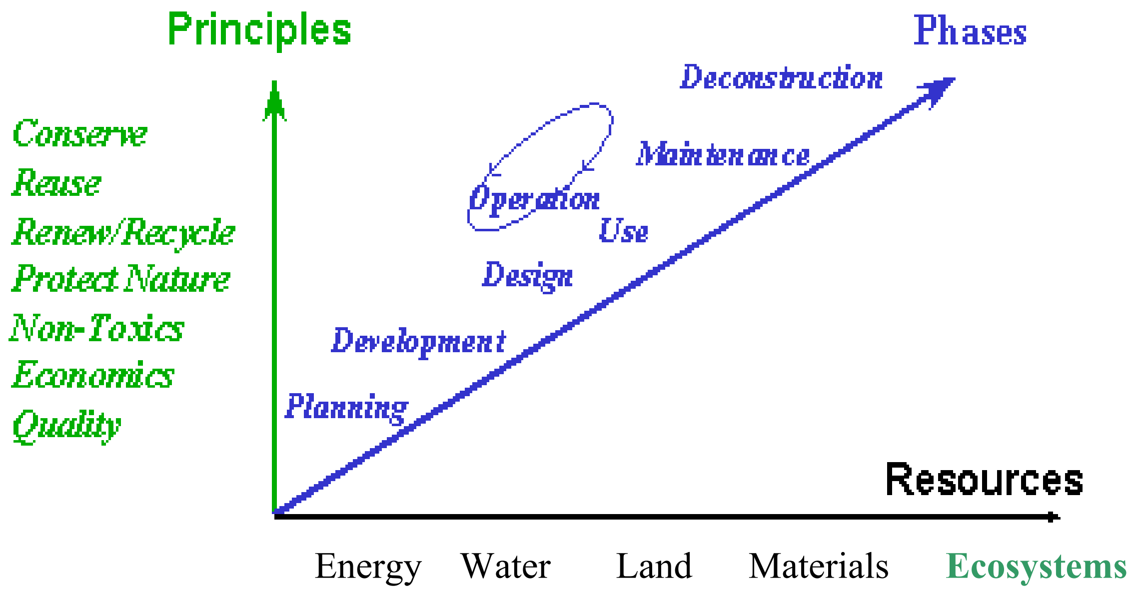

Figure 1: *Sustainable Construction: Life Cycle Stages, Principles, and Resources (after Kibert, 1994)*

Supporting disciplines that address the various life cycle stages of the built environment are emerging to support the shift to Sustainable Construction (see Table 1). Planning in a sustainable fashion can use the emerging concepts of *New Urbanism* (NU), *Transit-Oriented Development* (TOD) and/or *Conservation Subdivision Design*. New Urbanism, alternatively referred to as *Traditional Neighborhood Development* (TND), proposes to replace the typical American suburban dominated urban landscape with urban landscapes that mimic the classic, pedestrian, mixed use, mass transit dominated cities people cherish. These include European cities such as Paris, London, and Rome, to name a few, and American cities such as New York, Boston, and Chicago. Cities such as Atlanta and Los Angeles are cited as the antithesis of the classic city because the automobile becomes the dominant species accompanied by dehumanizing sprawl. Conservation Subdivision Design, proposed by Randall Arendt (1999), directly tackles the issue of suburbs by proposing homes be concentrated on smaller sites and that the land saved as a result be set aside as biological preserve that also has the function of providing environmental amenity.

Incorporating ecosystems into the urban fabric is addressed in *Biourbanism* while at large scale, *Bioregionalism* performs much the same role (Williams, 1999). *Ecological Design* is the foundation of the design stage of the life cycle, covering architecture, landscape architecture, interior design and engineering (civil, structural, mechanical, and electrical). Ecological design is also applicable to building changes during the operational phase (Van der Ryn & Cowan 1996; Van der Ryn & Peña 2002). The construction and operational stages do not specifically have 'green' approaches associated with them, but these are certain to emerge in the near future. At present it is sufficient to refer to these as *Green Building Construction* and *Green Facilities Management*. Renovation and retrofit are again covered by Ecological Design. Building disposal at the end of a building's useful life, in a sustainable senses, can occur using the emerging new approach know as *Deconstruction*.

The good news is that these supporting disciplines are helping to accelerate the implementation of Sustainable Construction. The bad news is that the key new discipline for implementing Sustainable

Construction, Ecological Design, contains very little actual ecology in its contemporary form and needs significant attention and development if design is to be truly transformed to create sustainable buildings.

Table 1: *Conventional Built Environment Life Cycle Stages Compared to Sustainable Construction Stages*

Life Cycle Stage	**Conventional Built Environment**	**Sustainable Construction**
Planning	Urban Design	New Urbanism Transit Oriented Development Conservation Subdivision Design Biourbanism Bioregionalism
Design	Conventional Architecture Conventional Landscape Architecture Conventional Interior Design Conventional Engineering	Ecological Design
Construction	Building Construction	'Green' Building Construction
Operation	Facilities Management	'Green' Facilities Management
Renovation/Retrofit	Conventional Design	Ecological Design
Disposal	Demolition	Deconstruction

REVIEW OF SPECIAL ISSUE CONTRIBUTIONS

The papers in this Special Issue of the IeJC are organized in a logical order in the Index and for professionals, academics, and students new to this topic, reading them in this order would probably most beneficial.

The Special Issue starts off with a contribution from Chissna du Plessis, from CSIR, the national center for construction research in South Africa. Her paper, "Boiling Frogs, Sinking Ships, Bursting Dykes and the End of the World as We Know It" sets the tone for this volume and challenges the state of the art in Sustainable Construction. She acknowledges that significant progress has been made in the past decade but that we may have unwittingly put ourselves on a path of limited possibilities because we are trying to address problems needing solutions in a fashion that could be called Einstein's Paradox. Simply put, Einstein noted that problems cannot be solved by using the same thinking and thought processes that created them. The Paradox then is: can we realistically create a sustainable built environment if nothing substantial is being changed with respect to energy generation, building climate conditioning, design, the construction process, operations, and disposal, to name a few things that are not really changing. Chrissna suggests that Einstein was in fact correct and that we desperately need to think outside the box, leaning heavily on ecology, biomimicry, and a wide range of other nature-based approaches that have been largely ignored by what may be called mainstream green buildings.

Ray Cole, Professor of Architecture at the University of British Columbia, is perhaps the most prominent international authority on building assessment, a process that creates a score or rating for a building. In his paper "Building Environmental Assessment Methods: A Measure of Success" he addresses how building assessment is changing. Building assessment as used today has several potential purposes. First it can be used to demonstrate how well a building meets generally accepted criteria for Sustainable Construction. Second, it can be a useful means for comparing building performance to others of the same type. Third, a well-crafted building assessment method or system can be used to inform and guide design by providing performance measures that indicate what high performance means across a wide range of resource, environmental, and health factors. He notes that the first building assessment systems, for example BREEAM (Building Research Establishment Environmental Assessment Method) in the U.K. and LEED (Leadership in Energy and Environmental Design) in the U.S., were created to score the "greenness" of buildings. Today there is discussion of how building assessment can address the built environment's contribution or lack of contribution to achieving sustainability. He also discusses the inherent difficulties and challenges in trying to address complex issues such as sustainability using relatively simple tools such as building assessment systems. He suggests that these assessment tools will have to be reinvented to maintain their vigor and potency and that what must still be resolved is how building assessment systems, largely successful as market transformation tools, can also respond to broader notions of sustainable development.

Peter Graham from the Royal Melbourne Institute of Technology (RMIT) in Melbourne, Victoria, Australia provides an overview of assessment and design tools available in Australia in his paper "The Role of Environmental Performance Assessment in Australian Building Design". He suggests that a desire has emerged to determine the environmental performance of buildings and that accountability for this performance is becoming of increasing importance in Australia. He describes the variety of tools available to help determine a building's environmental performance. These include life cycle assessment (LCA) tools, energy modeling tools, and building rating schemes. He shows how these tools can be used not only to determine the impacts of a given building, but also, and more importantly, guide to design process to achieve performance objectives. He also acknowledges that many of these tools have their subjective aspects, for example the weighting processes used to indicate the relative importance of various issues and that this can inhibit their usefulness. Nonetheless significant progress has been made and the groundwork has been laid for new and improved tools to aid in the design of high performance buildings.

Thomas Lützkendorf is a professor at the University of Karlsruhe in Germany and he provides insights on progress in Sustainable Construction in Germany in his contribution, "The Future of Sustainable Construction: Situation and Trends in Germany." He covers in detail the Sustainable Construction scenario in Germany, to include policy, building assessment, ecological assessment of construction products, design and assessment tools, and the role of building certificates. He concludes that the successful application of sustainable development in the building sector is not only dependent on new products and technologies, but also on the collaboration of all the actors in the building process, working together to insure that the positive ecological character of buildings translates to immediate economic advantage for the actors.

Economics are certainly an important factor in the success of any new approach in construction, to include Sustainable Construction. Demand for Sustainable Construction is influenced by buyer perception of the first costs versus life cycle costs of sustainable alternatives. Kevin Grosskopf, an assistant professor in the M.E. Rinker Sr. School of Building Construction at the University of Florida, addresses consumer willingness to pay in his paper "Investing in 'Green' Building Alternatives: U.S. Consumer Willingness-to-Pay." He focuses his attention on the specific case of single family residential home construction in Florida and uses a survey instrument to determine the tradeoffs between capital cost and return on investment (ROI) that home buyers are willing to make for sustainable alternatives. He found that some of this willingness to invest in sustainability components was a function of age and income. People that are older and have higher incomes are twice as likely to invest in high performance green building alternatives than younger people who have lower incomes. The positive news from his investigation is that over 90% of the respondents were willing to invest in green building alternatives having capitol cost or long term savings benefits.

A new approach to addressing waste in the disposal phase of the built environment is *Deconstruction* or disassembly rather than demolition of buildings, accompanied by maximizing component reuse and materials recycling. Two contributions about deconstruction are provided in this Special Issue of the IeJC. Both major authors are members of CIB Task Group 39 (Deconstruction) and their work has contributed to the rapid progress in making deconstruction mainstream.

The first is from Abdol Chini and Stuart Bruening, a professor and graduate student respectively in the M.E. Rinker Sr. School of Building Construction at the University of Florida. Their paper is“Deconstruction and Materials Reuse in the United States,” and it covers the status of this approach in the U.S. in great detail. The authors address the wide range of deconstruction and materials activities presently underway in the U.S. Particularly noteworthy is the progress in developing methods for recertification of dimensional lumber recovered from a wide range of wooden structures, especially homes and barracks from decommissioned military bases. The U.S. Forest Products Laboratory has been effective, in cooperation with other research organizations, in developing draft visual grading standards for regrading the extracted lumber. The result of regrading is to double the value of materials that as a result of regrading can potentially be used as a direct replacement for virgin lumber in construction. Other deconstruction related activities covered in this paper are in-situ building reuse and relocation of existing buildings to new building sites.

In his contribution, “A Model-Based Approach for the Management of Deconstruction Projects,” Frank Schultmann of the German-French Institute for Environmental Research in Karlsruhe, Germany shows how optimization techniques can be applied to scheduling deconstruction activities to make them more efficient and hence more economical. He shows how a model-based approach that focuses on environmental and economic goals can reduce the time and cost of deconstruction by at least 50% and increase the recycling rate to over 90%. He uses the concept of material-flow management and applies it to deconstruction projects as a starting point for creating mathematical models that can be processed by optimization programs.

Lars Myrhe and Trine Pettersen, both of the Norwegian Building Research Institute in Oslo, discuss the general state of Sustainable Construction in Norway in their paper “Sustainable Construction in Norway: Climate Change and Energy Challenges.” They discuss the role of buildings in their relationship to climate change and meeting the targets of the Kyoto protocols. Due to the availability of cheap hydroelectric power Norway has the highest per capita use of electric energy in the world. Economic trends and growing consumption, together with a lack of incentives for creating energy efficient buildings, have resulted in a situation where Norway must now import electric power. Additionally there has been increasing construction of coal-fired power plants that have major implications for Norway’s contribution to global warming. The authors provide a strategy for reversing the trend of increasing electrical consumption by shifting to renewable energy sources such as windpower, the use of heat pumps and improving building regulations to dramatically reduce energy consumption.

In the final paper, “The Challenge: Proposals for Strategies and Targets towards Sustainable Building”, Peter Schmid, Professor Emeritus of Architecture at Eindhoven Technical University, provides insights about the current problems and issues of ecological design. He covers the roots of where we are today, starting with survival, still an issue in many parts of the world and eventually leading to the recognition that this is the only planet we have-there is simply no place else for us to go. The net outcome is that we have to consider significant reductions in consumption to survive and begin the process of long term planning. The barriers to change are first and foremost the current economic system, followed by government policy, and then issues of technology. He suggests that the challenge for all of us is to demand quality, not in the sense of ‘more’ stuff but in the sense of ‘less’ destructive life styles. He offers a strategy that he calls Method Holistic Participation (MHP) as a means for interdisciplinary cooperation and collaboration for building consensus that can bring about appropriate solutions. He also emphasizes the need to rely on renewable energy and materials resources and presents a specific system, the Straw

Panel System (SPS), as an example of a materials approach that has the virtue of being renewable, relatively low technology, and able to be produced by local industry.

SUMMARY AND CONCLUSIONS

As noted in the Introduction, papers in this Special Issue are a compilation of the most recent thinking of an international cross-section of practitioners, researchers and thinkers who have dealt with issues of Sustainable Construction since its inception. Substantial progress has in fact been made. There are robust green building movements in many countries, with new products and services emerging every day to provide additional support. Research centers worldwide are devoting substantial time and resources to the investigation of Sustainable Construction concepts, tools, technologies, materials, energy systems, water conservation, and many other connected matters. National and local governments are adopting high performance building standards. Universities are offering degrees in Sustainable Construction and related disciplines. In spite of all this progress, the fact is that there is a long way to go for a new movement that has scarcely scratched the surface of creating buildings that can be remotely called 'sustainable'. Peter Schmid has referred to the need for a 'radical Sustainable Construction,' a notion seconded by Chrissna du Plessis in her paper in this Special Issue. Until buildings and their supporting resource systems are totally based on renewable resources, consume a factor 10 less resources than conventional buildings, are deconstructable and the components able to be totally reused and recycled, are designed using as yet unknown ecological principles, are integrated into a sustainable urban plan, are healthy for their occupants, process their waste using biological systems, and have a host of other similar features, sustainability in the built environment will be just a distant objective. Hopefully it is not just a grand illusion. The bad news is the journey is a long and difficult one and we are only in day 1 of an incredibly long process. The good news is that we have at least started on this difficult path and are beginning to understand the basic concepts needed to achieve sustainability in the built environment. Hopefully we will be able to shift from Sustainable Construction to 'radical Sustainable Construction' and start thinking, as both Chrissna du Plessis and Peter Schmid suggest, out of the box using thinking substantially different than the thought processes that caused us to be in the very difficult situation we now find ourselves.

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