

BRIDGING THE GLOBE

Engineering and Construction Solutions for Sustainable Development in the Twenty-First Century

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In every nation of the world, the designers of the built environment shape the way the world population uses the physical infrastructure to live, travel, and work. As the economies of the world continue to expand, designers are faced with the challenge of leading future development in a way that protects and conserves environmental quality and the natural resources base. Future development undertaken in a sustainable manner represents new ways of thinking in planning, designing, building, operating, and maintaining the built environment.

In February 1996 in Washington, D.C., world leaders met to forge international partnerships with common research agenda to guide design, engineering and construction practices essential to support the quality of life for a growing world population and meet the challenges of the twenty-first century.

This four-day meeting, *Engineering and Construction for Sustainable Development in the Twenty-First Century: An International Research Symposium and Technology Showcase*, marked the second assembly in a continuous process by the Civil Engineering Research Foundation (CERF) designed to accelerate innovation and the application of research in engineering and construction within the context of environmental sustainability.

Planning for the 1996 Symposium centered on the development of a series of white papers corresponding to focus areas targeted by an earlier Delphi study undertaken by CERF. These focus areas are **management and business practices, design technology and practices, construction and equipment, materials and systems, and public and government policy**.

More than 700 government, industry, and academic leaders of the worldwide industry attended the symposium. Of the 300 invited leaders that participated in working sessions throughout the week to identify and describe the critical research needed by the design and construction industry to achieve sustainable development, almost half were from thirty different countries. Their joint collaboration produced *thirty-eight research prospectuses* that will guide the formation of partnerships and the development of mechanisms for the implementation of projects promoting sustainable development by the engineering and construction community. *These prospectuses are highlighted below. CERF will be pleased to work with the participants of the CE&M workshop to focus on the progress to date of one or more of these initiatives.*

The Prospectuses

Symposium participants set about the task of producing prospectuses that would turn the group's vision into reality. The participants went about their work by subdividing into five focus areas and nineteen breakout groups. The focus area groups were comprised of management, design, construction, materials, and policy. Collectively, members of these focus area groups produced thirty-eight prospectuses, which addressed six crosscutting areas, or "enabling foundations," that define opportunities to advance sustainable development through innovative constructive technology. These enabling foundations are Learning, Education, and Training (E); Information Systems and Technology Transfer (T); Performance Specifications and Global

Standards (**S**); Modeling and Measuring Systems (**M**); Demonstrations and performance Testing (**D**); and Integration Delivery Systems (**I**). Each of the prospectuses described below carries the letter identification of its crosscutting issue.

Focus Area 1: Management and Business Practices

Symposium participants committed to "develop new approaches to management and business practices through advances in technology and promotion of planning, education, communication, and research." Management Focus Area members produced nine prospectuses to address this objective.

⌘ Managing Sustainability in Project Selection (M)

Owners of constructed facilities usually consider direct costs and regulatory requirements in selecting constructed facilities. Often ignored are other considerations such as renewability, recyclability, and reuse, energy consumption, operating cost, waste and pollution reduction, and risk and liability. These should be incorporated into an owner's decision process. This prospectus proposes to field test and conduct demonstrations to provide information based on the operation and maintenance cost of these facilities to help owners become familiar with sustainable construction opportunities that ultimately increase the likelihood they will be adopted.

⌘ Developing Risk Guidelines for Construction Industry Stakeholders (I)

Risk assessment in the design and construction industry needs to be better understood. This work proposes that the industry develop an information technology-hazards database for different types of construction. Existing risk analysis methods and techniques, case studies, and success stories would be incorporated into the database and updated, which leads to a better understanding of risks and assigning risks.

⌘ Establishing Consensus Construction Goals (I)

The many stakeholders in a construction project often have differing goals, especially in the case of international projects. This prospectus proposes convocation of key stakeholders in the development and use of built facilities to identify goal-setting processes and benchmark high-performance strategies. These groups would produce reports on their findings, such as handbooks on the process that could be used by other practitioners and provide the basis for an international program of education for all types of stakeholders.

⌘ Enhancing Innovation through Updated and Streamlined Construction contracts (I)

Current standard conditions of construction contracts are deficient and result in contract forms that are not reflective of current practice and have been shown to impede innovation. These standard forms are often unilaterally modified; creating adversarial conditions and resulting in claims and litigation that negatively affect the performance of the worldwide construction industry. This prospectus proposes that organizations involved in the preparation of such standard contract documents collaborate to find solutions to the problem of inadequate standard conditions. A steering committee will define the longer-term development of contract criteria and update the "families" of documents.

⌘ Establishing Affordable Sustainable Construction Objectives (E)

This prospectus addresses the cost impact of achieving sustainability. The work should develop a framework for allocating costs and benefits, develop methods for observing these

values, and report on the implications for design, construction, materials, operations, and human resources. Anticipated outcomes of the research will include a model for conducting cost-benefit analyses that involve sustainability. These models should include examples and case studies, and electronic tutorial for distribution on the Internet, and applications across various projects in the public and private sectors.

Avoiding Adversarial Relationships (I)

Adversarial relationships have resulted in suits and other detrimental actions. This prospectus recommends a number of such actions to promote understanding and encourage cooperation: reports and training courses should address the construction process and the impacts that various parties' actions can have on the outcome of a construction project; manuals of best practices for the administration and management of contracts; and continued education of all parties, including public authorities, on the problems and solutions for dealing with adversarial relationships in the construction process. The use of popular trade journals and other news media should encourage the industry's communication with the public. Training must take place at colleges, workplaces, and community centers to educate future stakeholders on cooperative methods for resolving potential disputes.

Incorporating Performance Criteria into the Design and Construction Process (S)

This work addresses the establishment of a performance-based framework for specifying and evaluating qualities of construction products and systems without restricting design and construction industry innovation. Prescriptive restrictions in regulation and procurement practices suppress innovation. The testing of products for compliance with performance concepts can be costly and often lacks a scientific basis. Often, stakeholders lack experience and expertise working under performance concepts. This prospectus establishes a benchmark of current performance practices in the construction industry to produce standards and codes for testing; to develop manuals, testing mechanisms for approval of nonstandard products, and model procurement systems and contract documents for performance concept implementation.

Developing Virtual Project Delivery Systems (T)

Information technology (IT) systems for the construction industry to date have been driven by technological approaches, instead of focusing on the more general management approach to projects, including planning, organizing, leadership, and controls. New IT-based "virtual" delivery systems are available that, if applied, could lead to cost reduction, increased productivity, improved quality, and efficiency. To begin to develop virtual project delivery systems, this prospectus conducts a global inventory of existing systems, develops global standards, identifies risk management issues, and encourages common educational curricula.

Promoting the Seamless Knowledge Transfer in Construction (T)

The design, construction, and operation of constructed facilities requires timely and accurate information. Often this information exists but is dispersed and not uniformly presented. The absence of consistent and common protocols impedes the awareness, transfer, and accessibility of this information, holding back innovation and increased efficiency and productivity. This prospectus proposes to address these constraints through the creation of an easily accessible database. This process involves the inventory of existing efforts, the development of information transfer protocols, the bringing together of key stakeholders in the international design and construction industry to facilitate the establishment of a customer base, and the design of a commercially viable mechanism to reward participation.

Focus Area 2: Design Technology and Practices

Symposium participants committed to "effect informed decisions about the functions, forms, and uses of resources through improvements in design procedures, methods, tools, and global human capabilities." Design Focus Area participants proposed four prospectuses aimed at addressing this objective.

⌘ Reinventing Design Concepts for the Twenty-First Century (M)

The design process currently is limited in its degree of openness or involvement of stakeholders. There is a gulf between the design industry's concerns that is driven by constraints imposed by the incentive systems for designers and the environmental-sustainable concerns of the public. The existing system lacks the flexibility needed to respond to customer and societal needs and desires, especially as it pertains to sustainability issues. The objective of this proposal is to develop and document principles of the design process that will transform current development patterns to a sustainable built environment. Specifically, this prospectus recommends a collaborative process involving all stakeholders to define sustainable development patterns, practice, and measures as it pertains to design, and to establish new process, guidelines and tools for the design industry that reflect these concerns.

⌘ Sharing the Sustainable Design Knowledge Base (S)

Designers currently rely heavily on their own personal experiences. This situation exists in part because of a lack of readily accessible information on global design practices and experiences. This prospectus proposes to address this deficiency by establishing and international clearinghouse, through the collaborative efforts of the design community and government, for the exchange of information on design principles and practices.

⌘ Forming Consensus Performance Criteria for Sustainable Facilities (T)

There is a growing appreciation of the need for society to account for sustainability in their actions. There is no consensus that defines sustainability for facilities that feature political, social, economic, and technical consideration. This prospectus recommends that the industry convene a working group of key stakeholders to establish consensus on sustainability in facilities and to develop the methods for defining, benchmarking, measuring, monitoring, and disseminating results. Participants should commit to share relevant information, which would be managed by a lead organization. Results would be disseminated to industry.

⌘ Establishing Education and Training Programs to Advance Sustainable Design (E)

This prospectus recommends the development of basic design education that incorporates the multidimensional nature of design for sustainability. Design education will address broader scopes and engage the full range of stakeholders to become more effective. This work would develop specific collaborative education programs and initiatives through a multiple strategic alliance of educators, practitioners, professional associations, and funding sources. The expected outcome of the prospectus would include a curriculum for education in sustainability; the engagement of multiple constituencies from pre-college through the professional level, to public education; and a specific pedagogical and technological infrastructure. An international conference on education for sustainability, involving practitioners, academics, and accrediting bodies should be held to address its implementation.

Focus Area 3: Construction and Equipment

Symposium participants committed to "achieve an efficient and sustainable construction and equipment industry and support all participants in the engineering and construction process through improved access to data, information, decision support tools, and automated operations." Construction Focus Area members proposed seven prospectuses to achieve their goal.

 **Establishing International Standards of Conduct and Ethics (E)**

Legal and government practices restrict innovation in the construction industry. This prospectus proposed to establish an Ethic Council to develop standards of professional conduct to review, determine, and sanction violations; and to assist in ensuring that society is adequately protected as industry seeks new and innovative approaches. Information would be collected on this issue, including a review of various countries' systems and an assessment of benefits and costs. The council would serve as a professional watchdog to help ensure that all parties are treated equitably.

 **Creating a Global Construction Forum to Advance Innovation (S)**

The construction industry is large and diverse; its fragmentation hinders effective information sharing. A uniform and open system to share and advance infrastructure technologies would improve construction practices. This prospectus would establish a global forum through the coordinated efforts of international organizations to facilitate sharing information on innovation, to support each other's recognition of innovation, to disseminate results, and to track the commercialization of innovative technologies.

 **Using Demonstration Projects to Encourage Construction Innovation (D)**

Innovation in the design and construction industry is slowed by a lack of real-world experience on the cost and benefits of innovation technologies and systems. Users are unwilling to try new concepts that have no proven track record. This work encourages construction industry organizations to actively promote demonstration projects through recruiting projects, obtaining financing, developing risk-sharing mechanisms, and documenting and reporting on progress. Construction industry organizations with an interest in demonstrations should collaborate to gain maximum leverage from this effort.

 **Forming an International Dynamic Project Database for Construction (T)**

During the past twenty years, vast improvements in manufacturing efficiency and productivity have been made through an improved information flow and automation. The construction industry stands ready to realize similar benefits with the development of methods to ensure a seamless flow of project information. This prospectus recommends the development of a dynamic project database of 3-D design data, architectural schematics, engineering data, material selection criteria, vendor and manufacturing information, and other information that needs to be communicated throughout the useful life of a construction project. This work proposes an assessment of current standards and capabilities; a definition of an open architecture that maintains flexibility; the development of a test-bed for implementation; and the development of collaborative protocols with organizations with analogous situations, such as the military with battlefield logistics.

 **Achieving Sustainable Development through Sharing Knowledge between Developed and Developing Countries (T)**

Developing countries are experiencing rapid growth, with the associated need for their infrastructure to support that growth. At the same time, developed countries are replacing old

and obsolete infrastructure to meet existing and future requirements. Technologies should be developed to meet the social, economic, and environmental needs of all these citizens. Technology transfer will be a large factor in this process. Recognizing that we can each learn from each other, this prospectus proposes to develop construction and equipment strategies that help transfer infrastructure innovation. In the near term, attention would be given to identifying existing technologies that best meet the needs of developing countries and conducting demonstration projects in cooperation with host countries. The results will be disseminated to decision-makers of developed and developing countries. In the longer term, the work would investigate research and demonstration activities that would facilitate the transfer of innovative technologies.

Developing a Decision Support System for Eco-Construction (M)

Traditional life-cycle assessments of construction projects lack an explicit consideration of the environmental impact of alternative approaches. This prospectus involves an international effort to develop a life-cycle framework that explicitly incorporates environmental impacts into the assessment of construction activities. This effort would be coordinated among national construction industry associations and other interested bodies. Current methodologies and practices would be shared with the ultimate aim of building consensus eco-construction methodologies.

Developing and Integrated Sustainable Project Life-Cycle Management Approach (I)

The compartmentalization and fragmentation of the project-delivery process have led to lack of accountability among participants in the various project phases (i.e., planning, design and engineering, manufacturing and procurement, construction, operations, maintenance, repair, demolition, recycling, and waste treatment), and corresponding suboptimization within the overall project. This prospectus proposes to reduce the barriers to integration by a variety of measures including promotion of strategic alliances, rationalizing the regulatory and legislative structures, using government projects to set the example, developing an overall government policy framework to encourage integration, shifting to performance-based specifications and standards, maximizing the use of information technologies, developing appropriate incentive structures, and improving decision tools such as the use of lifecycle cost-benefit analysis.

Focus Area 4: Materials and Systems

Symposium participants committed to "foster change in sustainable development practices in the materials, design and construction industry through the use of high-performance materials and systems that improve function, durability and safety while minimizing life-cycle costs and environmental impacts." Materials Focus Area team members prepared eleven prospectuses aimed at achieving their goal.

Creating Predictive Models for Construction Materials and Systems Performance (M)

The construction industry is hindered by a lack of information and assessment tools that are consistent, comprehensive, quantifiable, reliable, and organized for easy use. The information that exists is chaotic without a logical structure. This prospectus recommends that standards organizations establish standards for reporting and measuring construction data. Attention should be focused on developing consistent reporting formats and a coherent system of organizing information and predictive models that address clear objectives.

Establishing a Materials Life-Cycle Information System for Constructed Facilities (T)

Sustainable development practices will depend on the availability of reliable life-cycle assessment capabilities that currently are not adequate. This prospectus centers on performing a worldwide public-private effort to develop models and methods that identify and gather data needed for life-cycle analyses, assessment materials and systems, and renewal assessments. Industries advanced in life-cycle methods, such as the chemical, electronics, and communications industries will be recruited as collaborators. The result of this effort would be comprehensive, and systematic life-cycle information systems for the engineering and construction industry.

Developing Client-Oriented Flexible Engineering to Improve Industry Efficiency (I)

Client-oriented flexible engineering (COFE) involves integrated engineering design methods, information networks, and automated technologies applied to sustainable constructed systems. This prospectus proposed to encourage COFE to realize the economic potential of automated and modular systems. Among the work required is to adapt the principles and methods of information and automation technologies and flexible manufacturing to sustainable constructed systems. In its final phase, the COFE prospectus would develop, deploy, and maintain commercial-scale networked knowledge systems for modular constructed systems.

Exploring the International Use of System Modularity for Constructed Facilities (I)

The process of construction is nonsystematic leading to increased first costs and higher operations and maintenance costs. System modularity (sets of units designed to be arranged or joined in a variety of ways) can ensure successful integration of building materials and systems which will, in turn, improve overall economics and quality. This prospectus proposes developing a guide for using system modularity for design and construction. The guide should describe the design methodology and data protocols for design, manufacture and system integration. An international steering committee is proposed to administer the process and conduct and initial feasibility study.

Demonstrating Performance Testing of Materials and Systems to Reduce System Costs (D)

Many countries are faced with increasingly complex requirements to assure the performance of structures and facilities. New demands are arising about strengthening and repairing structures. Uniform procedures are needed to collect performance data of structures and facilities in-situ and conduct rational test procedures to evaluate these data. A public-private consortium should be created to collect the data and conduct demonstrations, workshops, and training in the use and application of innovative designs and materials in large- and full-scale testing and perform long-term monitoring of structures and facilities. The consortium would collect information and data of similar projects carried out by various worldwide laboratories and facilitate publication of results and implementation of findings into codes and standards. It would also develop uniform testing procedures for comparison of test results carried out and to establish database. It is expected that this work will achieve a major reduction in infrastructure costs due to more efficient design and construction practices.

Developing Globally Acceptable Performance-Based Specifications for Construction Materials and Systems (S)

Design and construction practices traditionally follow a prescriptive approach. There is increasing awareness that this approach does not account for transposing human needs to user requirements for safety, comfort, and health. Alternatively, performance-based solutions have

great potential in permitting flexibility in materials solutions and design. This prospectus proposes to produce internationally accepted performance specifications. A consortium of international materials experts fluent in the performance approach will evaluate national construction projects that employed the performance-based approach. Evaluation data will be synthesized into simulation models and knowledge bases for use by design and construction community decisions makers. It is expected that improved uses of materials will result, based on the enhanced predictive and assessment tools, simulations of new material development, knowledge bases, and better prediction methods of material durability and environmental degradation phase.

Establishing Training Programs for Life-Cycle Cost Analysis (E)

The engineering of sustainable facilities requires evaluation of alternatives for materials, systems, and construction-operations approaches. This prospectus proposes to develop the tools and databases to support these analyses of alternatives and create training and education programs targeted at professionals, and a global communication network to reach the professional community and public policy and opinion leaders as well as professions. The objectives are expected to be realized through a combination of symposia, application of Internet communication capabilities, the development of model curricula, dissemination of existing databases and creation of new ones, collecting case histories of applications, and publishing a journal targeted to the issue.

Developing the Discipline of Renewal Engineering (I)

This prospectus would develop an organized discipline of design and construction technologies and methodologies, which focus on design for renewal, renovation, and reuse. The discipline will be built on the basis of understanding the processes and technologies for demolition, renovation, recycling, and construction; the use of analysis tools such as life-cycle cost analysis and life-cycle assessment; and the development of associated databases such as for construction materials.

Promoting and Conducting Cross-Disciplinary and International Research in Renewal Engineering (E)

There is a tremendous amount of renewal research occurring throughout the world. But this work is fragmented, involves many disciplines, and it is often not transferred to practical use. Practitioners from other fields often fail to recognize or to transfer technology that has application in the construction industry. To address these deficiencies, this initiative proposes that industry, with seed money from the government, establish a data resource base on renewal technology development. This database would be maintained and operated by a private concern with subscriptions helping to defer expenses. This service would benefit the user and the industry more broadly by helping to focus research, enlisting new research, and advancing technology transfer.

Creating an Incentive to Reuse, Renew, and Recycle (I)

In a modern throwaway society, there is often little incentive to reuse, recycle, or renew construction materials and infrastructure. Wasting resources results in inefficiencies and loss of resources that need not occur. To ensure that resources are not wasted requires that their true value be recognized. This initiative proposes that the industry push for a combination of tax incentives and disincentives on construction materials that would result in the market price of materials reflecting their societal values and that, thus, would rationalize their true costs. The initial step in the process would be to conduct and assessment of the materials market to determine the extent that recycling, renewal, and reuse is occurring. This assessment would also include life-cycle cost analysis and data gathering to assist in the analysis for determining appropriate tax policy that promotes efficient use and reuse of finite materials.

Developing Life-Cycle Methodology Tools for Materials and Systems (M)

Analysis and selection of materials for constructed facilities are often undertaken without consideration of their performance as systems in the built environment. These decisions are plagued by the lack of a standardized methodology to conduct life-cycle cost and environmental life-cycle assessments. This prospectus proposes a research and development effort to produce the needed models and methods for the construction industry. For example, environmental life-cycle assessment models for inventory assessment, impact assessment, and impact evaluation need to be developed. Other industries' models and methods would be examined in this program.

Focus Area 5: Public and Government Policy

Symposium participants committed to "achieve public and government policy actions for sustainable design and construction practices to ensure that appropriate investments are made in research and technology diffusion, and in implementation of public-private partnerships through increased involvement of engineering and construction professionals in public debate." Policy focus Area participants proposed seven prospectuses to advance their goal.

Gaining Efficiency through International Collaboration (I)

This prospectus seeks to reduce the average time to market for innovation in construction, in part, by increasing the number of international collaborative research projects. To serve as a catalyst for these ambitious goals, relevant national and international construction and engineering organizations would need to establish an international foundation to set the framework for developing research and innovation strategies that can be applied on a consistent basis. The establishment of an international clearinghouse to channel communication would promote collaboration. The proposed foundation would perform an analysis of "best practices" for current collaborative models; public-private, public-public, or private-private; develop prototypical best practice partnership agreements; establish an information exchange network; and facilitate the establishment of international construction goals.

Sharing Information on Best Practice for Demonstration Projects (D)

Acceptance of innovation in the construction industry is a difficult process because of the reluctance of owners to take on the attendant uncertainties and risk. This prospectus proposes to improve innovation in the construction industry through encouraging wider use of innovative demonstration projects. An international resource center would be established that would collect, exchange and disseminate information about demonstration projects. The purpose of the resource center is to provide assistance and support to those considering establishing demonstration projects. The resource center may not be a single center, rather an international network of national centers. A first significant task would be to develop a manual of best practice for establishing demonstration projects. The manual, to be updated regularly, could include information on how partnerships should be arranged, mistakes to avoid, examples of successful projects, and promotion strategies for demonstration projects.

Using Field Testing to Demonstrate Sustainable-Development Practices (E)

To achieve sustainability, development projects in the twenty-first century will move from a parochial disciplinary focus to a multidisciplinary approach that seeks mutual understanding, coordination, and consensus. In order to show how this multidisciplinary approach can be

organized and be effective, this prospectus proposes to target one or more complex projects (such as the rehabilitation of urban brownfields) where engineering and community interests are paramount. Multidisciplinary partnerships would be examined, and modes for success would be developed and tested at other sites. At the macro-scale, the prospectus proposes that a multidisciplinary coordinated approach be pursued involving key construction stakeholders to advance the sustainability "profession," to promote innovation and collaboration on sustainable development, and to encourage new national and international approaches to sustainable development.

Examining and Coordinating Codes, Standards, and Regulations Internationally (S)

The processes by which codes, standards and regulations are developed and modified, and the content developed vary widely internationally. In general, there is a need to promote innovation and associated risk sharing. This prospectus describes an approach to allowing greater use of appropriate materials and products, faster review of innovative technologies and systems, and greater global cooperation in the pursuit of innovation, cost savings, and productivity improvements. The prospectus would be accomplished through the development of international teaming arrangements among codes and standards organizations, international agreements among testing organizations, universities, standards organizations, user organizations, and the promotion of performance-based standards.

Taking a Leadership Role in Defining Sustainable Solutions (E)

The public opinion leaders and policy makers who make up the constituency of the design and construction industry are the ultimate decision-makers in implementing change. This prospectus recognizes the need to provide more information on the issues and consequences of actions to that constituency, and proposes an organized program of public education to accomplish it. In particular, the proposed effort would be implemented through a broad context of issues (ranging from prospects for the future to specific design approaches), across a variety of mass and targeted (TV, radio, Internet, community meetings, and showcase displays in public arenas, and so on). The information would be designed with a multidisciplinary focus, and include case studies of success stories to highlight benefits. The program would be guided through the development of coalitions and partnerships coordinated internationally, but integrated to focus on the delivery of targeted programs at the local level.

Forming an International Information-Access System through Collective Actions (T)

Access to construction-related information and technical assistance is unevenly distributed globally. This prospectus proposes to make sustainable development information available through distribution of publications, access to computer-based information, technical assistance and training. Governments, industry, and academia should enter into an international agreement-a multilateral memorandum of understanding-that would further develop the international linkages and collaborations, inventory and access existing activities and resources, define new delivery mechanisms, identify additional resources required, and implement new centers and activities as required.

Expanding the Construction Industry Knowledge Base on Sustainable Development (E)

Local, national, and international engineering societies and associations have the potential to reach the over ten million engineers in practice worldwide. This prospectus proposes to align and focus the engineering and construction community through development of a process to network key organizations (professional societies and associations) for the purpose of sharing information on sustainable development in practice, education and research. The goal of this prospectus is to use existing professional societies and associations to address the

development and implementation of sustainable development principles in engineering and construction. A task committee should be established that would identify and contact all groups that have or should have an interest in sustainability as it applies to construction. The task committee would work toward the establishment of permanent joint committees to carry on the collaborative work.

Next Steps

Action to implement these prospectuses includes several steps; beginning with a call for partners to take ownership of the prospectuses and to lead and participate in establishing the collaborative programs needed to address prospectus objectives. Forums are needed to routinely discuss related and ongoing work. Extensions of corporate discussion groups and professional societies and trade association's technology and education committees need to serve as vehicles to enhance this planning resulting in cohesion and uniformity to national and international planning. Periodic progress reports are needed to keep the industry informed.

The Symposium is a milestone in the critical process of achieving sustainable development; however, its value will be determined by the actions that follow. The global design and construction industry must unite in an international partnership to develop and apply the technologies and techniques of sustainable development.

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Richard Belle is currently *Senior Program Manager* for the Civil Engineering Research Foundation (CERF), the research affiliate of the American Society of Civil Engineers. Richard is CERF's senior survey research methodologist, with expertise in survey design and operations, program evaluation, and statistical analysis. He has lead responsibility for design and analysis of all market research efforts, baseline data assessments, benchmarking analyses, and attitude surveys. Richard currently manages CERF's materials programs, notably the high-performance construction materials and systems program (CONMAT). Other recent and current projects focus on developing a national private-public sector partnership to spur infrastructure renewal through the use of innovative technologies (**Partnership for the Advancement of Infrastructure and its Renewal, or PAIR**), operational management of the National Council for Civil Engineering Research (NCCER), industry benchmarking activities, assessment of current technologies in use, outreach to small and medium size design and construction firms, barriers to rapid technology transfer, public/private collaborations, revitalization of the public works infrastructure, enhancement of environmental quality, and improvement of competitiveness.

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J. Peter Kissinger is the Vice President of the Civil Engineering Research Foundation (CERF) with executive level responsibility in a range of programs within CERF's mission. Most notably, Mr. Kissinger oversees the day to day management of the CERF Innovation Centers which provide technology verification (evaluation) services for a wide range of technologies across the spectrum of the design, construction, engineering and environmental markets. Mr. Kissinger joined the CERF staff in January 1993, as the Director of Highway Innovative Research. He was responsible for organizing and implementing the first CERF Innovation Center - HITEC (the Highway Innovative Technology Evaluation Center), which serves the highway and bridge community. In January of 1994 when HITEC became operational, Mr. Kissinger became Center's Director, a position that he still holds. In October of 1994, Mr. Kissinger was named a Vice-President of CERF, assuming executive level responsibilities in several areas. In that capacity, Mr. Kissinger's primary focus has been in expanding and refining the collaborative evaluation center concept developed for HITEC so that it could be applied to other markets. Presently, in addition to HITEC, the CERF Innovation Centers include CeITEC (public works and underground construction technologies), NES-BIC (building systems and technologies) and EvTEC, the Environmental Technology Evaluation Center. Mr. Kissinger is the Director of CeITEC and serves as a member of the NES-BIC Management Board and the EvTEC Advisory Council.

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