ACI Concrete Sustainability Forum VII

Sustainability, resilience, and innovation

by Koji Sakai and Julie K. Buffenbarger

The ACI Concrete Sustainability Forum VII took place in Washington, DC, on October 29, 2014, at the ACI Fall Convention. The forum series originated in St. Louis, MO, in 2008, when ACI Committee 130, Sustainability of Concrete, was formed. Following the first workshop, consecutive forums were held in New Orleans, LA, in 2009; Pittsburgh, PA, in 2010; Cincinnati, OH, in 2011; Toronto, ON, Canada, in 2012; and Phoenix, AZ, in 2013.[1-6]

The topics presented in Washington, DC, exemplify the great progress in concrete sustainability throughout the last 6 years. In addition, it is apparent that the concept of resiliency is becoming increasingly important because of frequent extraordinary natural disasters around the world—events that seem to be the effects of climate change.

Forum VII comprised four parts:

- Presentations on Concrete Sustainability Forum history and lessons, ACI Committee 130's sustainability guideline, sustainability in *fib* (International Federation for Structural Concrete) Model Code for Concrete Structures 2010, a low-carbon cement and concrete system, low-carbon footprint cement innovations, carbon dioxide (CO_2) use in concrete production, Federal Highway Administration's (FHWA) sustainable pavements program, and resilient buildings and communities;
- An interactive panel discussion between the speakers and the audience facilitated by Koji Sakai;
- A luncheon lecture by Henry L. Green, President of the National Institute of Building Sciences (NIBS), titled "Resilience: It's a Concrete Notion"; and
- A tour of the National Building Museum with a focus on the "Designing for Disaster" exhibit.

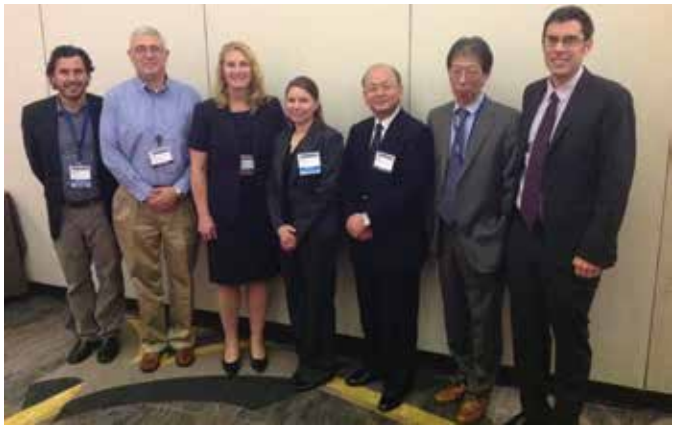
Forum VII Presentations

Concrete Sustainability Forum history and lessons

In his introduction to Forum VII, Koji Sakai, Representative, Japan Sustainability Institute, Sapporo, Japan, reviewed the content of previous concrete sustainability forums. In the last 6 years, 46 speakers have presented various sustainability issues. These forums have been very beneficial in promoting sustainability activities within ACI. He commented that in the beginning, the concrete industry as a whole did not know the direction to take with sustainability. After 6 years, however, we are reaching a certain level of understanding about the essence of sustainability. As evidence of this, both ACI and *fib* have incorporated "sustainability" into their codes.

ACI Committee 130 sustainability report

Julie K. Buffenbarger, Chair of ACI Committee 130, Sustainability of Concrete, and Construction Specialist, Lafarge, Medina, OH, outlined the current status of the preparation of ACI 130R, "Guideline to Concrete Sustainability." The guide, an inclusive document encompassing the economic, environmental, and social benefits of concrete, will comprise sections on the design phase, materials selection, concrete manufacturing, construction, building use, end of service life, rating systems,



Moderators and speakers for the ACI Concrete Sustainability Forum VII, October 29, 2014, from left: Laurent Barcelo, Donn C. Thompson, Julie K. Buffenbarger, Gina Ahlstrom, Koji Sakai, Etsuo Sakai, and Sean Monkman

and a glossary. Resilience, climate mitigation, and adaptation will also be covered. The format of the document will be useful to policy makers, owners, designers, and contractors who must select and implement sustainable solutions to mitigate climate change and provide infrastructure resilience.

Based on ACI 130R, a sustainable assessor program and sustainable certification program will be developed.

Sustainability in *fib* Model Code 2010

Koji Sakai discussed the *fib* Model Code for Concrete Structures 2010, published in 2013. Considering the depletion of resources and the risks of climate change on a global scale, any unchecked increase in the use of resources and energy in the construction sector is obviously unacceptable from a sustainability point of view. Therefore, it is very important to incorporate sustainability into design codes to promote more sustainable concrete structures. *fib* has included design criteria with relation to sustainability in its Model Code for Concrete Structures 2010. The document requires that a structure be designed in such a way that the impact on the environment is appropriately taken into consideration in the life cycle. Environmental impacts can include selection of materials, execution methods, use, maintenance procedures, demolition and waste disposal, recycling procedures, and consumption of energy and resources. For the future revision of the *fib* Model Code 2010, a new design system, in which the relation of structural safety/serviceability and sustainability is clear, should be created.

New materials for low-carbon cement and concrete system

Etsuo Sakai, Professor at Tokyo Institute of Technology, Tokyo, Japan, presented the Energy CO_2 Minimum (ECM) Cement Concrete System, developed by his research group under the support of the New Energy and Industrial Technology Development Organization (NEDO). The ECM cement concretes can be used in buildings, civil engineering structures, and foundations, as well as for soil stabilization. The high strength of ECM cement concrete is based on the packing fraction of blast furnace slag particles. A new high-range water-reducing admixture for blast furnace slag was also developed. The carbonation resistance of ECM cement concrete was improved by using high alite-clinker or expansive additives containing free CaO. These new materials have great advantages including 60% CO_2 reduction, resistance to thermal cracking, durability enhancement, and high strength.

Innovations in the cement industry to reduce carbon footprint

Laurent Barcelo, Manager of Strategic Projects for Lafarge Canada, Pointe-Claire, QC, Canada, described low-carbon-footprint cement innovations. There are three main levers to reduce CO_2 in cement manufacture, including energy efficiency, alternative fuels and biomass, and clinker substitution. The main impediment is the use of limestone. With ordinary portland cement (OPC), the opportunities to reduce CO_2 are limited. However, there are two solutions outside traditional OPC boundaries: Aether® (belite-calcium sulfo-aluminate-ferrite clinker) cement and Solidia Technologies® (carbonate-based binder) cement. The CO_2 footprint of OPC, Aether cement, and Solidia cement is 816, 571, and 570 kg/tonnes (1632, 1142, and 1140 lb/ton), respectively. The two systems demonstrate improved performance in comparison with OPC.

Beneficial CO_2 use in concrete production

Sean Monkman, VP Technology Development, CarbonCure™ Technologies, Halifax, NS, Canada, explained their use of CO_2 in concrete production by injecting it as an admixture into precast masonry products and wet-mixed concrete. The technology improves performance of industrially produced masonry block and strength of the carbonated wet-mixed concrete at 28 and 56 days, when the control and carbonated concretes had equivalent water contents. Pore solution pH has been found to be unaffected by the carbonation treatment. The CO_2 is a rheology-modifying agent that suggests several novel future uses of the carbonation technology. The environmental footprint of the resulting concrete was improved because the absorbed CO_2 was permanently converted into solid carbonate products rather than released into the air as a greenhouse gas.

Sustainable pavements program

Gina M. Ahlstrom, Senior Pavement Engineer, FHWA Office of Asset Management, Pavements, and Construction, Washington, DC, highlighted the FHWA's sustainable pavement program. The FHWA initiated the program to assist engineers and practitioners in understanding sustainability and how it relates specifically to pavement material selection, design, construction, preservation, and maintenance. The guidelines for the design, construction, preservation, and maintenance of sustainable pavements using asphalt and concrete materials are under development. The target audiences are State Department of Transportation practitioners, designers, maintenance engineers, materials engineers, construction engineers, inspectors, planners, and others.

Resilient buildings and communities

Donn C. Thompson, Director of Market Development, Portland Cement Association, Skokie, IL, discussed withstanding storms. The destruction from natural disasters causes social, economic, and environmental losses. Their costs and consequences continue to rise year after year. Assumptions are often made that these increases are due to stronger, more frequent storms. However, the root cause of greater disaster impacts to individuals, their homes, and their communities is the result of reduced property protection requirements in model building codes beginning in the late 1970s.

In addition to this, more vulnerable construction is being developed. Our towns and cities are less resilient. It is necessary to strengthen building code requirements to enable our built environment to better resist the impact of high

winds, fire, and floods, and to enable communities to recover more quickly when impacted by disaster. It was concluded that concrete can offer the solutions that the environmental movement seeks.

Panel Discussion

The Sustainability Forum presentations were followed by questions addressed to the speakers from the audience on the low-carbon technologies—CarbonCure, Solidia Technologies™, and Aether™ cements—as well as the FHWA's sustainable pavements program and the progress of the ACI Committee 130 document. Each of the panelists discussed building codes and the need for higher performance standards regarding to the resilience of buildings at great length.

The last question posed to the panelists pertained to the future of sustainable construction and the direction necessary by the concrete industry. Several panelists voiced concern for solutions in response to climate change including resilient design, low-carbon materials, reporting transparency with environmental product declarations, and the need for rehabilitation materials and techniques to repair concrete structures to extend service life. Also discussed was the necessity and inclusion of high-speed and high-resolution nondestructive evaluation (NDE) technologies for inspection, evaluation, and performance monitoring feedback to deterioration mechanisms that allow for timely preventive, corrective, and improvement measures to preserve good structural and functional performance with extended service life to concrete structures.

Lecture on Resilience

Henry L. Green, President of NIBS, presented an engaging keynote luncheon presentation titled "Resilience: It's a Concrete Notion." Green stated the importance and necessity of infrastructure being resilient to the increasingly frequent weather/climate disasters. Citing the National Infrastructure Advisory Council, he stated, "Government should endeavor to better understand the role of design and construction in infrastructure or enterprise resilience."

To achieve resilience in infrastructure and/or communities, high-performance building attributes must integrate and optimize, on a life-cycle basis, energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations. Additionally, an understanding of the potential disruptive events, anticipating how they will affect the community, and designing communities that can absorb, adapt to, and/or rapidly recover from a potential disruptive event is necessary.

Imparting resilient and hazard mitigation design guidelines is imperative as new construction and renovation activity represents over $800 billion annually in the United States, accounting for 13% of the gross domestic product (GDP), while employing 10 million people (5% of the total U.S. employment). Engaging hazard mitigation strategies in new construction and renovation allows for reduction to future hazard losses. On average, for each dollar spent, approximately four dollars in future benefits are achieved.[7]

Praising the attributes of concrete—durability, longevity, and resilience—Green stated concrete is a viable construction material. He also highlighted multiple innovations within the concrete industry as pathways to create more resilient infrastructure.

Green discussed the mission of NIBS, which is to "serve the nation and the public interest by supporting advances in building sciences and technology to improve the built environment." He further explained that building science is the analysis and evaluation of issues critical to the development of criteria, standards, and practices that yield buildings and structures that respond to the environmental, societal, business, and sustainable needs of our nation. NIBS pursues its mission through several pathways, including industry advocacy and outreach, facility performance and sustainability, information resources and technology, and security and disaster preparedness.

National Building Museum Tour

From earthquakes and hurricanes to rising sea levels and flooding, natural disasters can strike anywhere and at any time. Recent history shows that no region of the United States is immune from the rising costs of storm and disaster damage. In light of this stark reality, the National Building Museum curated a multimedia exhibition titled "Designing for Disaster," a call-to-action for citizen preparedness—from design professionals and local decision-makers to homeowners and school children—investigating how and where to build communities that are safer and more disaster-resilient.

During the tour, ACI convention attendees explored new solutions for, and historical responses to, a range of natural hazards. Artifacts from past disasters, such as a door battered by Hurricane Katrina, expressed the destructive, persistent, life-altering power of nature.

Attendees to the ACI Convention tour of the "Designing for Disaster" exhibit experienced a true-to-life safe room built to withstand tornado-force winds and flying debris *(photo by Allan Sprecher, courtesy of the National Building Museum)*

Attendees also experienced a true-to-life "safe room"—one of the few defenses against a tornado or violent storm—specified by the Federal Emergency Management Agency, in which exposed layers illustrate how it was built to withstand tornado-force winds and flying debris. And a "wall of wind" invited attendees to test various roof profiles against simulated hurricane-force winds (modeled at Florida International University's wind testing facility) to see which shape performs best. The exhibit explored a range of flexible design and planning schemes, public policies, and new forecasting technologies ranging from engineering advancements and seismic retrofits of esteemed historic buildings to interactive displays that demonstrate how to strengthen homes, hospitals, schools, and landscapes.

The exhibition remains open to the public through August 2, 2015.

Acknowledgments

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Selected for reader interest by the editors.

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