Sustainability of Shotcrete—An Overview

By Charles S. Hanskat

It seems all we hear about in design and construction these days are the buzzwords—sustainability, green construction, LEED, carbon footprint, CO_2, and global warming.

The topics that comprise the concept of sustainability are certainly hot ones that we constantly see in the media. Sustainability is more than a passing fad and has become a major consideration in how we design and build structures from now into the foreseeable future.

But what do we really mean by sustainable construction and why is it important to the concrete and shotcrete industry? This issue of *Shotcrete* magazine is dedicated to the sustainability theme. This article provides an overview on sustainability, its general impact on concrete, and how ASA is actively participating in sustainability initiatives. Other articles in this issue deal with the specific benefits of shotcrete in sustainable construction, and provide case studies of how different projects have created substantial sustainable benefits.

Sustainability 101

"Sustainability" as a concept is huge in scope. The widely used definition for sustainability created by the World Commission on Environment and Development (the Brundtland Commission) in 1987 is:

> "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Who can argue that we shouldn't do this? It really boils down to building today so that all those generations of people who come after us have an opportunity to live quality lives here on Earth. This simple concept is then commonly broken down into three key components to be considered in sustainable development:

- Social;
- Environmental; and
- Economic.

The social component is often considered to be development that is socially desirable, culturally acceptable, and psychologically beneficial. This applies to the individual, the community, the country, and the world. Simply put, we don't want development that creates more negative social impacts such as increased crime and poverty and resource hoarding. We do want to have more construction that instills civic pride, and structures we are proud to have as "good neighbors."

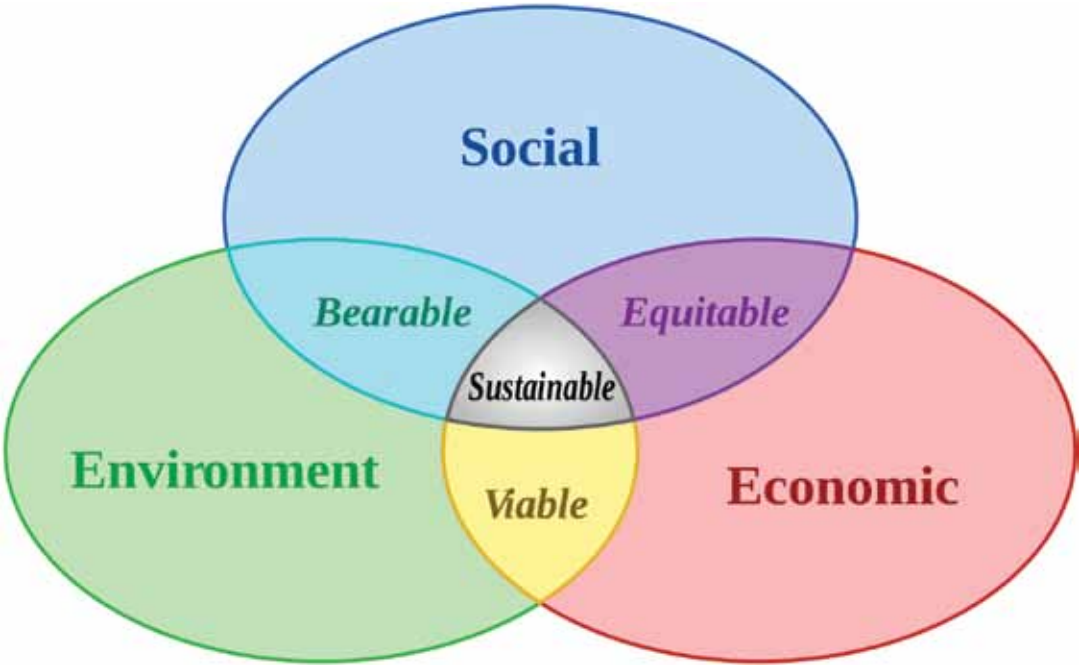
The environmental component is the impact on the environment. This component evaluates how the sustainable development affects the air, ocean, fresh water, land, food, and forests. All development has some impact on the environment—either good or bad. Global warming, acid rain, smog, depletion of the ozone layer, CO_2 levels in the atmosphere, and hazardous waste are environmental issues that have impacted us all over the last 20 years.

The economic component refers to the financial aspect of sustainable development. Is the development economically viable in initial and long-term operational cost? Is it technically feasible at a reasonable cost?

In practice, to achieve sustainable development, we need to evaluate each of these three components and then balance the overlap between them (refer to sustainable development figure).

As an example of the interaction between these three components, consider if a new development is good for the environment but extremely expensive to implement—it may then have a substantial negative impact on the economic and potentially social aspects of the development. A less expensive solution that would favorably impact the environment a little less, could have more positive economic and social impact, and thus move into the center portion and actually be more sustainable.

In evaluating the sustainable benefits of a particular project or product, one must keep a broad perspective on how all three of these components may be affected. For example, many sources have condemned concrete as an unsustainable material simply because of the CO_2 generated in the manufacturing of cement. Yes, it is a fact that cement production creates CO_2; however, this is only one aspect of sustainability (environmental impact) and it completely ignores



Sustainable development
By John Dréo, courtesy of Wikipedia Commons

the overall picture. Concrete is one of the most widely available (social impact) and cost-effective (economic impact) construction materials in the world today. Combined with the extremely long durability and serviceability of well-designed and built concrete structures (economic and environmental impact), the flexibility of concrete shapes (economic and social impact) and the ability to use recycled materials (environmental and economic impact) proves that concrete is an excellent choice for sustainable structures.

What Makes a Sustainable Project?

Just selecting concrete for a structure doesn't automatically make it sustainable. There still needs to be consideration of what can be done to maximize concrete's contribution to the overall sustainability of the project. The recently published U.S. Green Concrete Council (USGCC) book, *The Sustainable Concrete Guide—Strategies and Examples*, lists five key aspects that make for improved sustainability of buildings:

Improving functionality—Increased functionality means a more efficient structure to serve its intended purpose. Concrete—and to an even greater extent, shotcrete—allows great flexibility in structural shapes and efficiency. In some structural areas, such as ground-supported or buried portions of a structure, or in an arch dam, concrete is clearly the only cost-effective product.

Ensuring longevity—The longer the usable life of a structure, the less the need for repair or replacement of the structure that would entail using more resources. Concrete as a material, properly designed and constructed, is unmatched in its ability to provide durable structures.

Enhancing occupant comfort—A more comfortable environment within a building increases the productivity of the users and thus adds to the efficiency of the structure's overall use. The thermal mass of concrete can help moderate inside temperatures. The naturally light color of concrete and the ability to provide a variety of finishes to exposed surfaces can help to enhance natural lighting and reduce the use of other finishing materials.

Reducing the use of resources—Concrete is great for reusing many recycled materials, including supplemental cementitious materials such as fly ash or slag, or reused aggregates from crushed concrete. The ability to increase recycling means less material that ends up taking space in landfills. Also, the long-term durability of concrete means a much longer replacement cycle is needed; thus, resources are not used nearly as often as with other construction materials.

Aesthetics—This aspect addresses the social component of sustainability. Visually pleasing structures can give an increased sense of community pride. Concrete (and more specifically, shotcrete) can produce virtually any shape. It is like clay that architects or engineers can mold to their creative vision.

How to Rate a Project's Sustainability?

There are many different rating systems currently available to evaluate how a potential project may

provide enhanced sustainability. In the U.S., the three most commonly used systems are:

- Leadership in Energy and Environmental Design (LEED) from the United States Green Building Council (USGBC);
- Green Globes® from the Green Building Initiative (GBI); and
- National Green Building Standard from the National Association of Home Builders (NAHB) and the International Code Council (ICC).

The LEED system was started in 1998 and is now up to an online version 3 as of April 2009. It is produced and maintained by the USGBC (**www.usgbc.org**). In the LEED system, points are given to a commercial or residential building project based on performance in specific areas such as sustainable sites, water use, energy use, indoor environmental quality, stewardship of resources, innovation in design, and regional priorities. Individuals trained in the LEED evaluation and rating system can become certified LEED professionals.

The Green Globes® online tool is maintained by the GBI (**www.thegbi.org**). The current version of the GBI Standard document is ANSI/GBI 01-2010. The Green Globes® online system is the assessment protocol applying the GBI standard to evaluate and rate sustainable buildings. The online tool provides a score based on user input, and then offers best practices guidance for possible improvements.

The National Green Building Standard is primarily a residential green building rating system. It is maintained by the NAHB and was developed meeting the ANSI consensus process. There are four threshold levels, starting with Bronze as an entry-level green building, to Emerald as the highest level of sustainable green building incorporating energy savings of 60% or more. Single-family and multi-unit homes, residential remodeling projects, and site developments are all covered in the Standard. NAHB has a Green Scoring Tool available online at **www.nahbgreen.org**.

An interesting comparison study of the LEED and Green Globes® rating systems was prepared by the University of Minnesota in 2006. A PDF of the study was available at the time of writing this article at http://www.myfloridagreenbuilding.info/pdf/GG_LEED_10_06.pdf.

For projects outside the U.S., the BRE Environmental Assessment Method (BREEAM) rating system is commonly used. More information on this system can be found at **www.breeam.org**.

What is ASA Doing about Sustainability?

In 2009, ASA joined with 20 other concrete and cement-related associations to support the Concrete Joint Sustainability Initiative (CJSI). The CSJI was formed in Spring 2009 by the American Concrete Institute (ACI), the Portland Cement Association (PCA), and the National Ready Mixed Concrete Association (NRMCA) to focus industry efforts on sustainability in a coordinated and concentrated manner. The CJSI is not a stand-alone organization and has no staff. All work of the CJSI is supported entirely by the staff of the member organizations.

Currently, the member organizations of the CJSI include:

- American Coal Ash Association **www.acaa-usa.org**
- American Concrete Institute **www.concrete.org**
- American Concrete Pipe Association **www.concrete-pipe.org**
- American Concrete Pressure Pipe Association **www.acppa.org**
- American Shotcrete Association **www.shotcrete.org**
- American Society of Concrete Contractors **www.ascconline.org**
- Architectural Precast Association **www.archprecast.org**
- American Segmental Bridge Institute **www.asbi-assoc.org**
- Cast Stone Institute **www.caststone.org**
- Concrete Reinforcing Steel Institute **www.crsi.org**
- Concrete Sawing and Drilling Association **www.csda.org**
- Concrete Foundations Association **www.cfawalls.org**
- Expanded Shale, Clay and Slate Institute **www.escsi.org**
- Interlocking Concrete Pavement Institute **www.icpi.org**
- International Concrete Repair Institute **www.icri.org**
- National Concrete Masonry Association **www.ncma.org**
- National Precast Concrete Association **www.precast.org**
- National Ready Mix Concrete Association **www.nrmca.org**
- Portland Cement Association **www.cement.org**
- Post-Tensioning Institute **www.post-tensioning.org**
- Precast/Prestressed Concrete Institute **www.pci.org**

- RMC Research and Education Foundation
  www.rmc-foundation.org
- Silica Fume Association
  www.silicafume.org
- Slag Cement Association
  www.slagcement.org
- Tile Roofing Institute
  www.tileroofing.org
- Tilt-Up Concrete Association
  www.tilt-up.org
- Wire Reinforcement Institute
  www.wirereinforcementinstitute.org

Additionally, in late 2009, the ASA Board of Directors recognized the need for a focus group within ASA to address the sustainability issue. As a result, the Board established a new standing committee on sustainability. The mission of the Sustainability Committee is to compile and distribute information on the sustainability of shotcrete construction. The Sustainability Committee has been quite active since its formation in identifying key aspects of shotcrete construction's contribution to improving sustainability in a variety of concrete structures.

The committee has recently contributed material to help development of a new book being produced by the USGCC, *The Sustainable Concrete Guide—Applications*. This book is intended to be a follow-up reference to the book, *The Sustainable Concrete Guide—Strategies and Examples*, mentioned previously. Contributions to the book include a full chapter on shotcrete and also supplemental material for the repair chapter.

Interested in Learning More?

You will find much more information on the sustainability of shotcrete in the articles and case studies that follow in this issue of *Shotcrete* magazine. For more detailed information about the sustainability of concrete, you may also find these Web sites of interest:

- **www.ConcreteThinker.com**
  by Portland Cement Association
- **www.greenconcrete.info**
  by National Ready Mixed Concrete Association
- **www.green.concrete.org**
  by American Concrete Institute
- **www.greenrooftops.org**
  by National Ready Mixed Concrete Association
- **www.perviouspavement.org**
  by National Ready Mixed Concrete Association
- **www.tilt-up.org/sustainability**
  by Tilt-Up Concrete Association
- **www.concretecentre.com**
  by The Concrete Centre
- **www.sustainableconcrete.org**
  by the Concrete JSI

Also, the two books from the USGCC are valuable references on concrete's role in sustainable construction. *The Sustainable Concrete Guide—Strategies and Examples* is available for purchase now and the new book *The Sustainable Concrete Guide—Applications* should be available by the end of 2010. You will find information on these books at **www.usgreencouncil.org**.

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Hanskat is an ASA Board member and Chair of the ASA Sustainability Committee. He is also a member of ACI Committees 301, Specifications for Concrete; 350, Environmental Engineering Concrete Structures; 371, Elevated Tanks with Concrete Pedestals; 372, Circular Concrete Structures Prestressed by Wrapping with Wire or Strand; 373, Circular Concrete Structures Prestressed with Circumferential Tendons; 376, Concrete Structures for Refrigerated Liquefied Gas Containment; 506, Shotcreting; and Joint ACI-ASCE Committee 334, Concrete Shell Design and Construction.

Hanskat's service to the American Society of Civil Engineers (ASCE), the National Society of Professional Engineers (NSPE), and the Florida Engineering Society (FES) in over 50 committee and officer positions at the national, state, and local level was highlighted when he served as State President of FES and then as National Director of NSPE. He served as a District Director for Tau Beta Pi for 25 years from 1977 to 2002. He is a Fellow of ACI, ASCE, and FES, and a member of ASA, NSPE, ASTM, AWWA, and ASHRAE.