NATIONAL READY MIXED CONCRETE ASSOCIATION

2011 SUSTAINABILITY REPORT

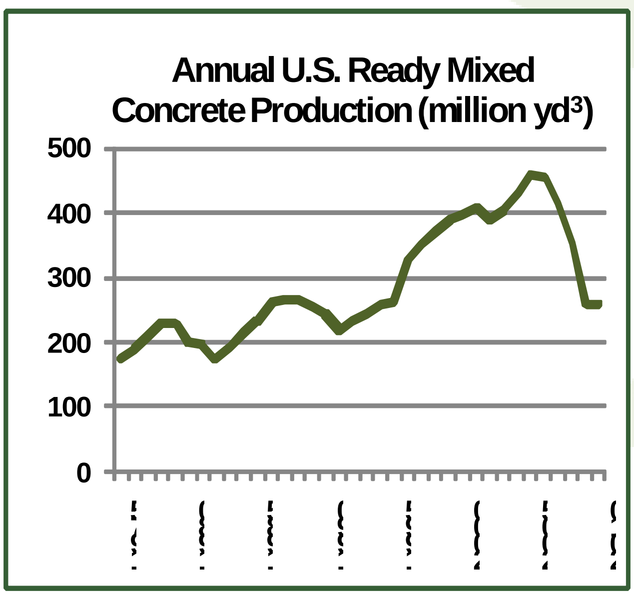
NRMCA®

The Concrete Industry: A Commitment to Sustainability

In 2009, the U.S. ready mixed concrete industry established a vision, strategies and goals toward sustainable concrete manufacturing and construction (see inset on page 3). At the same time, the concrete industry was experiencing the worst economic downturn in its history and unprecedented regulatory changes. However, despite these challenges, the industry has re-dedicated itself to upholding the principles of sustainable development by establishing programs to help meet the aggressive goals it set for itself in 2009. This report provides an overview of progress toward meeting these aggressive sustainability goals.

Industry Challenges

Economic Challenges—Since reaching its all-time peak of production in 2005 of over 458 million cubic yards, the ready mixed concrete industry in the U.S. has seen a decline in concrete production of nearly 44%, the worst decline in recorded history. The industry was forced to close concrete plants and reduce staffing to survive the unprecedented decline in construction demand during the last 5 years.



Regulatory Challenges—In 2010, the U.S. Environmental Protection Agency (EPA) issued a proposed rule to regulate Coal Combustion Residuals (CCR), including fly ash, as a hazardous waste. Although EPA indicated that beneficial uses of CCR, including the use of fly ash in concrete, would be exempt from the hazardous waste designation, the industry is concerned that the stigma associated with a hazardous waste designation for CCR would reduce or eliminate the use of fly ash.

Since there is scientific evidence to indicate that fly ash is not harmful when bound in concrete, the industry continues to oppose the hazardous waste designation for CCR. Fly ash is a critical component of concrete, helping lower its overall energy and carbon footprint in addition to improving long-term durability of concrete structures.

If restrictions on the use of fly ash were imposed on critical infrastructure projects as a result of these regulations, the concrete industry would experience a significant setback in its effort to meet the targets for reducing carbon and energy footprint. Although not directly addressed at the concrete industry, other regulatory changes affecting related industries could also hamper NRMCA members' efforts toward meeting their sustainability goals.

For example, EPA has imposed air emission standards for cement manufacturing that threatens to close a significant number of cement plants in the U.S. Cement, along with concrete, is one of the few building products still manufactured in the U.S. Pushing production off shore, where regulatory standards are not nearly as strict, will result in increased environmental burdens. In addition, the environmental and economic cost of transportation will increase as a result of forcing cement production off shore.

NRMCA Sustainability Vision Goals—established in 2009

Vision

The vision of the ready mixed concrete industry is to transform the built environment by improving the way concrete is manufactured and used in order to achieve an optimum balance among environmental, social and economic conditions.

Objectives

The concrete industry will be a leading player in helping society build infrastructure to support our desired standard of living and achieve a built environment that will minimize negative impacts on our planet's natural environment. The concrete industry will continue to listen, observe, research, reflect, consult and collaborate with all stakeholders to achieve its vision.

To fully realize this vision, the concrete industry will approach sustainable development through the life cycle perspective. Concrete's life cycle phases include material acquisition, production, construction, use (operations and maintenance), and recycling. It has and will continue to evaluate all phases of its product life cycle in order to reduce its environmental footprint. It has and will continue to evaluate each phase of the life cycle to employ strategies for reducing environmental impact with the following objectives:

- Minimize Energy Use
- Reduce Emissions
- Conserve Water
- Minimize Waste
- Increase Recycled Content

Key Performance Indicators

The concrete industry intends to measure and report annually its progress toward meeting its sustainability goals. Progress will be measured on a per unit of product basis and compared to 2007 levels. Key performance indicators are:

- Embodied energy: 20% reduction by 2020; 30% reduction by 2030
- Carbon footprint: 20% reduction by 2020; 30% reduction by 2030
- Potable water: 10% reduction by 2020; 20% reduction by 2030
- Waste: 30% reduction by 2020; 50% reduction by 2030
- Recycled content: 200% increase by 2020; 400% increase by 2030

Industry Progress

During this time of historic decline in industry profitability and challenging new regulatory challenges, it would be unreasonable to expect concrete producers to focus their efforts on anything other than the bottom line. However, despite these challenges, the industry has invested millions of dollars in cutting edge research, new education and training programs, new personnel and plant certifications and codes and standards advocacy to establish concrete as the sustainable material of choice for building and infrastructure projects and lower its environmental footprint. The following provides a summary of progress toward meeting these aggressive sustainability goals.

Research

Concrete is the most widely used building material on Earth; however, the production of cement, its most critical component material accounts for up to 5 percent of global carbon dioxide emissions annually. NRMCA believes that the environmental footprint of concrete can be reduced through innovative technologies developed through cutting edge research.

MIT Concrete Sustainability Hub—The MIT Concrete Sustainability Hub (CSH) was established at the Massachusetts Institute of Technology in 2009. This new research center was created in cooperation with the Ready Mixed Concrete Research & Education Foundation, the research organization for the ready mixed concrete industry, and the Portland Cement Association. The MIT CSH mission is to accelerate emerging breakthroughs in concrete science and engineering and transfer that science into practice. The research is organized around three platforms: 1) concrete science, 2) building technology and 3) the econometrics of sustainability.

Green Concrete Science—One of the most critical issues for the sustainability of concrete as the backbone material for infrastructure, commercial buildings and housing is to address the carbon footprint of concrete materials. The MIT researchers are proposing new ways to address this issue. Some strategies include producing higher cement mortar strengths with less material, reducing the energy of cement processing and improving chemical stability of concrete materials.

Researchers are developing the first atomistic-scale computational model of this complex material from which they will be able to predict new structures and improved properties that will revolutionize how cement and concrete is designed and slash carbon emissions.

There were three main focuses during year one of the research. The first was focused on lowering the process energy required to make cement. To do this, it is necessary to understand the critical role of the crystalline structure of alite and belite (the reactive minerals of portland cement) on the properties of cement. Alite contributes to desirable "early" strength, due to its higher reactivity and belite contributes to "late" strength. Belite requires less energy to produce and therefore if one could reformulate portland cement to incorporate more belite, the overall energy of cement production would be decreased, thus lowering the carbon footprint of cement.

The second area of focus was on increasing fly ash substitution in concrete. This research highlights the beneficial role of aluminum (an element found in fly ash) substituting for calcium on chemical stability and performance of calcium-alumino-silicate-hydrates. It suggests that a high amount of aluminum provided by a larger fly ash concentration can enhance properties of concrete, including strength and durability.

The third area of focus was on reducing shrinkage in concrete. This research highlights the importance of the water content within the cement paste. As water content decreases, the stiffness and strength of the individual particles increases. Water content can be varied by environment or controlled by cement composition. The theoretical model can now be extended to predict how chemical composition, temperature and humidity can affect the density and mechanical behavior of the aggregated cement paste that forms the "liquid stone" of concrete.

Building Technology—The MIT CSH is positioned to set a new standard in life cycle assessment (LCA) modeling for buildings and roadways. In 2010, the Hub issued two interim reports that discuss initial findings on the life cycle environmental costs of paving and building materials. The results provide a rigorous means of testing the relative environmental impact of paving and building materials and exploring design alternatives.

A comparative analysis of the carbon emissions of asphalt and concrete pavements over a 50-year lifetime was conducted, with a focus on the use phase of the life cycle. The research shows that the use phase of the pavement life cycle can account for up to 85% of carbon emissions for high volume roadways. The use phase emphasis sets the MIT study apart from the majority of previous LCA research on pavements.

The initial findings indicate that concrete pavements can lead to potentially significant vehicle fuel efficiency savings over asphalt pavements which lead to lower life-cycle carbon emissions. MIT researchers are poised to further analyze fuel consumption in future research to provide additional data on fuel savings associated with pavement design.

The MIT researchers also conducted LCA modeling of buildings to analyze the environmental impact of commercial and residential building materials. Both the residential and commercial building LCA studies utilized a comprehensive 75-year analysis period that highlights the operational energy demands of buildings in addition to construction, maintenance and disposal impacts.

For residential buildings, the researchers found that more than 90% of the life-cycle carbon emissions are due to the operation phase, with construction and end-of-life disposal accounting for less than 10% of the total emissions. The study also showed that in residential structures, the use of ICF walls instead of code compliant wood-framed walls can produce operational energy savings of 20% or more, with the highest energy savings occurring in colder climates.

For commercial buildings, which compared 12-story structures in both warm and cold climates, the added thermal mass afforded by the use of concrete frame construction when compared to steel framing construction yields annual heating, ventilation and air conditioning (HVAC) energy savings of between 5% and 6% depending on climate.

Education

NRMCA believes that industry education is another key strategy in progressing the concrete industry toward sustainable manufacturing and construction. NRMCA delivers hundreds of education and training programs to thousands of industry and design professionals each year focused on sustainability.

NRMCA Certified Concrete Professional—In 2010, NRMCA added a fifth career track to its industry leading Seminar, Education and Training Programs (STEPS®) specifically focused on sustainability. This sustainability track assures that concrete industry professionals are knowledgeable on concepts of sustainable development and green building practices. Additionally, all class work, readings and exams are offered in an interactive online format to facilitate participation. Industry professionals can pursue a Certified Concrete Professional (CCP*f*) designation in Sustainability, widely considered the most advanced professional education and training accomplishment in the industry.

Continuing Education—NRMCA also continues to deliver numerous continuing education programs for architects, engineers and contractors to help them better utilize concrete for green building applications. These seminars, delivered via the web and at different locations around the country, include:

- Building Green with Concrete
- LEED Green Building System and Concrete
- Life Cycle Assessment of Concrete Structures
- Pervious Concrete—A Stormwater Solution
- Pervious Concrete Contractor Certification

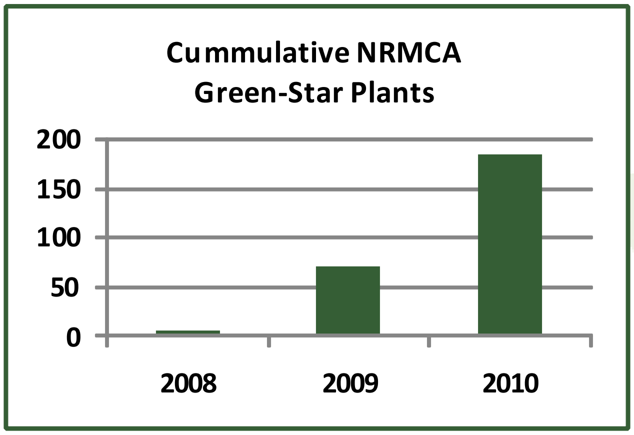
NRMCA offers these continuing education programs through leading industry organizations such as the American Institute of Architects, the U.S. Green Building Council and the American Society of Landscape Architects continuing education programs.

Concrete Sustainability Conference—NRMCA expanded its popular sustainability conference to international locations in 2010 and plans to continue to hold the conference in two locations each year, once in the western hemisphere and once in the eastern hemisphere. The objective of the conference is to provide learning and networking opportunities on the latest advances, technical knowledge, continuing research, tools and solutions for sustainable concrete manufacturing and construction.

Measurement

NRMCA has developed several programs designed to help concrete producers measure their progress toward meeting the NRMCA sustainability goals.

NRMCA Green-Star™ Certification—NRMCA is committed to promoting environmental stewardship at concrete plants through the NRMCA Green-Star™ Certification program. This program provides incentives and recognition for concrete producers to adopt comprehensive Environmental Management Systems (EMS) to help ensure an environmentally friendly concrete plant. NRMCA Green-Star™ Certification provides a nationally recognized standard for those industry members that are on the forefront of the environmental excellence. NRMCA's Green-Star Plant Certification Program has grown to include over 200 plants worldwide since its launch in 2008.



Sustainable Concrete Plant Certification—NRMCA launched a comprehensive certification program in 2011 designed to help concrete producers measure their progress toward sustainability. The NRMCA Sustainable Concrete Plant (SCP) Certification includes quantitative, performance-based metrics to provide concrete producers with specific guidance to assess their production practices and implement sustainability strategies to lower their overall footprint.

To certify, plant personnel use *Sustainable Concrete Plant Guidelines* to rate a plant's level of sustainability with the following objectives:

- Reducing carbon footprint,
- Reducing energy consumption
- Reducing water use
- Reducing waste
- Increasing recycled content
- Improving human health and social concerns

Plants can achieve between 0 and 100 points depending on how many sustainability credits are achieved and their level of performance within each credit. Once the plant documentation is verified by a third-party auditor, NRMCA awards the plant with the appropriate NRMCA Sustainable Concrete Plant Certification level:

- Bronze: 30-49 points
- Silver: 50-69 points
- Gold: 70-89 points
- Platinum: 90-100 points

Plant personnel can use the Guidelines to implement new sustainable practices or improve on existing practices with the objective of recertifying at a higher level to demonstrate continuous improvement toward meeting the NRMCA sustainability goals. Through the development of this program, NRMCA was able to set baselines for embodied energy, carbon footprint, water use, waste and recycled content.

Baseline Metrics for Key Performance Indicators

Key Performance Indicator	Member Survey*
Embodied Energy	2.73 MMBtu/yd^3
Emissions (CO2)	634 lb/yd^3
Water Use	177 lbs/yd^3
Waste	157 lbs/yd^3
Recycled Content	1.9%

*Data was obtained from NRMCA member surveys with limited sample size. In some cases this data was obtained from samples that would not be considered random. NRMCA continues to refine survey data for future reporting.

Biodiversity—In 2010, NRMCA and the Wildlife Habitat Council established a program that promotes the biodiversity of ready mixed concrete production facilities. This new partnership is designed to encourage participation in the programs of each organization and to engage and demonstrate voluntary corporate leadership in environmental performance, including enhancement and restoration of wildlife habitat.

Advocacy

NRMCA is committed to continuous environmental improvement through product standards that lead to reduced environmental impact.

Performance-based Specifications—NRMCA continues to implemented the P2P Initiative™ (Prescriptive to Performance Specifications) with the objective of providing concrete producers with more flexibility to optimize concrete mixtures with the ultimate goal of reducing environmental impact. Traditionally, construction specifications for concrete have required unnecessarily high quantities of portland cement along with other limits on the use of supplementary cementitious materials. The P2P Initiative™ intends to minimize many of these restrictions, thus providing more flexibility to meet performance requirements for strength and durability while minimizing environmental impact.

NRMCA, along with other industry partners, was successful in implementing performance requirements for concrete durability requirements within American Concrete Institute (ACI) 301-10, Standard Specifications for Structural Concrete and ACI 318-08, Building Code Requirements for Structural Concrete. These changes, which incorporate the concept of exposure class for concrete subject to harsh environments, are similar to progressive standards in other countries around the world that have moved toward performance-based specifications.

In addition, an ACI Innovative Task Group (ITG-8) report was published in 2009 that outlines considerations for implementing performance-based requirements on projects. As a result of this work, a new ACI committee (ACI 329), titled Performance-based Requirements for Concrete, was formed to further develop performance criteria in concrete standards.

Ultimately, this work will result in significant progress toward the increased use of industrial byproducts and other recycled materials in concrete. The environmental benefits of using these materials means a reduction in the amount of materials sent to landfills, reduced raw materials extracted, reduced energy of production and reduced emissions including carbon dioxide.

Sustainability Standards—The concrete industry supports and participates in the process of developing green building standards for homes, buildings and roadways. NRMCA continues to participate in the development process for sustainability standards such as Leadership in Energy & Environmental Design (LEED®), the International Green Construction Code (IgCC) and Greenroads, among others. It supports the concept of full environmental Life Cycle Assessment with emphasis on the use or operational phase of construction projects.

One major initiative from NRMCA is to develop model ordinances that members and local partners can use in their state and municipal government affairs activities. Several model ordinances specifically addressing sustainability issues have been developed to encourage local jurisdictions to adopt the following amendments to existing building codes:

- Adopting a green building standard
- Stormwater management standards
- Urban heat island reduction standards
- Life cycle assessment standards
- Durability and disaster resistance standards

Future Initiatives

NRMCA members will continue to work on existing and new programs with the objective of lowering the overall footprint of concrete construction. Many of these programs will take years to develop but will eventually yield positive results. NRMCA will continue to track progress toward the targets set in 2009 and report progress annually. Visit www.nrmca.org/sustainability to track progress.

About the National Ready Mixed Concrete Association

Founded in 1930, the National Ready Mixed Concrete Association is the leading industry advocate. The association's mission is to provide exceptional value for members by responsibly representing and serving the entire ready mixed concrete industry through research, education and advocacy.

Sustainability Vision

The vision of the ready mixed concrete industry is to transform the built environment by improving the way concrete is manufactured and used in order to achieve an optimum balance among environmental, social and economic conditions.

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Published May 2011