

Sustainable Concrete Solutions Center (SCSC)

Assessment of New Practices and Emerging Technologies Integrated into a Mix Optimization Decision-making Tool

Overview: Energy Costs, Climate Change, and the Future of Concrete

A total of 2.3 billion tons of cement was used in 2007, and demand rises by 130 million tons annually. Growing investment in infrastructure will lead to increased cement and concrete use. Cement production generates ~5% of global manmade CO₂ emissions (1 ton of CO₂ per ton of cement made) and is the second-largest industrial process-related source of CO₂ emissions in the United States. The construction industry will face new pressures as energy costs rise and new energy efficiency and CO₂ policies are adopted by governments and customers. Several states are already developing project specifications that will impose limits on CO₂ associated with concrete. The American Concrete Institute (ACI) is developing a “green rating” system that will be awarded for sustainable concrete construction solutions. The near- and long-term use of cement in concrete production is on the threshold of change.

The Challenge

These changes are leading construction companies to focus new attention on the use of cement:



- **Performance and Risk:** How well do improved conventional cements and new concrete materials meet the standards and specification requirements?
- **Energy and Environment:** How do new cements affect energy efficiency and carbon footprint throughout the construction life cycle?
- **Costs and Economics:** How does the use of improved or new concrete materials affect construction costs?
- **Policy Impacts:** How will new laws and standards influence demand for low-carbon cement and construction practices?
- **Decision-Making Challenge:** How can the construction industry make decisions that optimize all factors under different construction conditions?

The Opportunity

Assessment of the performance, energy efficiency, and cost impacts of novel cements and new concrete materials is needed to inform the construction industry and assist in the decision-making process. To meet the challenges listed above, decision-makers need to understand the advantages and trade-offs of three major directions in sustainable concrete technology:

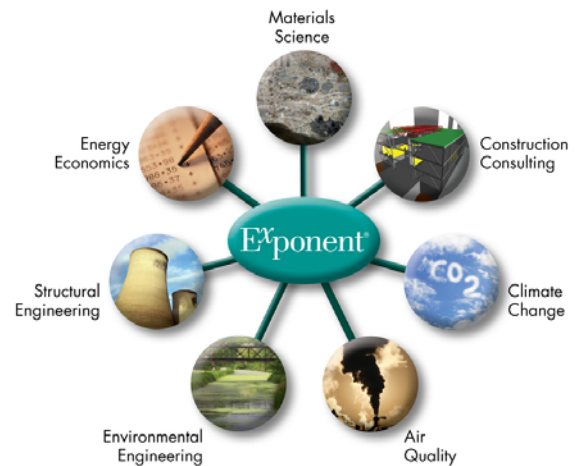
1. **Reducing CO₂ in Concrete Materials:** Supplementary cementitious materials (SCMs) and limestone filler (cement content reduction), aggregate size and gradation optimization (binder content reduction), low CO₂ cements (via low-CO₂ raw materials and energy-efficient production), and cement-free binders (geopolymers, alkali activated materials).
2. **Performance-Based Specifications:** Greater flexibility through innovative and optimized solutions that meet performance standards such as ASTM C 1157.
3. **High-Performance Concrete:** Composition tailored to enhance durability, strength, structural demand, environmental conditions, chemical exposure, extended service life, and lower maintenance.

To manage in this changing environment, an integrated assessment is needed of performance, energy, environmental, and economic impacts of improvements in concrete technology. Also needed is an appraisal of emerging next-generation concrete materials, and the creation of a mix-optimization decision-making tool for end-users in construction that puts new advances to work in the field. Exponent is offering to develop these tools with sponsors' participation.

About Exponent

Exponent (formerly Failure Analysis Associates) is a world-class, publicly traded corporation that specializes in engineering and scientific consulting. Over the past several decades, Exponent's civil engineers, materials scientists, construction consultants, energy economists, and environmental scientists have been leaders in assessing the causes of materials and structural failures and in developing cost-effective, innovative solutions to our clients' construction, engineering, and materials challenges. Our scientists and engineers have a deep understanding of how complex systems work—and fail—and are prepared to combine these capabilities with an end-user-driven analytical focus to assess new practices in the concrete industry, and to generate strategic decision-making tools for concrete optimization. Our highly experienced multi-disciplinary team, who works in offices around the globe, will support this multi-client program.

Exponent capabilities related to sustainable concrete technology



Our Sustainable Concrete Solutions Center program will be carried out in close cooperation with the civil engineering and materials science experts in existing concrete materials and emerging innovations at **Stanford, Purdue, and Villanova Universities**. This cooperation provides access to state-of-the-art laboratories and cutting-edge research on sustainable concrete (e.g., high-fly-ash-content concrete, alkali-activated fly ash/slag concrete, high-performance concrete, and performance-based concrete mix design).

The Exponent Sustainable Concrete Solutions Center Program

This program offers members of the project management, construction, and structural engineering industry, along with major investors in construction, an opportunity to share the costs of a rigorous engineering and economics-focused appraisal of new practices in green cement and sustainable concrete, leading to a new tool for mix-optimization. The program will consist of two concurrent tracks refined with sponsor participation.

Track 1: Develop Decision-Making Concrete Optimization Tool

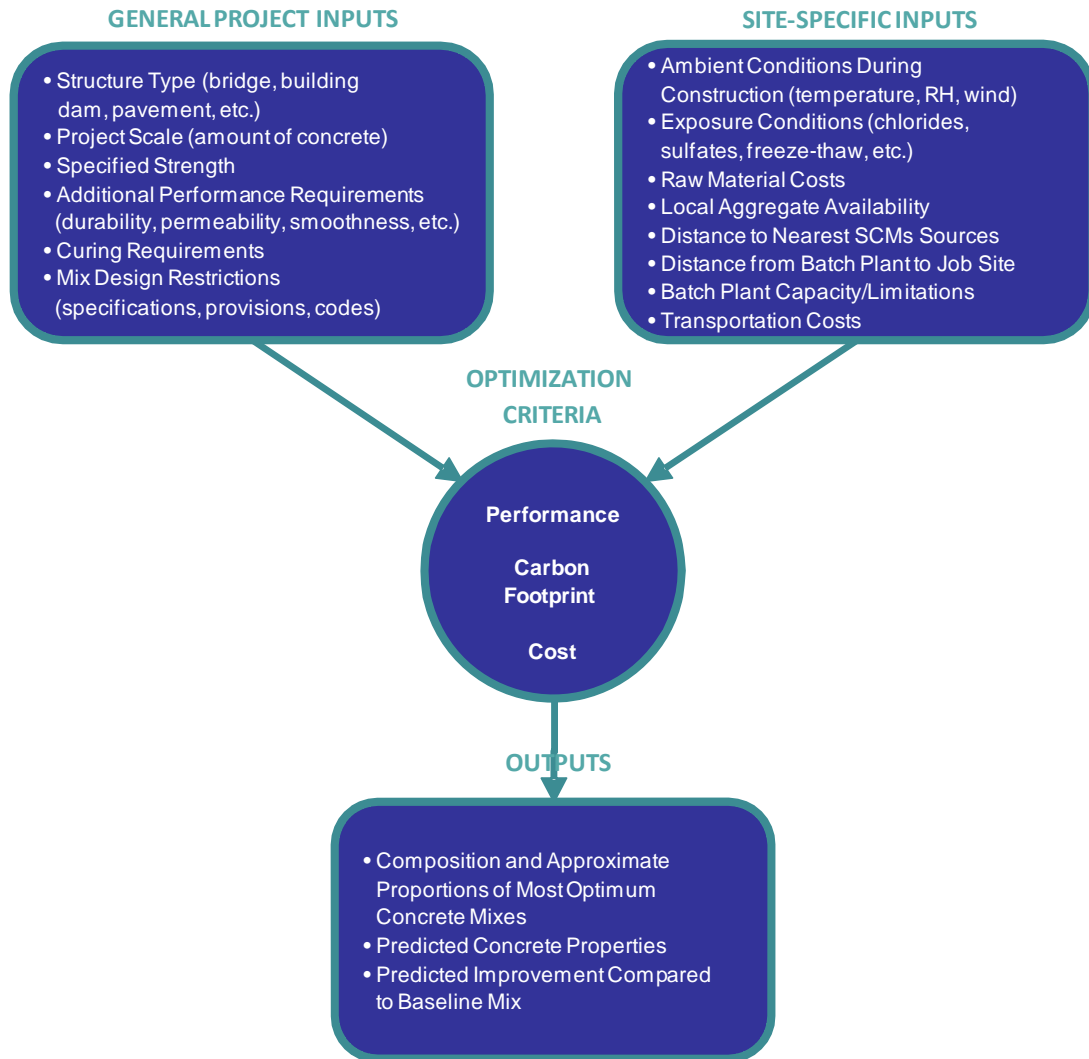
- Utilize currently available materials and technologies
- Based on voluminous published data
- Comprehensive tool integrating performance, environmental, and economic criteria on a project-by-project basis
- Allow end-user to select optimal concrete composition for given application (structure type and scale), location, and material availability.

Track 2: Evaluate New Materials and Emerging Technologies

- Develop and evaluate new materials
- Assess feasibility, availability, and practicality
- Integrate findings into the decision-making concrete optimization tool.

End-Use Optimization Application Focus

The Sustainable Concrete Solutions Center recognizes that there are major differences in the performance requirements of different applications of concrete, such as transportation infrastructure (highways and bridges), airport pavements, and major facilities (power plants, dams, ports, canals). The Exponent program is designed to analyze how different mix compositions including emerging materials and technologies meet the specific performance standards for particular end uses and integrate these into the proposed mix optimization decision-making tool.



Exponent will establish specific end-user working groups within our overall set of sponsors. These end-user working groups will help define the performance issues and parameters that each track of our two-track analysis and development program will address and will be integrated accordingly into the mix-optimization decision-making tool. First, these working groups will advise on our assessment of current and emerging best practices in green cement and sustainable concrete. Second, these groups will play an even more important role in the review of the assessment and implementation of emerging cements and concrete mixes, helping to establish guidelines and standards for future use.

Proposed Work Plan

The program will have a biannual flow of tasks, as follows, with quarterly progress deliverables:

- **Task 1.** Meeting 1: Program Launch—Sponsor meeting and confirmation of program structure
- **Task 2.** Concrete Mix-Optimization Tool Framework for Existing Materials: Objectives, criteria, collect data, catalog properties.
- **Task 3.** Plan Emerging Green Cement Assessment: Criteria, lab and field parameters, screen and select materials.
- **Task 4.** Meeting 2: Cement Technology Trends and Mix Optimization Potential.
- **Task 5.** Develop Decision-making Tool: Build prediction models; test, validate, and calibrate models; incorporate emissions outputs, economic considerations, and industry policy.
- **Task 6.** Conduct Technical Assessment of Emerging Green Cement Technologies: Test, analyze, compare.
- **Task 7.** Meeting 3: Hold Year One Findings Event—Deliver optimization tool, present findings on emerging materials assessment.
- **Task 8.** Continue Technical Assessment of Emerging Green Cement Technologies: Refinement of testing and analysis scope.
- **Task 9.** Meeting 4: Emerging Green Cement Materials Potential.
- **Task 10.** Integrate Emerging Materials Assessment Findings into Optimization Tool: Expand and refine tool, prepare and submit drafts, review, finalize.
- **Task 11.** Meeting 5: Program Conclusion—Current and emerging green cement technologies, impacts on energy/carbon footprint, technical performance, cost impacts, optimization of concrete.

Program Structure and Cost

SCSC is a multi-client service offering by Exponent that will carry out an agreed-upon set of annual research assessment tasks for a limited number of members. Companies that join SCSC will pay a renewable annual “membership fee” of \$50,000, which entitles them to actively participate in the assessment process, including helping to shape the final work program and receipt of the mix-optimization decision-making tool. For an additional \$10,000, a 2-day onsite assessment of concrete mix optimization needs, strategy, and application of the decision-making tool can be provided on completion of the program.



SCSC Launch and Operations

Once Exponent has obtained a minimum threshold of 10 members (our target is ~20 firms), SCSC operations will begin. At launch, Exponent will contact each member firm and provide a schedule and agenda for the launch meeting—the first of three collaborative work sessions during the year. A proposed work plan and descriptions of the program team and past projects are provided in our prospectus presentation.

Joining SCSC

Your firm is invited to join the 2010 Exponent Sustainable Concrete Solutions Center.

Please e-mail or call for further information:

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