



Mission:
To support research and educational programs that will increase professionalism and quality in the concrete industry.

RMC Research & Education Foundation

Project Funding Summary

Updated April 2010

Introduction

The RMC Research & Education Foundation is using the generous contributions of concrete industry members to fund programs that are helping to improve an already superior product in an industry committed to excellence. These projects are helping to demonstrate that the concrete industry is:

- Dedicated to strong environmental stewardship,
- Concerned with protecting the safety of its workforce,
- Working toward improving broad concrete applications, and
- Devoted to strengthening the education and training of current and future professionals within the industry.

The research and educational programs supported by the RMC Research & Education Foundation represent a broad spectrum of projects that are helping to keep the concrete industry on the cutting edge in the general public's interest. The quest of building an endowment to generate approximately \$1 million annually in interest income to fund programs in perpetuity is aggressive, but attainable. The mission of keeping the concrete industry forever moving forward has only just begun.

Concrete Sustainability Hub at Massachusetts Institute of

* Also falls under Concrete Applications: Quality & Performance Track

Sponsors:
RMCREF
PCA

**Research
Lead:**
Massachusetts
Institute of
Technology

Funding:
\$10 million
over five
years, split
evenly
between the
sponsors

**Progress
Report:**
Initial
project
deliverables
are due
August
2010.

Research at the Concrete Sustainability Hub (CSH) will initially be organized around three focus areas: concrete materials science, building technology and the econometrics of sustainable development. The first two projects, “Green Concrete Science,” and “The Edge of Concrete: A Life-Cycle Investigation of Concrete and Concrete Structures” are already underway. Initial progress will be reported on in Spring 2010. These projects will focus on quantifying and enhancing the sustainable nature of concrete.

MIT was selected to house the CSH because it is the #1 engineering and economics school in the U.S., and recognized as such worldwide. The agenda for the CSH will be directed through a Research Advisory Committee (RAC) that will include RMC Research & Education Foundation Executive Director Julie Garbini and Portland Cement Association President and CEO Brian McCarthy. The other two slots on the RAC will include representatives of MIT. Projects will include the participation of researchers from MIT’s School of Engineering, School of Architecture and Planning, and the Sloan School of Management. Progress and applicability to anticipated results will be monitored with the help of a joint RMCREF-PCA Industry Advisory Council and industry technical experts on RMCREF’s existing Advisory Council.

Effect of Pavement Type on Fuel Consumption and Emissions

Sponsor:
RMCREF

Research Lead:
University of Texas at Arlington

Funding:
\$119,230

Progress Report:
The final report and calculator are available for download from the Foundation's website

As fuel prices continue to be a major source of concern throughout the country, researchers examined ways to increase fuel efficiency wherever possible. One area where relief is found is through the use of different pavement types. The RMC Research & Education Foundation worked with the University of Texas at Arlington to produce the final report *Effect of Pavement Type on Fuel Consumption and Emissions in City Driving*. The study focuses on urban driving conditions on streets and local roads that will build on previous research that examined these issues on highways. The project includes the tool *Roadway Fuel Consumption and Emissions Calculator*, which includes a correlation to government data so that the model can be used to calculate fuel consumption savings and environmental benefits of a variety of pavement types by municipalities and state DOT's to assist in their decision-making. The work can be used to help understand the overall carbon footprint of concrete vs. asphalt pavements over the design life of a project.

Side-by-Side Comparison of Pervious Concrete & Porous Asphalt*

Sponsors:

RMCREF
Villanova
University
US EPA
Prince
George's
County, MD

In-Kind

Services:
NRMCA

Research

Lead:

Villanova
University's
Urban
Stormwater
Partnership

Funding:

\$50,000

Progress

Report:

The final
report is
available upon
request.

* Also falls under Concrete Applications: Quality & Performance Track

This study, being carried out by Villanova University's Villanova Urban Stormwater Partnership, will examine the differences between pervious concrete and porous asphalt with regard to durability, maintenance requirements, the ability to transmit or filter key contaminants such as hydrocarbons and the ability to mitigate heat island effects. There has been a great deal of interest, particularly on the part of the United States Congress and Environmental Protection Agency (EPA), to research the environmental impact of various pavements, and a key component of this research will include the impact these two pavements have on water quality. Since maintenance requirements will be studied as well, the researchers will also include recommendations for keeping the pavements functional.

Performance Assessment of Pervious Concrete and Maintenance Plan*

* Also falls under Concrete Applications: Quality & Performance Track

Sponsors:

RMCREF
Rinker
Materials (now
Cemex)
Federal
Highway
Administration

Research Lead:

Stormwater
Management
Academy at the
University of
Central Florida

Funding:

\$50,000

Progress

Report:

Study
completed. The
reports are now
available as
hard copies or
on CD.
Executive
Summaries are
available for
download from
the
Foundation's
website.

The use of pervious concrete pavements continues to grow as builders and communities move toward sustainable development. One of the environmental benefits of pervious pavements is its stormwater management properties. However, without proper maintenance, pervious pavement may become clogged and lose some of its permeability. Additional research is also needed to ensure acceptance of the use of pervious pavements. This research, carried out by University of Central Florida and in partnership with FHWA and Rinker Materials, addresses three main issues that are of interest to both the staff in water management districts and the concrete industry for widespread acceptance of pervious pavements: namely, 1. the design cross-section to ensure adequate infiltration, 2. credit for replacement of impervious areas, and 3. operational and maintenance issues.

Performance of Pervious Concrete Pavement in Cold Weather Climate*

*Also falls under Concrete Applications: Quality & Performance Track

Sponsor:
RMCREF

**Research
Lead:**
University
of
Minnesota

Funding:
\$49,950

**Progress
Report:**
This study
will be
completed
in summer
2010.

This research, performed by the University of Minnesota's Civil Engineering Department, will look at the structural and hydraulic performance as well as the durability of pervious concrete installations throughout the State of Minnesota. Through the evaluation of existing installations, this research will experiment with new pervious concrete mix designs and identify material, design, and construction-related performance criteria for the installation and maintenance of pervious concrete pavements in severe freeze-thaw environments. It will also develop a method of examining in-situ clogging of the pavement layers. The study will combine field analysis of existing pervious concrete installations, including an instrumented, three-year old installation at the unique MnROAD facility in Albertville, MN, with the evaluation of the microstructure of new mix designs. Additionally, a novel method for assessing the role of void structure in resisting clogging and reduced permeability will be validated and the effectiveness of cleaning methods will be evaluated. A panel made up of representatives from the Aggregate and Ready Mix Association of Minnesota and the Minnesota Department of Transportation will assist with review of this research throughout the process.

Long-Term Field Performance of Pervious Concrete Pavements*

* Also falls under Concrete Applications: Quality & Performance Track

Sponsor:
RMCREF

Research Lead:
Cleveland State University

Funding:
\$100,000

Progress Report:
The final report, titled “Portland Cement Pervious Concrete Pavement: Field Performance Investigation on Parking Lot and Roadway Pavements”, is available for download from the Foundation’s website. Hardcopies are also available upon request.

Pervious concrete pavements are growing in popularity but study of their long-term performance has still been needed in order to evaluate and improve them. This evaluation of the long-term field performance of pervious concrete pavement is helpful not only to the concrete industry but also to design and permitting communities and end users. The study, carried out by Cleveland State University, evaluates current pervious concrete pavements of various ages with differing soils, environmental conditions, and geographical locations, particularly those in colder weather climates. The final report includes recommendations for changes in designs, construction, and maintenance of pervious concrete pavements.

Pervious Concrete Research Compilation*

Sponsor:
RMCREF

Research Lead:
Dr. Heather Brown at the Concrete Industry Management Program at Middle Tennessee State University

Funding:
\$10,000

Progress Report:
The original report was released in 2006. The revised version, released in June 2008, includes new research, abstracts, and links to research reports as available. The report is available at from the Foundation's website.

* Also falls under Concrete Applications: Quality & Performance Track

Pervious concrete is one of the hottest research subjects today due to the application's environmentally-friendly nature. The Pervious Concrete Research Compilation is an excellent resource for producers, specifiers and owners seeking more information on pervious concrete research. It details past, current and proposed research regarding pervious concrete and helps to identify gaps in pervious concrete research. It is also a tool for the Foundation's Board of Trustees to use as they evaluate pervious concrete research proposals that are submitted to the Foundation, to ensure that we do not fund duplicative research.

Heat Island Mitigation Through Use of Pervious Concrete

Sponsors:
RMCREF
US EPA

Research

Lead:
Dr. Liv Haselbach - Washington State University and Dr. John Kevern - University of Missouri - Kansas City

Funding:
\$1,110

Progress Report:
This project was approved for funding in spring 2009 and has been incorporated into a larger EPA project which was placed in September 2009. Data will be collected and reviewed through spring and summer 2010 with report expected in fall 2010.

Pervious concrete's many environmental benefits are well-known. However, its potential contributions to the mitigation of the urban heat island effect have not yet been fully detailed. Dr. Liv Haselbach with Washington State University and Dr. John Kevern with the University of Missouri – Kansas City theorize that while pervious concrete's surface warms from solar reflectance, the full thickness of the pavement and base below remain cooler, due to the insulating properties of the pavement's void structure. This allows the pavement to demonstrate heat island mitigation properties with little or no regard to its Solar Reflective Index (SRI).

Equipment for monitoring the pavement's temperature at the surface and below was incorporated into an upcoming United States Environmental Protection Agency (EPA) pervious project in Edison, NJ. Drs. Haselbach and Kevern are working with EPA personnel to conduct the study. The RMC Research & Education Foundation approved funding to assist researchers in data collection and processing.

As part of the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) program, the mitigation of the heat island effect is currently awarded points based solely on the SRI. However, the results of this study could lead USGBC to establish a separate set of criteria for pervious pavement with regard to heat island mitigation based not on SRI, but rather on its insulating properties.

Pervious Concrete Mix Design for Wearing Course Applications*

*Also falls under Concrete Applications: Quality & Performance Track

Sponsors:

RMCREF
FHWA
CP Tech Center
DOT Pooled Resources Fund
ACPA

Research

Lead:

The CP Tech Center at Iowa State University

Funding:

\$100,000

Progress Report:

This project was approved for funding in October 2006 and is scheduled to continue for 30 months. Additional field work and monitoring will continue through summer 2011.

Carried out by The Concrete Pavement (CP) Tech Center at Iowa State University, this project will include a comprehensive study focusing on the development of pervious concrete mix designs having adequate strength and durability for wearing course pavements and having surface characteristics which reduce noise and enhance skid resistance, while providing adequate removal of water from the pavement surface and structure. The researchers believe the study's results will provide new information about the suitability and long-term behavior of pervious concrete mixes for highway, street and local road applications. The study's findings will be critical to realizing the goal of increasing highway safety through increased noise reduction, increased skid resistance and reduced road spray. Utilizing pervious concrete for highways would also provide many environmental benefits, which the study will also detail.

In addition to the RMC Research & Education Foundation and The CP Tech Center, other funding sources for this project include the Federal Highway Administration (FHWA), the Pooled Resources Fund of several state Departments of Transportation and the American Concrete Pavement Association (ACPA).

Development of Sustainable Concrete Plant Guidelines

Sponsor:
RMCREF

**In-Kind
Services:**
NRMCA

**Research
Lead:**
West Main
Consultants;
William C.
Twitty, Jr.,
P.E.

Funding:
\$122,500

**Progress
Report:**
The
Guidelines
are almost
finalized and
a pilot
program is
scheduled for
summer
2010.

One of the great benefits of concrete as a sustainable building material is its very nature; it is made in batches in local facilities. Small changes in how it is produced can make a significant environmental impact. This project will develop guidelines for a number of small and large changes that will allow the industry to establish itself as one of the cleanest and most progressive industries there is.

There is considerable knowledge available on how to produce concrete with lower environmental impacts and much work has been done to compile life cycle inventories of cement and concrete products. These guidelines will help quantify the effect of sustainable practices within the ready mixed concrete industry and encourage those practices. Some of the sustainable strategy categories that will be explored will include: waste management; water management; air quality; and energy efficiency. The project deliverables will include a literature search, survey of select concrete plants, guidelines with a narrative, a carbon calculator, a detailed companion document outlining implementation and environmental issues associated with each guideline, and a detailed procedure for concrete producers to follow in order to document meeting the criteria in the guidelines.

Ready Mixed Concrete Industry LEED Reference Guide

Sponsors:
RMCREF
PCA

**Research
Lead:**
Steven Winter
Associates,
Inc.
NRMCA
PCA

Funding:
\$49,460

**Progress
Report:**
The Third
Edition of the
LEED Guide,
revised to
include
information
on LEED
2009 NC, is
available for
download
from the
Foundation's
website.
Printed
hardcopies are
available for a
nominal fee
from the
NRMCA.

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is intended to be a design guideline and third-party certification tool, aimed to improve occupant well being, environmental performance and economic returns of buildings using established and innovative practices, standards and technologies.

The *Ready Mixed Concrete Industry LEED® Reference Guide*, funded by the RMC Research & Education Foundation and the Portland Cement Association (PCA), is helping specifiers understand the environmental benefits of concrete and how they meet the LEED rating system. It is also a tool for producers in understanding the environmental advantages of concrete and how they can improve their processes to be more environmentally friendly and score higher under LEED.

Concrete Joint Sustainability Initiative

Sponsors:

RMCREF
Many
Industry
Partners

Project

Lead:

ACI
NRMCA
PCA

Funding:

\$10,000

Progress

Report:

The
Initiative is
in the
process of
being
implemen
ted through
all major
industry
organizatio
ns.

RMCREF funded an effort started by ACI's Strategic Development Council to develop a Sustainability Vision Roadmap for the concrete industry. The effort was the genesis for what has now become a larger Joint Sustainability Initiative. As part of this initiative, a Joint Declaration of Industry Vision has been developed and signed by all the major concrete industry organizations. Each organization will play their role in embracing the sustainability initiative within the context of their own respective missions and capabilities. The commitment is to drive continuous improvement at component and integrated levels to enhance the social values of concrete structures including resource efficiency, safety/protection, financial responsibility, operational continuity, longevity/durability, byproducts reduction, esthetics, and societal connectivity.

Air Emissions Testing Program at Ready Mixed Concrete Plants

Sponsor:
RMCREF

**In-Kind
Services:**
NRMCA

**Research
Lead:**
Air Control
Techniques,
P.C.

Funding:
\$237,840

**Progress
Report:**
Study
completed. On
June 23, 2006,
the United
States
Environmental
Protection
Agency (EPA)
adopted
changes to the
AP-42 standard
based on the
findings of this
study.

For years, concrete producers and the Environmental Protection Agency (EPA) did not have an accurate assessment of actual emissions of total filterable particulate matter from ready mixed concrete plants. In an effort to better understand these emissions and the effect they have on air quality, the RMC Research & Education Foundation funded a study that developed a testing protocol and program, collected the data from a representative number of concrete plants, and established verifiable emission factors based on the collected data. This information was then used by the National Ready Mixed Concrete Association and EPA to make changes to EPA's AP-42, Chapter 11.12 to reflect the more accurate data. Due to operating permit fees being based on emission rates, the adoption of the Foundation's data has resulted in an estimated 25% reduction in permit fees for transit mixed concrete plants. The more accurate data will also be useful as EPA evaluates and recommends future control strategies under the National Ambient Air Quality Standards.

Hexavalent Chromium Personal Exposure Study

Sponsor
RMCREF

Research Lead
Clayton Group Services

Funding
\$27,610

Progress Report
Study completed. The data from this study was a critical element in the concrete and cement industries being excluded from OSHA's proposed rule, resulting in industry savings of over \$63 million. An Executive Summary is available for review.

This study, conducted by Clayton Group Services, collected exposure data from four ready mixed concrete facilities and found exposure rates to be significantly lower than OSHA's suggested personal exposure level. The study provides an assurance to employers and employees that there is extremely low inhalation exposure to industry personnel with regard to hexavalent chromium.

On February 28, 2006, the Occupational Safety and Health Administration (OSHA) released its final rule on hexavalent chromium exposure reporting requirements. The final rule excluded the concrete and concrete products industries (including ready mix, precast, prestressed and concrete pipe) based on data from the Foundation-funded Hexavalent Chromium Personal Exposure Study. The study was used as the basis for comprehensive comments submitted by the National Ready Mixed Concrete Association (NRMCA) to OSHA. In its proposed rule, OSHA estimated that compliance costs for the concrete and concrete products industries would have been \$63.6 million had concrete been included.

Examination of the Effect of Potassium Acetate on Concrete Durability

Sponsor
RMCREF
PCA

Research Lead
Michigan Technological University
University of Toronto

Funding
\$40,000

Progress Report
This project was approved for funding in June 2009. Completion is expected in late 2010.

Potassium acetate is increasingly being used for deicing on airport runways. However, there is increasing evidence that the use of potassium acetate can cause pavement deterioration. With concrete pavements, such symptoms include surface deterioration with alteration of paste, deleterious interactions with supplemental cementitious materials (SCMs) in concrete, freeze-thaw deterioration exacerbation, interactions between mechanisms and materials, and, in particular, alkali-silica reaction (ASR) exacerbation. In fact, the adverse affect potassium acetate seems to have on ASR has caused the Federal Aviation Administration (FAA) to implement an extremely severe modified ASR test. The Federal Highway Administration (FHWA) is also concerned about this issue since it is increasingly using potassium acetate on bridges.

This project seeks to identify the specific causes and effects of potassium acetate's impact on concrete by looking at mix design and experimenting with aggregates, SCMs and admixtures. The project will include recommendations on how to mitigate potassium acetate's impact on ASR damage and other pavement deterioration. It will also give guidance to FAA and FHWA on these issues, as well as on how specifications may be improved.

Virtual Cement and Concrete Testing Laboratory Consortium: National Institute of Standards and Technology

Sponsors:

RMCREF as part of an Industry Consortium

Research

Lead:

NIST
VCCTL

Funding:

\$220,000

Progress

Report:

NIST
Continues to refine the VCCTL software with input from participants in the consortium. A link to the current version of the software is available. Please contact us for more information.

Assuring the quality of the ready mixed concrete delivered to the job site is critical. This task is daily becoming more difficult due to the increasing complexity of concrete mixture proportions, the increased emphasis on including environmentally-friendly materials in concrete, and a lack of a fundamental understanding of the influence of curing environments on the performance of these more involved concrete mixtures. The National Institute of Standards and Technology (NIST), in collaboration with members of the cement and concrete industry, is developing the Virtual Cement and Concrete Testing Laboratory (VCCTL), a software tool that uses science-based models, validated by physical testing, to simulate and predict the properties and performance of cement and concrete. The Foundation's funding supports the participation of NRMCA to provide the industry's perspective and needs in the industry consortium. The VCCTL purports to improve the process of establishing concrete mixtures for performance, both in the plastic and hardened state, and to expedite the introduction of innovative concrete mixtures to the marketplace, as their longer-term performance will be accurately predicted and assessed. Performance properties that can be predicted using the VCCTL currently include plastic concrete rheology, setting time, mechanical properties, and fluid transport properties. The ultimate goal and benefit of the VCCTL can be stated as the following: the VCCTL will deliver the same kind of computational power to the design of concrete materials as finite element analysis brings to structural design.

Self-Consolidating Concrete Formwork Pressure Study

Sponsors:
RMCREF
ACI SDC

**Research
Lead:**
Université De
Sherbrooke
Purdue
University
Northwestern
University
CTL Group

Funding:
\$230,000

**Progress
Report:**
This project
was approved
in May 2006.
The Task I
Report,
which is a
literature
review, is
available for
download
from the
Foundation's
website. The
final report is
expected in
2010.

Self-consolidating concrete (SCC) can offer advantages for use in cast-in-place applications including a reduction in casting time, facilitating the casting of congested and complex structural elements, elimination of mechanical vibrations and noise and improvement of surface appearance. However, the growth in use of SCC has been hampered by the lack of knowledge on the lateral pressure that such concrete can exert on formwork systems. This project will study issues surrounding formwork pressure exerted by SCC such as mixture compositions, casting rates, geometry of formwork, reinforcement density and temperature. The project will also examine the relationship of the maximum lateral pressure and rate of decay in lateral pressure to the initial plastic properties of the SCC. The study will allow for the development of practical guidelines for lowering lateral pressure on SCC and will also include proposed design equations to predict formwork pressure that can be exerted by SCC on column and wall elements. Finally, the project will include the creation of a portable apparatus for measuring and predicting the lateral pressure and its rate of decay of SCC.

This project is being funded by the RMC Research & Education Foundation and the America Concrete Institute's Strategic Development Council (ACI SDC).

Novel Concrete Permeability Measurement Techniques for Quantifying Durability Performance

Sponsor:
RMCREF

**Research
Lead:**
Texas
Transportation
Institute at
Texas A&M
University

Funding:
\$25,000

**Progress
Report:**
This first phase
report is
complete.

The durability of concrete is a natural indicator of its long-term performance. However, there is a lack of satisfactory tests for rapidly and accurately measuring the permeability of concrete – an indicator of durability. This study is a first phase of a project that seeks to develop new test techniques that will allow rapid and consistent measurement of concrete permeability. To ensure that the new testing approach will be accepted, the first phase funds a feasibility study that will correlate results of the proposed new test method to results from currently accepted test methods.

Forensic Evaluation of the Impact of Hurricanes and Flooding on Building Systems in the US Gulf Coast Region*

*Also falls under Environment, Health & Safety Track

Sponsors:
RMCREF
MCIA

Research Lead:
Mississippi State University

Funding:
\$30,000

Progress Report:
This study has been completed and is available on CD or as a hardcopy.

The devastation caused by Hurricane Katrina and other natural disasters are well documented. However, it remains unclear what may be done to keep structural devastation to a minimum in the wake of a catastrophic storm, and protect life safety. In an effort to learn what role building materials and building codes play in preventing or contributing to structural damage from weather-related incidents, the Mississippi Concrete Industries Association (MCIA) and the RMC Research & Education Foundation worked with the Mississippi State University Civil Engineering Department to perform a forensic evaluation of building materials and building codes. This has assisted with the development of recommendations for the rebuilding of the United States Gulf Coast region affected by hurricane damage.

Concrete structures provide greater protection from high wind and projectile damage than most other building materials; however, building codes in regions prone to weather incidents such as hurricanes have not been updated to ensure that both commercial and residential buildings are adequately equipped to protect public safety during a catastrophic weather event. This study assessed how structures performed under hurricane conditions under the current building codes, similar to the evaluation that southern Florida building codes underwent after Hurricane Andrew struck in 1992.

Study of Crushed Returned Concrete as Aggregates for New Concrete*

*Also falls under Environment, Health & Safety Track

Sponsor
RMCREF

**Research
Lead**
NRMCA
Lab

Funding
\$45,284

**Progress
Report**
Study
completed.
The final
report is
available for
download
from the
Foundation's
website.

This study evaluates the use of crushed concrete aggregate (CCA) as aggregate in fresh concrete and provides producers with guidance on a methodology for the appropriate use of CCA in concrete. It will increase the acceptance of CCA as aggregate for use in fresh concrete, solving an important environmental problem and saving the industry approximately \$300 million annually in materials and disposal costs.

Guide for Inspection of Ready Mixed Concrete Production Facilities/Evaluation of Concrete Batching Accuracy

Sponsor
RMCREF
NRMCA

**Research
Lead**
Gene Daniel

Funding
\$29,670

**Progress
Report**
The Plant Inspector's Guide has been completed and is available through the National Ready Mixed Concrete Association as part of their Plant Certification Program. More information may be found at www.nrmca.org or by contacting NRMCA at 301-587-1400.

The first part of this project includes a guide for the inspection of ready mixed concrete plants in accordance with the NRMCA plant certification program. This guide will clarify intent and facilitate a better understanding of the inspection requirements on the part of both the producer and the inspector. With the increased interest of state highway agencies in adopting the NRMCA plant certification, the development of this guide is timely to assure the credibility of the NRMCA plant certification program.

The second aspect of this project evaluates whether the current batching accuracy requirements in ASTM C 94, and inspected in the NRMCA plant certification program, are reasonable and achievable. Data gathered from several production facilities has provided guidance in the plant inspector's guide and may facilitate a revision to ASTM C 94. The project also describes recommended procedures for calibration of measuring devices (scales and water meters) used in concrete production.

Slab Curling Testing Program

Sponsor
RMCREF
ASCC

**Research
Lead**
ACI SDC

Funding
\$20,000

**Progress
Report**
Results
from this
study are
anticipated
in 2010.

Slab-on-grade concrete designs often encounter challenges related to moisture, vapor drive, mold, and mildew. The goal of this project is to outline a slab-on-grade construction that allows the successful installation of applied finishes without creating increased curling. Ten contractors across the country will place concrete slabs upon a vapor barrier and on a properly prepared base on the same day using the same concrete mix design. One concrete mix will be a “quick-dry” mix with a maximum W/cm of 0.40. The other mix will be a typical low shrinkage mix that will have a W/cm ratio of 0.53 +/- . The installations will be at least one bay wide and 100 feet +/- long with joint spacing of 15-17 feet. Diamond dowels will be used at half the construction joints and load plate baskets at half of the saw cuts. The slabs will be measured in three, six, and twelve month intervals and all testing will be done in accordance with ASTM 1555 standard floor flatness.

Ultimately, the results from this study should help the industry to place successfully slabs-on-grade with applied finishes without undue curling and adhesion loss and will also restrict vapor drive so that there is minimum mold developed on these slabs-on-grade. Funding for this project will be shared between the RMC Research & Education Foundation and the American Society of Concrete Contractors, in cooperation with the ACI Strategic Development Council (ACI SDC).

Funding to Complete Coal Ash Study Originally Funded by DOE*

*Also falls under Environment, Health & Safety Track

Sponsor

RMCREF
US
Department
of Energy

Research Lead

NRMCA
Lab

Funding \$30,000

Progress Report

This study is complete and available from the Foundation's website. The Fly Ash Guide for the Construction Team is also available from the website.

Funding for this project originally came from a research grant from the United States Department of Energy (DOE). However, funding was later terminated by DOE due to budget cuts and the RMC Research & Education Foundation elected to fund completion of the study, titled *New Technology-Based Approach to Advance Higher Volume Fly Ash Concrete with Acceptable Performance*. The study addresses two major stumbling blocks to increased use of fly ash in concrete : 1) lower early age strengths (≤ 7 days), and 2) delayed initial setting times.

The study, performed at NRMCA's Research Laboratory in cooperation with the University of Maryland and researchers Dr. Nick Carino (retired, National Institute of Standards and Technology) and Professor Anton Schnidler (Auburn University), includes the development of a step-by-step guide for use by construction teams on the application of the maturity method to confidently and safely use optimized fly ash concrete mixture proportions without negative effects on construction scheduling.

Life Cycle Costing-Service Life Model (Life-365)*

*Also falls under Environment, Health & Safety Track

Sponsors:

RMCREF as part of an Industry Consortium

Research

Lead:

Industry Consortium

Funding:

\$20,000

Progress

Report:

Version 2.0 of the Life-365 software is now available and may be accessed from the Foundation's website.

An industry consortium is supporting the upgrade to Version 2.0 of the Life-365 model. The members include the Silica Fume Association, Corrosion Inhibitor Association, Slag Cement Association, and NRMCA (funded by the RMC Research & Education Foundation). Each partner originally committed \$20,000 to support further work.

The first portion of the upgrade is to incorporate probabilistic principles in the model. This feature allows the user to evaluate a range of results based on probabilities of the input parameters. This upgrade was conducted by Evan Bentz at the University of Toronto and one of the original developers of Life-365. The second portion of the upgrade is to improve the life cycle costing functionality of Life-365. This work is being performed by Mark Ehlen, who was involved in the life cycle costing initiatives at NIST. The industry consortium has agreed to arrangements where all members will contribute funds for this upgrade by Ehlen.

The Life-365 model is related to a document under development by ACI Committee 365, who will prepare a guidance document on it.

Preparation of a Model Performance-Based Specification~

~Supports the P2P Initiative

Sponsor:
RMCREF

**In-Kind
Services:**
NRMCA
P2P Steering
Committee

**Research
Lead:**
John Bickley
R. Doug
Hooton
Kenneth C.
Hover

Funding:
\$116,780

**Progress
Report:**
Both Phase I
and Phase II
of this project
are complete
and are
available for
download from
the
Foundation's
website.

The general argument for prescriptive specifications is that they have worked for years. These specifications tell the concrete producer how to put his mix together and raise the specifier's expectations that he will get the required performance. The fact that the specification is prescriptive does not remove the responsibility of the liability for the performance of the product from the producer. Further, many of these prescriptive provisions cannot be enforced with reliable testing. In the broader scheme, the producer is not challenged to be innovative and optimize materials for intended performance. It also hampers the use of recycled materials.

This project creates a framework for specifiers to use in specifying for performance versus a prescriptive specification by performing a comprehensive global review of current performance specifications and criteria used for concrete including a presentation of findings; developing a model specification as performance-oriented as possible, given the present state-of-the-art and current limits of technology; and identifying the steps needed to be taken in the development of rapid and reliable means of confirming specified performance.

Development of a Guideline for a Quality Management System~

~Supports the P2P Initiative

Sponsor:
RMCREF

**In-Kind
Services:**
NRMCA
P2P Steering
Committee

**Research
Lead:**
William Twitty

Funding:
\$24,550

**Progress
Report:**
This project is
complete and
available for
download from
the
Foundation's
website.

The purpose of this project is to develop a guideline document for a ready mixed concrete producer to use in developing an internal Quality Management System (QMS). The goal is to establish a quality management standard that establishes the credentials of a ready mixed concrete producer to bid on and furnish concrete on performance-based criteria. The project includes a comprehensive set of guidelines for various aspects impacting quality so that a concrete producer can assure the purchaser that a uniform and consistent product is capable of being designed, produced and delivered.

The QMS guidelines are specific to ready mixed concrete production and include a review of current industry standard requirements such as in ACI, ASTM, AASHTO, ISO 9000, and NRMCA. The QMS guidelines are supported by an example Quality Manual of a fictitious company that documents the procedures that support quality. The P2P Steering Committee will use these guidelines as the basis of developing a producer qualification system to support the P2P Initiative.

Experimental Case Study Documenting the Advantages of Performance Specifications~

~Supports the P2P Initiative

Sponsor
RMCREF

Research Lead
NRMCA Lab

Funding
\$38,020

Progress

Report

This project is complete and the final report is available for download from the Foundation's website.

This project is a laboratory study designed to show the advantages of performance-based criteria over prescriptive requirements in concrete specifications. For the study, typical specifications for two types of applications – warehouse floors and bridges – and the ACI 318 code durability provisions were chosen. Specifications for these applications are generally prescriptive in nature. Concrete mixtures were prepared according to the prescriptive provisions of these specifications and compared to mixtures that satisfy intended performance attributes. Fresh and hardened concrete properties were quantified and compared.

Three experimental case studies were obtained to quantify the benefits and optimized cost of concrete mixtures furnished under performance-based specifications. The study also identifies performance-based alternatives and criteria to prescriptive requirements in the selected applications. The case studies continue to be used in presentations by the P2P Steering Committee and clearly identify the advantages of the performance design specification over prescription.

Evaluation of Performance-Based Alternatives to the Durability Provisions of ACI 318 Building Codes and Pavements~

~Supports the P2P Initiative

Sponsor*
RMCREF
NRMCA

Research Lead*
NRMCA Lab

Funding*
\$177,550

Progress Report
This study was approved in May 2006 and will take several years to complete.

*This project is part of a larger \$1.4 million project also funded by FHWA and the State DOT Pooled Resource Fund

This study, carried out by the NRMCA Laboratory, will attempt to establish tests and criteria for concrete by pre-qualification, jobsite testing, and providing guidance to concrete producers on designing for a minimum level of performance to reduce the risk of failing the performance criteria. Developing performance-based alternative criteria to current prescriptive limitations in the ACI 318 Building Code will provide a significant boost to advancement of the P2P Initiative. It will allow for an increased use of performance specifications while eliminating restrictions on minimum cementitious contents/types, maximum w/cm ratios and required supplementary cementitious material quantities. The data from this study will be used by NRMCA to support code change proposals to the ACI 318 Building Code for Structural Concrete for performance-based alternatives to current prescriptive requirements. The study will also support performance-based alternatives to the American Association of State Highway Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Specifications.

Performance-based concrete requirements will allow for innovation and will establish better science-based principles of measurable concrete properties to provide enhanced durability and prolonged service life of concrete structures. The study has now been rolled into a larger \$1.4 million study in cooperation with the Federal Highway Administration (FHWA) and state DOT pooled resources fund.

Creation of an ACI Report Addressing the Development and Proper Use of Performance-Based Criteria for Concrete~

~Supports the P2P Initiative

Sponsor
RMCREF

In-Kind Services
NRMCA
P2P Steering Committee

Research Lead
ACI
Innovation Task Group 8 (ITG-8)

Funding
\$29,800

Progress Report
The final report is under review with release expected in summer 2010.

Building on the well-received Prescription-to-Performance (P2P) projects previously funded by the RMC Research & Education Foundation, this project will develop a report to the American Concrete Institute (ACI) outlining the proper use and specifications for performance-based criteria for concrete. The report would quantify specific recommended changes which ultimately may affect change in ACI 318 and other ACI standards allowing for the use of performance-based standards.

The primary author of this study will be Ken Rear, who has considerable experience working on the P2P Initiative and who serves as chairman of the P2P Steering Committee. Mr. Rear will work closely with members of ACI's Innovative Task Group (ITG-8) – Performance Criteria for Materials (established for this project) along with ACI's Strategic Development Council and the P2P Steering Committee in the development of this report.

Optimizing Concrete Mixtures for Performance and Sustainability*~

*~Also falls under Environment, Health & Safety Track/Supports P2P Initiative

Sponsors:
RMCREF
FHWA

Research Lead:
NRMCA
Lab
National
Concrete
Pavement
Technology
Center at
Iowa State
University

Funding:
\$60,000

Progress Report:
This project was approved in October 2009 and will take approximately two years to complete.

This project will provide guidelines on how much cementitious content is needed to achieve given strength and potential durability properties in a concrete mixture. Many specifications (DOT, commercial) impose minimum cementitious content requirements that may be in excess of that required, leading to increased costs and increased carbon loading on the environment. This project, which will take place at the National Ready Mixed Concrete Association's Laboratory, will include the preparation of a number of similar concrete mixtures with varying cementitious contents and types and measuring engineering properties over time. This project is one aspect of a larger project funded by the Federal Highway Administration and taking place at the National Concrete Pavement Technology Center at Iowa State University. The results from this project will be presented at meetings of the American Concrete Institute, the Transportation Research Board, the National Concrete Consortium and at other meetings that may influence specifiers. The Federal Highway Administration's support of this project will also help ensure that state DOT specifiers are made aware of the research results and subsequent recommendations.

Development of Industry Foundation Classes for Structural Concrete Components**

**Also falls under Industry Education & Training Track

Sponsors:
RMCREF
Charles
Pankow
Foundation

**In-Kind
Services:**
ACI-SDC

**Research
Lead:**
Applied
Technology
Council

Funding:
\$37,500

**Progress
Report:**
The
Strategic
Plan is
expected to
be
completed
in 2010.

Building Information Modeling (BIM) is increasing in use throughout construction because it helps owners, developers and all those on the construction team better design, estimate and time the critical elements of the construction process. Major specifiers and customers are demanding BIM be used on their projects because of the cost and dispute resolution advantages it provides. In fact, Wisconsin just announced that it is requiring BIM on public construction projects.

Industry Foundation Classes (IFC's) are the standard protocols to exchange electronic data between software systems used in BIM's. BIM's are not one software package or system, they are series of systems consisting of architectural, structural, detailing, analysis, and construction models. The systems are said to be interoperable when the data exchanged between the disparate systems is interpreted by each accurately and correctly. Each building system requires the development of its own protocols: geometry, internal and external properties, etc. Protocols for structural steel were developed in the 1990's and were adopted by software developers. No such protocols exist for the concrete industry. The precast industry recently launched an effort to develop these protocols for precast concrete. The project being funded by RMCREF would be the first step toward establishing these protocols for the cast-in-place concrete industry, developing a strategic plan for moving ahead. This effort has the support of all the major software developers as well as major design firms and contractors. The intent is to borrow whatever has been developed for concrete in precast (characterizing concrete mixtures and properties, reinforcement, etc.) and complete the IFC components unique to cast-in-place.

Concrete Industry Management Undergraduate Degree Program

Sponsor

RMCREF as part of an Industry Consortium supporting the CIM National Steering Committee

Funding

RMCREF committed \$300,000 in the First Phase and \$625,000 for CIM Expansion Through 2011

Progress Report

The CIM program now includes five universities: the flagship program at MTSU and programs at ASU, CSU-Chico, NJIT and Texas State.

The Concrete Industry Management (CIM) program is a unique undergraduate degree program that prepares college students for a career in the concrete industry through a combination of concrete-specific business management knowledge and technical skills. The initial commitment to CIM went largely to support the flagship program at Middle Tennessee State University (MTSU). Current total enrollment for all CIM programs is approximately 650 students with over 300 graduates.

The latest commitment, \$625,000 to the CIM National Steering Committee, will include the continued support to MTSU while also providing funds for additional CIM programs at Arizona State University, California State University – Chico, New Jersey Institute of Technology and at Texas State University.

Green Highways Partnership Training*

*Also falls under Environment, Health & Safety Track

Sponsors:
RMCREF
USEPA
Region III

In-Kind Services:
ASCE

Research Lead:
The Low Impact Development Center, Inc.

Funding:
\$50,000

Progress Report:
The training program is expected to begin fall 2010.

The project will establish a Green Highways Partnership Training and Development Center (GHPTDC) to support the Green Highways Partnership and water quality goals of US Environmental Protection Agency (EPA) Region III. Programs will be held at the University of Maryland Conference Center, off-site locations upon request, and through webinars.

The training and certificate program will address the water quality program and technical needs of the transportation and development industries. It will serve as a national model to help state Departments of Transportation (DOTs), municipal officials, and developers throughout the country to develop strategies for compliance with National Pollutant Discharge Elimination System (NPDES) and other wet weather regulatory and resource protection programs. There is a need to provide comprehensive training to these groups and consultants on how to address stormwater management challenges balancing the use of traditional, innovative, and green infrastructure approaches (e.g. pervious concrete) that meet regulatory requirements and watershed needs. A partnership with the American Society of Civil Engineers (ASCE) to provide certificate and training credits toward professional education requirements will help to reach an extensive audience with this information.

The course will be marketed in cooperation with ASCE, the American Public Works Association and the Federal Highway Administration. Papers will also be submitted at a minimum of four (4) key water quality and/or transportation conferences, such as the Environmental and Water Resources Institute (EWRI) and Transportation Research Board (TRB). Briefings will also be provided to each state DOT in the Mid-Atlantic region as a model to be taken nationwide.

Ready Mixed Concrete Plant Manager Certification Course

Sponsor
RMCREF

**In-Kind
Services**
NRMCA

Project Lead
Richard C.
Meininger,
P.E.

Funding
\$25,000

**Progress
Report**
The first
course was
conducted in
August 2004
with a wide
attendance
and excellent
reviews by
participants.
NRMCA
holds the
course
generally
twice a year
with
additional
regional
courses held
as requested.

Working with industry experts and funded by the RMC Research & Education Foundation, NRMCA has developed a modular education and certification program for ready mixed company plant managers. The course covers product knowledge, environmental issues, safety, business principles, and operational skills. Much of the material was gleaned from other NRMCA courses that target other industry personnel. The course is three days in length with a 3-hour certification exam at its conclusion. The certification fills the need for regulatory agency requirements in specific knowledge areas.

Supervisory Workshop Course Development

Sponsor
RMCREF

**In-Kind
Services**
NRMCA

**Project
Lead**
CIM
Program at
CSU-Chico
John
Richardson
NRMCA
EAC Task
Group

Funding
\$39,205

**Progress
Report**
The first
course was
held in
January
2008 and
garnered
great
reviews.
Additional
courses will
be held as
demand
necessitates
.

NRMCA's Educational Activities Committee (EAC) identified the industry need for a training course that would assist frontline supervisors with the transition to their new supervisory role. Many of these supervisors rise up from the ranks and often have little, if any, supervisory experience when faced with managing employees who were previously their peers. The goal of this course is to help frontline supervisors develop communications skills and train them to effectively assist with the recruitment, retention and training of their direct reports. Measurable improvements would include increased retention of supervisors, decreased turnover of drivers and better equipment and resource utilization on the part of supervisors. The new course, now known as "The Effective RMC Supervisor", was developed by the Concrete Industry Management (CIM) program personnel at California State University – Chico with additional development by John Richardson and practical exercises developed by an EAC Task Force.

Spanish Translation of the Concrete Delivery Professional Program (CDP) and the Truck Mixer Driver Manual

Sponsor
RMCREF

In-Kind Services
NRMCA

Project Lead
Federacion
Iberioamerica
na del
Hormigon
Premezclado

Funding
\$47,400

Progress Report
Both translations are now available for purchase through the National Ready Mixed Concrete Association.

These translations will be vital to improving the training of Spanish-speaking drivers who will be able to study these materials in their native language and then apply their training more readily. The Trustees recognize that the most widely expanding pool of concrete delivery professionals over the coming years will likely come from the Spanish-speaking population. The Trustees approved this project in order to ensure the industry has the best training tools available for Spanish-speaking drivers. These tools will also be made available to Central and South American concrete companies to improve the level of driver training in those countries as well. The translations were performed by the Iberio-American ready mixed concrete organization that represents the Spanish-speaking countries in Central and South America as well as Spain and Portugal. The organization's unique expertise in dealing with many dialects of Spanish as well as the concrete terminology specified in these materials, have made the translations highly accurate, widely understood and very well-received within the industry.

Certified Concrete Delivery Professional Training Videos

Sponsor
RMCREF

**Project
Lead**
NRMCA

Funding
\$16,400

**Progress
Report**
The videos
were
completed
in fall 2003
and are
being
distributed
throughout
the
industry.

NRMCA developed a Certified Concrete Delivery Professional program to ensure that delivery professionals are competent in the areas of product knowledge, environmental issues, customer relations, and safety and vehicle maintenance. Until recently, this consisted of training manuals in each of the five areas and an exam. Through a grant from the RMC Research & Education Foundation, NRMCA is now able to offer training videos to coincide with the manuals to increase the effectiveness of the messages and allow more organizations to use the information. The videos provide flexible training and education opportunities for the ready mixed industry as a whole.

Pervious Concrete Contractor Certification Craftsman Text

Sponsor
RMCREF

**In-Kind
Services**
ACI
Pervious
Committee
522 on
Pervious
Concrete

Project Lead
Magruder
Construction

Funding
\$10,000

**Progress
Report**
This project
has been
completed
and the text
is now
available.
The formal
certification
is available
through the
National
Ready
Mixed
Concrete
Association.

The environmental benefits of pervious pavements, particularly for parking lots, has spurred rapid growth for this market. It is especially popular for its stormwater management properties and has been recognized by the U.S. Environmental Protection Agency as a Best Management Practice for that use. The pervious concrete contractor certification craftsman text serves as the main training tool to support comprehensive certification for those who place pervious concrete. This certification is being administered by NRMCA. The content of the text serves as the basis for the certification and the exam questions. The text has facilitated local training for the necessary knowledge requirements of producing, placing, and maintaining pervious concrete pavements.

Plant Operator Certification Student Textbook and Corresponding Instructor Materials

Sponsor
RMCREF

In-Kind Services
NRMCA

Project Lead
Tennessee Concrete Association

Funding
\$15,550

Progress Report
The materials have been completed and are used as part of this certification course offered through the National Ready Mixed Concrete Association

The Plant Operator Certification Student Textbook and corresponding instructor materials have improved the quality of materials used to teach the Plant Operator course and provided a consistent instructors guide for all who teach the program. The textbook and instructors guide include additional examples and are expected to increase the credibility of the certification program, thereby assisting in its increased implementation by state DOTs. They have also made the course more portable, allowing state and local ready mixed concrete organizations and individual companies to offer the certification as frequently as their needs call for rather than having to wait for the program to be held their region.

Ready Mixed Concrete Sales Manager Training Course

Sponsor
RMCREF

Project Lead
NRMCA

Funding
\$40,000

Progress Report
This course is administered by the National Ready Mixed Concrete Association and continues to receive excellent reviews by participants.

This program is specifically for sales managers in the ready mixed concrete industry. Development of this course and recommendations for its content are the result of detailed discussions by NRMCA's Educational Activities Committee and its Sales Management Task Group. Given that ready mixed concrete industry sales managers' responsibilities encompass a wide-range of issues, it is essential that they possess a solid understanding of how best to manage both their projects and their staff. This course is comprehensive and includes both classroom training and e-learning modules over a period of six months. After all of the coursework is completed, participants have the opportunity to take a certification exam.

In its early stages, the Foundation also funded the development of the Certified Concrete Sales Professional (CCSP) Program.

Financial Management Course for the Ready Mixed Concrete Industry

Sponsor
RMCREF

Project Lead
NRMCA

Funding
\$7,500

Progress Report
This course is administered by the National Ready Mixed Concrete Association and continues to receive rave reviews by participants.

Funded by the RMC Research & Education Foundation, NRMCA developed a “Financial Management Course for the Ready Mixed Concrete Industry” to create a more highly skilled, financially savvy workforce in this industry that is so critical to America’s economy and infrastructure. The course is designed for mid- to upper-level managers in the industry who do not have a background in financial management, reading, or interpreting financial statements.

The program focuses on the makeup and analysis of the Balance Sheet, Income Statement, and the Statement of Cash Flows. Horizontal, Vertical, and Ratio Analysis is covered in detail. The program uses case studies from hypothetical ready mixed concrete companies in both the teaching of the course and the independent student assignments.

The RMC Research & Education Foundation Center

Sponsor
RMCREF

**Project
Lead**
NRMCA

Funding
\$40,000

**Progress
Report**
Dozens of
courses and
meetings
are held in
the Center
each year.

The Center is a central part of the RMC Research & Education Foundation's efforts to improve educational offerings for the ready mixed concrete industry. The facility hosts a wide variety of courses and seminars aimed at improving the performance of industry personnel, including those who dispatch mixer trucks to jobsites, the drivers themselves, sales personnel, and others. The Center is tangible proof of the Foundation's commitment to the industry. Having a state-of-the-art education facility adjacent to the headquarters of the National Ready Mixed Concrete Association means the education staff can more easily develop excellent educational resources to serve the industry. Industry personnel now have a first-class facility in which to hone their professional skills.

Similarly, the Foundation provided additional resources for the industry by funding for the purchase of a million pound testing machine used at NRMCA's laboratory.

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