Vision: The RMC Research & Education Foundation is a lasting resource for increasing quality, professionalism, and sustainability in the ready mixed concrete industry by funding and implementing research and education programs.

**RMC Research & Education Foundation**

**PROJECT FUNDING SUMMARY**

Updated August 2022
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Introduction

Since 1991, the RMC Research & Education Foundation has been putting the generous contributions of concrete and construction community members to work, funding and implementing programs to improve quality, sustainability and professionalism in the ready mixed concrete industry.

The research and education 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, and demonstrate that we are:

- Devoted to recruiting new talent, and strengthening the education and training of current and future professionals within the industry;
- Concerned with protecting the safety of our workforce;
- Working toward improving the quality of concrete and concrete construction; and
- Dedicated to sustainability, resilience and strong environmental stewardship.

Our goal is to be a lasting resource for industry research and education by building an endowment that can fund these vital programs for the long-term, benefitting both industry and general public.

Note: Funding amounts included in the summaries refer specifically to the funding provided by the RMC Research & Education Foundation, unless otherwise noted. Additional funding for a project may have also been provided by other sources not specifically mentioned.

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Sustainable Concrete Plant Guidelines

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 developed 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 help quantify the effect of sustainable practices within the ready mixed concrete industry and encourage those practices. Some of the sustainable strategy categories explored include: waste management; water management; air quality; and energy efficiency. The project deliverables 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.
As green building rating systems become more prevalent throughout the building community and sustainability practices become a priority, the need for transparency and disclosure of materials ingredients used in these projects increases. Version 4 of the United States Green Building Council’s (USGBC) Leadership in Energy and Environmental Design (LEED) system includes the opportunity to gain LEED point(s) through a Material Ingredients Credit. The development of a methodology and guide for reporting on material ingredients will assist concrete producers with the demands of customers seeking to use concrete in LEED-rated projects and will guide them in the necessary reporting to qualify for the maximum number of points possible.

The LEED v4 Materials Ingredients Credit is complicated and involves several schemes to be considered. Each ready mixed concrete producer can take the guidance offered by the guide to choose their own best path for meeting the credit’s requirements. Elements that are addressed in the guide include costs, time, intent, type and detail of information required, nature of assessment, confidentiality of reported ingredients and infrastructure. The final product provides instruction and resources for concrete producers in a guide that is practical and comprehensive in the direction it provides producers seeking to qualify for the LEED v4 Materials Ingredient Credit.

Study of Light Reflectiveness of Concrete and Asphalt Pavement

The objective of this research was to evaluate the reflectiveness of two most commonly used modern pavement systems in the United States (concrete and asphalt). The R tables, used for roadway lighting design, were established several decades ago as a critical parameter for determining the light reflectivity (luminance) of pavement surfaces. With the existence of modern pavement systems and also the new lighting technologies it is necessary to examine the applicability and representability of the current R tables. A total of 12 different pavement surfaces were evaluated to characterize the light reflectivity of two light sources incandescent and light emitting diodes (LED). The reflective properties of the pavements were evaluated considering the influence of angular light (incident lighting angles). Light intensity (illuminance) and pavement reflectivity (luminance) were measured to construct updated R tables. The research outcomes are useful as we work to address necessary updates to the R tables.
Carried out by the University of Wisconsin-Madison’s Recycled Material Research Center, in cooperation with work funded by the Portland Cement Association and DOT Pooled Resources Fund, the overarching objective of this project is to provide a sound scientific basis for best practices for limiting the pH of RCA leachate and its reasonable regulation in a variety of RCA applications. This was accomplished by completing the following three goals: 1) determine the nature of the reactions controlling the pH of water in contact with fresh RCA from member states; 2) investigate controls on leachate produced by RCA collected from the MNRoad field site after 8 years of use; and 3) develop a quantitative model to describe the pH and alkalinity of water in contact with RCA. This research utilizes a comprehensive approach to reconcile the contradictory results of previous studies of leachate pH and alkalinity in field and laboratory settings. Inclusion of field and laboratory components will provide fundamental and in situ information to normalize the expected variance of leachate pH and identify when it is or is not a behavior or condition of environmental concern.

Carried out by The Concrete Pavement (CP) Tech Center at Iowa State University, this project includes 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 results provide information about the suitability and long-term behavior of pervious concrete mixes for highway, street and local road applications. The study's findings are 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.

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).
This research, performed by the University of Minnesota’s Civil Engineering Department, looked 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 experimented with new pervious concrete mix designs and identified material, design, and construction-related performance criteria for the installation and maintenance of pervious concrete pavements in severe freeze-thaw environments. It includes the development of a method of examining in-situ clogging of the pavement layers. The study combines 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 is validated and the effectiveness of cleaning methods is also evaluated. A panel made up of representatives from the Aggregate and Ready Mix Association of Minnesota and the Minnesota Department of Transportation also assisted with review of this research throughout the process.

Performance Assessment of In-Service Pervious Concrete Pavements in Cold Weather*
*Also falls under Concrete Applications

Performance Assessment of Pervious Concrete and Maintenance Plan*
*Also falls under Concrete Applications

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. This research, carried out by University of Central Florida and in partnership with FHWA and Rinker Materials (now CEMEX), included three individual reports:

- Hydraulic Performance Assessment of Pervious Concrete Pavements for Stormwater Management Credit
- Construction and Maintenance Assessment of Pervious Concrete Pavements
- Compressive Strength of Pervious Concrete Pavements

Sustainability

SPONSOR:
RMCREF

RESEARCH LEAD:
University of Minnesota

FUNDING:
$49,950

PROGRESS REPORT:
This study is available from the Foundation’s website.

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:
The reports are available for download from the Foundation’s website.

www.rmc-foundation.org
SUSTAINABILITY

Long-Term Field Performance of Pervious Concrete Pavements*
*Also falls under Concrete Applications

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.

Picture courtesy of Master Builders Solutions

Side-by-Side Comparison of Pervious Concrete & Porous Asphalt*
*Also falls under Concrete Applications

This study, carried out by Villanova University’s Urban Stormwater Partnership, examines 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 includes the impact these two pavements have on water quality. Recommendations for keeping the pavements functional are also included.

Picture courtesy of Master Builders Solutions
**Pervious Concrete Research Literature Review**

*Also falls under Concrete Applications

The Pervious Concrete Research Literature Review is an excellent resource for producers, specifiers and owners seeking more information on pervious concrete research and applications. It details research regarding pervious concrete, provides additional resources on pervious concrete and helps to identify gaps in pervious concrete research.

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**Effect of Pavement Type on Fuel Consumption and Emissions**

The University of Texas at Arlington performed this research and produced 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.
HEALTH & SAFETY

Hexavalent Chromium Personal Exposure Study

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.

Air Emissions Testing Program at Ready Mixed Concrete Plants

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.
FAIL-SAFE: Understanding the Importance of Multiple Layers of Fire Safety in the Built Environment

Factually Analyzing Integrated Layers of Safety Against Fire's Effects (FAIL-SAFE) is a project launched by the National Association of State Fire Marshals Fire Research and Education Foundation. It studied the impacts on fire and life safety in structures equipped with multiple layers of both active and passive fire protection features. The goal is to understand how active and passive fire protection features are interdependent in providing the level of safety to the public and the fire service have come to expect. A series of coordinated research projects were conducted in an effort to provide quantifiable data to better understand the relationship between multiple layers of fire safety features and occupant survivability. The research provides critical insight into methods of increasing building and business resiliency when exposed to the effects of a fire event. Deliverables include several reports examining and reviewing elements of fire safety such as sprinklers, building types, risk potential, reviews of strengths and weaknesses of different types of fire protection systems, recommendations for changes and further action, as well as other information and tools. Results are being used in collateral materials for the Build With Strength campaign and to influence model codes.

Online Safety Training Lessons
*Also falls under Recruitment, Education & Training

Continuing education for ready mixed concrete company personnel including mixer truck drivers and others in the industry is a priority, but finding dedicated times to conduct such training can be a challenge. This project developed on-line training lessons that employees may access during poor-weather and slow schedule days. Employees have the opportunity to work on the lessons and then, upon achieving a 100% on each lesson’s exam, proof of training is automatically generated. This training is available for a nominal fee from the National Ready Mixed Concrete Association, which goes toward the development of additional lessons.

Lessons available include:
- Concrete Mixer Truck Rules for Using a Backing Spotter
- Backing Accident Prevention Program
- Lockout/Tryout/Tagout: Part 1
- Lockout/Tryout/Tagout: Part 2
- Working Safely On and Around Mixer Trucks
- Pre-trip Inspection for the Front Discharge Mixer Truck
- Pre-trip Inspection for the Rear Discharge Mixer Truck
- Working Safely Around Concrete Pumps
- Ready Mixed Concrete Plant Safety

*A lesson on jobsite safety is planned for 2022.*
## Concrete Applications

**Re-quantifying the Differences in Insurance Costs for Multifamily Buildings with Wood Frame and Insulated Concrete Structures**

Insurance rates both for the construction phase and use phase for midrise, multifamily structures vary depending on the building material used. This project seeks to update data last gathered in 2017 comparing insurance costs for wood and concrete construction around the country. The research on insurance rates will include information on how geography may also affect insurance rates. Ultimately, the data gathered will be used by NRMCA to develop insurance cost estimates for use by the Build With Strength team.

### Comparison of Earthquake Resilience of ICF to Other Materials for a Multifamily, Multistory Building

This project studied earthquake resiliency for a variety of construction types commonly used for multifamily housing, including: traditional wood framing, mass timber, steel framing, and insulated concrete forms (ICF). The objective of this study was to demonstrate that different structural systems, all permitted within the International Building Code, may deliver different performance in earthquakes. While a code compliant building regardless of structural system is expected to provide life safety, the amount of physical damage, repair costs and building functional recovery can depend significantly on the strength and stiffness of the selected structural system. Ultimately, the long-term goal of this project is for it to be used to advocate for incentives around high-performing building design. The emphasis on multifamily housing will draw interest from both the public and private sectors.
CONCRETE APPLICATIONS

Development of a Concrete Strength Model to Optimize Concrete Mixtures

Small and medium-sized ready mixed concrete producers often overdesign mixtures, unnecessarily wasting material and money. This project provides a simple, independent, and validated model that ready mix producers can use to optimize their concrete mixtures for strength without overdesigning them, helping producers to use their materials more effectively.

In this project, 21 concrete mixtures were broken down into five sets with varying water to cement ratios, varying air content, some with admixtures and some using Class F fly ash and low calcium fly ash. All were used to calibrate the model which will then be able to predict the strength of normal range concrete strengths (<6000 psi) for any water to cementitious ratio with any combination of materials used. The mixture evaluation took place at NRMCA’s Laboratory.

A written report and explanation of how to use the model is also be included.

Performance Engineered Concrete Paving Mixtures

Concrete for pavements has historically been specified and field controlled around acceptance criteria that do not relate well to durability (slump, air content, strength). Paving concrete specifications need to be built upon engineering properties that directly relate to good field performance. With the recent advancements in research knowledge on failure mechanisms, and the paralleled development of better tests, this is possible. A review of many current and new specifications has found that they are still largely based on strength, slump, and air, which provide limited correlation with the mechanisms of pavement failure currently observed. The need for change in the way we specify concrete, especially concrete for paving mixtures, is becoming increasingly apparent as mixtures become more complex with a growing range of chemical admixtures and supplementary cementitious materials. Traffic loadings continue to increase, more aggressive winter maintenance practices are implemented, and demand increases to build systems more quickly, cheaply, and with increased longevity.

This study will focus on the successful deployment of performance engineered mixtures and will involve building off the foundational work that FHWA and other partner states have done, with emphasis on implementation, education and training, adjusting the specification values to relate accurately to good pavement performance in the field, and continued development of relating early age concrete properties to performance.
This project brought ACPA, NRMCA, and PCA together to collaborate on a design tool for cement-based pavement solutions, encompassing roadways (streets and local roads), parking lots, airports pavements, and industrial facility pavements. The tool allows for designing conventional concrete pavements; concrete overlays; roller compacted concrete, and various composite pavements.

While ACPA, NRMCA, and PCA each had design tools available, the number of these programs made it a challenge for designers to determine their best choice for a given need. It also lead to confusion and frustration for designers when the different industry programs had inconsistent results and recommendations. These drawbacks lead to negative perceptions about the complexity and risk of cement-based pavement solutions.

This coordinated software effort changed that dynamic and provides a single tool for anyone to use no matter what type of pavement application or cement-based solution they are designing. The design software is free to users so that there are no financial barriers to implementation. With this approach, the software is available for use by agencies, consultants, academia and others for project design and education.

PavementDesigner.org was launched in early 2018. Thousands of design runs have been completed in all 50 states and internationally.

It is estimated that on an annual basis, approximately 3% of ready mixed concrete produced is returned to the concrete plant for disposal. One of the reasons that concrete is rejected at a project site is the 90-minute time limit to discharge a load in accordance with ASTM C94, Specification for Ready Mixed Concrete, that is enforced by specifying agencies. Although the standard provides conditions where this time limit can be waived, loads of acceptable quality are rejected, resulting in lost revenue and cost to the producer to manage returned loads.

In this project, NJIT researchers evaluated properties of concrete mixtures designed for a longer discharge time. Acceptable results were observed for all fresh concrete and durability indicator test results, such as resistivity and freeze-thaw durability, for concrete specimens prepared from samples obtained at different times up to 150 minutes. In the report, NJIT researchers conclude that the current discharge time limits and specifications are conservative and should be reexamined.

*In 2021, the 90-minute time limit for the discharge of concrete was removed from ASTM C94/C94M-21 Specification for Ready Mixed Concrete.
Durability challenges, particularly with respect to quantifying freeze-thaw, salt scaling and alkali-silica reaction (ASR), remain prevalent in the concrete industry. In an effort to further advance concrete durability, researchers at Oregon State University (OSU), the University of New Brunswick (UNB) and the Massachusetts Institute of Technology Concrete Sustainability Hub (CSHub) worked together to improve the durability of concrete pavements by improving the scientific understanding of pavement distresses. In particular, this project sought to develop a quantitative understanding of the chemical reactions to the physical manifestation of concrete pavement damage from alkali-silica reaction (ASR) and freeze-thaw (FT). This will lay the foundation for connecting pavement material properties and fracture and durability prediction, while also helping to establish the potential for ASR and/or FT damage in a concrete pavement and the rate at which it would happen.

Development of a Strategic Plan and Information Delivery Manual for Building Information Modeling for Cast-in-Place Concrete*
*Also falls under Recruitment, Education & Training

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.

Industry Foundation Classes (IFCs) are the standard protocols to exchange electronic data between software systems used in BIM’s. BIMs 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.

The first phase of this project developed a strategic plan as a first step toward establishing these protocols for the cast-in-place concrete industry and that strategic plan is now available. The second phase funds the development of an Information Delivery Manual (IDM) for cast-in-place concrete. Preparation of an IDM is critical in the development of interoperability standards for industry use cases. A working group of construction industry experts and a software developer will work together to identify industry critical data exchanges. From there, the IDM will be developed and then balloted for approval by ACI 131 Committee.
Although freeze-thaw challenges with concrete are well documented, there has been rather little research on frost damage on air entrained concrete treated with salts and the resulting impact the salt water has on the concrete and how the impact may be mitigated. This project produced improved specifications, and test methods, while improving the understanding of the underlying mechanisms of frost damage. This project developed new test procedures that are faster and/or more reliable than the existing methods. The objectives of this project included:

- Determine the necessary properties of the air-void system to provide satisfactory frost durability in laboratory testing of laboratory and field concretes with different combinations of admixtures, cements, and mixing temperatures in salt environments;
- Determine the accuracy of a simple field test method that measures air void system quality with field and laboratory concrete;
- Determine the critical combinations of absorption and the critical degree of saturation on the frost durability in accelerated laboratory testing in the presence of deicer salts; and
- Establish new test methods and specifications for fresh and hardened concrete to determine frost durability and field performance.

Comparison of Vehicle Fuel Consumption on Rigid v. Flexible Pavements on the Florida State Highway System*

*Also falls under Sustainability

This project, undertaken by Florida International University (FIU) with the cooperative support of local producers, collected fuel consumption data on rigid versus flexible pavements on the Florida State Highway system. The research complements the work performed by the MIT Concrete Sustainability Hub (CSHub) on pavement-vehicle interaction (PVI), expanding the data collection and validating the MIT CSHub model findings. (For more information on the MIT CSHub PVI research visit [http://mit.cshub.edu](http://mit.cshub.edu).) The FIU project has been performed in multiple phases and seeks to investigate all pavement and traffic scenarios on the Florida State Highway System.
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.

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.
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.

In 2008, the National Concrete Pavement Technology Center (CP Tech Center) at Iowa State University published a Guide for Overlays for Roadways. This project funded the development of a tool, Guide to Concrete Overlays for Asphalt Parking Lots. Information and guidance areas that are contained in the document include: assessing the integrity of the existing pavement; selecting project candidates; pavement design principles and design life; managing parking lot drainage; and dealing with entry evaluations of adjacent buildings. The guide also incorporates aspects of ACI 330 “Guide for Design and Construction of Concrete Parking Lots”.

In 2021, the Guide underwent a comprehensive update, and now includes detailed case studies and updated information on costs, standards, design software and fiber use.
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 studies issues surrounding formwork pressure exerted by SCC such as mixture compositions, casting rates, geometry of formwork, reinforcement density and temperature. The project also examines the relationship of the maximum lateral pressure and rate of decay in lateral pressure to the initial plastic properties of the SCC. The study includes the development of practical guidelines for lowering lateral pressure on SCC and also includes proposed design equations to predict formwork pressure that can be exerted by SCC on column and wall elements.

This project was funded by the RMC Research & Education Foundation and the American Concrete Institute’s Strategic Development Council (ACI SDC).

Design Methodology for Subgrades and Bases Under Concrete Roads and Parking Lots to Address Erosion Potential

The Texas Transportation Institute (TTI) located at Texas A&M University, has developed a new design methodology for subgrades and bases under concrete roads and parking lots. Faulting - loss of support due to erosion - is a primary mechanism for failure in concrete pavements. Faulting is difficult to identify until the point of non-repair and is the single-most cause of premature pavement failure, particularly with low volume concrete pavement. The goal of this work is to help designers assess whether the natural, compacted subgrade at a project site is adequate for long-term pavement performance or if subgrade stabilization or a subbase is required to meet the design criteria. The two documents available are Design Methodology for Subgrades and Bases Under Concrete Roads and Parking Lots and Test Methods & Results of Erosion Potential of Commonly Used Subgrade and Base Materials.
CONCRETE APPLICATIONS

Study of Crushed Returned Concrete as Aggregates for New Concrete*
*Also falls under Sustainability

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 is being used to 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.

Concrete Preservation Institute*
*Also falls under Recruitment, Education & Training

The Concrete Preservation Institute (CPI) is a nonprofit public benefit organization structured and operated exclusively for charitable purposes to provide training and education in historic preservation, stewardship, repair, and research of concrete cultural resources. Their participants include Concrete Industry Management (CIM) program and other college students, local high school graduates, and post 9/11 military veterans. Although the experience is inspiring and potentially life-changing for all participants, military veterans tend to identify particularly well with the experience and sites that are uniquely well suited to help them acclimatize and find their path forward after their military service. CPI partners with the National Park Service (NPS), the Golden Gate National Park Conservancy (Conservancy), local communities, and concrete, construction, and other industries to make our program available in three 12 week sessions each year. In addition to advancing concrete repair and preservation on a board scale, CPI focuses on providing youth mentorship through community-based service learning projects and helping our young adult participants develop into future leaders or valued vocational employees, engaged park stewards, and responsible citizens.
Life-365 is a modeling software that predicts the service life of reinforced concrete structures and is used by designers to establish concrete mixture and other options to extend service life of reinforced concrete structures for intended design service life. NRMCA participates in this consortium with funding from the RMC Research & Education Foundation. The most recent funding includes making the updated software (version 3.0) a cloud-based application that will allow for broader and streamlined use on desktops, tablets and smartphones. By moving to a cloud-based system, the software may be more-easily updated.

The Role of Air Content and Supplementary Cementitious Materials Replacement in Deicing Salt Joint Damage in Concrete

With the use of calcium and magnesium-based deicing salts on the rise, so is the damage to concrete pavement joints, which is attributed to, in part, by the formation of calcium oxychloride from a reaction between the calcium or magnesium chloride deicers and the calcium hydroxide in the concrete. This project seeks to examine how this damage may be mitigated, specifically with respect to the use of supplementary cementitious materials (SCMs) and entrained air. The research will have several benefits to the concrete industry, including:

1) The benefit of a more “realistic” specification with respect to the 35% limitation on the use of SCMs;
2) The development of a specification that takes the synergy between air content, transport and pozzolanic reaction into account. Air content, reduction in transport, and pozzolanic reaction all act in reducing calcium oxychloride formation/damage, though their synergy has not been investigated previously; and
3) The development of a more scientific specification based on concrete testing and rigorous testing of the current specification.
When ACI 347.3R-13, “Guide to Formed Concrete Surfaces” was published in early 2014, there were several areas of concern regarding the document identified by members of the American Society of Concrete Contractors (ASCC), including surface void ratio recommendations, concerns with clarity, and achievability of the recommended requirements. In order to explore the Guide and surrounding concerns more fully, ASCC commissioned a thorough examination, and partnered with the Concrete Industry Management (CIM) program at Middle Tennessee State University to perform the related research and analysis included in the final report.

There is strong evidence and instances that suggest certain de-icing chemicals and salts can negatively affect pervious concrete and initiate a rapid degradation of the paste matrix, aggregate bonding, pavement durability and strength. A number of project locations have reported a failure of pervious concrete pavements as a result of their exposures to deicers and salts in the very severe winter of 2013-2014. These instances suggest there is a required necessity to better understand what is causing this disintegration of pervious concrete paste when exposed to deicer chemicals and evaluate mitigations to modify pervious concrete mix designs to enhance paste characteristics and quality, and to be more resistant to these widely used chemicals.

In order to better understand what has contributed to these failures and to adequately evaluate pervious concrete paste characteristics to withstand harsh deicer and salt applications, development of a standardized laboratory approach and process is necessary. This will require analysis to effectively and consistently:

• Determine the effect of various de-icing methodologies on pervious concrete;
• Define and understand the chemical relationship and reactions of deicers and salts on cement paste; and
• Research and evaluate the potential for improved resistance of different pervious concrete mixes to the deleterious effects of deicer methodologies in use.
The purpose of this project was 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.


Evaluation of Chloride Limits for Reinforced Concrete - Phase I

The ACI 318 Building Code for Structural Concrete establishes limits on water soluble chloride ions in concrete mixtures used for reinforced concrete. The limits in the current code are based on research from the 1980s of the threshold chloride concentration causing the initiation of corrosion. These limits are currently stated on the basis of cement only. Thereby, for mixtures that contain supplementary cementitious materials (SCMs) such as fly ash and slag cement, the limits are reduced as the quantity of SCMs increase. This project developed technical data to support a code change that will change the limits to the basis of cementitious materials. The research includes the establishment of a relationship between total chlorides from the materials used for concrete and water soluble chlorides measured on hardened concrete at test age between 28 and 42 days and will assist the concrete producer in establishing concrete mixtures that will not exceed the ACI 318 chloride limits during the mixture proportioning phase. It supported a Code change to permit a calculated chloride estimate in a project submittal rather than by testing concrete after the project is underway. The change was approved in ACI 318.
This guide provides specifiers with design and construction information for concrete trails that may be used for biking, running, walking, and for golf courses. The trail and pathway market has grown considerably in recent years and so the need for such a design guide is quite high. The Foundation partnered on this project with the CP Tech Center, with whom we also partnered on the highly-successful Guide to Concrete Overlays of Asphalt Parking Lots. In the absence of a standard quality-control method for compaction of pervious concrete pavements (PCP), frequent subpar installations negatively impact the market and limit PCP usage. In this project, field testing of PCPs and laboratory testing of collected specimens helped to identify a nondestructive, simple, and reliable in-situ test to control the quality of PCP jobs by lightweight deflectometer testing. The results of field testing were extended beyond quality-control purposes to obtain in-situ infiltration rates to estimate the required compaction efforts for future projects and also to estimate structural properties for layer thickness design.
The Insulating Concrete Form Manufacturers Association (ICFMA) produced a study in Canada in 2016 evaluating thermal performance comparison data for heating between ICF walls commonly used in residential and mid-rise construction versus the commonly used wood and steel frame assemblies used in Canada. This study replicated the study in the United States evaluating similar data but for both heating and cooling and utilizing US assemblies. The data from this study will also be used to enhance modeling used at the MIT CSHub.

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.
**CONCRETE APPLICATIONS**

**Improving the Reliability of Resistivity Tests of Concrete**
~Supports the P2P Initiative

The move from prescriptive to performance-based specifications for ready mixed concrete supports goals of optimized concrete for strength and durability, sustainability, and improved competitiveness with other building systems. However, one hindrance to implementing performance-based specifications is the lack of a reliable and cost-effective test method for permeability of concrete.

This research project seeks to fill that gap. Resistivity of concrete is an indicator of its potential permeability. The research evaluates various factors that impact the measurement of resistivity to reach conclusions that can be incorporated in standards. The study concludes that measuring the resistivity is a reliable measured indicator that predicts concrete’s permeability property and potential durability. The results of this research will be used to improve testing protocols for improved reliability of results and can be used as an alternative to water-to-cementitious material ratio (w/cm) in industry codes and standards for more optimized concrete mixtures.

**Minimum Design Requirements for Insulated Concrete Forms (ICF) Wall Systems**

Insulated Concrete Forms (ICF) wall systems offer a variety of benefits. However, because they are reinforced concrete components, ICF walls must meet ACI code minimum requirements including maximum spacing and minimum area for vertical and horizontal reinforcement even when structural analysis predicts significantly lower requirements. For serviceability and shear strength, another option is to replace some or all of the reinforcement with steel fibers. Because the ACI 318 building code does not provide design guidance to design using this approach, the continued increased cost for steel reinforcement decreases ICF market potential and competitiveness. These projects seek to develop the technical data necessary to provide the design guidance for potentially reducing the minimum steel design requirements and permitting the use of steel fibers. There are two phases to this project which will investigate the design requirements for ICF walls with the ultimate goal of proposing revisions to design requirements, which will be developed collaboratively with an advisory panel of engineers, code and industry representatives. The first phase used modeling to develop technical data to provide design guidance while the second phase will test wall specimens at four different spacings to validate the technical approaches.
This project provides 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 was conducted at the National Ready Mixed Concrete Association’s Laboratory, included 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 have been 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.

Building on the well-received Prescription-to-Performance (P2P) projects previously funded by the RMC Research & Education Foundation, this project included the development of a report to the American Concrete Institute (ACI) outlining the proper use and specifications for performance-based criteria for concrete.

The primary author of this study was Ken Rear, who has considerable experience working on the P2P Initiative and who serves as chairman of the P2P Steering Committee. Mr. Rear worked 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. After disbanding ITG-8, ACI formed Committee 329. This committee reviewed, balloted revisions and approved a revised version of ITG-8 as ACI 329R-14 and the committee is now working on developing a guide performance specification.
CONCRETE APPLICATIONS

Preparation of a Model Performance-Based Specification~
~Supports the P2P Initiative

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.

Evaluation of Performance-Based Alternatives to the Durability Provisions of ACI 318 Building Codes~
~Supports the P2P Initiative

This study, carried out by the NRMCA Laboratory, establishes 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 is being 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.
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.

Inaccurate test data, especially regarding cylinder strength results used for acceptance, are a major concern in the ready mixed concrete industry. Data compiled by the Colorado Ready Mixed Concrete Association (CRMCA) has determined that proper testing procedures have not been followed a significant percent of the time, especially involving initial concrete curing. To counteract this problem, CRMCA developed the Concrete Testing Adherence Collaboration (CTAC) where experienced individuals who are typically employees of concrete producers and testing firms who maintain ACI certification, observe the field testing of third-party (quality control/quality assurance) testing technicians. The observations are documented on a phone app with additional notes and pictures also being included for each observation, if desired. The concept of this project is to upgrade the app for North American implementation, including subsequent updates, and to make it available to other states and Canadian provinces that wish to participate and who would pay annually for the service.
Comparing Cost & Energy Performance: Houses Built with ICF vs. Conventional Construction

Houses with built with insulated concrete forms (ICF) exterior walls in place of conventional wood frame construction are often higher in initial cost, but offer savings over time due to energy performance. This study provides a very unique opportunity for a true side-by-side comparison of homes being built in Oklahoma. Previous studies that have shown energy performance savings have generally depended on computer simulation to come to this conclusion. This project will combine actual energy usage data with computer simulation to compare the energy performance of houses with ICF exterior walls with that of conventional wood framing. In addition, the proposed project will also track the cost of ICF to compute the current cost difference between ICF and conventional wood framing. The project will include the building of six homes – two different floor plans each built three times, one with ICF walls, one with stick frames walls but upgraded insulation and one stick framed home with fiberglass insulation. The homes will be in the same geographical area and will be built by the same builder who is working with the researchers. Post occupancy, actual energy usage (gas and electricity) from the six houses will be collected biweekly for 12 consecutive months, providing usage data for an entire year, including peak cooling and heating seasons.

Compilation of Acoustic Data for Concrete Construction

Concrete construction provides many acoustical advantages over other systems. This project seeks to provide a one-stop shop for designers, owners, occupants and others to access latest research on acoustical performance of concrete components for better decision-making. The researchers will collect acoustic information regarding concrete construction, including laboratory test results, field measured test results, calculations, case studies and manufacturers’ information. Assemblies to be evaluated include: cast in place floors and walls including pan joists, flat slab and ICF construction, other structural systems with concrete slabs, tilt up walls, sandwich panels, precast floors and walls, and the effect of various acoustic treatments on the performance. The data will then be evaluated to determine: 1) the range of STC and IIC values (as appropriate) for each component and assembly type; 2) average (or median) values of the data for each component and assembly type; and 3) suggested values for preliminary design or when more detailed information is unavailable for each component or assembly type. Also to be provided is a simple method for calculating the acoustic properties of concrete components without any treatment that accounts for thickness, density, and strength (if appropriate) at a minimum. A basic primer on acoustics measurements and how to use the data will be developed and all information will be shared on a website made available to the public.
Over the past decade, significant localized outbreaks of concrete degradation caused by oxidation of the iron sulfide mineral pyrrhotite in concrete aggregates have occurred in Connecticut, Massachusetts, and Quebec, affecting thousands of residential structures. The costs of repairing the affected structures is upwards of $150,000 per home, while uncertainty over the potential for future distress has negatively impacted home values in the affected regions. In the US, the most common standard specification for concrete aggregates, ASTM C33, does not explicitly exclude or limit the presence of iron sulfide minerals. The U.S. also has no standardized approach or guidance for evaluating concrete aggregates for their potential to degrade concrete through oxidation of pyrrhotite and other iron sulfide minerals. The funding from the RMC Research & Education Foundation will be used to develop a standardized method to test for sulfur in concrete aggregates. The test method will be used in subsequent round robin testing and will aid in the evaluation of aggregates for their potential to degrade concrete through oxidation of pyrrhotite and other iron sulfide minerals. The deliverable will also include a report on the measurement of total sulfur in concrete aggregates.

Transforming the Concrete Delivery Professional Workforce

Building off of current knowledge within the industry, the MIT Concrete Sustainability Hub (CSH) will collaborate with the MIT Initiative for Knowledge and Innovation in Manufacturing (iKIM) and the MIT Center for Transportation and Logistics (CTL) to 1) understand current innovative solutions to the CDP supply shortage, 2) map job requirements (skills and competencies) for the future concrete delivery professional (CDP), 3) identify alternative ways to organize CDP skills, 4) work with industry to identify key challenges to implementing alternative occupation models, and, based on those learnings, and 5) develop a plan for how to reorganize the CDP role to maximize recruitment and retention and recommend changes for future industry training to implement the new models.

This project will build on existing industry programs and survey results by understanding how the role may evolve with technological advancements, competing industries, and new types of training. Results will be grounded in interviews and surveys with current operational managers, mixer drivers, truck manufacturers, and managers in adjacent industries (other trucking occupations). Next, the research team will incorporate those learnings into a draft report for discussion during an in-person workshop on the value of alternative models and the challenges to realizing those models. Finally, the team will develop a plan and report to allow the industry to transition to a more sustainable workforce model for mixer drivers while providing recommendations and driving new content for training curricula.
Concrete Industry Management
Undergraduate Degree Program

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.

Programs are thriving at Middle Tennessee State University, California State University – Chico, New Jersey Institute of Technology and at Texas State University. A new program will be established at South Dakota State University and is expected to begin in September 2022. There are now over 1,500 graduates. More information may be found at www.concretedegree.com.

Mixer Driver Recruitment/Hiring/Onboarding Resources

Finding, recruiting, hiring and training new drivers in the ready mixed concrete industry is a universal challenge faced by producers in all corners of the country. The resources produced as part of this project include:

**Nine-Minute “Day in the Life of a Mixer Driver” Video:** This video can help to acquaint potential commercial drivers to the industry and what their day-to-day roles and responsibilities will be. This video is especially helpful for potential mixer driver employees to view on your website or during an interview or during your onboarding process so that they can fully understand the job’s scope and the benefits of being a driver for the ready mixed concrete industry.

**Two-Minute, Twenty-Second “Day in the Life of a Mixer Driver” Video:** This is a shorter version of the video noted above. It is suitable for your website as well as use in recruiting and job fairs.

**Thirty-Second “Driver Promo” Video Clip:** This clip was prepared as a promotional piece for these resources and may be of use to concrete producers, such as on their website.

**Audio for a Thirty-Second Radio Spot:** Producers may add their company name and contact information for use at radio stations in their service areas. Note: audio provided is less than 30 seconds providing “time” to add contact information.

**Audio for a Sixty-Second Radio Spot:** Producers may add their company name and contact information for use at radio stations in their service areas. Note: audio provided is less than 60 seconds providing “time” to add contact information.

While concrete producers may add their company name, logo and contact information, where appropriate, to these resources, we ask that they not be edited further without permission.
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

NRMCA 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 course, 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 NRMCA Task Force.

While concrete producers may add their company name, logo and contact information, where appropriate, to these resources, we ask that they not be edited further without permission.
The project helped create 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 were held at the University of Maryland Conference Center, off-site locations upon request, and through webinars.

The training and certificate program addressed the water quality program and technical needs of the transportation and development industries. It served 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. The program met the 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. The program included a partnership with the American Society of Civil Engineers (ASCE) to provide certificate and training credits toward professional education requirements.

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

In mid-2018, the Occupational Safety and Health Administration (OSHA) promulgated a new silica standard, resulting in a new requirement that RMC producers implement a respiratory protection plan for their employees. This project includes a training video with content that covers what a ready mixed concrete producer needs to know to develop and implement an OSHA-compliant respiratory protection plan, but one that also trains employees who use respiratory protection at a concrete production plant. The precise, easy-to-access video supports producers’ effort to meet federal compliance. This lesson provides several benefits to the ready mixed concrete producer, including:

- Qualifying as the annual respiratory protection plan training required for employees working at ready mixed concrete plants who use respiratory protection;
- Teaching a producer how to determine if respiratory protection applies to that producer’s specific plant’s operations, including:
  * Assess communal areas that would involve respiratory protection at ready mixed concrete plants, such as monitoring dust for individuals;
  * Assess areas that can be more vulnerable, such as mixer drums during clean out, aggregate bin clean-out, belt transfer points in the plant and bag houses; and
- Teaching a producer how to implement a respiratory protection plan, train employees, evaluate it, and modify as necessary, including:
  * Pre-and post-inspection, maintenance, cleaning and storage of respiratory protection instruments;
  * Be introduced to the medical questionnaire as well as procedures for employee medical clearances;
  * Be introduced to qualitative and quantitative respirator fit-testing; and
  * Be introduced to selection of cartridges for respirators.
This program is specifically for sales managers in the ready mixed concrete industry. 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. 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.

Skate4Concrete: A Program for Successful Recruitment by Connecting Concrete Careers with the Skate and Youth Community

The concrete industry continues to struggle attracting young people into the industry. The Skate4Concrete project seeks to cultivate interest in the concrete industry from a young age, particularly through the skate community, which utilizes concrete skateparks across the country. Approximately 3 million skateboarders are between the ages of 12 and 17, which is a prime time in career development plans. The deliverables will include:

- A series of videos to be shared on social media platforms that tell the story of who mixed, delivered, finished and designed the concrete skateparks;
- A website where the video content can lead interested individuals to learn more about career opportunities available in the concrete industry, including a job search feature and information on the CIM undergraduate degree programs; and
- The development of a high school level Concrete Certification recognized by the concrete industry.

The appeal of this endeavor is expected to reach beyond those who actually skate as the messaging is targeted specifically to relate to the younger generation and to demonstrate concrete’s unique benefits and applications. Understanding what careers are available in the concrete industry and the benefits they offer – through the use of a series of three short videos spread through social media – and how concrete enhances their recreation and communities, will help draw students in.

The videos, high school certification, and website developed through this project will be marketed through a partnership with Skate4Concrete and the concrete industry through social media platforms, and educational groups, such as State Career Technical Education outlets and Science, Technology, Engineering, Art, and Math (STEAM) Educational offices, CIM Program schools and state/regional associations to use as part of local job fair recruitment efforts.
**Pervious Concrete Contractor Certification Craftsman Text**

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**

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 in their region.
Frequently in architectural education there is little more than a cursory discussion regarding the use of concrete in building design and construction with the emphasis instead being placed on wood-framed projects leading many newly minted architects to select wood for projects over concrete. This project seeks to increase the exposure of architectural students to concrete and concrete design. The National Ready Mixed Concrete Association and its Build With Strength coalition are partnering with Habitat for Humanity International and the Association of Collegiate Schools of Architecture to educate architecture students on the best practices, development of specifications and a variety of concrete construction systems and strategies through a design and construction competition with the intention of having winning designs be considered for further development and construction by Habitat for Humanity affiliates in select markets in 2022.

Additional information may be found at https://www.acsa-arch.org/competitions/2022-habitat-competition/.

Update to NRMCA’s Certified Concrete Delivery Professional Program

Developed over 20 years ago, NRMCA’s Concrete Delivery Professional certification has educated over two generations of drivers. The program is now in need of a significant update, both in the platform on which it is delivered – upgrading its online platform – and in the curriculum content, which include the focus areas of: product knowledge, environmental, customer service, safety, and mixer truck operations and maintenance. NRMCA’s annual Mixer Driver Recruitment & Retention Survey has regularly documented that drivers who are invested in and who feel they have a career are more likely to stay in their positions. The program update will include an interactive learning experience with a gaming look that will feature cutting-edge graphics and a learning experience with interactive engagement tools that will help attract a younger generation of drivers.
National Training Program for State and Local Public Agencies on Cement-Based Paving Products

With funding from the RMCREF, PCA, ACPA, and a Pooled Fund, the CP Tech Center developed training on the causes of premature concrete deterioration at pavement joints. The 6-hour workshop addressed potential premature failure mechanisms and how to prevent their recurrence on new pavements. The target audience was city and county engineers who seem to be observing the problem the most. Training was held in Iowa, Indiana, Michigan, Minnesota, New York, South Dakota, Wisconsin, and other states with more than 450 participants and excellent reviews.

Each program was customized based on local practices and how recommendations fit with existing specifications. A CD was given to each participant with manuals and reports on it. The agenda included:

- Mechanisms and Recommendations
- Drainage – Keeping Water Out of the Concrete
- Mixture & Construction Practices Guide Specifications
- Quality Assurance and Testing
- Industry Led Discussion on Local Specifications and Practices
- Repair Approaches

Funding was also used to provide travel assistance and attendance costs for state DOTs that were considering joining the National Concrete Consortium (NCC). Because of this support, there are now 30 DOTs and the Illinois Tollway that are members.

Financial Management Course for the Ready Mixed Concrete Industry

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.
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. Previously, this consisted of training manuals in each of the five areas and an exam. Through this grant from the RMC Research & Education Foundation, NRMCA now offers training videos on-line 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.

Certified Concrete Delivery Professional Training Videos

These translations are vital to improving the training of Spanish-speaking drivers who are able to study these materials in their native language and then apply their training more readily. The Trustees recognized that the most widely expanding pool of concrete delivery professionals are coming 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 are also 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 Federacion Iberoamericana del Hormigon Premezclado (FIHP), which 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.

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

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