THE FIRST 5 YEARS

April 2000 – March 2005

THE PCC CENTER AT IOWA STATE UNIVERSITY

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"Advancing the State of Art of
Portland Cement Concrete Pavement Technology"

THE PCC CENTER AT IOWA STATE UNIVERSITY

contents

From the Director 3

Who We Are 4

PCC Center Staff 4
Faculty Affiliates 4
Advisory Groups 5
Partnerships to Pursue Commom Goals 5

Facilities 6

PCC Pavement and Materials Research Laboratory 6
Mobile Concrete Research Lab 6
Combined Test Capabilities of the PCC Center's Two Labs 7
Offices at CTRE 8
Other Facilities 8

Research 9

Research Funding Amounts and Sponsors 9
Completed PCC Center Projects 10
In-Progress PCC Center Projects 12

Big-Picture, Long-Term Planning 16

Long-Term Plan for Concrete Pavement Research and Technology: The CP Road Map 16
International Workshop on Sustainable Development and Concrete Technology 17

Technology Transfer 18

Training Publications 18
Tech Transfer Summaries 18
Training Events 19
Education 19

abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ACPA	American Concrete Pavement Association
ASTM	American Society for Testing and Materials
CCEE	Department of Civil, Construction and Environmental Engineering/ISU
CM&T	Construction Management & Technology Program/ISU
CTRE	Center for Transportation Research and Education/ISU
ICPA	Iowa Concrete Paving Association
Iowa DOT	Iowa Department of Transportation
ISU	Iowa State University
FHWA	Federal Highway Administration
PCC Center	Center for Portland Cement Concrete Pavement Technology/ISU
PGA	Partnership for Geotechnical Advancement/ISU
SUDAS	Statewide Urban Design and Specifications/ISU

In 1999, the Iowa Concrete Paving Association, Iowa DOT, and Iowa State University held a series of workshops on how to improve the quality and durability of concrete pavement in Iowa. Through those discussions, the idea was conceived that, by joining together to form one center dedicated to concrete paving research and training, much more could be accomplished to meet the growing challenges of the concrete paving industry and deliver a new generation of durable, performance-driven concrete pavements to the traveling public.

The PCC Center was founded in April 2000, and the idea of private industry, highway agencies, and academia teaming to pursue common goals became a reality. Not only that, the PCC Center became a success story that no one could have even imagined. The visionary leadership of the PCC Center's founding organizations is largely responsible for this success. I would like to offer special thanks to the many people who worked tirelessly to provide the center with critical support and direction over the last five years:

The idea of private industry, highway agencies, and academia teaming to pursue common goals became a reality.

- Advisory Board Chairs Steve Gillotti (2000–2002) and Andy Wyckoff (2002 to present);
- Iowa Concrete Paving Association President Gordon Smith;
- Kevin Mahoney, Ian MacGillivray, and Sandra Larson of the Iowa DOT;
- Contractor members who championed the vision;
- Volunteers on the PCC Center Advisory Board and Standing Committees on Research and Technology Transfer; and
- Dale Harrington, the PCC Center's founding director.

The PCC Center's founding and continuing mission is to advance the state of the art of portland cement concrete pavement technology. The center has been accomplishing this on two major fronts—research and technology transfer—each guided by a standing committee of leaders in the field.

The PCC Center's coordinated program of applied research is funded by a diversity of sponsors, including the Federal Highway Administration, Iowa Highway Research Board, numerous state highway agencies, and private industry. Annual Congressional appropriations to the PCC Center have been wisely managed through a cooperative agreement with the FHWA. In the short five years of the PCC Center's existence, two major research laboratories have been developed, dedicated, and put to serious work.

The PCC Center is dedicated to both training the concrete paving workforce and educating future concrete pavement engineers and researchers. As you will read in this report, the center has made enormous efforts to produce quality tech transfer publications, provide critical training opportunities, and offer courses that deliver practical current concrete paving knowledge.

In addition to these efforts, over the last five years the PCC Center had the distinct privilege of leading development of the CP Road Map—a comprehensive national plan for concrete pavement research that will guide approximately $250 million of investment over the next 10 years, resulting in a new generation of concrete pavements. Dale Harrington, Ted Ferragut, and the rest of the CP Road Map team also developed a progressive, cooperative strategy for managing and conducting the research constituting the CP Road Map.

Please take a few minutes to browse through some of the center's accomplishments presented in this report on our first five years. We are pleased to announce that the PCC Center has recently been named a national center by the American Concrete Pavement Association. Be sure to join us over the next years as we continue to advance the state of the art of portland cement concrete pavement technology nationally.

E. Tom Cackler, P.E.
PCC Center Director

PCC Center Staff

Tom Cackler
Director

Dale Harrington
Associate Director, Founding Director (2000–2003)

Vern Schaefer
Associate Director for Research

Mark Anderson-Wilk
Editor

Heath Gieselman
PCC Research Technician

Jim Grove
PCC Paving Engineer

Jeremy McIntyre
PCC Research Technician

Sharon Prochnow
Assistant to the Director

Harold Smith
Training Engineer

Bob Steffes
PCC Research Engineer

Denise Wagner
Secretary

Lori Wildeman
Former Assistant to the Director (2000–2003)

Bryan Zimmerman
PCC Research Technician

Faculty Affiliates (Department of Civil, Construction and Environmental Engineering, Iowa State University)

Jim Cable
Transportation Engineering

Augusto Canales
Construction Engineering

Halil Ceylan
Geotechnical and Materials Engineering

Chuck Jahren
Construction Engineering

Ed Jaselskis
Construction Engineering

Max Porter
Structural Engineering

Scott Schlorholtz
Geotechnical and Materials Engineering

Kejin Wang
Geotechnical and Materials Engineering

Dave White
Geotechnical and Materials Engineering

Advisory Groups

The PCC Center is guided by an Executive Committee, Advisory Board, Standing Committee on Research, and Standing Committee on Technology Transfer.

The Executive Committee includes the following:

- Kevin Mahoney, director of the Iowa DOT Highway Division
- Gordon Smith, president of the Iowa Concrete Paving Association
- Lowell Greimann, chair of the ISU Department of Civil, Construction and Environmental Engineering
- Steve Andrle, director of the ISU Center for Transportation Research and Education

The Advisory Board has been chaired by Steve Gillotti, president of Eco-Tech Construction, LLC, and Andy Wykcoff, vice-president of Fred Carlson, Inc.

Jim Cable of the ISU Department of Civil, Construction and Engineering has chaired the Committee on Research. Chris Brakke of the Iowa DOT has chaired the Committee on Technology Transfer.

The Advisory Board and Standing Committees on Research and Technology Transfer are composed of representatives of the following entities:

- Iowa Department of Transportation
- Iowa Concrete Paving Association
- Iowa State University's Department of Civil, Construction and Environmental Engineering
- Iowa State University's Center for Transportation Research and Education
- Cement industry
- PCC aggregate industry
- PCC equipment industry
- PCC contractor industry
- Iowa Ready Mix Association
- Consulting industry
- American Public Works Association
- Iowa County Engineers Association
- Federal Highway Administration

Partnerships to Pursue Common Goals

The mission of the PCC Center is to advance the state of the art of concrete pavement technology. The PCC Center teams with the federal government, state highway agencies, academia, and the concrete paving industry to find solutions for improving pavement performance. The benefits are shared by the concrete paving community and the motoring public across the country.

The PCC Center Standing Committees on Research and Technology Transfer at their joint meeting in spring 2005

Hundreds of people tour the mobile lab as it visits numerous states, providing both research facilities and hands-on technology transfer opportunities.

facilities

PCC Pavement and Materials Research Laboratory

The PCC Pavement and Materials Research Laboratory on the Iowa State University campus opened in 2002 thanks to contributions from the Iowa Concrete Paving Association, Iowa DOT, Iowa State University, and private industry. The 2,500 square-foot lab is fully equipped with state-of-the-art laboratory equipment. The lab helps researchers discover practical solutions to the challenges faced by the concrete paving community and provides students with opportunities for hands-on research experience.

The PCC lab at Iowa State University

Mobile Concrete Research Lab

The Mobile Concrete Research Lab opened in 2004 thanks to contributions from the American Concrete Pavement Association, state/regional concrete paving associations, and Iowa State University. The mobile lab brings high-tech concrete materials and concrete paving testing capabilities to the field.

See following page for test capabilities of these labs.

Inside the mobile lab

Mobile lab in the field

Combined Test Capabilities of the PCC Center's Two Labs

The PCC Pavement and Materials Research Laboratory and the Mobile Concrete Research Lab work in concert to provide a comprehensive, coordinated suite of test capabilities (see table).

Property Measured	Test Method	Test Equipment	PCCLab/ISU	Mobile Lab/ Field
WORKABILITY				
Gypsum content of cement, fly ash, and slag	Differential scanning calorimetry (DSC); x-ray diffraction (XRD)	Differential scanning calorimeter; x-ray diffractometer	X	
Sulfate and alkali content of cement, fly ash, and slag	X-ray fluorescence (XRF) (ASTM C 114)	XRF spectrometer	X	
Fineness of cement, fly ash, and slag	Blaine fineness test (ASTM C 204)	Blaine air permeability apparatus	X	
Gradation of coarse aggregate and fine aggregate	Shilstone coarseness/workability chart; 8/18 chart; 0.45 power curve	Sieve shaker	X	X
Set time of mortar	ASTM C 403	Mortar penetrometer	X	X
Early stiffening	ASTM C 359 (lab); modified ASTM C 359 (field)	Mortar penetrometer; Vicat consistency apparatus	X	X
Early stiffening of cement and fly ash	Heat evolution quick test	Insulated container	X	X
Early stiffening	Flow table test (Dan Johnston method; modified ASTM C 1437)	Flow table	X	X
Slump	Inverted slump test	Slump cone	X	X
Heat signature of mortar and concrete	Heat signature test	Heat signature drums (calorimeters)	X	X
Concrete temperature	Concrete temperature measurement	Infrared noncontact temperature measuring device (thermo gun)		X
STRENGTH				
Compressive strength and flexural strength development	Compressive strength and flexural strength tests	Concrete compression tester with molds	X (400,000-lb capacity)	X (250,000-lb capacity)
Elasticity	Modulus of elasticity test	Compressometer-extensometer	X	
Tensile strength	Splitting tensile test	Jig	X	X
Water-cement ratio	ACI 318-02	Microwave oven	X	X
Subbase temperature	Subbase temperature measurement	Infrared noncontact temperature measuring device (thermo gun)		X
Maturity	Maturity curves; break maturity samples; maturity sensors	Concrete maturity loggers	X	X
AIR SYSTEM				
Air void system of fresh concrete	Air void analyzer (AVA) test	AVA; sample collection equipment	X	X (with isolation base)
Air content of fresh concrete	Pressure method (ASTM C 231)	Pressure meter	X	X
Air content of fresh concrete	Unit weight test	Unit weight balance	X	X
Air void system of hardened concrete	Image analysis (ASTM C 457)	Scanning electron microscope	X	
Air entrainment	Foam index test	Sample container	X	X
SHRINKAGE				
Temperature gradient	Coefficient of thermal expansion test (AASHTO TP60)		X	
Temperature profile	HIPERPAV analysis	Weather station; HIPERPAV software		X
PERMEABILITY				
Resistance of concrete to chloride ion penetration	Ponding test (AASHTO T 259)		X	
Resistance of concrete to chloride ion penetration	Rapid chloride permeability test (ASTM C 1202)	Rapid chloride permeability device	X	
Resistance of concrete to chloride ion penetration	Rapid migration test (AASHTO TP64)		X	

from left to right:
AVA testing, flow table testing, field testing, curing tank outside and inside

Offices at CTRE

The PCC Center's main offices are within CTRE's 14,000-square-foot office suite in the ISU Research Park, roughly three miles from both the Iowa State University campus and the Iowa DOT's headquarters in Ames, Iowa. The facility offers the following features:

- Videoconference classroom
- Large conference room accommodating 15–25 people
- Smaller conference room
- State-of-the-art computing hardware and software, including desktop publishing capabilities and a T1 connection to the university's communications backbone
- Transportation technology transfer library
- Office space for visiting and affiliate faculty

Other Facilities

The PCC Center has access to a variety of other resources at Iowa State University and the Iowa DOT:

Iowa DOT Materials Laboratory
Certified by the American Association of State Highway and Transportation Officials, this lab provides equipment and expertise for materials quality verification and specification compliance testing, as well as pavement performance testing.

ISU Materials Analysis Research Laboratory (MARL)
MARL provides researchers with the capability to conduct elemental materials analyses to determine the chemical makeup of cements, fly ashes, limestones, and other pavement materials.

ISU Geotechnical Engineering Laboratory
This facility includes equipment for index tests, classification of soils and aggregates, and research on permeability, strength, and stress/strain characteristics.

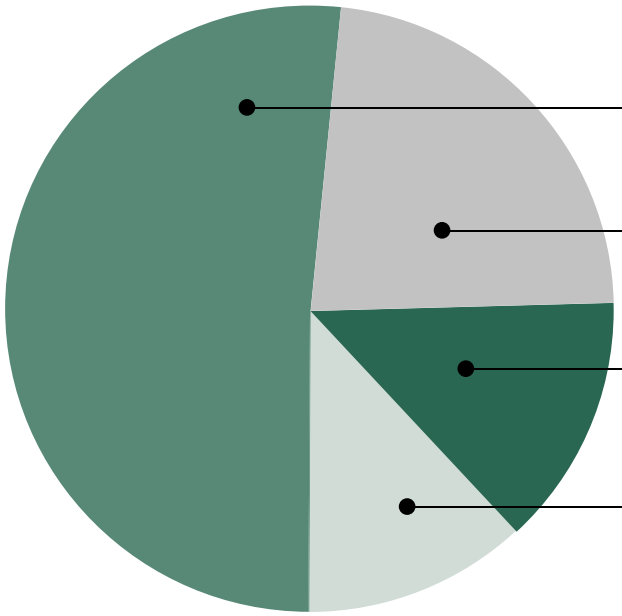
ISU Scheman Conference Center
The Scheman Conference Center features 21 meeting rooms with many unique features, 8,000-square-foot lobby exhibit space, and 2,600-square-foot outdoor exhibit space. A complete audiovisual center is available at Scheman, with up-to-date equipment and personnel to handle its operation. Overhead projectors, slide projectors, projection screen, and microphones are included with each meeting room at no charge. Parking is convenient, ample, and free.

ISU Parks Library
The Iowa State University library collection includes more than 2 million book volumes, about 22,000 journals and other serial publications, and extensive interlibrary loan capabilities.

Iowa DOT Transportation Library
The Iowa DOT manages an extensive transportation library and collects copies of many specialty publications. This library also provides access to the Transportation Research Information Service (TRIS) and associated resources.

Research Funding Amounts and Sponsors

The PCC Center is conducting a coordinated program of applied research totaling over $8.5 million and more than 30 projects.



Federal Funds
$4,423,000

State DOTs
$1,909,000

Iowa Highway Research Board
$1,182,000

Private Industry
$1,026,000

Completed PCC Center Projects

Dowel Bar Optimization

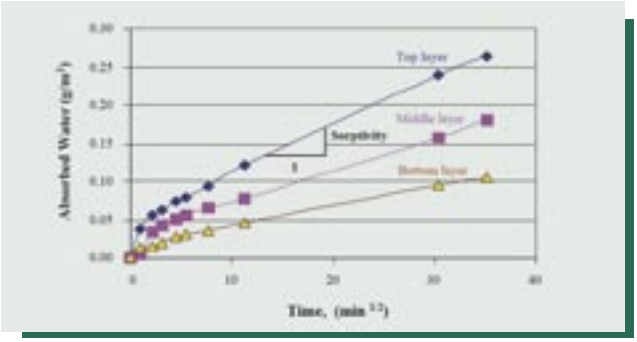
The objectives of this project were as follows: (1) investigate the static behavior of steel elliptical and round epoxy-coated dowel bars, (2) investigate the failure modes of steel elliptical and round epoxy-coated dowel bars, (3) evaluate the benefits and drawbacks of elliptical dowel bars for load transfer, (4) determine the effect of dowel bar spacing and projected load transfer efficiency, and (5) evaluate whether variable spacing in combination with shape factor and dowel bar size can optimize costs and constructability.

Sponsor: American Highway Technology
Funding: $60,000
PI: Max Porter
Products: Final Report (October 2001)

Improved Concrete Pavement Curing Materials and Techniques

Curing of concrete is important for concrete pavement durability. Adequate curing can help ensure the uniformity of the concrete layers, control moisture and temperature conditions, and prevent or minimize random cracking in concrete pavements during the first few days after construction. The objectives of this research were to evaluate the effect of different curing materials and techniques on concrete pavement properties, and to better understand the relationships between various concrete test measurements and concrete properties affected by curing. Different curing materials and application techniques were selected and evaluated in the lab and field. Concrete property values were found to vary considerably with depth. Of the test methods applied in the lab study, the sorptivity test proved to be the most sensitive for evaluating the subtle changes in near-surface-layer concrete properties related to microstructure development as impacted by different curing methods.

Sponsor: Iowa Highway Research Board (TR-451, TR-479)
Funding: $176,000
PIs: Jim Cable; Kejin Wang
Products: Part 1 Report (April 2002); Part 2 Report (March 2003); Tech Transfer Summary (December 2004)



Typical concrete sorptivity test results from the PCC Center's curing study

Measuring Pavement Profile at the Slip-Form Paver

Pavement profile or smoothness has been identified nationally as a good measure of highway user satisfaction. Operational highway profiles are typically measured with high-speed inertial profilers. New highway profiles are usually measured with profilographs in order to establish incentives or disincentives for pavement construction. In most cases, these two processes do not measure the same value. In an attempt to correct the inconsistency, lightweight profilers intended to produce values to be used for construction acceptance are being made to measure the same profile as inertial profilers. This project evaluated two profiler systems that can measure pavement profile during construction. The profilers were able to detect roughness in the final profile. Dowel basket ripple was found to be a significant source of pavement surface roughness. The profilers evaluated were able to detect dowel basket ripple with enough clarity to warn the paving crew. String-line disturbances degrade smoothness. The profilers were able to detect some string-line disturbances during paving operations.

Sponsors: FHWA (Project 12); Iowa Highway Research Board (TR-512); PCC Center (Sponsored Research Fund); GOMACO; Ames Engineering
Funding: $296,000
PI: Jim Cable
Products: Final Report (February 2005); Tech Transfer Summary (February 2005)

Performance Properties of Blended Cements for Concrete Pavements

This project was triggered by interest in sustainable development and new environmental regulations on waste disposal. The addition of supplementary cementitious materials (SCMs) such as fly ash, slag, and other industrial byproducts to cements can improve concrete workability, durability, and long-term strength, but a gap in knowledge about the performance of SCM concrete under a variety of conditions has limited its use by the PCC paving industry. In this project, correlations were found among the source and proportion of the SCMs, curing conditions, concrete set time, maturity, strength development, and cracking potential. Other findings include the following: (1) concrete performance varies with the source and proportion of cementitious materials used; (2) as SCM content increases, longer curing times or higher curing temperatures may be needed; (3) SCM concrete can perform comparably to or better than ordinary portland cement concrete under hot weather conditions; (4) traffic opening time of pavement should be based on strength and time-temperature factor. Potential benefits of a more informed use of SCM concrete include improved concrete workability, lower risk of thermal cracking, improved concrete durability and long-term strength, and reduced overall concrete cost.

Sponsor: PCC Center (Sponsored Research Fund)
Funding: $54,000
PI: Kejin Wang
Products: Final Report (December 2003); Tech Transfer Summary (April 2004)

Performance Properties of Ternary Mixes for Concrete Pavements

Supplementary cementitious materials (SCMs) such as pozzolans and slag extend the market for concrete products by improving specific concrete properties. In properly formulated concrete mixes, pozzolans and slag have been shown to enhance long-term strength, decrease permeability, increase durability, reduce thermal cracking of mass concrete, minimize or eliminate cracking related to alkali-silica reaction, and minimize or eliminate cracking related to sulfate attack. This project evaluated the need for additional research into the use of SCMs in concrete for highway applications.

Sponsor: FHWA (Project 13)
Funding: $25,000
PI: Scott Schlorholtz
Products: Scoping Report (June 2004)

Smooth, Quiet, Safe Concrete Pavements

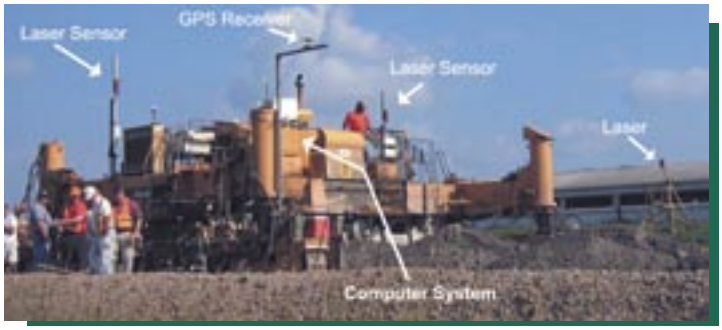
Current public surveys indicate that the traveling public wishes to have smooth, quiet, and safe pavements. This project collected existing information and identified the challenges remaining to developing smooth, quiet, and safe concrete pavements. A framework for additional research was developed around the following areas: texture and traffic noise, pavement friction, and pavement smoothness.

Sponsor: FHWA (Project 14)
Funding: $14,000
PI: Jim Cable
Products: Scoping Report (March 2004)

Stringless Concrete Paving

Conventional concrete pavement construction uses a string line on one or both sides of the paving train to ensure proper pavement thickness and alignment. This approach requires space on each side of the paving machine to set the string line. The placement and verification of the string line is time intensive and limits access to the area in front of the slip-form paver. Several companies have developed stringless equipment control and guidance systems. These stringless technologies have been successfully implemented on construction earthmoving and grading projects. This project evaluated the potential of stringless control methods in a new area—concrete paving. Stringless paving control using a global positioning system (GPS) was compared with the conventional string-line method of paving control. Stringless GPS control was found to successfully guide the slip-form paver and adequately control the concrete yield quantity, pavement depth, and surface elevations.

Sponsors: Iowa Highway Research Board (TR-490); PCC Center (Sponsored Research Fund)
Funding: $140,000
PI: Jim Cable
Products: Final Report (February 2004); Tech Transfer Summary (April 2004)



Stringless paving using GPS guidance

Synthesis of Dowel Bar Research

This project provides a synthesis of completed, ongoing, and needed research on dowel bars for highway pavements. A literature search was conducted, and dowel bar research knowledge and gaps were identified and documented. The project report provides an annotated bibliography of all sources used to determine the gaps in technology and knowledge for dowel bar and alternative dowel bar topics.

Sponsor: Iowa Highway Research Board (HR-1080)
Funding: $30,000
PI: Max Porter
Products: Final Report (August 2002)

Two-Lift Concrete Pavements

Changes in the availability of aggregates, advances in materials knowledge and construction equipment, and increasing demands for pavement surfaces that meet specific noise, durability, and safety objectives are prompting the need to reconsider two-lift paving as a construction technique for building concrete pavements. Two-lift construction involves the placement of two wet-on-wet layers or bonding wet-to-dry layers of concrete. The bottom layer is thick and consists of lower quality, locally available aggregate or recycled aggregate. The top layer is thin and consists of high-quality aggregate designed to provide better resistance to freeze-thaw damage, reduce noise, or improve friction. Certain cost, mix design, and construction concerns are inhibiting the use of two-lift paving. Two-lift paving often requires the use of two plants, two slip-form machines, and a special haul road, all of which add to the cost of the paving project. As quality aggregate becomes scarce in some regions, two-lift paving will likely become a more viable economic option. Two-lift paving could also help some agencies around the country consume growing recycled asphalt stockpiles, which could reduce overall costs while benefiting the environment. In addition, two-lift paving has the potential to meet emerging surface characteristics needs by providing a high-quality, durable surface.

Sponsor: FHWA (Project 8)
Funding: $70,000
PI: Jim Cable
Products: Final Report (September 2004); Tech Transfer Summary (October 2004)

In-Progress PCC Center Projects

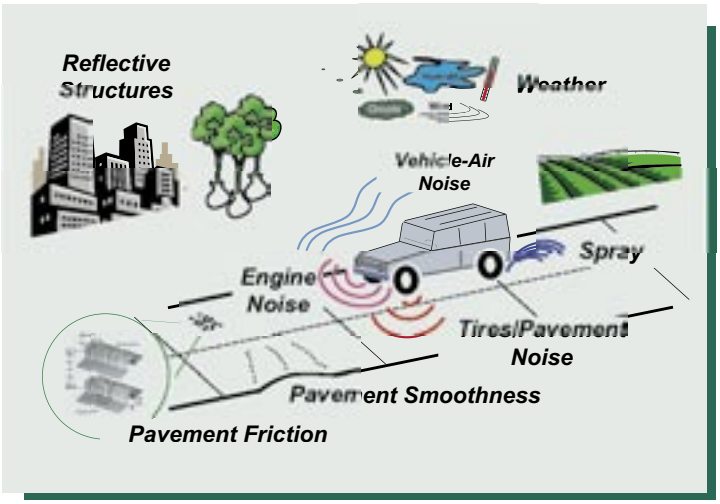
Attributes of Good In-Service Concrete Pavements

The objective of the project is to improve knowledge of the attributes of good in-service concrete pavements. Phase I identified existing knowledge and evaluated the need for additional research on the attributes of well-performing concrete pavements. Phase I tasks included a literature survey, pavement performance data collection from many counties, cities, and primary and interstate roads in Iowa, field visits to selected pavement sites, and analysis of the collected data. The concept of "zero-maintenance" concrete pavements was examined. Phase II will investigate the additional research needs identified in Phase I.

Sponsor: FHWA (Project 9)
Funding: $11,000
PIs: Jim Cable; Halil Ceylan
Status: Phase I Report (December 2004); Estimated Completion 2007

Concrete Pavement Surface Characteristics

One of the most pressing concerns to the concrete paving industry is the surface characteristics issue. Demand continues to grow for quieter environments in and around highway facilities, without experiencing adversely affected safety or smoothness. The FHWA, ISU, and ACPA have joined financially and technically to develop and implement a Concrete Pavement Surface Characteristics Program. The purpose of the program is to determine the relationships among noise, friction, smoothness, and texture properties of concrete pavements in order to optimize surface characteristics. Part 1 is synthesis and strategic plan development and management. Part 2 is a field assessment of current practices. A proposed Part 3 includes the construction, measurement, and analysis of new and innovative surfaces. A better understanding of surface characteristics will provide the traveling public with concrete pavement surfaces that meet or exceed predetermined requirements for friction/safety, tire-pavement noise, smoothness, splash and spray, light reflection, rolling resistance, and durability/longevity.



Factors affecting concrete pavement surface characteristics

Sponsor: FHWA (Project 15); ACPA; Iowa Highway Research Board (TR-537)
Funding: $1,022,000
PI: Dale Harrington
Status: Estimated Completion 2005

Deicer Scaling Resistance of Concrete Pavements, Bridge Decks, and Other Structures Containing Slag Cement

This project investigates the important variables that impact the scaling resistance of concrete containing slag cement. The project consists of a field study and a laboratory study. The field study will collect and evaluate concrete samples extracted from pavement slabs. The laboratory study will investigate how specific variables influence the deicer scaling resistance of concrete mixtures.

Sponsors: FHWA (Pooled Fund Study); 7 state highway agencies; Slag Cement Association
Funding: $275,000
PI: Scott Schlorholtz
Status: Estimated Completion 2007

Design and Construction Procedures for Concrete Overlays and Widening of Existing Pavements

The objectives of this project are to (1) conduct a structural analysis of concrete overlay and widening unit contributions to stress reductions and extended pavement life, (2) develop construction guidelines for thin concrete overlays, (3) develop overlay design procedures, and (4) validate the structural analysis and design procedures with field load tests.

Sponsors: FHWA (Project 6); Iowa Highway Research Board (TR-511)
Funding: $217,000
PI: Jim Cable
Status: Estimated Completion 2005

Elliptical Steel Dowel Performance

The objective of this project is to determine the relative performance over time of medium- and large-sized elliptical steel dowels compared with conventional round dowels, including the impact of spacing, placement in cut or fill sections of the roadway, and constructability issues.

Sponsors: FHWA; American Highway Technology
Funding: $282,000
PI: Max Porter
Status: Estimated Completion 2008

Field Evaluation of Elliptical Fiber Reinforced Polymer Dowel Performance

Fiber reinforced polymer (FRP) composite materials are making an entry into the construction of both buildings and pavements. To date, the application of FRP materials in pavements comes in the form of joint reinforcement (dowels and tie-bars). FRP's resistance to salt corrosion in dowels has made it an alternative to standard epoxy-coated dowels for pavements. This project compares the performance of elliptical FRP dowels in the lab and in the field. Truck loading and falling weight deflectometer tests will be conducted on the field pavement sections with instrumented elliptical FRP dowel joints.

Sponsors: FHWA (Project 5); Hughes Bros.
Funding: $202,000
PI: Max Porter
Status: Construction Report (June 2003); Estimated Completion 2005

Impact of Curling, Warping, and Other Early-Age Behaviors on Concrete Pavement Smoothness

The objective of this project is to conduct a controlled field evaluation of the impact of early-age concrete pavement behaviors on concrete pavement smoothness. Both field and laboratory testing of concrete materials and construction operations will be conducted. Extensive pavement profiling will be performed at strategic times after construction. By using mathematical models, a better understanding will be gained of the complex relationships between concrete pavement curling, warping, and other early-age behaviors on concrete pavement smoothness.

Sponsor: FHWA (Project 16)
Funding: $131,000
PI: Halil Ceylan
Status: Estimated Completion 2005

Improving Concrete Mix Consistency and Production by Mixing Improvements

The objective of this project is to find optimal mixing procedures for production of a homogeneous and workable concrete mixture and quality concrete using a two-stage mixing operation.

Sponsors: FHWA (Project 11); Iowa Highway Research Board (TR-505); PCC Center (Sponsored Research Fund)
Funding: $351,000
PI: Vern Schaefer
Status: Estimated Completion 2005

In Situ Nondestructive Testing Methods for Materials-Related Distress in Concrete Pavements

Phase I of this research summarized existing nondestructive testing methods that have the potential to detect materials-related distress in concrete pavements. The most promising technique, ground penetrating radar, is currently undergoing further evaluation in Phase II of the project.

Sponsors: FHWA (Project 1); Iowa DOT (Phase I); Iowa Highway Research Board (Phase II, HR-1081)
Funding: $270,000
PI: Scott Schlorholtz
Status: Phase I Report (July 2003); Estimated Completion 2005

Pavement cores showing materials-related deterioration, from the PCC Center's nondestructive testing methods research

Integrating Material and Construction Practices (IMCP) for Durable Concrete Pavements Manual

The PCC Center is developing a manual to help project and field engineers, mix designers, technicians, material experts, and construction supervisors and foremen achieve desired concrete pavement performance characteristics through an integrated systems approach to concrete pavement construction. The field manual will include information about why and how to use state-of-the-art performance prediction technologies during materials selection, mixture design, mixture verification, and pavement construction; and a thorough, easy-to-use troubleshooting reference.

Sponsors: FHWA (Project 10)
Funding: $397,000
PI: Dale Harrington; Jim Grove
Status: Estimated Completion 2005

Laboratory Study of the Structural Behavior of Alternative Dowel Bars

The objective of this project is to determine an improved test procedure to replace the AASHTO T 253 procedure and the corresponding analysis to incorporate the modulus of dowel support based upon laboratory tests.

Sponsors: FHWA (Project 7); Iowa Highway Research Board (TR-510); Hughes Bros.
Funding: $178,000
PI: Max Porter
Status: Estimated Completion 2005

Material and Construction Optimization (MCO) for the Prevention of Premature PCC Pavement Distress

The objectives of this five-year Transportation Pooled Fund study are to evaluate conventional and new technologies and procedures for testing concrete and concrete materials to prevent material and construction problems that could lead to premature concrete pavement distress, and to develop a suite of tests that provides a comprehensive method of ensuring long-term pavement performance. A preliminary suite of tests to ensure long-term pavement performance has been developed. Shadow construction projects are being conducted to evaluate the preliminary suite of tests. A mobile concrete testing laboratory has been designed and equipped to facilitate the shadow projects. The results of the project are being compiled in a user-friendly field manual.

Sponsors: FHWA (Pooled Fund Study); 17 state highway agencies, private industry
Funding: $1,850,000
PI: Jim Grove
Status: Phase I Report (September 2004); Phase I Summary (September 2004); Estimated Completion 2007

Five focal areas	Mix design	Preconstruction mix verification	Construction quality control
1. Workability			
2. Strength development			
3. Air system			
4. Permeability			
5. Shrinkage			

Suite of tests being evaluated and refined in the MCO project

Materials & Mix Optimization Procedures for Concrete Pavements

This project will investigate the key parameters of concrete mixing; evaluate new field-testing methods that may be used to monitor mixing processes and control concrete quality; develop a database of information that represents the results of field evaluation of certain variables; and establish optimal mixing procedures for various materials and mixing methods.

Sponsors: FHWA (Project 3); Iowa Highway Research Board (TR-484)
Funding: $314,000
PI: Scott Schlorholtz
Status: Estimated Completion 2005

Nondestructive Testing Methods for Evaluating Concrete Pavements

This project will provide state highway agency engineers with a field-validated nondestructive pavement evaluation toolbox that will be used to assess pavement condition, estimate pavement remaining life, and eventually help assess pavement rehabilitation strategies by the pavement management team.

Sponsor: Iowa DOT
Funding: $120,000
PI: Halil Ceylan
Status: Estimated Completion 2006

Pervious Concrete Pavement Water Quality Project

The Federal Clean Water Act mandates that government agencies and private entities manage both the quantity and quality of storm water runoff. As a result, state and local governments are instituting regulations that provide limits on the amount of impervious surfaces allowed in new or renovated development. Portland cement pervious concrete pavements have shown potential as a durable solution to this issue. As part of Phase I of this project, researchers are collecting case information of existing literature and research and documenting the performance of pervious concrete field applications. A small lab study is also being conducted to gain knowledge on the freeze-thaw performance of pervious concrete with the objective of developing viable options for mix designs. The study will answer questions regarding construction procedures, design parameters, and maintenance and durability of pervious concrete pavements. A proposed second phase of the project would include a multivariable field demonstration of the recommended design and maintenance methods.

Sponsor: PCC Center (Sponsored Research Fund)
Funding: $30,000
PI: Dale Harrington; Vern Schaefer
Status: Estimated Completion 2005

Self-Consolidating Concrete Applications for Slip-Form Paving

The objective of this project is to develop a new type of self-consolidating concrete (SCC) for slip-form paving. It is envisioned that SCC will produce more workable concrete and smoother pavements, better consolidation of the plastic concrete, and higher rates of production. The project will begin with a feasibility study to determine whether subsequent phases will be conducted.

Sponsors: FHWA (Pooled Fund Study); 4 state highway agencies; private industry
Funding: $180,000
PI: Kejin Wang
Status: Estimated Completion 2005

Simple and Rapid Test for Monitoring the Heat Evolution of Concrete Mixtures for Both Laboratory and Field Applications

The objective of this project is to develop and evaluate an open standard test procedure for monitoring concrete using a calorimetry technique. The test will provide an important method of controlling concrete quality in the field during construction. The test should be simple and practical, requiring a minimum of cost and effort to develop the equipment and train the operator.

Sponsor: FHWA (Project 17)
Funding: $138,000
PI: Kejin Wang
Status: Estimated Completion 2005

Soil Stabilization of Nonuniform Subgrade Soils

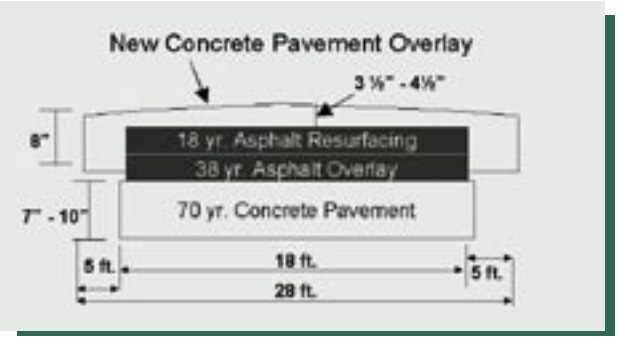
The objective of this project is to determine how various raw ash types, hydrated fly ashes, and conditioned fly ashes in combination with a wide range of soil types can bring about desirable engineering properties and provide uniform properties for subgrade strength and stiffness.

Sponsors: Iowa Highway Research Board (TR-461); FHWA (Project 4); Iowa Fly Ash Association; PCC Center (Sponsored Research Fund)
Funding: $180,000
PI: Dave White
Status: Estimated Completion 2005

Thin Unbonded Concrete Overlays

In recent years, thin unbonded concrete overlays (whitetopping) have evolved as a viable rehabilitation technique for deteriorated asphalt pavements. Although the main factors affecting concrete overlay performance have been identified by previous research, questions still exist as to the optimum design incorporating these variables. The objective of this research is to investigate the interaction between these variables over time. In Phases I/II, laboratory testing involved shear testing of the bond between the concrete overlay and the asphalt surface, and field testing involved falling weight deflectometer deflection responses, measurement of joint faulting and joint opening, and visual distress surveys. Variables investigated included asphalt layer preparation, concrete overlay thickness, synthetic fiber reinforcement usage, and joint spacing. Phase III will evaluate the performance of construction variables such as asphalt layer preparation, joint patterns and spacing, and the use of fibers in concrete overlays. The project will also help to demonstrate the use of automated maturity measurements to reduce cost and time and to relate joint sawing time to strength.

Sponsors: FHWA (Project 2); Iowa Highway Research Board (TR-478, HR-1093)
Funding: $477,000
PI: Jim Cable
Status: Construction Report (April 2003); Estimated Completion 2006



Cross section showing proposed thin unbonded concrete overlay

Training Programs for Hispanic Supervisors and Construction Workers

Hispanics make up a growing percentage of workers entering the construction industry, and this has created several challenges for American construction companies. This project addresses the situation by investigating training needs for Hispanic construction workers and developing a training program for them within the industry. As a part of Phase I, two training courses were designed to help both American construction companies and their Hispanic labor force to overcome the barriers that keep them from succeeding safely and productively. Phase II of this project is an initiative to develop a training program for supervisors to learn some relevant Spanish words to further improve the level of communication between employees.

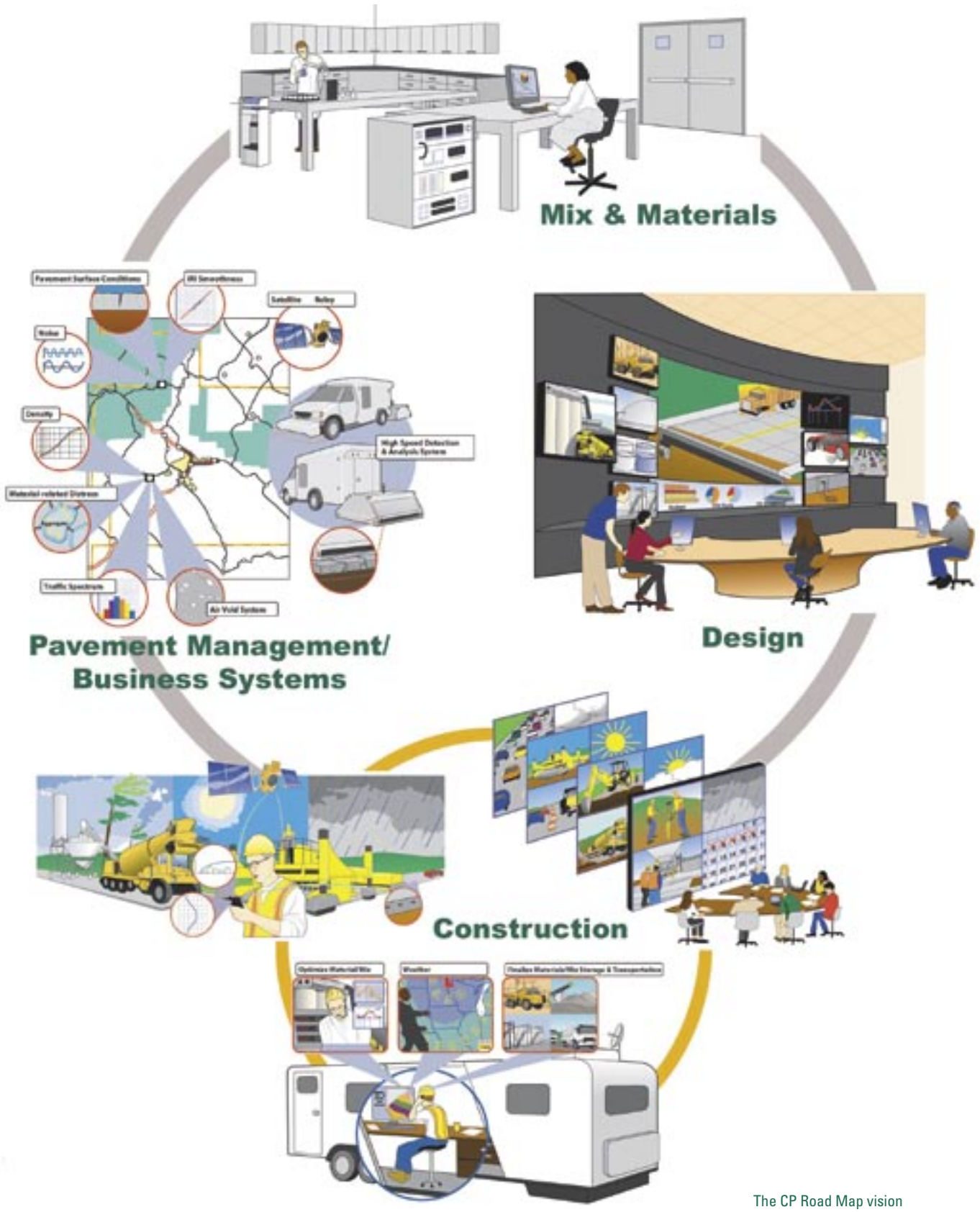
Sponsor: Iowa DOT
Funding: $270,000
PI: Tom Cackler, Edward Jaselskis
Status: Phase I Report (January 2004); Estimated Completion 2005

Ultrathin Unbonded Whitetopping of Brick Streets

The objective of this project is to evaluate the performance of an unbonded concrete overlay (whitetopping) approximately three inches thick placed on an existing base of asphalt and brick streets.

Sponsor: Iowa Highway Research Board (TR-466)
Funding: $20,000
PI: Jim Cable
Status: Estimated Completion 2006

Long-Term Plan for Concrete Pavement Research and Technology: The CP Road Map



The CP Road Map vision

The PCC Center led development of a new, comprehensive, and strategic plan for concrete pavement research: the CP Road Map. The overall goal for the CP Road Map is to respond to significant recent and ongoing changes in materials, practices, and service needs and to build an integrated concrete pavement system that provides innovative solutions to customer-driven performance requirements.

To accomplish this goal, key research objectives were defined related to concrete pavement mixtures and materials, design, construction, and pavement management/business systems. To meet these objectives, approximately 250 problem statements were written and organized into 12 research tracks that compose the CP Road Map:

1. Performance-Based Concrete Pavement Mix Design System
2. Performance-Based Design Guide for New and Rehabilitated Concrete Pavements
3. High-Speed Nondestructive Testing and Intelligent Construction Systems
4. Optimized Surface Characteristics for Safe, Quiet, and Smooth Concrete Pavements
5. Equipment Automation and Advancements
6. Innovative Concrete Pavement Joint Design, Materials, and Construction
7. High-Speed Concrete Pavement Rehabilitation and Construction
8. Long-Life Concrete Pavements
9. Concrete Pavement Accelerated and Long-Term Data Collection
10. Concrete Pavement Performance
11. Concrete Pavement Business Systems and Economics
12. Advanced Concrete Pavement Materials

All together, the plan represents approximately $250 million of research investment over the next 10 years, resulting in a new generation of concrete pavements.

In addition to the research plan, a progressive, cooperative strategy for managing and conducting the CP Road Map research was also developed. Following this research management plan, organizations will identify common interests and partner with each other to executing specific contracts within the CP Road Map.

The CP Road Map was developed with the full participation of the concrete pavement industry, state departments of transportation, academia, and the Federal Highway Administration. The project team was led by Dale Harrington of Iowa State University and Ted Ferragut of TDC Partners and included the Transtec Group and ERES Consultants.

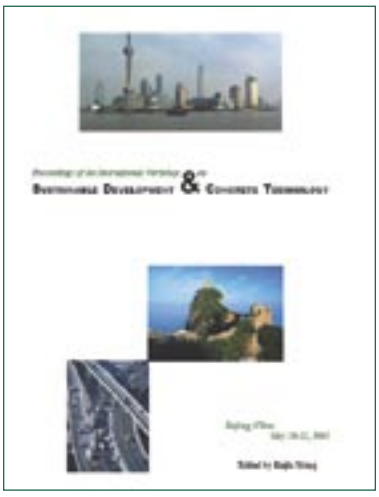
International Workshop on Sustainable Development and Concrete Technology

Iowa State University joined the National Science Foundation, American Concrete Institute, Northwestern University, and many distinguished organizations in China, in sponsoring the International Workshop on Sustainable Development and Concrete Technology held in Beijing, China, May 20–21, 2004.

The international workshop was co-organized by ISU and Beijing's Tsinghua University in response to growing concern about the concrete industry's impact on the environment worldwide. The meeting of over 70 interested experts was held to address the role of concrete materials and construction in sustainable development.

Iowa State University, with support from the CCEE Department, CTRE, and PCC Center, published a volume of proceedings containing papers presented at the workshop. Two major themes are explored: (1) emerging technologies for "green" concrete and (2) concrete durability and sustainable development.

The workshop is expected to contribute to the development of emerging technologies for production of "green" concrete materials and "green" concrete pavements. This effort will also lead to a significant improvement in integration of infrastructure development with industrial ecology, resource management, information technology, and economic development.



Proceedings of the International Workshop on Sustainable Development and Concrete Technology, published by Iowa State University

Committee of the International Workshop on Sustainable Development and Concrete Technology, PCC Center's Kejin Wang speaking at left

The PCC Center is committed to moving innovative and well-tested concrete paving technologies and information into the hands of people who can benefit from them, with targeted publications and training events.

Training Publications

The PCC Center works with its Technology Transfer Committee and experts in the field to identify priority topics and develop publications in two different series: (1) Concrete Paving Notes and (2) Workforce References.

	Concrete Paving Notes	Workforce References
Description	12–24 page booklets with in-depth explanations and detailed illustrations	6-page foldouts, with lists of common problems and recommended procedures
Audience	Engineers, designers, superintendents	Foremen, crew leaders, crews
Purpose	1/2–1 day training, office resource	Short training, field/shop reference
Topics Completed	 • Materials No. 1. Formation and Characteristics of Portland Cement Concrete for Pavements: The Basics • Construction No. 1. Portland Cement Concrete Pavements:Construction Basics	 • No. 1. Concrete Materials Storage, Mixing, and Delivery • No. 2. Concrete Paving Site Preparation and Construction • No. 3. Concrete Paving Joint Sawing, Cleaning, and Sealing • No. 4. English and Spanish Terms for Concrete Paving Workers

The PCC Center is producing bilingual (English-Spanish) versions of some of these publications to help address the safety and productivity issues associated with the growing numbers of Hispanics in the concrete paving workforce in the United States.

Tech Transfer Summaries

The PCC Center produces two- to eight-page summaries of its research projects and innovations. The tech transfer summaries include project sponsors, contact information, objectives, problem statement, technology description, key findings, implementation benefits, and implementation readiness. The concise, illustrated format effectively communicates research results to a wide audience and helps move research advancements into practice.

The following tech transfer summaries have been developed:

- Blended Cements: Improving Concrete Properties Using Environmentally Responsible Mixtures

- Improving Concrete Pavement Curing
- Material and Construction Optimization for Prevention of Premature Pavement Distress in PCC Pavements (Phase I)
- Measuring Pavement Profile During Construction
- Mobile Concrete Research Lab: Bringing Advanced Laboratory Capabilities to the Field
- Reassessing Two-Lift Paving
- Stringless Paving
- Ultrathin PCC Overlays
- Using the Air Void Analyzer for Real-Time Quality Control Adjustments in the Field

Training Events

Over 1,000 individuals in the concrete paving industry have participated in PCC Center training events. The PCC Center has offered the following major workshops:

- Concrete Chemistry, Microstructure, and Performance Workshop (November 14, 2001)
- FHWA Concrete Admixture Workshop (December 18, 2001)
- Concrete Restoration Workshop (March 27, 2002)
- Basic Soils: Subbase/Subgrade Workshop (April 2, 2002)
- Formation and Characteristics of PCC for Pavements: The Basics Workshop (December 19, 2002)
- Fly Ash in Concrete Workshop (April 17, 2003)
- FHWA Hydraulic Cement Seminar (November 18, 2003)
- PCC Pavements: Construction Basics Workshop (February 4, 2004)
- PCC Pavement Design Seminar (April 1, 2004)
- Municipal Streets Seminar (October 15, 2004)
- FHWA/ACI PCC Pavement Overlay Workshop (December 14, 2004)
- FHWA Concrete Paving Best Practices Workshop (March 22, 2005)

In addition, PCC Center staff provide direct in-shop workforce training programs to contractors across Iowa.

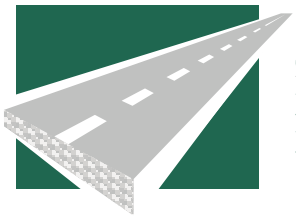
Education

The PCC Center provides learning and mentoring opportunities to hundreds of students every year. Iowa State University offers the following concrete pavement courses to prepare students for the needs of the concrete pavement industry:

- Design of Concrete and Pavement Structures
- Design of Portland Cement Concrete
- Applied Concretes and Pavements

Each spring, students from Assistant Professor Kejin Wang's "Applied Concrete and Pavement" course present their research poster papers to the PCC Center Research and Technology Transfer Committees. The students pose here with committee members outside CTRE offices.

Assistant Professor Kejin Wang takes her "Design of Portland Cement Concrete" class for a tour of a cement plant.



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PAVEMENT TECHNOLOGY

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The PCC Center thanks the Iowa Department of Transportation and Iowa Concrete Paving Association for their ongoing support and guidance.

The CD-ROM that accompanies this document contains reports and publications published by the PCC Center between April 2000 and March 2005. Adobe Acrobat is required to view these PDF files.

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