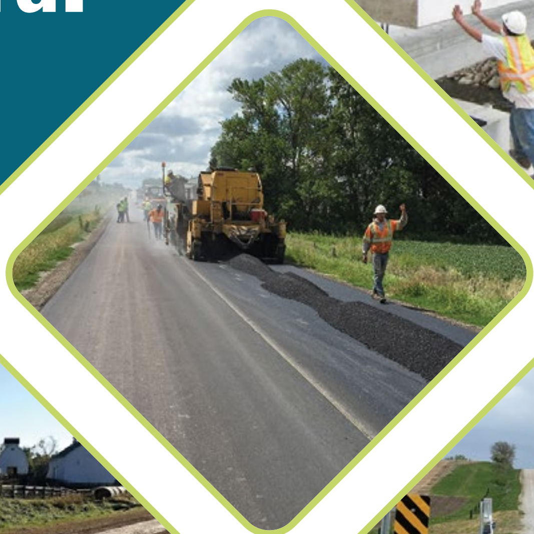




Iowa Highway Research Board: 2000–2024

IHRB
celebrating 75 years


IOWA DOT

TR-825

Iowa Highway Research Board: 2000—2024

JULY 2025

Principal Investigator

Oksana Gieseman, Communications Manager, Institute for Transportation

Co-Principal Investigator

Shauna Hallmark, Director, Institute for Transportation

Writers

Christinia Crippes, Communications Specialist, Institute for Transportation

Brandy Haenlein, Communications Specialist, Institute for Transportation

Designer

Alicia Hoermann, Digital Communication Specialist, Institute for Transportation

Copyeditors

Peter Hunsinger, Communications Specialist, Institute for Transportation

Neeve Funston, Communications Specialist, Institute for Transportation

ISBN: 979-8-218-71968-5

The preparation of this document was financed in part through funds provided by the Iowa Department of Transportation through its "Second Revised Agreement for Management of Research Conducted by Iowa State University for the Iowa Department of Transportation" and its amendments.

Acknowledgments

This book was developed and published through a project sponsored by the Iowa Highway Research Board (IHRB). IHRB Executive Secretary Vanessa Goetz provided access to the 25 years of meeting minutes documenting the board's activities since 1999 and answered numerous questions throughout the book's development.

The project team would like to thank the technical advisory committee members for their input in developing this book: Ahmad Abu-Hawash, Lee Bjerke, Mark Dunn, James Hauber, John Joiner, Ronald Knoche, Rudy Koester, Brian Moore, Mark Nahra, Dustin Skogerboe, Omar Smadi, Jacob Thorius, Wade Weiss, Bret Wilkinson, and Bob Younie.

Completion of this book would not have been possible without the contribution of multiple individuals who generously shared their memories and professional experiences during interviews and who provided the valuable quotes included throughout the book. The team is grateful to all of the interviewees for their time and input.

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CHAPTER 1

INTRODUCTION

Iowa was one of the first states to have a research board dedicated to performing research that benefits local agencies—which led to adoption in other states.

IHRB's Role

The Iowa Highway Research Board (IHRB) has for 75 years served as an advisory group comprising cities, counties, the Iowa Department of Transportation (DOT), and two of the state's public universities that "assists in the development and continuation of an effective, coordinated program of research and development in highway transportation" (IHRB 2019).

The 15 regular members who make up the board and typically serve three-year terms are responsible for overseeing the initiation of 17 projects on average each year and the completion of another 16, spending about $2.4 million annually since 2000 on this research (IHRB Annual Reports 2002–2024).

Since its founding, and particularly over the past few decades, one of the keys to the board's success has been the collaborative nature of the advisory group.

"When you look at a board that has four different entities being represented, it allows for a collaborative environment to be able to execute the research projects, with the goal to improve the efficiency and effectiveness of highway transportation and engineering in Iowa," said Ron Knoche, Iowa City public works director, who has been on the board since 2010.

The board's cultivation of that collaborative spirit led the IHRB to assume an additional role as Iowa's Every Day Counts (EDC) Statewide Transportation Innovation Council (STIC) in 2012, which in turn solidified the Federal Highway Administration (FHWA) as an active partner.

Collaboration is also a connecting thread intertwining IHRB researchers and national, state, and local practitioners who will ultimately implement the results of the research.

The board has a long-standing partnership with the U.S. Geological Survey (USGS) to collect and analyze streamflow data—with an initial agreement dating to 1950 but a partnership officially established in 1968—which provides researchers and practitioners alike with flood-frequency and -magnitude probabilities to help them design and build safe structures and better estimate risks (TR-140).

At the state and local levels, researchers are more inclined to collaborate beyond their specific area of interest (e.g., the intersection of bridge and safety research [TR-679]) and with researchers from other universities (e.g., on a five-phase series of recycled asphalt pavement [RAP] projects [TR-826]). Because of the trust built, local agency practitioners are willing and eager to volunteer to be test cases for researchers.

"We've got more concrete pavements than any other state, but more especially, the county engineers are more than happy for us to treat them as guinea pigs to see if the research works, which is really useful," said Peter Taylor, director of the National Concrete Pavement Technology Center (CP Tech Center) at the Institute for Transportation (InTrans) at Iowa State University (Iowa State), who's had research projects with the IHRB since 2008.

Though the board has refined the methods by which it has sought and funded research projects over the years, there's been remarkable consistency for the past 25 years in its members' views of the IHRB's role, thanks in part to the board's adoption of an official Business Plan in 2001.

"The first questions the board asks when funding a project are always, What's the potential payback? What's the benefit? Is there really a need for it? Is it really a problem?" said Ahmad Abu-Hawash, now infrastructure team leader at the National Cooperative Highway Research Program (NCHRP), who previously had served on the IHRB between 2005 and 2018 while working at the Iowa DOT.

That sentiment was echoed by Ashley Buss, who joined the board in 2025 in her role as a bituminous materials engineer with the Iowa DOT but who had also submitted proposals to the IHRB in the past as an InTrans researcher.

"The board wants accessible research that can be implemented quickly," she said. "There's always an implementation focus from the inception of the project."

Others who've interacted with the board during the past 25 years also noted that the practicality of the research it sponsors goes hand-in-hand with cost-effectiveness, offering practitioners a cost savings or a "better bang for their buck."

"There's always going to be more challenges going on in spreading the dollars that are available and utilizing them in the best way for a longer-lasting, safer transportation system, and I believe the research and collaboration among the board's entities can help agencies get where they need to go," said Sandra Larson, who was the director of the Iowa DOT's Research and Technology Bureau from 2002 to 2012 before leading the Systems Operations Bureau until her retirement in 2017.

Fruits of Their Labor

For rural Greene County Engineer Wade Weiss, who served on the board from 1997 to 2023, the board's role includes solving problems that agencies of all sizes and jurisdictions throughout the state are experiencing.

"We all have the same problems, whatever size county we are, and I'd say across the nation too," he said.

That broad perspective on agencies' common experience was echoed by Knoche as well: "You know the IHRB vision is 'improve lives through innovative transportation research.' That doesn't say only in Iowa."

Mark Dunn, IHRB executive secretary from 1998 to 2014 and current Iowa DOT Contracts and Specifications Bureau director, has seen projects go from practical research to everyday use. Some examples include the use of RAP (TR-624), concrete overlays (TR-698), stringless paving (TR-490), rumble strips (TR-696), and nondestructive testing (TR-653).

TR-696 assessed when to install rumble strips based on various site-specific factors.

TR-698 evaluated the performance of concrete overlays in Iowa.

These are "[s]imple things that most people would never notice," he said of the projects.

IHRB researchers have also seen the fruits of their labor manifest throughout Iowa.

"They're keeping a healthy transportation infrastructure system in our state and communities. It's like veins in our body. Without that network, we can't be competitive in world markets," said Halil Ceylan, director of the Program for Sustainable Pavement Engineering and Research (PROSPER) at InTrans, who's had research projects funded by the IHRB for the past 23 years.

He added, "I can't imagine how other states are doing business without having an entity like the Iowa Highway Research Board."

Uniqueness

The uniqueness of the IHRB cannot be understated, nor can its influence.

According to Vanessa Goetz, current executive secretary of the board and state research program manager at the Iowa DOT, Iowa was "one of the first states to have a dedicated research board or group focused on local road research."

The IHRB remains unique. For decades, Iowa and Minnesota were the only US states with research boards dedicated to performing research that benefits local agencies. But more and more states, such as Alabama, are forming volunteer boards through county engineer participation or creating similar organizations, such as Ohio's Research Initiative for Locals.

IHRB representatives also participated in a peer exchange in Michigan in 2022 to share their perspective on the board and its benefits and impacts in Iowa. Michigan is now the latest state to initialize a formal program targeting local research.

"But it all began in Iowa," said Goetz, referring to this and other ongoing national collaborations, which have resulted in outcomes ranging from information sharing to numerous pooled fund studies, particularly between Iowa and Minnesota, all because of IHRB involvement.

Weiss added, "Our cooperative nature is what sets us apart, and I don't just mean [the jurisdictions] on the board itself, but how we interact with other states. It is a real benefit and a cooperative effort all around."

"And now, with the designation as Iowa's STIC, we have strengthened our partnership with the FHWA," Goetz said.

Peggi Knight, director of the Iowa DOT's Research and Analytics Bureau, summarized the IHRB's singular position. "What sets Iowa apart is our cooperative nature and our commitment to innovation," she said. "The IHRB was the first of its kind in the nation specifically focused on local road research, and our influence has only grown over the years. Our unique approach has inspired other states to form similar organizations, and our ongoing national collaborations continue to yield significant benefits."

IHRB's Impact in Iowa, the Nation

Over the past 25 years, IHRB members have seen nearly 400 projects completed, with funds of around $60 million (IHRB Annual Reports 2002–2024).

IHRB funding is sourced from three programs: the secondary roads research fund, street research fund, and primary road research fund. Implementation of innovations is funded through the FHWA's STIC and Accelerated Innovation Deployment (AID) programs.

"They sponsor projects that keep us competitive," said Ceylan, whose work in sustainable pavement engineering has helped redefine Iowa's rural road network. "IHRB research keeps Iowa on the map."

From practical repairs (TR-784) to sustainable solutions (TR-624) to innovations that have since gone on to redefine our transportation systems (TR-810), the IHRB has always been ready and willing to support interdisciplinary ideas and the projects that are born of them.

"Transportation is interrelated," noted Shauna Hallmark, director of InTrans and principal investigator (PI) on more than 12 projects with the IHRB over the past 25 years. "The IHRB understands that even if a problem is concrete related or maybe it's safety related, there can be implications to both."

The intertwining of different research areas in many ways resembles the close involvement of university researchers with the board, in particular with the standing positions for Iowa State and the University of Iowa (UI).

University researcher involvement has only increased with this collaboration, which has "helped foster active research in the transportation field," according to David White, a previous InTrans researcher with expertise in pavement design and embankment quality.

TR-694 led to the creation of a broad, easy-to-understand reference for temporary traffic control in work zones.

Larson called universities "the glue" between cities and counties and the state DOT, saying "it is everyone working together, from the experts to the people actually seeing the results being tested out. IHRB research needs to be applicable, and I think universities understand that."

IHRB researchers have gone on to deliver numerous benefits to the state, from identifying ways to cut costs on bridge repair (TR-561) and road repair (TR-490) to improving the efficiency of outdated practices across the system (TR-694), thus providing a return on taxpayer investment in funded research.

"I see myself as a public trust employee," said R. Christopher Williams, InTrans researcher and director of the Asphalt Materials and Pavements Program (AMPP), whose work has varied from crack mitigation and warm-mix asphalt (WMA) to sustainable materials, which includes fundamental research on bio-based polymers (TR-639). "There is a social benefit to seeing our research go into practice."

Implementation became a major focus in 2005, when the IHRB began requiring all IHRB-funded projects to include a component explaining expected outcomes. This focus on outcomes has now become a known and welcome addition to the research process.

"Our end-to-end research process entails field work, laboratory work, numerical work, in situ implementation, and follow-up on estimating the operational improvement," said Marian Muste, UI's Iowa Institute of Hydraulic Research (IIHR) research engineer.

According to Abu-Hawash, "We wanted to make sure the impact was there. We can take risks, but they have to be calculated risks."

"And we wanted products with outcomes that we could rapidly implement," added John Adam, previous chief engineer for the Iowa DOT and IHRB member and current associate director of the CP Tech Center. "A lot of the time, we were trying to solve a problem or make an improvement. But we wanted the work to be implementable too. We wanted to support the industry while producing results that were meaningful and added value."

In other words, Weiss added, "We wanted to make sure that the project wasn't just going on a shelf somewhere. We wanted to make sure [the results] got out there."

That meant that projects couldn't just be research based—they had to be application based. But that didn't mean that the IHRB was willing to take innovation off the table, especially when innovative projects could possibly yield even higher payoffs.

"Our culture of innovation began a long, long time ago and continues and thrives today," Larson said, pointing to 10 projects funded through the IHRB's innovative projects program since 2000 and even more projects outside the program with "flashpoint" innovative elements that have left an equally impressive footprint on the national stage. Ultra-high performance concrete (UHPC) is just one example of a widely influential technology seeded through innovative research (TR-529, TR-574, TR-614).

"It's about standardization, about being cutting edge," Abu-Hawash said on the adoption of UHPC as well as accelerated bridge construction (ABC), both in Iowa and across the nation. "We did the research, we developed the language, the requirements, then we saw it become common practice across the country."

TR-574 evaluated the effectiveness of UHPC pi-girders for bridge superstructures.

But at the end of the day, the IHRB's impact isn't about geography—it's about problem solving.

"In my experience, the problems that we've been trying to solve in Iowa have overflowed to other states. That's why our results and products have been so accepted in the broader, national community," Taylor said.

And really, it's not just about problem solving either—it's about going out there every day and doing the work, seeing what works and what doesn't, and showing up the next day and doing it all over again.

"The fact that [the IHRB] has continued to grow speaks volumes," said Brent Phares, bridge research engineer at the Bridge Engineering Center (BEC) at InTrans. "There is such a strong research presence [in the state]. And when people talk about state research programs, Iowa is seen as the model, an example of how state research should be done, and I agree."

"The IHRB's impact over the past 25 years has been profound," added Knight. "Our research has kept Iowa at the forefront of transportation innovation. From practical repairs to sustainable solutions, our work has consistently delivered cost-effective and impactful results, ensuring that Iowa continues a legacy of excellence at the city, county, and state level."

The Next 25 Years

In a 1999 book summing up the IHRB's first 50 years (Isenberg 1999), Dunn predicted opportunities for research on "innovations in alternative materials for use in highway construction" and on "the maintenance and replacement of bridges during a time of budgetary constraint."

Now almost three decades later, Dunn points to the innovations in UHPC and asphalt recycling as examples of the former prediction coming to fruition during the past 25 years and low-volume road bridge solutions as an example of the latter.

Looking ahead once more, Dunn predicts that the board will take up projects related to capacity issues within the existing transportation network's footprint and continued difficulties managing budget constraints.

"I don't think the funding situation is going to change at all," he said. "I think local agencies will have to try to come up with different ways to fund their efforts."

Dunn also foresees challenges arising from the introduction of new technologies, including an increase in distracted driving and in autonomous vehicle traffic.

Whatever may come, the IHRB will work collaboratively to fund research that finds practical and innovative solutions to tomorrow's problems for Iowans.

Book Scope

This book builds off of previous work documenting the IHRB's first 50 years: *Iowa Highway Research Board: 1949–1999* (Isenberg 1999). The scope of this book covers the board's next 25 years, from 2000 to 2024.

In addition to the history of the board's most recent 25 years conveyed in this introduction and in the timeline of the board's activities, this book reviews the meaningful advances in transportation and technology by highlighting significant IHRB research projects during that time.

The book includes information from a literature review and from 19 interviews and additional email correspondence with board members, researchers, practitioners, and past and present Iowa DOT staff. The 200+ highlighted projects span 18 themes divided into the following 8 chapters:

- Rural Road Safety
- Low-Volume Roads
- Pavement Preservation
- Concrete Pavements
- Bridges
- Standards and Specifications
- Sustainability
- Innovative Projects

With more information available than ever before, it is often difficult to break through the noise to promote research impacts. We hope this book serves as a resource that demonstrates the impacts and necessity of the IHRB and its contributions over the years.

Timeline

The following timeline includes significant events of the IHRB during the past 25 years. It covers changes to the board's structure and organization, highlights historical achievements, and notes changes in leadership, with quotes showcasing consequential moments.

2001

- The board decides to give precedence to solicited over unsolicited proposals, with unanimous support.
- The board approves its first Business Plan after months of discussion, with the intent to review it on an annual basis and make modifications as needed.

"[The proposal process] used to be just an open door. It wasn't balanced against any other program or idea—just a first come, first served, best salesman wins kind of thing. And while there was a lot of value in that, it wasn't necessarily the best strategy for research in Iowa."

–MARK DUNN, 2001 IHRB EXECUTIVE SECRETARY

2002

- Long-time Iowa DOT Research Management Division Director Ian MacGillivray retires, and Sandra Larson fills a similar position as director of the new Research and Technology Bureau within the Iowa DOT's Highway Division.

"[MacGillivrary] made a lot of great changes during his time [on the board]. He was a pioneer and got the board to where it is today."

–WADE WEISS, 2002 IHRB COUNTY BOARD MEMBER

2003

- To enhance the solicitation process, the board overhauls the required format for IHRB proposals, including budget guidelines, as an amendment to the Business Plan.

2004

- Mark Dunn commissions a design for the first IHRB logo and presents it to the board, with the intention to "help raise the profile of the board as the logo becomes more widely used."

"There is now a logo to represent the group as a whole, since the Iowa DOT logo is normally the only one seen on [most board items]; the new logo is more representative of the state, county, and city IHRB cooperation."

–MARK DUNN

2005

- The board unanimously approves a 40% primary, 50% secondary, and 10% street funding split for all projects starting in the next fiscal year, a move away from the practice of setting the percentages for each project individually.
- A pre-existing pilot program for "novel ideas and fundamental advances" is promoted/expanded and is set to be implemented in the next fiscal year.
- The requirements for projects are revised, including the addition of an "implementation" element and the inclusion of a technical brief as a deliverable.

"By switching to this formula, it made it so that all board members basically had a little skin in the game. Projects don't necessarily benefit certain jurisdictions over others, as the state [as a whole] gets the true benefit."

–VANESSA GOETZ, CURRENT IHRB EXECUTIVE SECRETARY

2006

- The board selects proposals submitted under the first Innovative Projects request for proposal (RFP) and invites the top six vote-getters to present to the board's members.

"A goal in all this, aside from getting new ideas to the board, is introducing new 'faces' to the board. Criteria looked at include who is new here, particularly younger people who have not yet connected with the DOT, counties, or the cities, rather than re-funding people who are well established."

–CLARK SCHLOZ, 2006 BOARD MEMBER

2007

- The proposal selection process for Innovative Projects RFPs is changed to require presentations from proposers rather than a simple discussion and vote among board members, thus improving the board's internal processes.
- The board requires all projects to provide Implementation Project Closure Reports (IPCRs), which indicate project utilization efforts and whether additional research is warranted, in addition to project Final Reports.

"Some of those early decisions made the board more cooperative in nature, in comparison to how projects were handled prior to that process."

–MARK DUNN

2008

- The board makes changes to funding levels, increasing its total spending on innovative projects from $150,000 to $200,000, with an estimated $75,000 limit per proposal.

"With modification of the board procedures, RFPs use the predominant amount of our funding. This is a way to ensure that innovative ideas can be considered; in the long range, this process pays off."

–AHMAD ABU-HAWASH, 2008 BOARD MEMBER

2009

- The board begins to solicit proposals annually rather than three times per year.
- University involvement with the IHRB evolves to include a relationship with the University of Northern Iowa (UNI).

2010

- Sandra Larson initiates a new process for the Iowa DOT and IHRB requiring technical advisory committees to meet at least quarterly and establishing a checklist format for PI quarterly reports.

"The intent is to provide more information about work that researchers are doing [after winning] competitive proposals."

–SANDRA LARSON, 2010 DIRECTOR OF THE IOWA DOT'S RESEARCH AND TECHNOLOGY BUREAU

2011

- The Iowa DOT creates a new implementation engineer position to manage the State Planning and Research (SP&R) program and develop ways to implement state and federal research in conjunction with the secondary roads coordinator.
- The first County Engineers Research Focus Group is held in May. About 50 people attend the event to discuss county road issues and possible related research projects, two of which are brought forward through the IHRB.

"One of the greatest things that happened for county engineers was that we developed the Research Focus Group."

–WADE WEISS

2012

- The Iowa DOT is reorganized, and the IHRB's research efforts are combined into the Office of Research and Analytics, directed by Peggi Knight under the new Performance and Technology Division.
- The board further emphasizes the "implementation" aspect of its funded projects by setting aside funds for future, follow-up efforts and adding a discussion on implementation as part of the final approval process.
- The IHRB begins to serve as Iowa's EDC STIC, established at the direction of the FHWA.

"When the Iowa DOT reorganized in 2012 and brought the IHRB's research efforts under the Office of Research and Analytics, it allowed us an opportunity to streamline our processes and remove the silos between the IHRB and our federal research program. It was a pivotal change that gave us ability to address the evolving needs of Iowa's transportation infrastructure."

–PEGGI KNIGHT, CURRENT DIRECTOR OF THE IOWA DOT'S RESEARCH AND ANALYTICS BUREAU

2013

- The board begins using an online form for research topic submission.

2014

- Mark Dunn retires as IHRB executive secretary after taking a new Iowa DOT position. Vanessa Goetz, secondary roads research engineer, becomes the new IHRB executive secretary.
- The Iowa DOT management team now helps select the Iowa DOT's representatives on the board.
- Iowa receives funding from the FHWA STIC Incentive program for the first time, with $100,000 going to fund three projects.

"When the IHRB took on the mantle of becoming the STIC for the state, we wanted to highlight projects that had been funded over the past 10 years—ones aimed at implementing innovations that have already been proven."

–VANESSA GOETZ

2015

- The IHRB provides funds for the secondary roads research engineer, which had previously been funded by the Iowa DOT out of its secondary roads research fund, starting in the next fiscal year. The position is currently funded by the Iowa County Engineers Association (ICEA) Service Bureau.

"The [secondary roads research engineer] is basically a 'mini-DOT' in their own right. So, having this new position was very valuable to practitioners, to ensure that projects were meaningful and implementable."

–VANESSA GOETZ

2016

- The IHRB again provides seed funding through its innovative projects program, after a gap in funding from 2011 to 2015, in collaboration with the Midwest Transportation Center.
- The IHRB begins selecting project proposals submitted in response to RFPs based on its own "strategic goals."
- The Iowa DOT receives a federal grant for a "one-of-a-kind project" not done elsewhere in the nation using UHPC in a bridge deck overlay. The project serves as a showcase for the first International UHPC Conference in Des Moines later in the year.
- The board works with the Iowa Local Technical Assistance Program (LTAP) and the Iowa Chapter of the American Public Works Association (APWA) to hold a city research focus group similar to the one established for counties.
- The IHRB hosts a one-time event, the Innovations in Transportation Conference, in August, in partnership with the Midwest Transportation Center and InTrans.

"Being a part of the brainstorming ideas for city-related research has been an exciting new chapter for the Iowa Chapter of APWA. The city focus group provides a mechanism for the cities to have an active role in brainstorming and prioritizing research topics."

–BETH RICHARDS, 2025 APWA IOWA CHAPTER PRESIDENT-ELECT

2018

- The IHRB develops a new vision and mission statement. The vision statement reads, "Improving lives through innovative transportation research."
- The board increases its internal funding for innovative projects from $200,000 to $250,000 in future fiscal years.
- The board changes its proposal solicitation process from using an annual schedule back to using a trimester schedule.
- Vanessa Goetz advises board members to dedicate the excess balance of the secondary roads research funds for projects that solely benefit counties.
- Ahmad Abu-Hawash becomes the longest-serving member in recent IHRB history, with a tenure spanning from 2005 to 2018.

"Moving [back to] a trimester solicitation was a big change, but an important one. That way, we could accept ideas all the time, and there was more to consider."

–VANESSA GOETZ

2020

- The Iowa DOT Office of Research and Analytics creates a new ideation platform to facilitate innovation and research management at https://ideas.iowadot.gov.

2021

- STIC Incentive funds increase to $125,000, with priority given to innovations that advance the FHWA's EDC initiatives.
- The board provides funding to sponsor the 13th International Conference on Low-Volume Roads to be held in Cedar Rapids in 2023, the first time it's been held in Iowa since 1979.

"[The STIC fund increase] is another boost to the board's focus on implementing innovations. Since 2014, we have been very successful in taking advantage of the STIC funding and bringing those dollars to Iowa. We have a great relationship with the FHWA, and it has allowed us to reap the benefits of collaboration by utilizing the funding sources available."

–VANESSA GOETZ

2022

- The board begins to meet in person again, having conducted meetings online throughout 2020 and 2021 due to the COVID-19 pandemic.

2023

- The IHRB partners with the Iowa Army National Guard at Camp Dodge on gravel road research, with the first project under this partnership a benefit-based study on the aggressive rehabilitation of granular roads.
- The 13th International Conference on Low-Volume Roads is held and attracts a record-setting 360+ registrants, over 100 of which are from Iowa.
- Board members are designated "research liaisons" by the Iowa DOT's Research and Technology Bureau.

"The initiative and financial support provided by the IHRB and its state-based partners were essential to bringing the Transportation Research Board's [TRB's] 13th International Conference on Low-Volume Roads to Iowa after it was last here over 40 years ago. That same support made the conference a great success by enhancing the agenda content and activities."

–KEITH KNAPP, IOWA LTAP DIRECTOR AND CHAIR OF THE CONFERENCE PLANNING COMMITTEE

2024

- Created in December 1949, the IHRB turns 75 years old.

2025

- The IHRB celebrates 75 years since its first meeting in July 1950.

CHAPTER 2

RURAL ROAD SAFETY

TR-523 evaluated traffic calming treatments on major roads through small Iowa communities using low-cost single-measure or gateway treatments.

Importance and Stakes

During the Iowa DOT's 100th anniversary celebration in 2013, then Governor Terry Branstad observed that Iowa is viewed as a predominantly rural state but has a transportation system that at the time supported 26.3 million rides annually covering all 99 counties (Iowa DOT 2013b), from Plymouth to Clinton, on a roadway network encompassing over 97,000 rural miles across the state.

At this scale, a safe and efficient transportation system does not come without effort.

Safety, as a priority for the IHRB, has remained at the forefront of implementable research. Since the IHRB's inception in 1949, and even more recently over the last 25 years, board members have sought to fund research that seeks to make motoring safer.

That has often included funding innovative, high-risk projects that bridge the gap between research topics. After all, safety on rural roads isn't a one-size-fits-all fix. Research is needed across the board—from internal processes at railroad crossings to the efficiency of lighting to understanding how crash performance is affected by roadway improvements.

"The IHRB has a history of understanding the implications of research that doesn't fit in one category or the other. Their approach is broad but has resulted in a lot of amazing findings over the years, which in turn has spurred more research and discoveries that continue to impact Iowa today," said Shauna Hallmark, InTrans director and researcher focusing on traffic safety.

With crashes on local, rural roads occurring at more than twice the rate of crashes on state roads (Iowa DOT 2013c), rural road safety became a major focal point in the early 2000s, with research focused on traffic calming techniques (TR-523). However, because rural communities needed to achieve the highest return on their infrastructure investments—and lacked the resources to include elaborate traffic calming measures—the focus was on low-cost alternatives that could be easily implemented.

The research results and tools developed from the work over the past 25 years have provided Iowa's highway authorities and local road stakeholders with an enhanced means of identifying needs and opportunities for potential safety improvements while staying within budget.

"The issues that our agencies face are limited resources and where to prioritize and focus their efforts," said Omar Smadi, InTrans researcher and director of the Center for Transportation Research and Education (CTRE). "You can't maintain a system without enough resources, so you're trying to do the best that you can where it matters, and safety does matter. [Our] strategies, [our] research projects, definitely have made an impact."

TR-695 evaluated low-cost rural intersection treatments and their impact on safety.

Iowa's county engineers, thanks to research funded by the IHRB, have been able to utilize the results of safety analyses, such as those on the use of lighting to address nighttime crashes at rural intersections and intersection treatments to mitigate failure-to-yield crashes. Results have shown the overwhelmingly positive safety benefits of both, with noted changes to driver behavior (TR-601, TR-695).

Ultimately, the ability to establish a culture of safety and maximize the positive impact of safety on Iowa's rural roads is paramount to future innovation. What has been learned over the course of decades sets a precedent for the future of safety—not just on Iowa's rural road network, but throughout the state.

Project Highlights

Because road safety has long been a key focus area for the IHRB, Iowa has led the nation in innovations that have made its rural roads safer. The state was the first to introduce the "No Passing" pennant sign in 1959, which has since been adopted nationally and included in the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) (Iowa DOT 2008b).

"Think back to what it was like to drive on a lot of rural roads," Ian MacGillivray, then director of the Iowa DOT's Research Management Division, told the *Des Moines Register* in 2000 (Petroski 2000). "It was hard to see over the crests, and with a little bit of traffic you start to pull out to pass and you can't see the sign on the right that says no passing. Out of this came research to put the triangular-shaped sign on the left-hand side of the road. That probably saved a lot of lives."

During the past 25 years, IHRB researchers have continued to save lives through the results of their research while also ensuring that local agencies manage their pavement assets efficiently and effectively.

Traffic Calming and Speed Management

Starting in 2006, InTrans researchers began studying traffic calming techniques for small Iowa communities (TR-523), specifically seeking to identify low-cost or gateway treatments that are meant to slow vehicles entering a community and reinforce speeds throughout the community.

"We had some federal funding, and we got the research board to match it," recalled Hallmark, the project's PI. "I think that was probably the first application of rural traffic calming in the United States. Every document now that you see on rural traffic calming actually references our original work."

The project investigated treatments that included peripheral transverse pavement markings, lane narrowing through median and shoulder widening, and driver feedback signs and found the first of these to be most effective at decreasing vehicle speeds and sufficiently easy to implement at relatively low cost for small communities.

"If you put up chevrons, what's the impact? If you put up a flashing beacon on a stop sign, what's the impact? If you put a dynamic speed feedback sign? Wider edge lines on pavement markings? Those are all things that can be done reasonably quickly," Hallmark said. "And then if they don't work out, they don't have to keep them, and it's not a major investment."

InTrans research, again led by Hallmark and funded by the IHRB, continued in this vein to evaluate and provide guidance on effective traffic calming and traffic control techniques in rural areas (TR-630). The project expanded the number of communities that participated in the study and included additional treatments.

In all, the research evaluated transverse speed bars, colored entrance treatments, temporary islands, radar-activated speed limit signs, and speed feedback signs, culminating in the development of toolboxes for local agencies to use when focusing on roadway-based rural traffic calming treatments.

"If we pay attention to what is happening and address the issues, we can make improvements," said Buchanan County Engineer Brian Keierleber, whose county was one of the study sites. "Our aggressive actions on roadway safety have cut our fatalities and crash rates in half over the years."

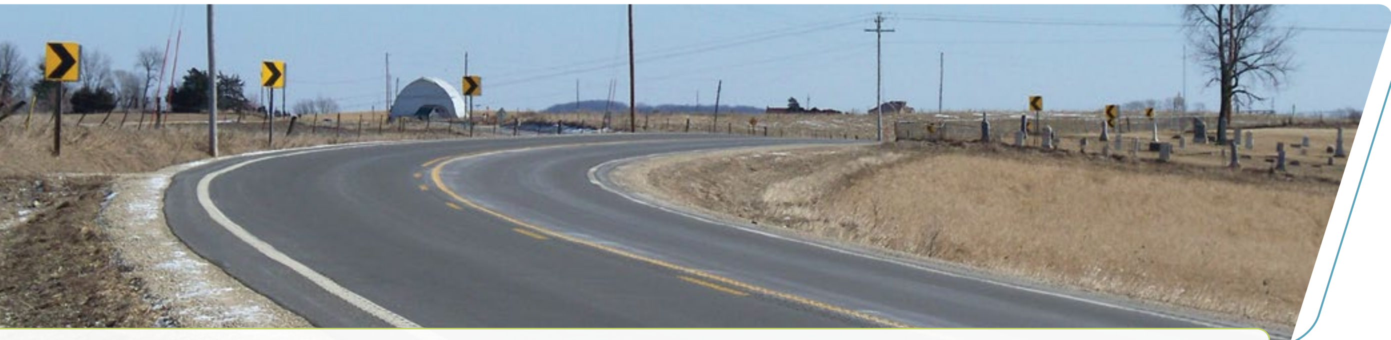
TR-630 evaluated low-cost traffic calming devices for rural communities.

He added that if counties "inspect what they expect," they can make a difference.

"After we did that project, Neal [Hawkins, fellow InTrans researcher and project co-PI] and I went on and did several toolboxes and an e-primer, which the FHWA put out in conjunction with ITE [Institute of Transportation Engineers]," Hallmark said of the research's reach beyond Iowa. "It's pushed us to where a lot of the national work we've done has been based on the initial IHRB research."

She added, "Getting that expertise has given us the advantage where we've actually been able to become national experts and draw on the Iowa experience, where what we've learned in Iowa will apply in other places."

Reducing vehicle speeds in communities remains a challenge, but it can be even more difficult on rural highways, where speed limits are higher and there may be less traffic. Still, researchers are always seeking techniques to get drivers to slow down, and the IHRB is continuing to fund potential solutions.



To assist agencies in addressing crashes at rural curves, a toolbox was developed under TR-579 that summarized the effectiveness of various known countermeasures.

Another IHRB project looked at low-cost strategies to reduce speeds and crashes on curves (TR-579). It involved installing narrow rumble stripes—a combination of conventional rumble strips with a painted edge line—along the edges of travel lanes and found that the treatment may help prevent run-off-road crashes on rural paved roads.

Another similar but more recent project studied centerline and edge line rumble strips. The project, which concluded in 2017, provided guidance to local agencies and the Iowa DOT on when to install rumble strips on narrow pavements based on site-specific factors (TR-696), with the aim to reduce cross-centerline and run-off-road crashes.

"Getting people to slow down is always really hard, so we're trying to understand why they are doing what they're doing," Hallmark said. "It's made me think more about not just the engineering side but what are people thinking, and that's been particularly challenging."

Pavement Markings and Asset Management

Another way that the IHRB has invested in local roadway safety is by funding research related to pavement markings and other cost-efficient pavement asset management techniques for both county and city agencies.

Between 2001 and 2018, InTrans researchers conducted at least five research projects, all funded by the IHRB, assessing and providing guidance on pavement markings. The projects have covered everything from the materials used to agency planning to specific safety impacts.

"There was talk at the national level that there should be minimum retroreflectivity standards," recalled Smadi, PI or co-PI on four of the five projects. "We were trying to be proactive. We were trying to work with the counties in terms of better products, because we know the impact of good, visible lines on safety."

Smadi was PI on a 2010 project that sought to identify a correlation between pavement marking retroreflectivity and crashes by analyzing five years of data provided by the Iowa DOT (TR-580). A correlation was found across several datasets, supporting increased investment in the application and maintenance of pavement markings.

"It's a documented impact that improved pavement marking reflectivity actually improves safety, especially on two-lane rural roads," he said. "We wanted to address what products would provide [our agencies] better and also long-lasting retroreflectivity. There are now more cities and counties that are switching from a product that lasts six months on a busy road to products that last three or five years."

That same year, Smadi was co-PI on a project led by InTrans Associate Director Neal Hawkins that focused on support for local agencies regarding pavement markings, which are a costly and difficult asset for counties to manage (TR-551). Both projects were spurred in part by expected FHWA amendments to the MUTCD that would change the way local agencies manage their pavement markings.

"The research demonstrates how a pavement marking maintenance method can be developed and used at the local agency level," Hawkins said. "The report addresses the common problems faced by agencies in achieving good pavement marking quality and provides recommendations specific to the problems."

Specifically, the research was able to provide suggestions on assessing pavement marking needs, selecting pavement marking materials, contracting out pavement marking services, measuring and monitoring performance, and developing management tools to visualize pavement marking needs in a geographical information system (GIS) format.

A 2011 project (TR-597) then focused on the impact of retroreflectivity on wet pavements.

"If you're driving at night and it's raining, then you can barely see the lines. So, we were looking at what reflective products would work best in those conditions," Smadi said. "We were leading that work, even in the US."

Beyond pavement markings, several IHRB projects have supported local agencies and the Iowa DOT by investing in studies on the broader issue of pavement asset management. Since these agencies often need to justify and defend maintenance and rehabilitation decisions, IHRB projects have provided the needed guidance.

A 2015 project (TR-651) provided structured guidance and a tool to help in decision-making. More recently, in 2021 the ICEA modernized the Transportation Program Management System (TPMS), first developed in 1999 (TR-394), as a web-based software application that provides an efficient and effective workflow for projects let through the Iowa DOT Contracts and Specifications Bureau (TR-726).

Another innovative IHRB project led by the ICEA developed an operations management system for Iowa's secondary roads departments that included a set of web-based tools to optimize the maintenance of assets that require regular service, such as granular surfaces and shallow ditches (TR-745). The tools are available to all secondary roads staff members through wireless, Global Positioning System (GPS)-enabled devices.

"This project allowed for the development of a common application that can be used by all 99 counties," said ICEA Service Bureau Executive Director Brian Moore. "The operations management system increases the efficiency and productivity of each road department, and it allows for integration with existing applications to create a suite of applications that are integral to the daily job duties of every county road department's staff members."

Innovations and Impacts

One of the key aspects of the highlighted IHRB projects, beyond simply the findings, is that they result in a tangible product that can continue to have impacts well after the conclusion of the research, whether the product is a guidance document or tool for local agencies.

An example of an innovative tool developed out of IHRB research is the Equipment Life-Cycle Cost Analysis Tool (E-L-T) for Iowa counties that, like other asset management tools, helps local agencies justify their spending and, in this case, find the optimum time for equipment replacement (TR-727).

"We know that counties spend about half their budgets on maintenance, and equipment is about 27% of maintenance at any given time," Jennifer Shane, an InTrans researcher and PI on the project, said in *Technology News* (2020a). "We wanted to develop something county engineers can tailor to their needs and use to present to their boards on their equipment needs."

She added, "This tool will give Iowa counties and cities an enhanced ability to make defensible equipment management decisions."

Another tool resulting from IHRB research, developed in a project led by HDR, Inc., is the Economic Analysis and Development of a Revised Project Prioritization Tool to help the Iowa DOT prioritize highway-rail grade crossings that are most in need of safety improvements (TR-732).

Tools like these often provide cost-effective solutions to local agencies or the Iowa DOT and help them make the most of limited budgets.

However, there's a limit to the value of the research if it doesn't make it out into the world to be implemented. The IHRB helps spread the word by requiring not just a final report for most projects but also a shorter, more accessible technical summary of the research that highlights its immediate implementation impact and benefits.

The IHRB is also aided by another of its funded programs, the Iowa LTAP, whose mission is to provide training and technical assistance to Iowa's local governments. That often means spotlighting research from the IHRB.

"LTAP has also done a good job of getting stuff out there," Hallmark said. "So, we've done the research, and then the Iowa LTAP has done a really good job of having us present at events such as the County Engineers Research Focus Group meetings."

Another example is the Iowa LTAP's series of webinars based on presentations from the TRB's 13th International Conference on Low-Volume Roads in summer 2023.

One of the presentations featured in that series was a virtual event on "Highway Design and Maintenance for Horse-Drawn Vehicles." While the research behind that particular presentation was out of Indiana, once again Iowa led the nation on the topic.

The IHRB funded a project led by InTrans researchers in 2009 that focused on improving safety for slow-moving vehicles (SMVs)—vehicles such as large farm equipment, construction vehicles, or horse-drawn buggies that do not maintain a constant speed of 25 mph—on Iowa's rural roadways (TR-572). The agricultural industry's use of tractors and other industrial vehicles and select Amish communities' use of horse-drawn vehicles prompted the IHRB to invest in research in that area.

"Among the variety of road users and vehicle types that travel on US public roadways, SMVs present unique safety and operations issues," said Hawkins, who was PI on the project. "Though the number of crashes involving SMVs is relatively small, SMV crashes tend to be severe."

TR-572 focused on improving safety for SMVs on Iowa's rural roadways.

The project ultimately provided a set of safety recommendations based on the following principle: "SMV safety on Iowa's high-speed roadways should be based on an understanding of crash performance and input from slow-moving vehicle communities" (TR-572).

"We are dealing with humans, and human behavior is not always logical," Keierleber said. "If an agricultural tractor is entirely in our lane, the mind perceives it to be traveling the same speed as we are, and if the tractor is partway off a road with a widened shoulder, the mind says something is different here, and it makes for a safer experience for everyone. So, it's critical to pay attention."

Though it is often easier to determine the impact of IHRB research with years of hindsight to see how far a particular project's findings have spread, it doesn't by any means suggest that innovative research in the area of local road safety and asset management has stalled.

"I think sometimes we're just doing the same thing over and over because there's just more to do and to just find different ways of trying to address the problem," Hallmark said.

Citing a current project on speed reduction on gravel roads (TR-828), she added, "We're taking some of the same principles from speed reduction on rural curves and in rural communities and seeing if it works in this situation. So, it's applying knowledge that we've gained that seems to be successful in one area and seeing if is applicable in another area."

Changes to the State of the Practice

Cost savings, increased safety, and improved service and procedures all lead toward improvements to the state of the practice and ultimately the wellness of the people of Iowa.

Over the past 25 years, results from rural road safety projects funded by the IHRB have helped to improve transportation practice. Researchers have developed widely implemented methods, ranging from new ideas for tree and brush control (TR-462) to innovative approaches to pavement asset management (TR-651) and the development of guidance for the use of lighting on rural roadways (TR-540, TR-601).

Speed management has been a persistent concern on rural roads. One project in 2013, led by Hallmark, looked at low-cost strategies to reduce speed and crashes on rural curves, specifically the effectiveness of rumble stripes in reducing run-off-road crashes and in improving the longevity and wet-weather visibility of edge line markings (TR-579). The results were positive, indicating that narrow-width rumble stripes could mitigate run-off-road crashes on lower-volume rural paved roads.

"The research we've been doing has seen its share of success. If we can show an improvement, then someone may benefit from it. Local agencies—and organizations like the Iowa LTAP—can take our work from there and see if it's implementable and if it could work for them," Hallmark said.

TR-540 investigated the effectiveness of lighting designed to reduce nighttime crashes at rural intersections.

Other times, funded research results in safety analyses that are even more directly implementable.

In 2008, Hawkins completed a project that developed updated lighting guidelines aimed at reducing nighttime crashes at rural intersections (TR-540). While later those guidelines were further developed and incorporated into the Statewide Urban Design and Specifications (SUDAS) manual, the underlying analyses—which indicated that locations without lighting had twice as many crashes as locations with lighting—were immediately available for county engineers to utilize.

This project spurred a second phase of research in 2011, where Smadi, with the assistance of Hawkins, looked at the quality, durability, and efficiency of roadway lighting (TR-601). IHRB funding gave the team the opportunity to explore the impact of illumination levels on safety (i.e., nighttime crashes)—information that rural agencies still find benefit in today.

The report for the second phase of the research noted that "lighted intersections experience fewer crashes when compared to unlighted conditions. Quantifying the safety contribution of light quality remains elusive at best. Even with the far majority of intersections falling below standard illumination levels, the presence of lighting still made a significant impact on safety when compared to non-lighted locations."

Smadi reflected, “Our understanding of the issues and some of the countermeasures or solutions to those safety issues have definitely improved in the last 20 to 25 years, but the challenges also have increased.”

The IHRB has a stake in funding research that promotes progress toward critical safety goals. For rural road safety, countermeasures are key, which is why Hallmark’s research on effective traffic control in 2004 (TR-527) and on traffic calming in 2006 (TR-630) was needed, with the two projects culminating in a toolbox that summarized the effectiveness of the treatments. This research ultimately paved the way for future research both in Iowa and beyond.

“Our original work prompted several other projects. Most of the research on rural traffic calming came from Iowa,” Hallmark said.

Hallmark also noted that because the IHRB is willing to invest in innovative ideas, board members have also been open to ideas that have the potential to address multiple, seemingly disparate challenges. “The fact that the IHRB invests in something, and that they’ve been willing to be cutting edge, has made it so that we could try things and be ahead of the curve nationally.”

CHAPTER 3

LOW-VOLUME ROADS

The results of TR-735 helped agencies develop treatment strategies that could lengthen the service lives of highly distressed low-volume roads.

Importance and Stakes

As Bailey Cichon wrote in *The Gazette's* July 2024 installment of "Curious Iowa," "An intricate maze of gravel roads surrounds Iowa's towns and cities. Drive down a gravel road on a dry day and your car will kick up a cloud of dust. Travel on a wet day and you may find yourself in a muddy, slippery situation" (Cichon 2024).

The state of Iowa has more than 115,000 miles of roads, with gravel roads making up about 58% of the state's total road miles (Cichon 2024, Iowa DOT 2024b).

Throughout the state's history, roads were built and upgraded depending on what was available at the time. According to the Iowa DOT (2025), the first state-funded concrete pavement was installed in 1917, and asphalt paving came in 1928. But the most cost-effective option for gravel roads—and the extensive network of low-volume roads (LVRs) throughout the state—is often simply to keep them as they are.

Low-volume roads are typically made of gravel or earth. Since these types of LVRs make up such a significant portion of the rural Iowa road inventory, keeping them in good working order poses unique challenges. Two of the most significant are (1) frequent maintenance and (2) drainage, with the need for low-cost solutions due to the vast mileage that must be managed. Additionally, a considerable number of LVRs are paved and require still another set of maintenance strategies.

"Low-volume rural roads are generally low funding priorities compared to roads that are part of the National Highway System (NHS)," said InTrans researcher R. Christopher Williams in his 2020 IHRB report focusing on LVR holding strategies for paved rural roads (TR-735). But studies like this point the way forward for keeping LVRs in service, with Williams adding, "Our research [has resulted] in helping local agencies and the Iowa DOT to develop strategies and find the appropriate treatments beyond preventive maintenance to lengthen the service life of low-volume roads without the investment needed for a complete rehabilitation."

Findings from TR-568 indicated that sheet pile abutment bridges provide an effective solution for LVR bridges.

TR-674 deployed Otta seal technology on Iowa's low-volume roads.

"The practical aspects we've seen come out of [LVR] research have been extremely important," added Wade Weiss, who served on the IHRB from 1997 to 2023. "We are all dealing with trying to make the system last longer."

Recent IHRB research involving granular LVRs—which include unpaved roads surfaced with gravel or other materials—has encompassed everything from effective shoulder designs and maintenance (TR-531, TR-634, TR-685, TR-797) and rural road surface alternatives (TR-632, TR-664, TR-721, TR-725) to the development of a data-driven road management system (TR-729). Additionally, IHRB research has delved into the "nitty-gritty" performance of different aggregate options (TR-704, TR-747).

Broader topics that also apply to paved LVRs have included the impact of superloads (TR-781) and a related issue, preservation strategies to improve long-term pavement function (TR-520), as well as drainage issues (including streamflow, flooding, and culverts). This portfolio of research also has addressed deterioration challenges, which include bridge maintenance (TR-444, TR-592, TR-679, TR-568, TR-710).

Iowa has had to tackle "problems on all fronts"—from road stabilization to flooding issues—according to Weiss, who currently serves Greene County as its county engineer. "Our problem [in Greene County] is a problem across the state, and really, across the nation."

"These are serious problems facing our transportation infrastructure systems," added InTrans researcher Halil Ceylan, in reference to his work on LVRs and Otta seal surfacing (TR-674, TR-753). "We need to come up with new, sustainable ways to deal with the challenges."

Otta seal technology has been used in northern Europe and Africa, among other locations, as an economical and practical alternative to traditional bituminous surface treatments (BSTs). It provides a flexible, durable, and impervious surface more tolerant of the higher anticipated pavement deflections on low-volume roads constructed using lower-quality materials (TR-674).

As of 2023, Iowa is designated as being located in Climate Zones 5a and 5b, which denote warm-to-hot (humid) summers and cold (sometimes bitterly cold) winters (USDA 2023), both of which can have an impact on roadway stability.

"To appreciate the various difficulties posed in creating a quality state road system in Iowa, it is necessary to understand the geological and topographical characteristics of the state," read *Building Better Roads* (1997).

That includes "fielding in" the influence of some of Iowa's most memorable natural disasters—floods. Throughout the years, major floods have left roadways impassable and destroyed some bridges completely, especially during the historic 1993 flood (Landis 1997) and the subsequent events in 2008 and 2011, the latter of which received multiple Presidential Disaster Declarations and affected 14 Iowa counties (Iowa HSEM 2024).

"We've had a lot of flood events, and predicting the flows is beneficial, especially in areas with more rough terrain," Weiss said.

IHRB drainage research in the past few decades has focused on three subtopics: (1) streamflow, (2) flooding, and (3) culverts. Streamflow research has primarily involved studies on data collection and analysis (TR-140) but also discharge (TR-567) and basin (TR-692) characteristics. Flooding studies, on the other hand, have investigated the frequency of flood events (TR-533, TR-678), alongside developing damage assessment and mitigation strategies for outstanding weather events (TR-638, TR-792).

Culvert research, said UI researcher Marian Muste, "has been approached with nature-based solutions, which is an attempt to pass the streams through culverts as close as possible to their natural/undisturbed flow."

Drainage studies funded by the IHRB have led to a variety of enhancements to the design and implementation of culverts throughout the state, from the development of culvert standards and guidelines (TR-517, TR-620), including for innovative self-cleaning culvert designs (TR-545, TR-619, TR-719, TR-596), to the exploration of sedimentation mitigation in multi-box culverts (TR-665) and, most recently, self-cleaning solutions for twin- and single-box culverts (TR-805).

Muste, who has been a key figure in IHRB culvert research, said, "My main expertise is in river mechanics and sediment transport with a secondary interest in data analysis and communication in water-related domains, under the broader label of hydroinformatics."

"Culverts are hydrologically and functionally related to bridges, but their challenges related to sediment transport are the opposite: culverts are most often exposed to sediment accumulation, while bridges are affected by erosion/scouring at their structural elements and abutments. That's how I got involved," he added in regard to his ongoing culvert research, which began in 2009 with TR-545 and is still in progress with projects such as TR-805. "IHRB has been a great partner."

The importance of IHRB's LVR research—from Muste's culvert work to Williams' projects related to the state's rural roads, was summed up by Weiss: "[Iowa's] roads were originally built for farm to market, but now we're seeing market to farm. The Interstate system is important, but people have to get to that system. So now we need to see what services are needed with the [increased use] of county roads and work on circumventing any problems."

Project Highlights

Iowa has been "out of the mud" for about 100 years, as the automobile became the preferred means of traveling across the country (Iowa DOT 2008b). Despite a century of progress, however, the challenges inherent to the state's unique physiography (Landis 1997), particularly as it relates to LVRs, often persist.

Iowa's uneven distribution of aggregate across the state, for instance, is still a problem that researchers are seeking to address (Landis 1997, TR-704). Other challenges, like increased springtime precipitation (INHF 2025) and heavy rainfall events (Jibon et al. 2024), are worsening. Still others, like the exponential increase in delivery trucks (WEF 2020) and escalating vehicle loads (TR-781), would have been entirely unexpected a century ago.

Adding to these challenges are the rising costs of materials and unchanging or shrinking local budgets.

TR-721 helped identify economical and effective granular roadway stabilization methods that Iowa counties can implement with readily available equipment.

"In my 30-year tenure, I went from $100,000 a mile to over $1,000,000 a mile to pave, and our funding hasn't kept up," Weiss said. "That's where the IHRB offers a real benefit, in providing local agencies with low-cost implementable strategies that can have an immediate impact."

Low-Volume Road Solutions

Iowa's well-known freeze-thaw cycles cause problems across the state's roadways, whether paved or unpaved. However, because of the state's greater than average number of gravel roads (Cichon 2024), these cycles present a particular challenge.

"Our climatic zone is the most challenging, which means we have a large number of freezing and thawing cycles. We also get a lot of precipitation, so it makes it extremely challenging because of the state's many unbound gravel roads," Ceylan said.

Former InTrans researcher David White conducted an initial investigation into low-cost rural road surface alternatives to address the impacts of freeze-thaw cycles on unbound gravel roads in 2011. The research consisted of a literature review that winnowed a list of over 300 technical articles to 71 that may be applicable to Iowa's conditions, analyzed the solutions provided in those articles, and made recommendations for potential research (TR-632).

Subsequent phases, led by InTrans researcher Jeramy Ashlock, included demonstration test sections and later field tests to further explore the various best solutions identified in the first phase (TR-664, TR-721, TR-725).

The field studies identified "the most economical and potentially effective" solutions to stabilize granular-surfaced roads and thus reduce freeze-thaw damage, including optimized gradation with clay slurry, a 4 in. cement-treated surface course, and select liquid chemical base stabilizers (TR-721). The Phase III report noted that for all but the cement stabilization method, county agencies typically have on hand or can easily obtain all of the needed materials and equipment and can implement the solutions using conventional construction techniques.

"Washington County has gone all in on stabilization using the results of the field tests in Hamilton County. They bought a road stabilization tool to inject the chemical base stabilizers, and they've had a lot of success with that," Weiss said.

He added that his own Greene County had implemented another of the solutions, aggregate columns, which includes auguring boreholes in a pattern and filling the holes with clean aggregate. This treatment had more success in Phase II than in Phase III (TR-721), but Weiss found it to be beneficial to Greene County's gravel roadways.

"I think it was innovative and something we readily were able to do. I think we've seen some benefit from it," Weiss said.

In a separate IHRB research project completed in 2021, Ashlock demonstrated the successful use of waste quarry fines as a binding material to stabilize unpaved roads (TR-747).

"The project showed that mixing quarry fines with surface aggregate materials could be an efficient way to reduce costs due to the binding provided by such materials, which can help reduce gravel and thickness loss. Thus, use of quarry fines on unpaved roads could be a more economical and environmentally friendly alternative to chemical stabilization," read the final report (TR-747).

More recently, an in-progress IHRB project led by Ceylan is currently investigating the use of recycled plastic waste materials as a base stabilizer for granular roads (TR-799). This project is more thoroughly discussed in the Sustainability chapter.

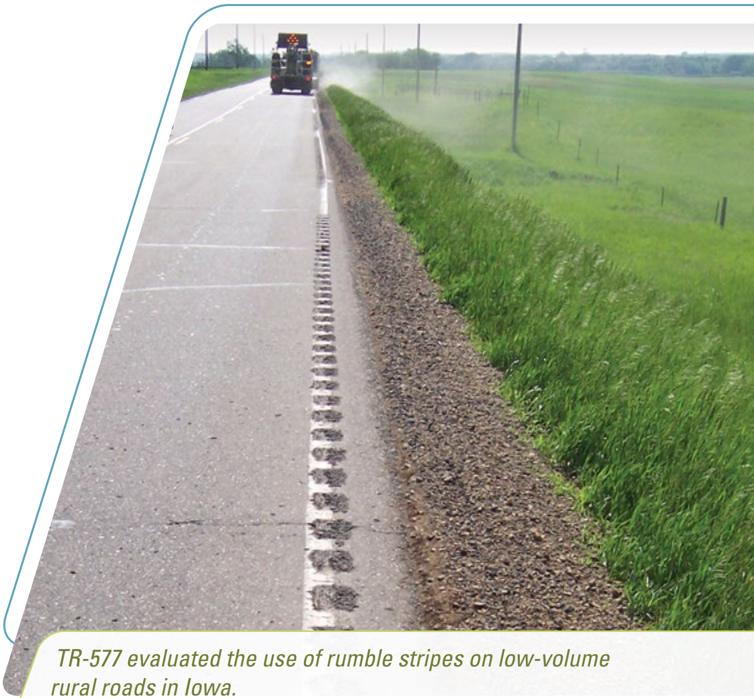
Projects focused on solutions for paved LVRs have included TR-598, which developed updated SUDAS specifications for fog seal, seal coating, slurry seal, and microsurfacing roadway rehabilitation techniques, and TR-735, which recommended the best holding strategies for maintaining composite pavements in poor condition, particularly where resources are unavailable for complete rehabilitation.

Given scarce resources, Weiss said that the local agency perspective is typically focused on lowering costs first and foremost. However, he also acknowledged the role that short-term rehabilitation or retrofit projects can have in improving public safety as well.

And some IHRB projects have specifically addressed safety on LVRs. One project, completed in 2009 in conjunction with the Iowa DOT and FHWA and led by InTrans researcher Shauna Hallmark, evaluated the use of rumble stripes on paved LVRs to address the most common crash type on Iowa's rural two-lane roads: single-vehicle run-off-road crashes (TR-577).

"[P]reliminary results indicate that local agencies could install narrow-width rumble stripes as feasible and relatively low-cost mitigation for lower-volume paved rural road sections with a history of or potential for lane departure crashes," read the final report (TR-577).

Mark Dunn, who was IHRB executive secretary when that project was completed, noted that the results of TR-577 have made their way from research to everyday use.



TR-577 evaluated the use of rumble stripes on low-volume rural roads in Iowa.

"Rumble strips, both the centerline and edge line rumble strips, we're using those, and we've got programs out there adding more lane miles with them every year," he said.

Much IHRB research on LVR bridges has also tackled safety concerns, particularly bridge rails and approach railing (TR-592, TR-679).

A project completed in 2010 and led by InTrans researcher Brent Phares surveyed the state's LVRs to describe the state of the practice and perform an analysis of crashes involving bridge rails and approach guardrails (TR-592). Building off of that research, InTrans researcher Zachary Hans led an IHRB project completed in 2016 that determined that no prescriptive guidelines were needed on bridge rail use, given the limited crash expectancy, but supported revisions to the Iowa DOT's Instructional Memorandum (I.M.) (TR-679).

Other bridge projects applicable to LVRs, such as TR-444, which first demonstrated the use of railroad flatcars as bridges, and TR-710, which recommended partially grouted revetments as a cost-effective countermeasure for scour, are discussed in the Bridges chapter.

Dealing with Drainage

The combination of the state's climate, especially its springtime precipitation, and the rich soils that characterize the geographic region has resulted in a myriad of drainage issues for Iowa (Iowa DOT 2008b). And that physiography hasn't changed in a century.

But the understanding of drainage and the technology to address it is always advancing to help both researchers and practitioners better mitigate flooding and other drainage issues that impact roadways.

In fact, streamflow data analysis is the subject of one of the IHRB's longest-running projects. An agreement with the USGS was established in 1968, with reports in 1988 and 1996, and then established anew in 2000 (TR-140), with a report last issued in 2015 (TR-669). The project, led by the USGS, has provided summaries of data collected at 184 streamgages in Iowa that have had at least 10 years of continuous record collection.

While the collection of streamflow data in Iowa is not new to the USGS—the first data were collected in 1873 for the Mississippi River at Clinton—technological advances have meant that the agency can put the streamflow conditions on a website, WaterWatch, which is updated on an hourly basis (TR-669).

"We've gotten a lot of insights thanks to the streamflow data, like the predictability of storm events and where they're going to hit," Weiss said. "It's been very useful to the public, from the Interstate system down to the lowest-volume roads we have."

The IHRB funded another project led by the USGS, completed in 2017, that used lidar data to better determine stream channel and watershed boundaries and measure basin characteristics (TR-692).

However, much of the IHRB-funded research related to drainage issues has been led by UI researchers. And a lot of that work has concerned flooding, particularly after the first historic event of this century in 2008 that affected much of the state.

One IHRB project, led by UI's Allen Bradley and completed while some parts of the state were still recovering from the 2008 flood, evaluated the design flood frequency methods for smaller Iowa streams to assess their predictive accuracy (TR-533).

TR-638 assessed flooding impacts on infrastructure and offered mitigation strategies.

A later project, led by UI's David Eash and completed in 2015, built off of that work to compare flood estimation models for small drainage basins in Iowa and developed new models to make better estimates (TR-678).

Another UI-led project similarly sought to estimate flow at ungagged stream sites, particularly in western Iowa drainage areas. The project, led by Thanos Papanicolaou and completed in 2010, represented the first orchestrated monitoring effort in the western part of the state (TR-567).

A few years later, after another historic flood event in 2011 overflowed the Missouri River on the western side of the state, White led an IHRB project assessing the flood's impact on infrastructure and offering mitigation strategies, ultimately resulting in a catalog of field assessment techniques and 20 potential repair solutions (TR-638).

"The state of Iowa experienced severe geo-infrastructure damage due to flooding in 2008, 2010, and 2011. The flood damage assessment methods and repair and mitigation solutions presented in the report will aid city, county, state, and federal agencies in a future flood event," read the 2013 report (TR-638).

Innovations for Low-Volume Roads

For roadway infrastructure, culverts have long been a solution to prevent overtopping. Wooden culverts were used at the end of the 19th century, but the early 1900s began to offer a newer solution in concrete (Isenberg 1999). Now, in the 21st century, culvert design is on the brink of another great leap forward.

"Culverts are specifically designed for conveying the flow of small and medium streams. Their design doesn't account for sediment transport considerations," Muste explained. "There is no full understanding of the sediment movement—a complex hydraulic problem—nor guidelines for sedimentation mitigation in place."

He added, "Lacking specifications for avoiding sediment buildup at culverts, agencies are left without alternatives other than mechanically cleaning the culverts after they are severely sedimented."

Because of this complication, the IHRB challenged Muste to find a solution. Thus began a multi-phase and still-ongoing series of projects aimed at developing self-cleaning box culvert designs.

"So, in 2006, we were tasked by the IHRB to start the research on three-box culverts, because these structures are the most often constructed in Iowa while also most prone to sediment accumulation. Until a few years ago, three-box culverts were the only ones we'd studied," he said.

The earliest study, TR-545, included some field evaluations but mostly focused on laboratory experiments and numerical simulations to better understand the mechanics of the sedimentation process and begin to develop self-cleaning concepts. However, modeling real-world conditions proved difficult in the lab, and so Muste went back to the board to request a separate study specifically to research the origins and characteristics of the sedimentation process across the state (TR-596).

"Properly figuring out the scale effects between real-world structures and the laboratory replicas has critical implications in the hydraulic modeling results," Muste said. "We did a lot of

Under TR-665, software was designed that identified sediment-prone culverts.

field inspections—walked by nearly 300 culverts throughout the state [Iowa]. After garnering more insights from field visits and additional laboratory tests, we were able to better understand the triggering mechanisms for sedimentation and its subsequent development. Following the field visits, we've kept working with variable water flows and sediment rates similar to those observed in natural settings."

The next phases of the project, TR-619 and TR-719, included real-world testing of various self-cleaning culvert designs and long-term monitoring of their success at reducing sedimentation. In between, Muste also worked on technology transfer, sharing with agencies the software used to identify sediment-prone culverts (TR-665) and then developing its use for the Iowa DOT (TR-744).

"It's really worked very well," said Iowa City Public Works Director Ron Knoche, whose city participated in some of the field tests. "It was a situation where we had an existing relationship with Marian to conduct the tests, but then we were able to implement it to help reduce our infrastructure maintenance costs as well."

Weiss echoed Knoche's sentiments, agreeing that while the current three-box designs may have been too large for his county's needs, he recognized the value of the research statewide.

The potential of the initial concepts was not only appreciated within the state, but the Phase II research project also earned national recognition, being named an American Association of State Highway and Transportation Officials (AASHTO) "Sweet Sixteen" High Value Research Project in 2018.

Most recently, Muste's work through the IHRB is looking at self-cleaning designs for twin- and single-box culverts (TR-805).

Through the Iowa DOT, he has also expanded the scale of testing and monitoring beyond Iowa by leading a pooled fund study, which concluded at the end of 2024, that brought the self-cleaning culvert designs to four new states, some with new, semi-arid environments (TPF-5(445)).

"That was an interesting project, where we analyzed nine design configurations for temperate climate areas and six configurations for semi-arid areas," Muste said. "We conducted over 100 tests. It was a lot of work, measurements, and data, but eventually the hydraulic modeling outcomes helped us to deliver innovative solutions for each culvert setting."

"In the end, the research outcomes of this multi-year research were well received by the participating agencies," he added. "We felt proud that ideas originated in Iowa were embraced by other states in the nation."

Separately, another recent IHRB project that also featured a UI research team, led by Larry Weber and completed in 2024, looked at an alternative to conventional culverts in the form of on-road structures that use the embankment as a dam. The project included a web portal identifying on-road structures and their potential flood storage capacities (TR-792).

Tools of the Road

Given all of the difficulties associated with maintaining LVRs, and granular roads in particular, the IHRB has invested in not just understanding the challenges but developing tools to help agencies solve them.

TR-685 studied the feasibility of granular road and shoulder recycling.

Building off of work to effectively design and maintain granular shoulders (TR-531, TR-634), InTrans researcher Jeramy Ashlock has led subsequent IHRB projects studying the feasibility of granular road and shoulder recycling and, ultimately, developing and improving on an Excel-based gradation optimization tool (TR-685, TR-797).

"The idea is to optimize the gradation of what you put down on the road rather than just put down whatever you already have. This way, you can use some of the existing material for the new road," Ashlock said (InTrans 2017a).

He added, "If you get the tightest particle packing, you'll get the best performance, the longest life possible for the road. That is where we're headed right now. We call it more performance-based specs" (InTrans 2017a).

The tool was developed in the first phase of the project, which concluded in 2018, based on laboratory and field evaluations. The second phase, which is expected to conclude in 2025, will improve upon the tool by including a wider range of material blends and material types after further testing (*Technology News* 2024a).

TR-704 investigated the cost-effectiveness of hauling in high-quality coarse aggregates to improve the performance and reduce the maintenance frequency of granular roadways in regions having only low-quality aggregates.

"When we know a certain road section is going to go to pot—and it happens every year—then we fix it, and we move on. But if we had something that showed the strength of that roadway, maybe we could identify and concentrate on those specific areas," Weiss said. "I'm interested to see if we can have some predictability in areas where we can do more in-depth work, so that we don't have the same problems year after year."

Separately, Ashlock was co-PI on an IHRB project led by former InTrans researcher Bora Cetin that investigated the costs and benefits of using high-quality clean aggregates in areas with low-quality aggregates. The project, completed in 2019, ultimately developed a spreadsheet tool to help local agencies assess those costs and benefits for a variety of road maintenance and construction alternatives (TR-704).

The same year, Cetin completed another IHRB project that also developed a spreadsheet tool, dubbed the Granular Roads Asset Management System (GRAMS), to help local agencies make more reliable gravel loss estimates and thus determine annual aggregate requirements for proper budgeting (TR-729).

"Local agencies have traditionally used their previous experience and quick visual inspections to estimate their annual aggregate needs," Cetin said (*Technology News* 2020b). "We hope this tool will significantly help local agencies to better maintain and manage their granular roads and further help them to defend their estimated materials needs and budget requests."

In response to recent state legislative changes allowing vehicles to exceed gross weights by up to 12%, Ceylan led an IHRB project that ultimately developed an Excel-based tool called the Road Infrastructure-Superload Analysis Tool (RISAT) that quantifies the impacts of superloads on Iowa infrastructure (TR-781).

"[T]he development of the RISAT provides a user-friendly platform for engineers and planners to evaluate the structural damages and associated treatment costs induced by superload traffic, enabling informed decision-making and efficient management of road infrastructure," Ceylan said (*Technology News* 2024b).

TR-753 evaluated the performance of Otta seal in Iowa through laboratory and field investigations and established recommended specifications for Otta seal implementation.

Solving Tomorrow's Problems

Tools like the RISAT are not only useful for helping local agencies maintain their LVRs. They also signal new challenges—and advanced solutions—affecting Iowa's roadways.

"One pass of a legally loaded grain cart, for example, can cause as much damage as 3,000 legally loaded 18-wheelers," Ceylan said. "We call them low-volume roads, but actually if you do the math, the number of trucks equivalent to the number of superloads, they're no longer low volume."

The impact of these heavy loads is further exacerbated by the widths of the vehicles that carry them, which lead to impacts on the roadway at its most critical points, the lane edges.

Weiss said it's not only heavier, wider vehicles but also changes in Iowans' behavior, such as their desire to move to more rural subdivisions and their preference for e-commerce, that are making LVRs more heavily trafficked.

These challenges, combined with the previously mentioned budgetary constraints of local agencies, have led the IHRB to fund several projects tackling various impacts of changing traffic demands on LVRs.

Demonstrating the board's early recognition of these new challenges, it first funded research that was completed in 2008 evaluating dowel bar retrofits for local pavements, a study prompted by the fact that "truck traffic on Iowa secondary roads has increased" (TR-520).

Another series of IHRB projects led by Ceylan aimed to tackle several new and long-standing LVR issues by adapting a Norwegian BST, called Otta seal, for Iowa's climate (TR-674, TR-753).

"I was interviewing one of our county engineers, and one of the standard questions was 'How often do you go and grade roads?' His answer was six times a week. I was jumping to the next question, and then I processed his answer in my brain."

Ceylan said that the interview was in response to early research on Otta seals and whether they may be an economical solution for low-volume granular roads. Ceylan also noted that the previously mentioned gradation optimization tool developed by Ashlock (TR-685, TR-797) may be another solution, one that could go hand in hand with Otta seals, for county engineers to avoid near-daily or too-frequent grading on granular roads.

"The method developed as part of the Phase II project can help county engineers determine optimal binder and aggregate application rates for local materials and better understand how various parameters—such as aggregate gradation, aggregate and binder type, and aggregate and binder application rate—can affect the performance of Otta seal surfacing," Ceylan said (*Technology News* 2024c).

Not only have Otta seals proved to be a solution that can offer lower costs and improved performance for LVRs, but Ceylan said the technology is also more environmentally friendly because it reduces dust particulates in the air.

"This research shows Otta seal is like a turbocharged conventional chip seal—a cost-effective maintenance tool to support sustainable roads in Iowa conditions," said ICEA Service Bureau Secondary Roads Research Engineer Lee Bjerke of the Phase II research (Iowa DOT 2024c).

TR-781 developed methods for evaluating the impact of superloads on Iowa's road infrastructure.

Changes to the State of the Practice

"When the roads are poor, it is the local people who suffer the most," said Ceylan, whose LVR work with PROSPER includes the previously mentioned IHRB study on superload traffic and its impact on Iowa's local road infrastructure (TR-781). That project has since contributed to the adoption of sustainable strategies for preserving the road network amidst evolving heavy-transportation demands.

While the IHRB's LVR research isn't singularly focused, projects over the past few decades have switched from new construction toward rehabilitative techniques. This move demonstrates a more vested interest by the board to fund projects focusing on better designs and, at the same time, revised standards.

Weiss, having seen the increased annual average daily traffic (AADT) of local roads firsthand, noted it as "an ever-evolving cycle" and "part of the pattern."

IHRB-funded investigations such as TR-685, which looked at the feasibility of gravel road and shoulder recycling, found success in making the maintenance of Iowa's county roads more efficient, with positive effects on long-term durability.

"The set of recommended testing, design, and construction procedures developed in this research [provides] state secondary roads departments with more cost-effective solutions for building or reconstructing granular road systems […] with the option of recycling existing surface course and subgrade materials," Ashlock wrote in his 2019 report on the project.

Similarly, White's research on low-cost rural road surface alternatives (TR-632) in 2013, and the subsequent demonstration project (TR-664) led by Ashlock in 2015, helped improve granular road and LVR practices. Two additional projects/phases were also funded through the IHRB, focusing on the use of readily available materials and construction equipment (TR-721) and additional monitoring and prediction (TR-725).

The detailed literature review and systematic assessment under TR-632 identified rural road surface technologies suitable for future evaluation and implementation in Iowa, resulting in an organized database of literature with 150+ technical articles on the topic. In the end, Ashlock published a "how-to" guide detailing stabilization methods and an implementation methodology to "assist county and district engineers with choosing the best materials for long-term performance of their roads," as he noted in his 2022 report (TR-725).

In addition to developing guidance, IHRB research has been undertaken to update specifications for roadway rehabilitation techniques, including the updates to the Iowa SUDAS specifications involving fog seal, seal coating, slurry seal, and microsurfacing made under TR-598, a project led by former InTrans researcher Charles Jahren.

But it isn't just LVRs that have benefited from IHRB-funded research.

Bridge rails and approach railing also saw improvements through TR-592, a project led by Phares that featured efforts to synthesize data and improve safety on LVR bridges in Iowa.

According to Phares in his 2010 report on the project, "Iowa's 17,000+ inventoried LVR bridges and unknown number of non-inventoried LVR bridges will benefit from an understanding of how various agencies apply guardrail policy, potential safety impacts including benefits and costs, and current state of practice for guard rail systems."

"I feel really proud about our work with counties in trying to develop new systems for our bridges," Phares later said. "Some of the projects I've enjoyed the most involved predicting future performance."

More recent work on bridge rails included a study by Hans in 2016 under TR-679. The project's conclusions supported potential revisions to the Iowa DOT's I.M. 3.213, which provides guidelines for determining the need for traffic barriers (guardrail and bridge rail) at secondary roadway bridges—specifically, factors that might be significant for the bridge rail rating system component of I.M. 3.213.

Improved practices and more efficient design strategies also involved culverts—the hydrological and functional brother of bridges, as mentioned previously by Muste. The insights garnered from the phased research on culvert sedimentation have been incorporated in the development of design guidelines for self-cleaning box culverts (TR-545, TR-619, TR-719).

"It is an effective, long-term solution," Muste said of his self-cleaning culverts research. "Observing multiple culvert sites shaped by natural processes taught us a lot about the sedimentation at culverts. We returned to the lab with better understanding, and then we replicated the processes in our flumes. We started first with the simplest settings and flow conditions, and gradually we ramped up the complexity of the modeling to get closer to what we observed in the field."

The original design (TR-545) was found to be simple to implement in any stage of the culvert lifetime, which revolutionized the function of the culverts in Iowa, ultimately bettering researchers' understanding of the mechanics of the sedimentation process at multi-box culverts, while developing self-cleaning systems that flush out sediment deposits using the power of drainage flows.

By Phase III of the project (TR-719), Muste and his team were able to take even more steps toward finding solutions that "permanently solved the sedimentation at culvert problem by using the self-cleaning concept—an Iowa innovation that keeps the culvert clean by using the water flowing through the streams. These solutions mimic riverine natural processes, whereby the moving waterbody carries the sediment downstream without leaving behind sediment accumulations."

"Through my work [through the IHRB], I got to hear real stories from outside my field [of hydraulics]. I learned that a bigger structure isn't always a better solution. The field observations coupled with the research in the lab led us to 'smart' holistic sediment mitigation solutions akin to those rendered harmoniously in nature," Muste said.

CHAPTER 4

PAVEMENT PRESERVATION

A pavement performance and remaining service life prediction tool was developed under TR-740, allowing local agencies to make better-informed planning decisions.

Importance and Stakes

Today, pavement preservation has become synonymous with asset management, with research having been completed to help guide investment strategy and inform decisions about when to extend pavement life and when to replace pavements (Iowa DOT 2013).

"We can do a lot more with pavement preservations now than we used to," said Ashley Buss, an Iowa DOT bituminous materials engineer and current IHRB member. "Before, we mostly used a lot of old-school materials and techniques. But with materials and equipment continuing to get better and better, the process has become more seamless. When you take variability out of it, you can streamline everything."

Buss, a previous InTrans researcher whose experience with IHRB projects goes back to 2008, when she was an undergraduate at Iowa State, identified a common theme among the IHRB's pavement preservation projects. "It always comes down to doing more with less. A lot of commonalities to a lot of pavement preservation research is how we do more with less and effectively communicate that we can keep doing it."

That sentiment is not surprising, given the range of preservation-centered research that the IHRB has funded over the past 25 years. Research has ranged from investigating crack mitigation strategies for flexible pavements (TR-641) and assessing nondestructive testing technology for asphalt mixtures (TR-653) to the performance of cold in-place recycled roads (TR-502) and pavement design strategies that have made a big impact on Iowa counties and their management efforts (TR-563, TR-740).

As such, the board has continued to recognize the need for timely pavement preservation methods and techniques and has sought to fund projects that bridge the current gaps in knowledge, including on topics like pavement foundations, WMA, and cold in-place recycling (CIR).

Hosin "David" Lee, a researcher focusing on CIR at UI's Iowa Technology Institute, noted the IHRB's role in the success of Iowa's researchers. "Our state universities wouldn't be as well recognized in the nation and the world without their support," he said. "The Midwest region has maintained a tradition of putting effort toward transportation research, and it shows. I became successful as a researcher because of their funding and assistance."

In summer 2024, in recognition of Lee's research efforts supported by the IHRB, he was invited as a keynote speaker to two of the most prominent international conferences on pavement preservation in Greece and Portugal.

In part through Lee's IHRB-funded work, Iowa has become a leader in CIR, pioneering changes in standards and processes that have been adopted nationally (TR-578, TR-609).

"There are many areas where we've been able to make improvements to pavements over the years," said David White, a previous InTrans researcher and PI in charge of such projects as TR-516, which involved seasonal measurement testing to improve overall pavement foundation performance. "It is a bottom-up and top-down approach, where we are looking at different ways that life can be improved and trying to push forward to create pavement systems that will last."

White, who has been involved with IHRB research for over 25 years, has seen firsthand the progress in pavement preservation research, calling it "extremely important" not just for transportation users but for future research.

"At first, it was just about identifying pavement problems and doing field testing. Then, it led to new concepts for construction specifications. At a national level, our research has taken the next step and brought forward innovations in near-real-time compaction quality."

TR-516 documented changes in soil properties due to seasonal environmental effects.

Good engineering and management decisions are of paramount importance to both city and county engineering, as well as state work. It has been well acknowledged that engineers must keep abreast of the changing times and technology, and that building and maintaining bridges and roads must always be based on sound engineering practices (Iowa DOT 2019).

"What has really changed our ability to improve engineering in this space is data," White said, regarding recent technological advancements in pavement preservation practices. "Twenty-five years ago, it was hard to get physical data, and testing was difficult. But with today's technology and mapping, we have access to 1,000 times more data at a fraction of the cost. Having this information has completely changed the engineering process and construction workflow."

For Iowa, that translates to the kind of data-driven preservation guidance resulting from Buss's work on TR-709 in 2019, which resulted in a tool for agencies to assess their localized pavement performance, allowing for more effective treatment selection in terms of both performance and economics.

"The main benefit is that when there is a problem, the IHRB can add bandwidth to solve it," Buss said. "One of the best things we can do for the roads is make them last longer, and with the IHRB's support, we can tackle those problems."

Project Highlights

The old adage about necessity being the mother of invention could have been coined specifically with pavement preservation in mind.

Going back at least to the decades after World War II, when the Iowa State Highway Commission sought innovative resurfacing methods to expand existing roadways, and later when a scarcity of aggregate led to testing with new materials, Iowa engineers have responded to pavement needs with ingenuity (Landis 1997).

As Buss said so well, "It always comes down to trying to do more with less."

Counties typically spend about half of their secondary roads funds on maintenance (Iowa DOT 2019), and in fiscal year 2023 cities overall spent about 20% of their budgets on maintenance and preservation efforts (Iowa PWSB 2025). So, they know well the funding challenges.

It's then up to researchers and funding agencies like the IHRB to help "effectively communicate" the best ways to maximize efficiency.

Giving Good Guidance

The turn of the 21st century saw a "quantum leap forward" in pavement design with the release of AASHTO's *Mechanistic-Empirical Pavement Design Guide* (MEPDG) in 2004, and within a year, InTrans researchers, with support from the IHRB, had provided potential users "with a practical understanding of the workings of the new guide" (TR-509).

Around the same time, then LTAP Director Duane Smith led an IHRB project to develop a manual for roadway maintenance workers outlining best practices "from the center line to shoulders, ditches, and drainage," along with guidance on "public relations, bridge maintenance, and snow and ice control" (TR-514).

The manual not only spread the word about best practices to maintenance workers, but the first two chapters are dedicated to helping those workers effectively communicate with the public they serve (TR-514).

A manual developed under TR-514 outlined best roadway maintenance practices for Iowa's local roads and streets.

In addition to the manual, LTAP's outreach publication *Technology News* ran a series of articles between 2006 and 2008 called "Just for Street and Road Workers" that offered insights from the manual, including maintenance of asphalt pavements (2006), concrete pavements (2007), and shoulders (2008a), as a few examples.

Another guide, developed in 2008, specifically sought to fill the gap between the state-of-the-art understanding and the design and construction practices at the time (TR-525). The *Design Guide for Improved Quality of Roadway Subgrades and Subbases* "synthesizes current and previous research conducted in Iowa and other states into a practical geotechnical design guide […] and construction specifications" (TR-525).

More recently, after Buss completed her project on the effectiveness of various pavement preservation techniques (TR-709), which determined that the secret to success is "choosing the right pavement at the right time, and choosing the right treatment" (*Technology News* 2020c), InTrans researchers began building off of that effort to create a statewide pavement preservation guide (TR-784).

The guide, expected to be completed in 2026, is meant to be "tailored to serving the needs of Iowa practitioners who have active pavement preservation programs or plan to implement a pavement preservation program" (TR-784).

While the guide is anticipated to focus on cost-effective techniques that extend the service life of pavements, the impacts will go beyond infrastructure improvements.

"If we can get more life out of the pavements, then we're not creating a work zone as often," Buss said. "Longevity and cost-effectiveness go hand-in-hand, but there's also a safety aspect to it too."

Cold In-Place Recycling

One specific pavement preservation technique that the IHRB has invested time and money into has been CIR, mostly through research led by UI researcher Lee.

"There was no mix design procedure in place in Iowa when I joined the university, so we did laboratory tests to determine the optimum foamed asphalt contents, or emulsified asphalt contents," Lee said.

Soon after, Lee set up an asphalt materials laboratory at the Iowa City campus and quickly established himself as a leader in CIR research and advancement, starting with developing a mix design process for the state in 2005 (TR-474, Phase I) and then validating it in 2007 (TR-474, Phase II).

"The 'lab-designed' CIR will allow the pavement designer to take the properties of the CIR into account when determining overlay thickness," read the Phase II final report (TR-474, Phase II).

Lee's work next examined the curing criteria for CIR, finding the industry standard of 1.5% moisture content to be "very conservative," and explored technically sound ways to identify the minimum CIR properties needed to permit placement of a hot-mix asphalt (HMA) overlay (TR-553, TR-609).

"At the time, we recommended the Iowa DOT increase their moisture content requirements, and at the same time we developed prediction models for moisture levels," Lee said. "I think one of the major impacts of my CIR research was leading to a change in the Iowa DOT's specification."

TR-553 explored effective ways to identify the minimum CIR properties needed to permit placement of an HMA overlay.

In 2009, Lee completed two projects on CIR, one examining the use of emulsion mixtures in the design process (TR-578) and one further assessing the impacts of temperature, moisture, deflection, and distress on CIR pavements (TR-553).

"CIR is a great tool, especially with emulsions. It allows us to rehabilitate the existing pavement easily and then seal with an overlay," said Lee Bjerke, current ICEA Service Bureau secondary roads research engineer, whose experience includes 28+ years with Winneshiek County.

"Using CIR versus just doing an overlay helps preserve shoulder width, revitalize the existing pavement structure, and reduce the reflective cracking that is so common to HMA, and all in a cost-effective manner."

More recently, Lee teamed up with now-retired InTrans researcher Charles Jahren—who had previously completed a project evaluating the long-term field performance of CIR roads (TR-502)—on an IHRB project completed in 2023 that investigated "the deterioration processes experienced by CIR projects in Iowa with the goal of ultimately improving project selection, design, construction, and maintenance" (TR-774).

"That was a really fun project," said Buss, who worked on the project with Jahren and Lee before joining the Iowa DOT. "We actually dug into the performance data and came up with a two-page summary of what practitioners should be looking for in a CIR project."

Pavement foundation research conducted under TR-671 used a range of stabilization construction and testing technologies on about 4.8 miles of roadway at the Central Iowa Expo facility in Boone, Iowa.

Building on a Solid Foundation

Of course, the best way to build a road that lasts is to start with a solid foundation, and that can be a big challenge in Iowa.

"As a lot of folks from Iowa know, it's great soil for growing crops but pretty challenging for building roads on," White said. "From a researcher standpoint, it's fantastic because we have lots of different challenges to investigate because of the soil."

White, whose work has focused on embankment quality and pavement base quality, has seen an evolution in his work during the past 25 years, from first understanding the problem to then learning more through field tests to finally developing and demonstrating solutions.

An early research project led by White did all of the above, ultimately developing tools to determine the optimum base characteristics for pavements that filled a "major technology gap" that prevented practical determination of the saturated hydraulic conductivity of granular bases (TR-482).

The tools include an Excel-based application called the Pavement Drainage Estimator (PDE) that helps "pavement designers estimate the drainage characteristics of subsurface drainage materials" and an air permeameter test (APT) device "to determine the hydraulic conductivity of pavement bases in just seconds" (*Technology News* 2004b).

Still, work continued to further understand and characterize the challenges associated with pavement subgrade layers in an effort to evaluate pavement performance. A 2008 project monitored seasonal variations in temperature, frost depth, groundwater levels, and moisture to document changes in soil properties due to seasonal environmental effects (TR-516).

A 2012 project funded through the Iowa DOT and led by White to "design comparative pavement foundation test sections at the Central Iowa Expo Site in Boone, Iowa," ultimately gave the IHRB and InTrans researchers the opportunity to assess the long-term performance of pavement foundations (TR-671, TR-817).

"That research led to new concepts for construction specifications, which is really the guidelines that state the level of quality required and provide acceptance criteria during construction," White said. "That then led to some national-level research that looked at taking the next step to bring more innovation, specifically the ability to map compaction quality in real time."

Performance and Innovation

A throughline in pavement preservation is understanding pavement performance over time. Until recent technological advances allowed some predictive capabilities, the best way to know whether a pavement design or preservation technique improved longevity was simply to observe and report findings.

A two-phase project led by InTrans researcher Halil Ceylan evaluated roadway subsurface drainage practices to make recommendations for pavement foundation improvements—and ultimately enhance overall pavement performance. The first phase, concluded in 2013, conducted field investigations on 64 selected sites with 371 outlet locations; the second phase, concluded in 2015, brought those totals to 118 sites with 450 outlet locations (TR-643, TR-662).

Another 2015 IHRB project, led by InTrans researcher R. Christopher Williams, provided guidance on reflective crack mitigation for flexible pavements after initially conducting surface wave method tests on 28 pavement sites. Modified rubblization and rock interlayer treatments were ultimately determined to be best for reflective crack mitigation (TR-641).

While field investigations remain key to monitoring pavement performance, more recent IHRB projects have been able to take advantage of the many technological advancements within the past few years, which have allowed for better access to and a greater ability to record and store data.

"Now, with the technology of spatial mapping tools, edge computing, and cloud computing, among others, we now have access to more data in real time and at a fraction of the cost compared to what it used to take," White said.

One recent IHRB project that utilized advanced computational techniques, including artificial neural network models, developed an Excel-based tool called Iowa Pavement Analysis Techniques (IPAT) to help local agencies estimate a roadway's remaining service life (TR-740).

"Artificial intelligence [AI] is very good at pattern recognition. So, if you know the last four, five, or six years of performance of a road, our IPAT tool can really help you know how a road is going to look in 8 to 10 years. It can forecast it," said Ceylan, who led the project.

Ceylan's research team specializes in utilizing AI to package together Excel-based tools that are accessible to local agencies. "Iowa's counties needed an easy-to-use tool to predict the life of their pavements based on ride quality. This research was successful in meeting those needs," said Brian Moore, who was then the secondary roads research engineer with the ICEA Service Bureau (Iowa DOT 2022b).

However, for as long as performance testing has been conducted, researchers have sought to utilize the advanced technologies of the time. Whether it's using new nondestructive testing techniques for asphalt mixtures (TR-653) or outfitting pavement test sections with state-of-the-art sensors to determine the effects of heavy farm equipment (TR-563), the IHRB has promoted innovative methods to improve Iowa pavements.

Asphalt Innovations

In response to nationwide budget shortfalls in the early 2000s, an IHRB project led by Jahren provided public works agencies with an innovative—and more importantly, cost-effective—means of extending pavement service life (TR-507).

The treatment, thin maintenance surfaces, involves the application of asphalt binder and aggregate to an existing bituminous pavement, and it not only economically extends pavement life but also improves the driver's experience (*Technology News* 2009).

In a prelude to what Buss would later say of various pavement preservation techniques, Jahren said that successful implementation required figuring out not just the "right treatment" but also "considering what a community can afford" (*Technology News* 2009).

Utilizing the Iowa DOT's Pavement Management Information System, TR-709 evaluated a variety of pavement preservation methods to determine their effectiveness.

Around the same time, and in response to efforts to reduce carbon emissions, InTrans researchers Williams and Buss were conducting studies into using innovative WMA mixes (TR-599, TR-635). Even in the first phase, the research found that WMA not only reduces emissions, fuel, and energy use but also has paving benefits that include "less compaction effort, longer haul distances, and a better workability with high-RAP mixes" (TR-599).

"The rule of thumb that we use is every 10°C decrease, which is an 18°F decrease, in production of an asphalt mix cuts the emissions by 50%, and now we're able to lower that by 20°C, so we're able to reduce emissions by 75%. That's huge," Williams said.

He added, "In addition, WMA can act as a compaction aid so that contractors can more easily put in place a pavement that has higher density, which is key in terms of performance and leads to a longer-lasting asphalt pavement."

Having demonstrated the benefits of the technology, the second phase of the project, completed in 2013, focused on the curing behavior of WMA mixes, quality assurance testing, and hybrid technologies (TR-635).

Though it was within the scope of the Phase II project (TR-635), more recent studies into WMA have investigated incorporating recycled materials into the mixes. Those studies are discussed in the Sustainability chapter.

"I may not be here in 25 years, but in the future, I'd like to see more use of warm-mix asphalt. I think it can help save the planet," said Lee, who's been involved with WMA through his research into recycled asphalt materials (RAM).

Changes to the State of the Practice

According to Buss, the move toward data-driven practices is what has propelled further change to the field of pavement preservation.

"It has led to exponential growth," she said. "Data is only becoming a bigger component of what we do. Since we were able to establish databases early on, we can now build on that information."

In 2019, Buss, while an InTrans researcher, led TR-709, which focused on the effectiveness of current pavement preservation techniques. Knowing that any state program or initiative was unlikely to be successful without an accurate understanding of local preservation performance, Buss and her team set out to create a database that combined both construction and performance data in one place. The result was a tool for agencies to assess their localized pavement performance, allowing for more effective treatment selection in terms of both performance and economics.

And before that, in 2014 Ceylan led TR-659, which resulted in data on asphalt concrete (AC) dynamic modulus master curves. This research would later be used to characterize and document Iowa AC-mix damaged master curve parameters in the state's Pavement Management Information System (PMIS), which could then be used by city, county, and state pavement engineers in conducting flexible pavement rehabilitation analysis and design.

"Selecting the right treatment for the right pavement at the right time has been a fundamental principle to pavement preservation success," wrote InTrans researcher Omar Smadi in his proposal for TR-784.

While TR-784 is currently ongoing, the results will be of paramount importance for future changes to pavement preservation strategies. The expected guide aims at providing practitioners with an efficient way of identifying candidate roadways for preservation treatments and enhancing project delivery of pavement preservation treatments.

"It is important that pavement preservation guidance include project-level and system-level selection strategies so that project-level decisions can have a network-wide impact," Smadi added.

Over the past 25 years, IHRB research in regard to pavements has cast a wide net. But one overarching commonality is the subsequent results—and their tremendous value to existing practices. This is especially true in the area of CIR, which in recent years has become an attractive method for rehabilitating asphalt roads that have good subgrade support but are suffering distress related to nonstructural aging and cracking of the pavement layer.

"Iowa is a national leader," said Lee, in reference to the IHRB's ongoing support of CIR research.

IHRB-funded research on CIR that has led to changes in pavement practices (as well as updated specifications) includes TR-502, which considered changes that could be made to the design, material selection, and construction of CIR recycled roads to improve their performance, and both TR-474 and TR-578, with their review of mix design processes for CIR and the implementation of CIR-foam to improve field performance.

"Asphalt pavement recycling has grown dramatically over the last few years as the preferred way to rehabilitate existing asphalt pavements," wrote Lee in the 2007 report for TR-474. "Rehabilitation of existing asphalt pavements has employed different techniques, with one of them being CIR-foam, which has been effectively applied in Iowa."

Additional research by Lee has further shaped the state of the practice for CIR both in Iowa and nationally, including the development of a moisture loss index in TR-590 and curing criteria in TR-609. Results from these projects have changed the current practice in Iowa regarding the maximum moisture content in CIR.

"Determining moisture was a critical issue that the Iowa DOT faced at the time," Lee said. "Through that extensive long-term field study, we discovered the significant impact of rainfall on the moisture content and then developed a prediction model to estimate moisture content in a CIR layer. It led to a complete change in specification."

But it isn't just CIR research that has led to a better understanding of pavements over the past 25 years.

In looking at pavement foundations, former InTrans researcher Vernon Schaefer led a team in 2008 (TR-525) that investigated a gap that had emerged between the state-of-the-art understanding of subgrade/subbase geotechnical properties, based on research findings, and the design and construction practices for optimizing geotechnical parameters. The result was the previously mentioned *Design Guide for Improved Quality of Roadway Subgrades and Subbases*, which provided practitioner-ready guidance on soil and pavement foundation topics.

Similarly, Ceylan in 2013 conducted TR-643, which evaluated roadway subsurface drainage practices. According to the final report, the research findings can be used directly by city, county, and Iowa DOT engineers to assess the performance of their pavement subdrains and improve their drainage practices.

"The findings and recommendations will help refine Iowa DOT pavement/subdrain design, construction, and maintenance practices and policies to achieve long-lasting drainage performance," wrote Ceylan in the final report detailing his results.

"We are in a new era in the pavement world," White noted regarding improved preservation practices in the transportation industry, specifically pavements.

CHAPTER 5

CONCRETE PAVEMENTS

TR-765 established a suite of performance criteria to define the acceptability of a given concrete sealer product and a protocol for agencies to use in evaluating a product.

Importance and Stakes

Over the past 25 years, the IHRB has supported concrete-centered research through a slew of projects focusing on concrete pavements and internal curing (IC) concrete, with a total funding amount of over $2 million.

Work has covered everything from evaluating paving equipment (TR-490, TR-512) and portland cement concrete (PCC) construction processes (TR-532) to concrete overlay performance (TR-698), innovative distress detection methods (TR-637), deterioration (TR-668, TR-749), and strategies for long-lasting pavements (TR-700, TR-675, TR-765).

Although Iowa ranks 26th in the nation in land area, it is 5th in the number of rural road miles (Iowa DOT 2019b). As of January 2024, the Iowa DOT reported more than 90,000 miles of rural secondary roads, with approximately 6.7% being PCC paved (Iowa DOT 2024d). For comparison, Iowa's total lane miles were reported as 236,440 to the FHWA (FHWA 2024).

"It is beneficial to have a funding source within Iowa that allows us to do projects that support the state," said Peter Taylor, CP Tech Center director and InTrans researcher.

Taylor, who has been working with the IHRB on projects since 2008, has seen the impact of IHRB-funded research from start to finish.

"[IHRB] funding has allowed us to conduct successful pilot projects, and then by building on that work, we've been able to take it further—to the national stage," he said.

According to Taylor, his work has always been collaborative—a "two-way street"—with both local and national, multi-state partners benefiting from the shared project experience.

"When we are able to engage with communities and agencies from across the country—and world—we can learn a lot. We've probably touched 45 states by now, and our reach is always expanding."

Among the research areas related to PCC construction techniques and mix design, IC concrete has steadily risen to the forefront. Perhaps no longer considered a "new" technique, regardless, in the past few decades it has come to be regarded by researchers as a useful way of promoting hydration in PCC mixes.

IHRB research involving IC has included lightweight fine aggregate (LWFA) evaluation (TR-648), as well as a better understanding of its relationship to cement hydration, microstructure development, and concrete performance (TR-451, TR-479). In addition, the effects of IC on the performance of practical concrete mixtures designed for the construction of jointed plain concrete pavements (JPCPs) was investigated in 2017 (TR-676), with a follow-up study completed in 2021 on warping in concrete pavement overlays built in Iowa (TR-746).

In the TR-746 report, Taylor, the PI on the project, summarized the advantages of IC concrete paving: "The technique does appear to be of benefit for reducing the potential for early-age cracking, improving ride and increasing the longevity of relatively thin overlays. Assuming that the challenges of transportation and storage can be overcome, this is a viable technique to help improve the performance of such pavements."

Some of the "challenges" mentioned by Taylor—discovered thanks to the original IHRB research—are already being addressed by Taylor and his team at the CP Tech Center, who in 2024 were awarded a $6.7 million FHWA Cooperative Agreement to "promote the deployment and rapid adoption of new and innovative materials, design and construction procedures, specifications, practices, and methods to improve concrete pavement performance and extend pavement life." This currently ongoing effort involves 13 consulting firms from across the country (InTrans 2024).

"We are fortunate that in the state of Iowa, people are receptive to innovation. That's why we are a leader in concrete paving," added John Adam, who served on the IHRB from 2001 to 2011 and currently serves as associate director of the CP Tech Center. "As technology develops, materials change, but we are not insular [here in Iowa]. As new solutions and processes are developed, we work with other industries and states so the work can be drawn on by others—and leveraged—but on a larger scale."

Project Highlights

Nationally renowned civil engineer and Iowa State alum Roy Crum made the case in the early 1900s that the two required components to ensure good concrete are quality materials and proper manufacturing conditions (Landis 1997). Those two components identified by Crum, who served as director of the National Research Board for 23 years (ISU COE 2025), remain key to long-lasting, durable concrete pavements to this day.

It's just that the materials and manufacturing techniques look a little different than when Crum penned those words in a bulletin for the university's Engineering Experiment Station in 1919 (Landis 1997), shortly after the first concrete pavements were placed in Iowa (Hanson 2009).

Improving Manufacturing Conditions

The Iowa innovation of the slipform paver in 1947 (Iowa DOT 2008b) was a game changer for concrete production—not just in the state, but worldwide. The turn of the 21st century again brought major changes to the concrete industry, with Iowa continuing to lead the way.

Former InTrans researcher James Cable led two IHRB-funded projects in the early 2000s that looked into ways of improving upon the now-commonly used slipform paver, evaluating the use of GPS and laser technologies for stringless paving (TR-490) and then-new profiler systems to better measure smoothness during construction (TR-512).

While the former project found some minor drawbacks, the new technology was so promising that Cable was "enthusiastic about the GPS-based, stringless concrete paving method" and at the time believed that stringless systems "are the future of concrete pavement construction technology" (*Technology News* 2004a).

"It started with [Cable] and his original work, and now it's an everyday strategy," Adam said. "Most of the concrete pavements done now use [stringless paving], and we are seeing good results: improved efficiency, improved safety, and cost savings."

The latter project also showed promise, finding that the two profiler systems evaluated could detect many different roughness measurements and developing construction guidelines (TR-512).

Shortly after these projects wrapped, Iowa DOT PCC Materials Engineer Todd Hanson (Hanson 2009) noted their impact among other early 2000s Iowa research: "Current research in areas such as stringless paving, determining pavement smoothness during construction, and nondestructive pavement thickness are currently being investigated. These new technologies and others will certainly affect the way concrete pavements are built in the future."

Two other IHRB projects led by InTrans researchers also focused on improving manufacturing conditions, with a particular emphasis on joint-forming techniques.

The earlier of these projects, led by Cable and completed in 2006, studied "known and conceptual joint-forming equipment" designed to form

TR-532 examined alternative ways of developing transverse joints in portland cement concrete pavements.

transverse joints in PCC pavements, though no specific conclusions could be drawn as to their effectiveness at the time (TR-532).

Nearly a decade later, Taylor similarly studied methods to predict the ideal sawcutting window for joints (TR-675). Based on data collected over a two-year period at 16 test sites in Minnesota and Missouri, the 2015 report noted that "both early-entry and conventional sawing windows can be predicted for the range of mixtures tested" using the ultrasonic pulse velocity (UPV) method.

Adding Quality Materials

Taylor says that modern concrete production is a bit like alchemy when determining the proper mixture proportioning. This is true not only for the concrete's base components of rock, sand, water, and portland cement but also for the more recent addition of industrial waste byproducts (InTrans 2020).

"Some of these materials, such as fly ash and slag, started out being used just to save money, because they were waste products that you could substitute for cement. Then, over time, it was recognized that they don't just save money, but they improve the product," Adam said. "They improve performance, adding years to the pavement life, and durability."

TR-648 evaluated an LWFA concrete bridge deck in Buchanan County, Iowa.

TR-746 investigated the impacts of IC concrete paving on warping in test pavements built in Iowa.

The inclusion of various chemical admixtures—for instance, to improve durability or prevent cracking—further complicates concrete production but also provides ample opportunities for improvements to the pavement's longevity.

One promising technology that the IHRB has recently taken an interest in is IC concrete, that is, introducing moisture-filled materials into a concrete mixture to slow internal drying and thus prevent cracking and improve pavement smoothness.

The board funded projects in the early 2000s led by InTrans researchers to study improved pavement curing materials and techniques that found benefits to curing generally (TR-451) and assessed various curing products on the market (TR-479). Both projects, however, noted that even with these curing methods and products, differences between the surface and internal concrete still remained.

More recently, Taylor has found success with using saturated LWFA as an IC method (TR-648).

"It significantly slows the drying, and that's where it's been really beneficial for bridge decks, in that it cuts down on the risk of cracking in bridge decks in a big way," Taylor said. "We used this internal curing method on a couple of small bridges in Iowa, and then we went out and did a big bridge in Ohio, and now we're sharing that success across the country."

Buchanan County Engineer Brian Keierleber was more than happy to let his county be used as an initial testing ground for this innovation.

"Better materials will improve some of the issues," Keierleber said. "Most of the time, it is a failure of the materials due to age and exposure, or overloads, that shortens the life of a bridge."

The initial success with concrete bridge decks, which typically would not need more than one truckload of LWFA, led the IHRB and Taylor to delve deeper into the potential of these new IC methods for concrete pavements.

The first foray into a field investigation of pavements, completed in 2017, used IC on an Iowa State campus sidewalk and allowed Taylor and his team to research the material's impact on contraction joint spacing and conduct a life-cycle cost analysis (LCCA) of the pavement (TR-676, InTrans 2017b). The second phase of the research, TR-746, expanded the field investigations to full scale in Washington and Winneshiek Counties.

"The first real pavements using IC built in the country were those two, and again, we've been able to travel around the United States saying, 'Hey, look, it works,'" Taylor said. "We end up with a mixture that's better hydrated, has more strength, and has better permeability, all the good things we're looking for."

The challenges of transportation and storage of the saturated LWFA, particularly on larger-scale pavement projects, are currently a hurdle, but the Phase II final report notes that if they can be overcome, the IC method "does appear to be of benefit for reducing the potential for early-age cracking, improving ride, and increasing the longevity of relatively thin overlays" (TR-746).

Despite the challenges, and after studying the use of superabsorbent polymers as an alternative curing method (TR-793), Taylor said that IC technology is promising, particularly when it comes to bridge decks.

"The risk of cracking in bridge decks is enormous. In fact, it seems to be a holy grail: Can we make a bridge deck that doesn't crack? I think the answer is yes, but it's been an interesting journey to get there," Taylor said.

Separately, Taylor has also investigated commercial penetrating sealers to increase concrete pavement durability by reducing moisture and deicing chemical penetration (TR-765).

"We are always looking to find ways to improve the life and durability of our pavements. So, the idea of sealing them and preventing the infiltration of water and deicing salts was something I thought Washington County should try to help prolong the life of our concrete pavements," said Washington County Engineer Jacob Thorius.

Concrete Innovations

Iowa's earliest forays into concrete pavements proved the technology to be durable and long-lasting. The state's first concrete pavement, placed in 1904 on a city street in Le Mars, was in service for 64 years, and an Eddyville concrete pavement placed on a local road in 1909 was still in service a century later (Hanson 2009).

Still, IHRB-funded research has continued to focus on making the most durable and longest-lasting concrete pavements while also improving ride quality and promoting the use of sustainable materials in production.

"The changes that we've seen, particularly in the past few years, have challenged the industry to do things differently," Taylor said of the new material properties and machinery that have resulted from developing more sustainable concrete pavements. "So, as more changes come, we are going to have to provide the tools to practitioners to be able to continue to do their jobs well."

Recent and exponential technological advances in computing have enabled researchers to better assess and understand pavement performance. A two-phase IHRB project led by InTrans researcher Halil Ceylan applied structural health monitoring techniques to concrete pavements through the use of wireless microelectromechanical sensors and systems (MEMS) (TR-637).

"By detecting pavement distresses and damage early enough using smart sensing technologies, transportation agencies can develop more effective pavement maintenance, rehabilitation, and management programs and thereby achieve significant cost and time savings," read the final report for the project, completed in 2016 (TR-637).

Ceylan also used technological advances to look into curling and warping behavior (TR-668, TR-749), which are some of the same defects that IC aims to address. He also completed research in 2018 on the prevention of longitudinal cracking (TR-700) in concrete pavements.

The former projects, completed in 2016 and 2023, respectively, collected lidar data on numerous slab surfaces to develop a MATLAB-based algorithm that calculates the degree of curling and warping and thus helps the Iowa DOT and local agencies better understand these conditions on their concrete pavements (TR-749). The latter project, completed in 2018, likewise collected field data, this time from 14 ft widened concrete pavements, as inputs for finite element analysis programs that assessed the potential for top-down longitudinal cracking on these pavements (TR-700).

TR-816 investigated the behavior of fiber-reinforced concrete overlays in the field and provided insights that will allow for improvements to concrete overlay design and performance.

Innovations in Overlays

One of the most cost-effective methods for longer-lasting concrete pavements is a concrete overlay.

"Overlays are a good way to get extended life out of a pavement in a very cost-effective manner," Taylor said. "Rather than ripping out the old pavement, having a disposal headache, and building new pavement sections, we can use the existing system, put a slightly thinner surface on top and get another 40 years out of it. It's extremely cost-effective."

After the invention of the "Iowa Method" in 1964 to replace concrete bridge decks by employing overlays (Iowa DOT 2008b), the concept of using concrete overlays was expanded to pavements, particularly in Iowa but also across the United States. However, until the IHRB funded a study in 2015, there had been few comprehensive studies into their long-term performance.

Taylor led the study, completed in 2017, which included pavement condition index (PCI) and international roughness index (IRI) performance data from 384 concrete overlays on 1,493 miles of roadway and encompassed 14 years of data collection. The study found "definite evidence on a large scale that concrete overlays are a successful preservation technique that can provide extended service lives to roadways in need of rehabilitation" (TR-698).

"This is a great case of an IHRB project, where we monitored or reviewed the performance of existing overlays, which has now become the basis for us telling these great stories about overlays elsewhere in the country," Taylor said.

Adam also noted that part of that story includes the cost-effectiveness of overlays for local agencies.

"It's really overly expensive to reconstruct pavements, and there's always the common need to stretch your dollars. Concrete overlays, I think, have provided county engineers a pretty good tool."

In addition to demonstrating the extended service life of pavements through concrete overlays, the IHRB has continued to fund studies into the technique to make them last even longer.

A second phase of TR-698, again led by Taylor with InTrans researcher Dan King, offered guidance on the optimum joint spacing for concrete overlays with and without structural fiber reinforcement. More recently, Taylor and King have further studied the use of fiber-reinforced concrete (FRC) in overlays (TR-816).

"The known properties of FRC and experience of using fibers in concrete overlays offer promising evidence of good performance and improved pavement properties. However, a number of the additional potential benefits of using FRC in concrete overlays […] have yet to be fully investigated in practice," read the TR-816 final report.

Still, Keierleber sees its potential.

"Economics will always drive our decisions. Providing better pavements through technology improvements is essential," he said.

Changes to the State of the Practice

Concrete standards remain the bedrock for pavement construction. However, studies looking to improve concrete mixes are ongoing, with research having been conducted that, though it doesn't reinvent the practice completely, does "mix it up."

"Iowa has the most overlays of any state," according to Taylor, which means that Iowa research on overlays has been extensive. "It adds equity to the existing system, in order to make it last longer."

With pavement preservation and rehabilitation only growing in importance nationwide, Taylor's research focusing on overlay performance on Iowa's roadways (TR-698) has helped further shape the practice.

"The long history of concrete overlay construction in Iowa coupled with the availability of performance data presents the opportunity for a comprehensive, long-term performance study of concrete overlays," Taylor noted in his final report for TR-698. The CP Tech Center partnered with the Iowa Concrete Paving Association (ICPA) and the Iowa DOT on this project.

In sum, this research has allowed steps to be taken toward a better understanding of overlays as an effective preservation option.

But the IHRB's concrete pavement research has not just led to improvements in overlays—concrete practices have also been pushed toward new areas and limits. One example, mentioned previously, was Cable's research on stringless PCC paving in 2004 (TR-490).

According to Cable's report, "Several companies have developed stringless equipment control and guidance systems using technologies such as robotic total stations and GPS with laser positioning. These stringless technologies have been successfully implemented on construction earthmoving and grading projects. [Our] research tested this technology in a new area—concrete paving."

The results have yielded several benefits, including shorter construction periods, reduced labor costs, and even an increase in the amount of traffic access along roads under construction, especially on county roads where the shoulders are limited.

Additionally, Cable's evaluation of various pieces of paving equipment and processes a year later in 2005 (TR-512) resulted in the development of construction guidelines.

For IC, the movement toward practice has been a slow one, with a "give and take," according to Taylor, in terms of presaturation and storage difficulties for road projects and the effectiveness of polymers.

"We saw improvement with the properties, but then the strength and permeability got worse," he said.

According to the *Guide Specification for Internally Curing Concrete*, which was published by the FHWA in 2017 through a pooled fund study led by Taylor, "Although the concept of internal curing was discussed for use in higher performance concrete [...] nearly four decades ago, it wasn't until the late 1990s that research papers on IC began appearing in earnest" (Weiss and Montanari 2017).

He noted that afterwards, IC began to make "a transition from laboratory research to field trials" and then to "use in daily construction and contracts." With IC having previously only been researched for use in bridge decks in other states, this 2017 project marked IC's introduction to Iowa (Weiss and Montanari 2017).

IHRB studies related to IC concrete—such as Taylor's 2016 project on LWFA, which researched shrinkage, strength, and permeability in an effort to extend the service life of concrete structures (TR-648)—have helped the Iowa DOT and local agencies address their ever-demanding preservation needs.

And even before that, with TR-451 in 2002 and TR-479 in 2003, IHRB research had tackled appropriate curing strategies, resulting in evaluation data that validated currently approved curing materials in Iowa and gave notes on future field applications.

"Some very successful [concrete] projects have been run through the IHRB," Adam said. "We've been able to reach a wide audience and get the word out and show how our products and processes are profitable."

CHAPTER 6

BRIDGES

TR-723 evaluated the effectiveness of different amounts of longitudinal reinforcement in resisting negative moment.

Importance and Stakes

According to the American Society of Civil Engineers' (ASCE's) *2021 Report Card for America's Infrastructure*, 42% of the more than 617,000 bridges in the United States are at least 50 years old, and 46,154, or 7.5%, are considered structurally deficient, meaning they are rated in "poor" condition. At the same time, 178 million trips are taken across the nation's bridges every day (ASCE 2021).

Of the 23,799 bridges in Iowa, one in every five is rated poor, giving the state the worst ranking in the nation by number of poor bridges, and seventh worst by poor bridge deck area (ASCE 2023).

In response, according to the ASCE's 2023 *Iowa Report Card*, reducing the number of poor bridges has become an Iowa DOT priority. Since 2019, it has achieved a 26% reduction in state-owned poor bridges. However, all but 30 of Iowa's 4,599 poor bridges are owned by cities and counties (ASCE 2023), which means that repair and replacement falls directly to those agencies.

It is often because of funding constraints that improvements to locally owned bridges are slow to be implemented, an observation made by Ahmad Abu-Hawash based on his 17-year tenure as former Iowa DOT chief structural engineer.

"For the sake of Iowa's county engineers, IHRB research [over the past 25 years] has focused on practical repairs," he said. "You have to understand that bridge repair isn't just a one-time cost. You must look at the long-term costs over the life cycle, not just the costs at the beginning, and you must also consider the user's costs during maintenance activities due to traffic interruptions."

The ASCE added that even though the number of structurally deficient bridges has continued to decline, the average age of America's bridges has increased to 44 years, and, echoing Abu-Hawash's sentiments, the rate of improvements has slowed (ASCE 2021).

TR-711 investigated exterior girder rotation and the effect of skew during deck placement when constructing new or widening existing bridges.

"The nation needs a systematic program for bridge preservation like that embraced by many states, whereby existing deterioration is prioritized and the focus is on preventive maintenance," the ASCE stated (ASCE 2021).

The IHRB began its initiatives by promoting investigation into effective, low-cost options for bridge repair and replacement.

For example, researchers developed the "Iowa Method" of replacing concrete bridge decks (Landis 1997), which has ultimately saved Iowa taxpayers millions of dollars since its implementation (Petroski 2000).

"The experiment was a big success, and the technique spread throughout the United States," as Ian MacGillivray, then director of the Iowa DOT Research Management Division, told the *Des Moines Register* in 2000 (Petroski 2000).

Over the last few decades, bridge research in Iowa has further expanded, covering timely topics such as scour risk and damage (TR-515), "bump at the end of the bridge" and abutment bridge issues (TR-530/TR-539, TR-622), advancements in ABC (TR-556, TR-561, TR-605, TR-673, TR-701, TR-801, TR-803), next-generation cost analysis tools (TR-737, TR-795) and infrastructure monitoring (TR-611), bridge damage detection (TR-636) and repair (TR-715, TR-802) or replacement (TR-513, TR-800, TR-711), as well as updates to bridge design and specifications (TR-723, TR-775), all of which have gone on to benefit Iowa's engineers in their efforts to preserve the state's bridges.

"When people talk about state research programs, Iowa is seen as a model," said Brent Phares, BEC bridge research engineer. "It shows how state [bridge] research should be done."

But it isn't just steel and concrete bridges that have found support through IHRB research. According to the most recent National Bridge Inspection Standards (NBIS) listing, of the nearly 24,000 bridges across the state of Iowa (ASCE 2023), about 10% are timber bridges (InTrans 2017c).

"We have a great relationship with the Forest Products Laboratory in Wisconsin," Phares said of the IHRB research done regarding timber bridges. "Together, the collaboration has allowed us [Iowa] to accomplish a lot."

The IHRB, responding to the needs of Iowa bridge engineers, has worked with the U.S. Department of Agriculture's Forest Products Laboratory to leverage additional funds aimed specifically at timber bridge research.

"The flexibility of IHRB leadership to see those projects evolve ultimately allowed us to become a national leader in timber bridge research," Phares continued.

Under TR-604, a demonstration timber bridge was constructed and tested that utilized new design details to reduce the magnitude of asphalt wearing surface deterioration, increasing the durability of the entire bridge system.

Researchers from the BEC's National Center for Wood Transportation Structures (NCWTS) have contributed to timber bridge research for the IHRB since 2007, advancing the knowledge of preservation treatments (TR-552, TR-604), repair (TR-616, TR-644), inspection techniques (TR-645), and the next-generation timber bridge (TR-680).

But it was a once relatively unknown material—UHPC—that Iowa brought to the forefront of innovative bridge research.

It was only in 2000 that UHPC became commercially available in the United States. According to a technical note by the FHWA in 2011 (FHWA 2011), "The mechanical and durability properties of UHPC make it an ideal candidate for use in developing new solutions to pressing concerns about highway infrastructure deterioration, repair, and replacement. When UHPC became commercially available, a series of research projects demonstrated the capabilities of the material."

The FHWA technical note is referring to work completed by IHRB researchers in 2004, where—for the first time ever in the US—UHPC was used successfully on a single-span bridge in Wapello County, Iowa (TR-529).

"There are now more than 400 bridges in the United States that incorporate UHPC in one form or the other either during construction or rehabilitation, and the usage continues to grow at a rate of about 50 bridges per year," said Sri Sritharan, BEC researcher and PI of the original IHRB project (TR-529).

The IHRB went on to fund additional UHPC research, including projects on the design and evaluation of UHPC girders (TR-574, TR-806), waffle bridge decks (TR-614), mix standards (TR-684, TR-773), geotechnical applications (TR-558, TR-615), and deck overlays (TR-683, TR-748).

"If the IHRB didn't support us, I'm not sure if UPHC would be as prominent as it is today," said Sritharan, who has worked on bridge research for the IHRB for nearly 20 years. "Their vision for advancing infrastructure with considerations to new technologies is a key aspect of why Iowa is now a leader in this field of research."

Project Highlights

Since the IHRB's founding, its members have overseen a number of projects celebrating bridge-related "firsts," from the first welded aluminum girder bridge (1950s) to the first prestressed steel I-beam bridge (1960s) to the creation of the "Iowa Method" of bridge deck repair (1960s and 1970s) (Isenberg 1999).

The innovations continued throughout the first half-century of the board, with the development of inexpensive repair techniques for bridge approach settlement (1980s) and a bridge maintenance management database (1990s) (Isenberg 1999).

As a new century dawned, a number of new bridge project “firsts” arose thanks to the IHRB’s support: the development of UHPC, ABC methods, and new technologies to aid in structural health monitoring (SHM). This alphabet soup of innovation, along with research on timber bridges, shaped the past quarter century of the board’s efforts on Iowa bridges.

“I don’t know if I can really pick one over the other,” Abu-Hawash, who served on the board from 2005 to 2018, said of trying to select a most impactful project. “All of the projects are unique, and they all have a different purpose.”

UHPC

UHPC research demonstrates both the uniqueness of each IHRB project and how different projects build off of each other to further the body of infrastructure knowledge.

The successful proof-of-concept implementation in 2009 of a shear design procedure for UHPC girders on a Wapello County bridge (TR-529) led to the first bridge in the US constructed with a new prestressed UHPC girder system, referred to as a pi-girder, in Buchanan County in 2011 (TR-574).

“The IHRB project allowed us to test a full-size UHPC beam to validate design assumptions before moving into production of the beams for the overall bridge project,” ICEA Service Bureau Executive Director Brian Moore said. “That earlier project was imperative to the success of the construction project, as this type of bridge had never been built in North America before.”

Buchanan County Engineer Brian Keierleber agreed about the successful implementation of UHPC on bridges in his county and noted its long-term benefits.

“As [renowned UHPC expert] Dr. Joh Changbin told me, ‘It takes 200 years for the salt to penetrate one inch of UHPC,’ so I will not worry about salt effects on the UHPC bridges in Buchanan County,” Keierleber said, quoting the Korean Institute of Civil Engineering and Building Technology research fellow who in 2015 partnered with Buchanan County and the University of Iowa on another UHPC implementation project on a county bridge.

This initial innovative work with UHPC led to additional applications, including a UHPC waffle bridge deck (TR-614) in Wapello County in 2014—giving the county another first in the nation—and a UHPC bridge deck overlay (TR-683) in 2018. The latter project, which was led by Sritharan and included workshops on the technology, demonstrated that deck cracking and water and chloride ingress can be minimized because of UHPC’s higher tensile strength, increased toughness, and low permeability, leading to better deck surfaces and a longer bridge lifespan.

“We developed the concept and then had to secure the seed funding to demonstrate the deck overlay concept,” Sritharan said. “The Iowa Highway Research Board gave us some money to install the deck overlay concept in Buchanan County. At that time, I knew the concept would take off, and now it has been implemented by at least 10 different DOTs.”

Following those projects, Sritharan led a project (TR-748) that included another workshop and demonstrated the technology with machine placement. Because of the unique properties of UHPC, a new machine developed by international construction engineering company WALO had to be made that could place the concrete.

“I think the technology implementation is successful because everybody is participating with commitment and enthusiasm,” Sritharan said during the demonstration (InTrans 2018).

Walo Bertschinger, the owner of the eponymous company now in its fourth generation, added, “This is kind of the next stage, and we’ll see what’s next […]. It’s a startup for everybody, because the material is not that simple, and we constantly learn and adapt” (InTrans 2018).

TR-605 involved the construction of a two-lane single-span precast box girder bridge.

TR-684 evaluated the properties and performance of an alternative UHPC mix.

Work has continued to understand the material properties of UHPC mixes (TR-684), most recently with InTrans researcher Behrouz Shafei looking into more cost-effective nonproprietary mixtures using less expensive and more environmentally friendly synthetic fibers to partially replace the steel fibers used in traditional UHPC (TR-773).

"This research proved that a nonproprietary UHPC mix is a viable and cost-effective option for bridge construction and repair. Now we need to work out some details and get it out there," said Iowa DOT Bridge Project Development Engineer Michael Nop (Iowa DOT 2022c).

Shafei's latest projects, still in progress, are further investigating UHPC by using the mixture for the repair of steel bridge girder ends (TR-806) and prestressed concrete beams (TR-802).

"When you look at a new technology like UHPC, which was super expensive and probably is still expensive, if you just look at the initial cost, you're going to say 'Well, we can't afford it,'" Abu-Hawash said. "But you have to look at those long-term costs, and also indirect costs, because any time you come back to make repairs, you're going to close the road to traffic."

ABC

While UHPC innovations can help increase the lifespan of a bridge, and thus reduce the need for long closures and detours for repairs, a separate area of research that arose at around the same time, ABC, aimed to keep bridges closed for less time in a different way—by reducing the construction time.

In fact, one of Sritharan's projects mentioned above (TR-614) specifically used UHPC as an ABC method, with the 2014 report noting that the "use of a prefabricated UHPC waffle deck system in the Wapello County Bridge was a first for the United States and is one of many concepts being employed to reduce road closure time as part of the development of accelerated bridge construction practices to be used throughout the country."

Put another way by Abu-Hawash, "The motivation [for ABC] is, 'Why make the public suffer having to detour around for several miles or more, when you could get the project done in one week?' You're going to pay a premium up front, but if you factor in the cost for the users driving those extra miles, wasting time sitting in a car, even if those are not direct costs, to me, they're a real cost."

Phares added that ABC techniques not only reduce the impact to the traveling public in terms of time, they also improve safety for the people constructing the bridges.

After initial research demonstrated the feasibility of using precast components for ABC, including bridge piers (TR-556) and concrete elements (TR-561), a 2012 project used a number of rapid construction techniques to build a bridge in Buena Vista County (TR-605).

The design of the latter project involved the use of precast, pretensioned components in the bridge superstructure, substructure, and backwalls, leading to a bridge construction project that was completed in 18 days, from closure to reopening. Construction of the bridge itself took only 4 working days, with the remainder of the time spent on constructing the roadway approaches to the bridge.

However, as precast elements became more common in bridge design, new challenges arose. A 2015 project solved discrepancies between the designed and measured camber of precast, pretensioned concrete beams that had been observed (TR-625), and a more recent project sought to address long-term performance and durability concerns associated with the joints that connect high-quality bridge elements by using link slabs (TR-701).

At the same time, work has continued on the use of additional ABC techniques and lightweight precast elements. A 2020 project led by Sritharan demonstrated the use of prefabricated components to construct the entire bridge column/footing/pile system (TR-673). His work on the system has continued with an in-progress project investigating the use of lightweight precast members (TR-801).

Separately, another ongoing project led by Sritharan aims to advance the ABC method for integral bridge abutments supported on steel piles and constructed using prefabricated and in situ concrete and to explore three-dimensional (3D) printing as an advanced construction technique (TR-803).

SHM

As the new century gave rise to advanced computing technologies, new opportunities arose for collecting data to monitor the performance of new and existing bridges.

Initial efforts funded by the IHRB centered around developing software programs to understand the impact of waterways on bridge scour (TR-476, TR-515) and developing web-based models to assess archeological survey needs on bridge replacement projects (TR-513).

TR-701 investigated the use of link slabs as an alternative to expansion joints in ABC projects.

Then in 2010, a project led by M.D. Salim, at the time a staff member at UNI, recognized that the "advances in sensor technology and availability of low-cost integrated circuits" provided opportunities to develop a wireless sensor network for infrastructure monitoring on a Black Hawk County bridge (TR-611). The work was promising enough to lead to a statewide collaboration in 2013 integrating SHM system concepts and components to detect bridge damage (TR-636).

The 2013 project, led by Phares, resulted in a three-volume report that addressed (1) strain-based damage detection and the development of an autonomous software program called Bridge Engineering Center Assessment Software (BECAS), (2) acceleration-based damage detection, and (3) the creation of wireless bridge monitoring hardware. The software and hardware were tested on a Story County bridge.

"While I feel really proud of some of the work that we did for the counties in trying to develop new systems for bridge replacements, some of the projects that I enjoyed the most and were the most challenging were taking sensors, installing those on bridges, and then using the resulting data to assess the conditions or predict future performance, and really sort of leading on that data-driven decision-making process," Phares said.

Under TPF-5(219), state partners collaborated to develop an SHM system that evaluated structural capacity and better estimated the remaining service life of bridges.

Some of this work coincided with a 10-year pooled fund project with other states that developed an SHM system to evaluate structural capacity and better estimate the remaining service life of bridges (TPF-5-(219)).

With a similar emphasis on service life, the IHRB funded the development of an LCCA tool to help local agencies assess maintenance costs for their bridges. The tool, first developed as part of a 2020 project led by InTrans researcher Alice Alipour (TR-737), initially focused on bridge decks but was further expanded into a broader LCCA management tool by Alipour in a 2023 project (TR-795).

"The main objective of this research project was to develop a user-friendly LCCA tool for Iowa's bridges based on survival analysis of bridge condition ratings," Alipour said after the first phase of the project (*Technology News* 2021). "The tool was designed to cover the most common types of bridges in Iowa while integrating historical data from various sources into the predictive models that account for the cost of maintenance and repair activities during a bridge's service life."

Timber

Iowa is famous for Madison County's wooden covered bridges, but it is also a national leader when it comes to its research into other kinds of timber bridges. Though the state does not lead the nation in its number of timber bridges, the IHRB's culture of collaboration has led Iowa to be a leader in this research area, specifically because of its relationship with the Forest Products Laboratory.

"The research board recognized that relationship and allowed everyone to connect so they could double the efforts to get triple the bang for their buck," Phares said.

Much of the research on timber bridges has aimed to find cost-effective solutions for local agencies that already had aging or deteriorating timber bridge structures at the start of the 21st century. IHRB-funded projects along these lines have looked at effective timber preservation treatments (TR-552), advanced inspection techniques (TR-645), and improved repair techniques (TR-644, TR-616).

However, a couple of projects during the past 25 years have looked to advance timber bridge design techniques.

A joint project by the IHRB and Forest Products Laboratory completed in 2012 constructed and tested a demonstration timber bridge featuring design details that aimed to increase the durability of the entire bridge system by reducing the magnitude of deterioration in the asphalt wearing surface (TR-604).

While that project concluded that more work was needed to improve the effectiveness and long-term use of asphalt wearing surfaces, another IHRB project successfully demonstrated a "next-generation timber bridge" in Buchanan County (TR-680). The bridge system developed as part of the project was a composite glue-laminated girder-deck system using epoxy for the connection and an epoxy overlay wearing surface on the deck.

"For the first few years, there was absolutely no moisture coming through. Now I'm told we're getting some that comes through now. I haven't seen it myself, but again, if the wood is sealed off from the water, it'll virtually last forever," Keierleber said in a 2020 video (Iowa LTAP 2020). "So, if we can keep things sealed off that way, that would be a very, very good product."

The 2019 project, led by Phares and former InTrans researcher Travis Hosteng, also found that the "connection detail has the potential to increase viable bridge options for use not only for Iowa's roadways, but nationally and internationally as well."

Local Actions, National Innovations

One reason for the board's interest in timber bridges is that they represent a large percentage of the bridges built on low-volume roads, which are the responsibility of county engineers (TR-616). As noted above, many of those bridges were already in need of repair near the start of the new century.

But it wasn't just timber bridges. Many bridges on low-volume roads at the time were aging, a quarter were structurally deficient, and 5% were deemed functionally obsolete, and so cost-effective solutions were in high demand.

"People like Wayne Klaiber and Terry Wipf and myself spent a lot of time focusing on how we could come up with ideas that were low cost, either because they utilized recycled materials or because the county could construct them themselves with their own forces, which reduced the labor cost," Phares said.

TR-680 successfully demonstrated a next-generation timber bridge.

"Counties still use a lot of those ideas developed early in my career, which has really shown the value that we provided to those agencies."

One of the earliest innovations that the IHRB funded for low-volume road bridges tested the use of railroad flat cars as bridge superstructures (TR-444, TR-498). The initial testing started in the previous century, but the concept had become a proven technology by the mid-2000s. In fact, Buchanan County, where the test projects were constructed, earned a national award for the innovative solution in 2007.

Keierleber accepted the Excellence in Regional Transportation Award from the National Association of Development Organizations on behalf of the county after demonstrating the new technology, which cost on average a third of the price of standard concrete slab bridge construction and took less time to construct (*Technology News* 2008b).

"Rail cars is one of my keys. Matter of fact, we've got 29 of my 260 bridges [that] are built out of retired railroad flat cars," Keierleber said in a 2020 video (Iowa LTAP 2020). "The reason the railroads retire them is because they're concerned of fatigue, but they'll get more fatigue in one transcontinental trip across the United States than they would in 40 years out on my road system this way."

He also noted that the rail cars are generally designed for 80 to 100 tons per car, which is far in excess of any load expected on Buchanan County's road system.

Additional bridge research projects that intersect with the topic of low-volume roads are discussed in the Low-Volume Roads chapter.

Solutions on Deck

As low-cost technologies have delivered innovative solutions to the needs of county engineers responsible for the 85% of the state's secondary road bridges, the IHRB has focused more of its attention on the aging bridges on the primary road system, where costs and traffic volumes demand a different and more analytical approach.

Phares said that bridge decks on the state road system have been a major research focus recently, since the deck is the part of the bridge that takes the brunt of the traffic weight and is most exposed to other wear and tear.

Three recently concluded IHRB projects focused on three distinct bridge deck solutions.

A 2019 project led by Phares sought to provide data-driven guidance, rather than bridge designers' "rules of thumb," regarding the geometry of bridge deck overhang by investigating exterior girder rotation and the effect of skew during deck placement when constructing new or widening existing bridges (TR-711). The project resulted in valuable design guidance and construction procedure recommendations to reduce girder rotation.

"The research that we've been doing lately on bridge decks, I think, will ultimately lead to a real change in the way that the Iowa DOT and counties, to some extent, will design and maintain their bridge decks," Phares said.

A 2020 project led by Mohamed ElBatanouny of Wiss, Janney, Elstner Associates, Inc. also sought to

TR-710 studied partially grouted revetments as an affordable and effective countermeasure for bridge scour.

provide updated or revised construction procedures and specifications for bridge deck overlays on late-life bridges with limited service life extension requirements (TR-775). The project identified less expensive and smaller traffic impact solutions to late-life overlays rather than the costlier low-slump dense concrete overlays that have traditionally been used on the primary road system.

Most recently, an innovative 2021 project led by Shafei investigated the use of fiber-reinforced concrete in bridge decks to increase the longevity of the structures (TR-767).

"This research shows that fiber-reinforced concrete is effective and economical in solving the problem of concrete cracking when it shrinks. We are already implementing fiber-reinforced concrete in several projects," Nop said (Iowa DOT 2021b).

Bringing Back Local

The innovations on low-volume road bridges have slowed as researchers have turned to focus on broader needs, but they haven't stopped. A 2024 research project successfully demonstrated that partially grouted revetment is a cost-effective countermeasure for scour on secondary road bridges (TR-710).

TR-800 provided guidance for bridge owners and engineers on the design and installation of helical pile foundations for bridge structures.

"Partially grouted revetment offers county engineers an affordable and effective countermeasure for bridge scour," said Keierleber, whose Buchanan County served as one of the four pilot project sites for the project (Iowa DOT 2024e).

A 2023 project that provided guidance for bridge owners and engineers on the design and installation of helical piles for bridge substructures is applicable to a variety of structures, but the results showed that the research will be particularly useful for bridges on LVRs (TR-800). The work included a guide to help bridge engineers and designers take advantage of the benefits of helical pile technology.

"Helical piles may be an effective method for county engineers to design cost-effective bridge substructures," said Lee Bjerke, ICEA Service Bureau secondary roads research engineer (Iowa DOT 2024f).

Changes to the State of the Practice

According to Phares, who has been working on IHRB research since he was a graduate student at Iowa State in 1994, bridge practices are constantly adapting, with a conscious movement "away from engineering judgement to data-driven decisions."

"When it comes to bridges, there is always a financial justification needed, because it's hard to judge what's going to happen to that bridge over the next 100 years," he explained. "Which means our research needs to be scientific, sharper, and we need to utilize any data available."

IHRB research over the past few decades has continued to advance, keeping in mind the needs of both state and local bridge engineers, with funded projects focused on three key topics: (1) the general use of more advanced materials—or a better and more economical way of doing things, (2) how to accelerate construction to lessen the impact on the traveling public, and (3) the design and construction of common bridge pieces to make them last longer.

According to Phares, in the mid- to late-1990s the focus of IHRB research was on low-cost bridge replacements, but eventually the county need for this solution plateaued, and the focus changed to "designing better structures."

"Our research was then on making sure they [the bridges] were easily repairable," he said. "Most of the state structures were built in the '40s and '50s, so they [IHRB] wanted to make sure any future repairs were well researched and cost-effective."

For example, in 2008 Phares conducted research on integral bridge abutment-to-approach slab connections (TR-530/TR-539) in an attempt to correct the long-standing "bump at the end of the bridge" issue faced by the Iowa DOT. The research added to the understanding of integral abutment bridges and how to effectually mitigate this expensive maintenance issue.

According to Abu-Hawash, IHRB bridge research over the past 25 years has largely focused on solving practical issues through increasing safety, extending longevity, and aiding bridge owners by tackling common bridge issues.

One common bridge issue that affects many of Iowa's bridge waterways is scour.

When the IHRB was formed, the Iowa State Highway Commission had in hand a few research projects, including a study of scour at bridge piers, completed as HR-30, which led to significant findings cited worldwide and allowed engineers to formulate solutions capable of lengthening the useful lives of bridges (Isenberg 1999).

Later, in 2006 UI researcher Robert Ettema published a guide for monitoring and protecting bridge waterways (TR-515). Since state, county, and city engineering offices often expend a considerable amount of effort monitoring bridge waterways, the guide served to equip engineers with illustrations and explanations. According to Ettema's research, with the increasing incidence of scour failures at small bridges, a well-illustrated guide like this one could serve as a reference in bridge inspection offices or be used as an educational primer for new inspectors, with the goal of helping readers better recognize the range of scour situations and processes that can occur at bridge waterways, particularly at small bridges.

Additionally, in 2017 Terry Wipf, then an InTrans researcher, developed guidance for yet another common issue facing Iowa's bridges—the impact of implements of husbandry (TR-613). His work included a guide for engineers on how the loads from implements of husbandry are resisted by traditional bridges, with a specific focus on bridges commonly found on the secondary road system. Within the guide, he provided recommendations for accurately analyzing bridges for these loading effects while making suggestions for the rating and posting of these bridges.

"Sometimes there is a shared national interest, such as improving specifications and addressing resiliency," Abu-Hawash said. "The IHRB encouraged and supported the deployment of new technologies, and Iowa became a lead adopter for many of these innovations."

According to Abu-Hawash, one of those was ABC technology, which developed into multiple national initiatives and pooled funds. The results included improved efficiency, which ultimately changed how bridges were constructed.

Although ABC research had been conducted to varying degrees and with even more variable success over the past two decades—both in Iowa and across the country—the IHRB continued to look for ways to enhance the understanding of bridge construction through research aimed at the feasibility of precast bridge piers in 2008 (TR-556), precast concrete elements in 2009 (TR-561), and then the construction of a full bridge using prefabricated bridge elements and systems in Buena Vista County in 2012 (TR-605).

According to a report by Phares in 2022 (TR-701), ABC is widely used by DOTs because of the reductions in traffic disruption, social cost, environmental impact, and lost time. ABC is also known to improve work zone safety, on-site constructability, and project completion time. These benefits have changed how bridges are constructed today. Phares' research (TR-701) took it a step further by addressing issues with ABC (in this case, the link slabs used in jointless bridges). His work resulted in design guidelines and practical recommendations for proper implementation.

"Over the years, a lot of our projects that started out as Iowa initiatives evolved into a pooled fund project involving other Midwestern states," Phares said, echoing Abu-Hawash's sentiments. "There is value in collaboration. One of the reasons we have been successful is because those states saw value in our research and wanted to play a part."

It was the same for UHPC research, which, according to Sritharan, has “changed how we think about building durable bridges.”

“UHPC is a more permanent solution to bridge construction, because it provides better durability properties, so the bridges last longer,” he said.

For example, Wipf in 2011 tested UHPC pi-girders as a new and effective option for bridge superstructures, particularly for projects with accelerated construction schedules (TR-575). The positive results from this project helped shape future design considerations as they relate to UHPC in bridge projects, and with the continued decrease in the cost of UHPC and fiber reinforcement in North America, UHPC pi-girder bridges have become an increasingly more cost-effective option for bridge engineers to consider.

Even more recently, UHPC has continued to be researched and better understood.

Shafei’s work in 2021 (TR-773) on viable nonproprietary UHPC mixtures and Sritharan’s work in 2019 on UHPC bridge piles in comparison to steel (TR-615) have further changed the way both Iowa and the nation view bridge work by advancing the state of understanding and showcasing UHPC as an innovative material with a lot of potential.

TR-615 sought to improve the design of UHPC piles through the development of suitable connection and splice details.

“Projects that aren’t done thoroughly aren’t success stories,” Sritharan said. “I think the IHRB should take pride in their UHPC research, which has enabled its use in bridge construction nationwide.”

CHAPTER 7

STANDARDS AND SPECIFICATIONS

TR-629 provided an update to the traffic signal content within the related chapters of the SUDAS Specifications Manual *that's updated annually.*

Importance and Stakes

During the Iowa DOT's 100th anniversary celebration in 2013, Paul Trombino, then Iowa DOT director, reflected on the agency's origin in the Iowa State Highway Commission more than a century earlier. "The commission was known for creating standards that were not only adopted nationally, but many of them went on to [be adopted] internationally. We [drove] innovation for the most part, not only for the nation, but really—ultimately—for the world," he said (Iowa DOT 2013b).

The Iowa State Highway Commission was founded in 1904 and then expanded and reorganized as its own state agency in 1913, although it remained housed on the Iowa State College campus until the mid-1920s. The commission's success during that time was in part due to 1913 legislation that expanded its duties, including developing standard highway plans and specifications for the state, and provided funds to establish a staff of trained engineers and support personnel. In addition, the commission was given general supervisory control over county and township road officials (Landis 1997).

But it wasn't until the late 1980s, more than a decade after the merger of the Iowa State Highway Commission with other transportation agencies in 1974 to create the Iowa DOT, that the future of Iowa's urban specifications and standards came to the forefront.

A number of central Iowa urban jurisdictions—16 in total, including the city of Des Moines, surrounding cities, and two counties—began meeting to discuss developing common standards for urban public improvements. Such improvements included sanitary sewers and water mains, streets and sidewalks, utility locations, signalization, drainage and erosion control, and several others (InTrans 2025).

According to Iowa DOT PCC Materials Engineer Todd Hanson (Hanson 2009), Iowa has had a rich tradition of innovations. "Many of these [improvements] went on to become industry standards. There have been successes and failures. Industry has built on the successes and learned much from past failures, which has [spurred] innovation, to achieve a cost-effective, long-term, durable solution [...] that well serves the citizens of Iowa."

These early urban efforts came into focus when, in 1995, then Governor Terry Branstad assembled a Blue Ribbon Task Force on Transportation to investigate ways to use Iowa's Road Use Tax Fund more efficiently. One of the recommendations from the task force—known as the Central Iowa Committee, whose members included many of the central Iowa jurisdictions that initially discussed urban standards—was that agencies "adopt common standards for construction specifications." By 1998, the group had expanded to 34 Iowa jurisdictions, including several communities outside the Des Moines area, and had published its design standards and specifications (InTrans 2025).

In 2000, effort was underway to further expand the number of cities using the Central Iowa Committee's manuals and to convert them to statewide manuals (InTrans 2025). The effort eventually became known as the Statewide Urban Design and Specifications, or SUDAS, program.

"The goal was always to improve practice," said Paul Wiegand, SUDAS director from 2010 to 2023. "Iowa citizens simply appreciate uniform public improvements from town to town."

A statewide steering committee comprising various stakeholder groups, including the Iowa DOT, cities, counties, and consultant and industry groups, was organized in 2002 to oversee the new program. CTRE, later renamed to InTrans in 2009, was chosen to manage the program, and continues to do so today. And in 2005, the Central Iowa Committee acted to officially transfer ownership of the manuals to the Iowa SUDAS Corporation, a nonprofit entity. Statewide ownership of the manuals makes them truly statewide standards for urban public works improvements (InTrans 2025).

That means that the specifications for materials and processes in Iowa remain the same for both city and state projects.

Integration of the Iowa DOT and SUDAS specifications began around 2006, when the IHRB funded a project to identify differences between the specifications (TR-524). Two years later, the IHRB funded another project that began to reconcile those differences (TR-565), which led to the final project in 2010 (TR-607).

"Contractors will be able to rely on one set of specifications, and suppliers will be able to keep one set of supplies on hand for a particular type of project," said another previous SUDAS director, Larry Stevens, who held the position before Wiegand. "This uniformity and standardization, from the contractor's and supplier's standpoint, is invaluable" (*Technology News* 2008c).

"A comprehensive and complementary design and specification system provides a smoother integration of urban and state DOT specifications and design standards," Wiegand added, highlighting the benefits of SUDAS for project standardization.

Such uniformity across the state also helps innovations make their way into practice by ensuring that researchers, contractors, and engineers are fully informed about new products and procedures.

This rhetoric of collaboration has carried over to other standards projects funded by the IHRB, such as those looking at bridge specifications.

Project Highlights

It wasn't long after SUDAS was established that the Iowa DOT found the SUDAS standards important for its own uses in urban areas. However, the outstanding discrepancies between SUDAS' standards for Iowa's cities and the Iowa DOT's standards for more rural settings did originally lead to some inherent challenges.

Integration of Iowa DOT and SUDAS specifications began around 2006, when the IHRB funded a project to identify differences between their specifications (TR-524).

To reconcile the different standards, a three-phase, nearly five-year undertaking was sponsored by the IHRB and led by Snyder & Associates, Inc. (TR-524, TR-565, TR-607).

Wiegand remembers meeting about every other week for a period of three or four years during the endeavor.

"We read it word by word, line by line, and decided, 'OK, that's the best way,' 'this isn't quite as good,' or 'maybe we ought to both change,'" he recalled.

The challenge in the endeavor was apparent from the first phase. But so was that spirit of collaboration.

"[I]t was apparent during the committee meetings that representatives from both sides were open to suggestion and willing to change for the overall benefit of the public. With cooperation from both sides, the elimination of conflicts and possible merging of the two documents may take time, but is certainly achievable," read the report for the first phase of the project (TR-524).

The conclusion at the end of the third phase similarly noted the value of the project beyond establishing shared standards between the agency and SUDAS.

"While the three phases of [the project] resulted in the development of several shared specifications and numerous common figures, the project also established a culture of collaboration and cooperation between the two organizations that will continue into the future," read the report for the third phase of the project (TR-607).

There were also tangible benefits to having unified standards across the state. Just the establishment of the SUDAS program led to cities seeing an increase in the number of contractors bidding and a related decrease in costs.

"People did a little bit of investigation, and it showed that uniform specifications would bring about a 10% to 15% savings in construction. So that's really the impetus why SUDAS has been successful is the fact that it saves people money," Wiegand said.

Continued Collaboration between SUDAS and the Iowa DOT

In the report for TR-607, the final sentence recommended that "SUDAS and the Iowa DOT continue to expand their collaborative efforts to develop additional shared specifications and common figures."

And continue they did.

Through two IHRB projects led by InTrans researcher Neal Hawkins, the Iowa DOT participated in SUDAS' two-phase effort to revise the program's traffic signal standards (TR-546, TR-629). While the first phase addressed improvements to the design, construction, and testing of signalized intersections, the second phase focused on pole footing design, cabinets and controllers, monitoring systems, communications systems, and figure updates with input from the Iowa DOT, city traffic engineers, consultants, vendors, and InTrans staff.

The Phase II report also noted the intention of the Iowa DOT and SUDAS to work together to make a joint document for both agencies to "enhance the overall project timeline for traffic signal construction activities" and "save costs through the use of consistent equipment and materials" (TR-629).

"The idea behind it is commonality, and so contractors have less unknowns," said Ron Knoche, Iowa City public works director. "If there is a standard, the contractor isn't taking a risk, and they can see how it is paid out based on the products included."

The IHRB also supported SUDAS' effort led by Wiegand to create the *Temporary Traffic Control Handbook* (TR-694), a document based on the 2009 edition of the MUTCD that aimed to "provide a broad, easy-to-understand reference" for local agencies.

"The handbook includes sample layouts that can be used on various projects. Having sample layouts provides cost savings to agencies because the designer or contractor will not have to develop new plans for each situation. Following uniform procedures [also] increases safety in work zones," read a 2016 summary articulating the value of the then-new handbook (Richards 2016).

"It allowed for our staff to understand what traffic control they needed to implement," Knoche reflected. "And as a book that we could hand out to our contractors, they knew up front the expectations from a traffic control standpoint."

TR-584 developed LRFD recommendations for bridge pile foundations in Iowa.

Iowa DOT Bridge Standards Development

Around the same time that the IHRB supported the collaborative efforts to meld the SUDAS and Iowa DOT standards, the board was also busy developing standards for a bridge load testing process (TR-445), abutment design standards (TR-486), standards for the design of various prestressed concrete beam bridges (TR-496, TR-543), continuous concrete slab bridge standards (TR-542), and bridge "J" standards (TR-588).

The board also invested significant funding in a three-phase project to ensure that Iowa bridge projects initiated after 2007 would meet an FHWA mandate to design bridges according to the Load and Resistance Factor Design (LRFD) approach (TR-573, TR-583, and TR-584).

The main goal of the project, led by InTrans researcher Sri Sritharan, was "to develop regionally calibrated LRFD resistance factors for bridge pile foundations in Iowa based on reliability theory, focusing on the strength limit states, and incorporating the construction control aspects and soil setup into the design process," as stated in the Phase III final report (TR-584).

As Sritharan described the scope and impacts of the project, "I think I asked at that time for $750,000 for field testing and data collection, which was quite an investment. However, they funded the project and realized the value when we actually changed how pile foundations get designed in Iowa and brought in some new concepts that nobody else was using to reduce the foundation costs."

He said that a follow-up project collected data on how the LRFD standards were implemented and confirmed that the new methods had improved bridge pile design in the state. The research also confirmed that the developed procedures in Iowa would not significantly increase the pile design and construction costs in cohesive soils (Neary 2013).

That latter effort earned national recognition. At the 2013 TRB Annual Meeting, a paper summarizing the findings—"Verification of Recommended Load and Resistance Factor Design (LRFD) and Construction of Piles in Cohesive Soils"—authored in part by Sritharan and one of his graduate students, earned the Best Paper Award in the Soil Mechanics Section (Neary 2013).

"As an updated design method for bridge construction, LRFD has really helped [Iowa] counties even more than cities, as there can be hundreds of bridges in a county's system," said Knoche, current IHRB board member and former IHRB chair. "Engineering has protections if you are using the design of the time, but having the standards included is a benefit across the state."

In a series of projects led by HDR, Inc., the IHRB next turned its attention to standards for a short-span prefabricated county bridge system that would "improve bridge construction, accelerate project delivery, improve worker safety, be cost effective, reduce impacts to the traveling public by reducing traffic disruptions and the duration of detours, and allow local forces to construct the bridges" (TR-663).

After the standards were developed in 2016, HDR, Inc. later assisted in updating them to incorporate design alternatives into the casting process and to update the software platform (Iowa DOT 2024g).

"We've revised the short-span prefabricated bridge standards based on lessons learned in using the previous versions of the standards and converted the design files to our new software. The new standards are posted and ready to use," said James Hauber, Iowa DOT chief structural engineer (Iowa DOT 2024g).

Iowa's Culture of Collaboration and Innovation Continues

The development of the SUDAS standards and their reconciliation with the Iowa DOT standards showed Iowa's spirit of collaboration, but these efforts also put the state's innovative tendencies on display.

"In addition to the cost savings and increased competition, another benefit from the review as it relates to the IHRB is the innovations and making sure that the requirements for construction are up to date and are as close to cutting-edge as you want to be," Wiegand said. "It really gets down to keeping the engineers and everyone up to date with the best and most current ways to go about getting their work done."

One recent example of an IHRB-sponsored project that is "as close to cutting-edge as you want to be" is the testing of multi-performance level box beam standards. The project, led by InTrans researcher Brent Phares, developed an innovative wide joint designed with a roughened interface surface, shrinkage-compensating concrete, and reinforcement steel that compared favorably to a joint detail developed and tested by the FHWA (TR-681).

TR-681 developed and laboratory-tested an innovative box beam bridge joint for use between adjacent concrete box beams, with particular focus on its applicability for use by counties.

The joint detail was later tested as part of a field demonstration project that showed it to be a "well-performing joint that resists the early-age cracking often observed in box girder bridges with traditionally constructed joints" (TR-743). The corresponding final report outlined procedures and operations for designing the joint that can act as a "how-to" for counties interested in constructing their own box girder bridges with the innovative joint.

Not only has Iowa innovated on specific projects—it's still the only state in the nation that has a SUDAS program. However, the concept has been gaining national attention as word spreads, particularly as Iowa consultants who've interacted with the program take their message back to their national headquarters.

"I've been to Sioux Falls, South Dakota; Oklahoma City, Oklahoma; Topeka, Kansas; and Kansas City, Missouri, to talk to organizations that want to get more information about the program and its value," Wiegand said. "The concept is spreading out there."

County and City Cooperation

One other innovation funded by the IHRB and led by Wiegand got underway before he retired in July 2023: the establishment of a public works service bureau. Given the previous successful implementation in the state, also thanks to IHRB funding, of the county-specific ICEA Service Bureau, cities and the IHRB wanted to establish a similar program for public works agencies.

The initial phase, completed in 2019, assessed the feasibility of starting an organization for the more than 900 cities in Iowa—the Iowa Public Works Service Bureau (PWSB)—that would communicate and address public works activities in the state (TR-761).

"The ICEA Service Bureau is an excellent example of how a service bureau provides value to their users [and] a system for county engineers to communicate among themselves and with the Iowa DOT," read the report for the first phase of the project (TR-761). "Because cities do not have a corresponding organization, they are at a disadvantage when information is needed to justify changes in financing or regulatory issues related to streets and other public works issues."

The now-underway second phase of the project has established a website that provides public works employees several resources—including interactive dashboards, forum discussions, job boards, and bid tabulation reports, among others—and aims to secure long-term funding for the Iowa PWSB (TR-794).

"It's basically a kind-of 'one-stop shop' in regard to the urban side of the table," said Knoche, who is on the technical advisory committee for the Iowa PWSB.

Changes to the State of the Practice

It was through an IHRB project in 2004, led by former InTrans researcher Ed Jaselskis, that the tedious process of reviewing specifications and design standards was changed forever in Iowa. Turning paper-based design standards and construction specifications into a visual electronic reference library (ERL) or object-oriented design and specification (OODAS) system (TR-487) allowed for a more centralized practice, thus saving resources.

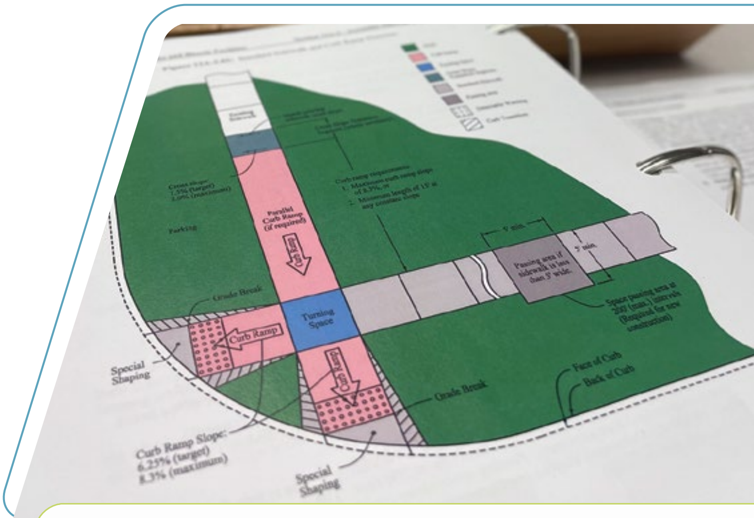
Before that, individuals including designers, contractors, and owners learned about the requirements for a project by studying a combination of paper and electronic copies of the construction documents, including project drawings, specifications (standard and supplemental), road and bridge standard drawings, design criteria, contracts, addenda, and change orders.

The move away from paper-based review was the first step that the SUDAS program, in coordination with the Iowa DOT, would take toward improving the state of the practice for all urban Iowa standards.

"That review and determination, as well as the movement toward uniformity, was probably the biggest thing we accomplished," Wiegand said.

The simultaneous effort between SUDAS and the Iowa DOT to make sure specifications were uniform continued in TR-524 and then TR-565 and TR-607, where Wade Greiman and then Steve Klocke (both of Snyder & Associates, Inc.) worked to bridge any existing inconsistencies in an effort to simplify design, bidding, and construction for future projects.

"As the name 'SUDAS' implies, the specifications were developed for public improvement projects located within urbanized areas. With that focus of the specifications, many jurisdictions, including the Iowa DOT, have determined the need to utilize portions of the SUDAS specifications on primary highway and federal-aid projects within urbanized areas.



TR-607 addressed remaining inconsistencies between the Iowa DOT and SUDAS specifications.

Reviewing the Iowa DOT and SUDAS specifications section by section was essential in responding to the needs of these many jurisdictions," wrote Greiman in the TR-524 report.

Through additional IHRB projects over the past few decades, SUDAS has also worked with other organizations, such as the Iowa LTAP, to update their handbooks to directly benefit local agencies. This was the case with TR-694, which included updating uniform standards for temporary traffic control. Uniformity in standards across communities ultimately increases safety in work zones and helps the public safely traverse them.

"Changes in technology have an impact on standard practice, materials, and equipment," wrote Hawkins in his 2009 report on traffic signal design (TR-546)—another example of efforts by SUDAS and the IHRB toward standardization. This project (along with the second phase, TR-629, which continued the revision process) provided an update to the traffic signal content within the *SUDAS Specifications Manual*.

Through years of effort to provide uniform design standards, the IHRB and SUDAS have improved urban guidance for the state—and these efforts are ongoing as standards change and practice can be improved.

An example of these efforts can be seen in TR-549, which in 2007 resulted in uniform design standards for roadways in rural and suburban subdivisions where none had existed at the time. Additionally, as a way to adapt to changing industry needs and practices, SUDAS staff led a feasibility study researching the establishment of the previously mentioned Iowa PWSB (TR-761) for the IHRB.

The IHRB has also funded dozens of projects over the past 25 years specifically looking at bridge specifications. The work has ranged from projects with Stanley Consultants on the development of standard plans for the design of single-span pretensioned, prestressed concrete beam bridges with concrete abutments (TR-496), continuous concrete slab bridge standards (TR-542), and bridge "J" standards (TR-588) to projects with HDR, Inc. on load rating (TR-734), single-span prefabricated county bridge standards (TR-663), and short-span prefabricated county bridge standards (TR-682).

An additional project with HDR, Inc. developed bridge inspection, load rating, and maintenance manuals (TR-646). "Previously, bridge inspection policies and procedures were documented by various means, making it difficult to provide consistent answers to questions regarding bridge inspection topics," read the 2014 manual for TR-646. "This manual is intended to ensure uniformity and document best practices for inspection of Iowa's bridges, especially as experienced inspection personnel retire."

IHRB projects completed by InTrans researchers have also led to significant updates that continue to provide value today.

For example, Sritharan in 2010 sought to develop LRFD procedures for bridge piles in Iowa (TR-573) after the FHWA issued a policy memorandum on June 28, 2000, requiring all new bridges initiated after October 1, 2007, to be designed according to the LRFD approach. As he noted in his report, for well over 100 years, the Working Stress Design (WSD) approach had been the traditional basis for geotechnical design with regard to settlement or failure conditions. This change in need prompted this IHRB project, along with others (TR-583 and TR-584), to change the practice.

This work has contributed to the body of knowledge that constitutes the state of the practice of bridge work currently performed in Iowa. It also adds to the "culture of collaboration" appreciated by engineers and public works staff alike.

"To be where we are today, it shows how well we get along as a state," Knoche concluded. "We are always looking for ways to stretch our dollars and see how well we can operate our transportation system."

CHAPTER 8

SUSTAINABILITY

TR-677 provided recommendations for improvements to existing specifications related to roadway embankment construction.

Importance and Stakes

As noted by Isenberg (1999), "Throughout its history, the [IHRB] participated in any number of significant project developments, financing the development of new construction methods, new machinery, new maintenance methods, highway safety studies, environmental studies, and dust control methods. [It] helped devise new ways for counties to solve seemingly intractable road problems."

That was in 1999, and now—25 years later—sustainability has become a clear throughline across the board's continued efforts to fund projects seeking equitable solutions to large-scale problems.

From improving embankment quality (TR-401, TR-492, TR-677) to finding data-driven ways to identify and evaluate erosion on state and local roads (TR-464, TR-485) to delivering effective winter maintenance treatments (TR-458, TR-472) and sustainable deicing solutions (TR-471, TR-581, TR-754), sustainability research completed through the IHRB has led to numerous benefits.

"The impact of [our] work is in how we support our infrastructure and build it to be sustainable," said David White, previous InTrans researcher and PI in charge of sustainable materials projects such as TR-461 and embankment projects like TR-492 and TR-677. "Every project is an investment, and [by providing] cost-savings and longevity, we are providing a return."

For example, as White wrote in his 2016 report for TR-677, "Because the quality of embankment construction directly influences performance of the support infrastructure, improvements to embankment compaction quality will reduce the cost of future maintenance and reconstruction."

Because transportation problems related to sustainability and the environment aren't encompassed within a single topic and don't fit under one domain in the industry, researchers across the board have been tasked with solving a larger problem: responding to change (and change at a rapid rate).

Under TR-720, optimized formulations of bio-based polymers in asphalt were implemented in field demonstration projects and provided resistance against low-temperature cracking and rutting.

"Here in Iowa, we are a progressive state, and we know that change is going to happen. Whether it be windmills or biodiesel production or asphalt, things are always changing," said R. Christopher Williams, an InTrans asphalt researcher who holds a shared materials position with Iowa State and the Iowa DOT. "It's about being transparent and honest and adjusting accordingly with our research. Doing things that way, we can get a lot done—and we have."

For example, Williams' 2014 research on bio-based polymers in asphalt has become renowned for its use of a cost-effective alternative to butadiene in asphalt binders, which, besides containing a dangerous and carcinogenic material, has trended upward in price, especially in the past few decades (TR-639). The IHRB funded a second phase of the research, which concluded in 2021, that explored opportunities to produce this innovative, high-value material derived from vegetable oil (TR-720).

According to Williams' original Phase I report, the bio-based polymer is made from soybean oil—the world's most abundant vegetable oil (TR-639)—which opens up new source materials for polymer-modified asphalt. Creating improved economic opportunities for soybeans has resulted in economic value for Iowa by maintaining soil quality through a balanced crop rotation with corn—of which Iowa is the top producer in the country (USDA 2024).

Additional IHRB-funded work led by Williams has included improvements to the performance of flexible pavements, with important economic and environmental benefits (TR-594, TR-650), and the use of lignin as a renewable alternative for asphalt binders (TR-557).

The research by Williams, among others, highlights the IHRB's continued work toward understanding transportation's ever-changing systems, specifically in Iowa.

"I've always had an 'Iowa-first' approach, […] so I always want to see how I can bring the impact back to Iowa," Williams said.

Project Highlights

Iowa's unique geography, with 23 distinct soil regions (USDA 2022) and ever-increasing springtime precipitation (INHF 2025), means many challenges for civil engineers. The land and its people, however, also provide ample opportunities for innovation.

Whether it's providing conservation strategies, reusing materials, or upcycling waste products, Iowa's researchers, and subsequently the state's transportation practitioners, have approached those innovation opportunities with a mind toward sustainable practices.

As InTrans researcher Halil Ceylan said, "The way that I see sustainability is that it's good engineering."

Built to Last

When it comes to conservation strategies, early IHRB projects applied "good engineering" principles to study erosion control measures (TR-464) and subsequently develop a user-friendly tool for practitioners to implement best management practices for erosion and sediment control (TR-485) in an effort to foster a more holistic perspective in roadway construction.

"The decision-aid tools for selecting erosion and sedimentation mitigation measures provided local agencies with easy-to-access answers extracted from a voluminous design specification manual. The answers were delivered through friendly interfaces and simple language, kind of like a primitive AI," said UI researcher Marian Muste, who led these initial efforts. "Our decision tool is valuable everywhere, because [erosion] and sedimentation are processes that occur locally in man-made and natural settings."

This mindset continued in later projects evaluating the Iowa DOT's Compensatory Wetland Mitigation Program and opportunities for cooperation with other agencies (TR-500, TR-526) and investigating the hydraulic performance of 22 fish-passage structures utilized in different streams in western Iowa (TR-521).

However, more often than not, IHRB projects during the past 25 years have focused on both bottom-up (starting with a solid base foundation) and top-down (evaluating sustainable options at each pavement layer) approaches to roadway research.

A series of IHRB projects led by InTrans researchers, starting in 1998 and concluding nearly a decade later in 2007, sought to address the former challenge to build good roads from the bottom up through improved embankment quality (TR-401, Phase I; TR-401, Phase II; TR-401, Phase III; TR-492).

"The challenge with embankments is if you don't do it right the first time, the only way to fix it is to take the pavement off and dig down and redo it," said White, who was involved in the first three phases of the embankment project and ultimately served as PI on TR-492. "The cost to fix the problem is exponentially more once it's buried."

TR-492 evaluated specifications for construction of roadway embankments in unsuitable soils.

The four-phase project ultimately resulted in quality-tested design and construction specifications for embankment soil compaction that include guidance on handling unsuitable soils.

Nearly a decade later, White returned to the specifications, which had since been used on about 190 projects in Iowa, to provide an independent evaluation of the "actual quality of compaction" using the current specifications at the time. The study found that further embankment compaction improvements would help reduce future costs (TR-677).

More recently, technological advances have allowed for better testing techniques to assess Iowa soils and geomaterials. A project led by Michigan State University researcher Bora Cetin (TR-780) evaluated the cross-anisotropic mechanical properties of 10 samples collected in Iowa and the freeze-thaw effect on the samples' properties.

"This research, using equipment that can more precisely replicate actual conditions, has really changed the way we look at material strength," said Lee Bjerke, ICEA Service Bureau secondary roads research engineer. "Results have given us strong confidence in the materials we use to support our roads" (Iowa DOT 2024h).

Recycled Materials

White also led another project in the early 2000s (TR-461) that both helped improve subgrade soil stabilization and utilized an industry byproduct, upcycled fly ash, which is a residue produced in the millions of tons at coal-fired and electric steam-generating plants (American Coal Ash Association 2003).

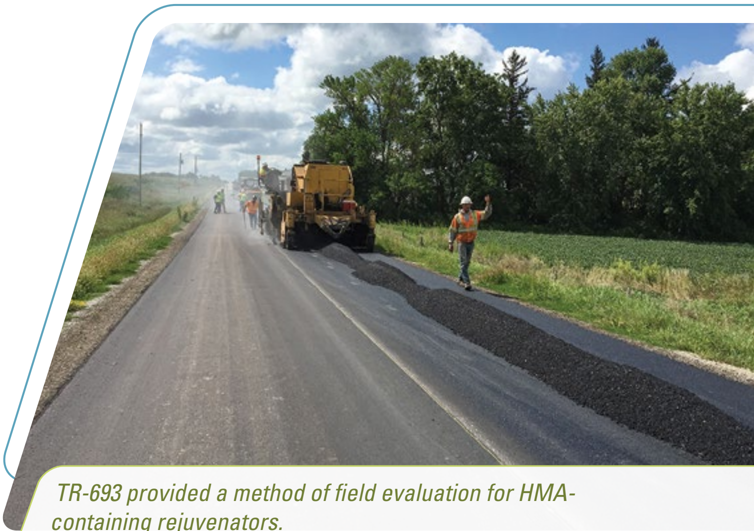
As the 2000s progressed, the IHRB's interest in using recycled materials only increased.

UI's Hosin "David" Lee and InTrans' Williams began to investigate increasing the amount of RAP content in asphalt mixtures, partly in response to a goal set by the National Asphalt Pavement Association (NAPA) in 2008 to double the national average, from 12% to 24%, in five years (TR-624).

Now, in 2025, the project is in its fifth phase (TR-826), as the researchers continue to increase the percentage of RAM above the current Iowa DOT specification of up to 30% RAM by exploring a "comprehensive asphalt recycling strategy for high-RAM mix up to 50%" (TR-826).

In between the first and current phases of this work, projects have focused on field assessments (TR-658); guidance on rejuvenator usage, including a field evaluation (TR-693); and the use of increased RAM content, including an additional rejuvenator study (TR-770).

"I was lucky enough to have a hot-mix asphalt project that fit the project guidelines for TR-770," said Cerro Gordo County Engineer Brandon Billings. "I was approached by David Lee and Heartland Asphalt [the contractor for the project] about possible collaboration for test sites for varying RAP percentages and asphalt rejuvenator sources. This only presented a small risk for the county and offered the chance to progress the research."



TR-693 provided a method of field evaluation for HMA-containing rejuvenators.

He added, "With this in mind, I enthusiastically jumped on board and participated. I appreciate the tactful way I was approached by the professional staff of the principal investigator and the honest layout of all possible risks and the added research value. I appreciate the innovative IHRB and support this, and many other innovative ideas under investigation, because of the progress obtained for our shared profession and for enabling us to provide better service to the public."

Lee said that despite the past research showing the acceptability of wider usage and increased RAM content, there is still room for the state's practitioners to utilize these materials.

"We think we can include up to 50% RAP, but Iowa is somewhere below 20% according to a NAPA survey, whereas other surrounding states are up to about 30% on average," Lee said. "So, our current research will also include writing a cracking test protocol to have recommended performance testing to accurately evaluate higher RAP content."

Another aspect of the current research is to evaluate the performance of WMA with a higher RAM content, which has so far performed similarly to HMA, to "verify if it meets both economic and sustainability requirements" (TR-826).

"This five-phase project has made beneficial changes already in the existing specifications, and we hope to make more beneficial updates to the specifications working together," Williams said. "And so, I value David Lee and what he's done."

Iowa's culture of collaboration remains evident not only in the mutual respect that each university's researcher has for the other but also in the way that Lee has been able to utilize data from the RAP research in another Iowa DOT-sponsored project: 21-SPR1-006.

As part of that project, Lee's research team developed a Database of Sustainable Practices with Implementation Records (LACT 2025), which includes performance data and specific implementation details from the IHRB-funded RAP test sites along with the results of field investigations of sustainable practices in Iowa (Lee et al. 2024).

"For a high-RAP test section, for example, we apply one of several rejuvenators on the market and various percentages of RAP content, and we either forget the exact details or we don't follow up on its condition," Lee said. "The idea with the database is [that] anybody who wants to know about recycled pavements and certain rejuvenators can go online and get that information."

For more on Williams' and Lee's WMA projects, refer to the Pavement Preservation chapter.

Innovations in Sustainability

Not only has the IHRB invested in recycled materials—it has also supported innovation in the use of sustainable materials and upcycled waste products for transportation purposes.

As ethanol production throughout the United States and in Iowa, the nation's leading corn producer (USDA 2024), nearly doubled from 2003 to 2006 and was anticipated to nearly double again within a decade (TR-557), researchers took an interest in making use of the industry's byproducts.

The IHRB and InTrans researchers first focused on uses for lignin, a plant-derived polymer and byproduct of wet-milled ethanol production (TR-557). Williams investigated the use of the material as an antioxidant in asphalt to improve its performance (TR-557), and Ceylan explored its use as a soil stabilizer (TR-582, TR-656), with both efforts finding some level of success.

TR-650 developed a bio-binder capable of replacing conventional asphalt in flexible pavements.

The way Ceylan sees it, the research was successful both in terms of sustainability and improved roadways but also in terms of the benefit to communities with biofuel plants.

"You have a lot of truck traffic carrying the biofuels or the raw materials, and now you're giving back to the local community by using the lignin products to improve pavement performance," Ceylan said.

Both researchers continued their efforts to utilize sustainable materials for pavement purposes but with different materials.

Williams continued down the path of using plant-based products to replace petroleum-based materials in asphalt production, starting with determining an ideal plant-based source. The first phase of the research, completed in 2010 (TR-594), tested the use of bio-oils derived from oakwood, switchgrass, and corn stover as binders. The second phase, completed in 2015 (TR-650), improved the performance of the bio-binders by incorporating used ground tire rubber.

TR-799 is investigating the usage of upcycled plastic waste materials as a base stabilizer on granular roads to reduce the effects of the freeze-thaw cycle in Iowa.

"[T]his technology can improve pavement performance with important economic and environmental savings," read the Phase II report (TR-650). "The developed bio-asphalt/asphalt blends using ground tire rubber have been shown to perform as well [as] or better than the traditional asphalt mixtures using ground tire rubber."

During the time that Williams was researching bio-based alternatives in asphalt production, there was also a global shortage in styrene-butadiene polymers (EMTSP 2008), a petroleum-derived material used throughout industry, including transportation.

"The research board had a call for high-risk but potentially high-payoff research projects, and so we said, you know, we think there's a pathway here for bio-based polymers," Williams recalled of the origins of the projects that developed soybean oil-derived polymers for use in asphalt (TR-639, TR-720).

This is perhaps an understatement of the success ultimately achieved from that series of projects, which have now resulted in a $5.3 million bio-polymer facility at Iowa State's BioCentury Research Farm and a spin-off company founded by the researchers, including Iowa State Professor of Chemical Engineering Eric Cochran (ISU News Service 2015, 2022).

However, Williams is quick to note that the success of the project involved a number of people working collaboratively together.

"This success doesn't happen without the involvement of industry and soybean associations, and it doesn't happen without the involvement of the end customer, the local agencies and the Iowa DOT," Williams said.

Ceylan, meanwhile, has more recently returned to his roots in geo-materials and is currently investigating the use of upcycled plastic waste materials as a base stabilizer on granular roads (TR-799).

While the project is expected to wrap up in 2027, test sections constructed in Buchanan County have already had positive impacts. During a site visit in late 2024, when precipitation from a recent snowstorm had begun to melt, a test section with a geosynthetic base stabilizer was practically dry, but the surrounding granular roads were wet, some with standing water.

"The geosynthetics help to increase the strength and modulus. They act as a drainage layer. They act as a separation layer, so it's a fantastic story," Ceylan said. "We're taking 100% waste material, which is one of the biggest challenges in today's world, and turning it into a fantastic value-added engineered material."

Or put another way by Buchanan County Board of Supervisors Chair Clayton Ohrt, “This here is like a triple win,” citing the environmental benefits, infrastructure improvements, and potential economic opportunities in the county that could result from the research and improved roadways (InTrans 2023).

The IHRB research on granular roads over the past decade by InTrans researcher Jeramy Ashlock could also constitute a similar triple win. His work has included the “use of locally generated waste materials” as both a sustainable and more economical stabilization option (TR-747) and the use of recycled materials (e.g., TR-664, TR-685), particularly as virgin aggregates are becoming more scarce and more expensive (TR-664).

“Approximately 68,000 miles, or 60% of Iowa’s roadways, are aggregate surfaced. These roads are crucial to the state’s agriculture-based economy and require significant labor, natural resources, and portions of annual budgets for Iowa’s 99 counties to maintain,” Ashlock said. “The research that my group and our collaborators have performed on granular-surfaced roads over the past 10+ years has consistently sought more economical and effective solutions for improving the performance and longevity of such roads. From investigating various stabilization methods or developing new ones, like the clay slurry approach, to developing new methods for optimizing gradations, we aim to improve performance and reduce maintenance requirements for such roads.”

Ashlock also offered his appreciation to the board, the ICEA Service Bureau, and county engineer crews that have supported and guided the research over the years, including in-progress projects such as TR-817 and TR-823.

See the Low-Volume Roads chapter for more details about Ashlock’s granular road research.

Corn Yields in Winter

Recent innovative research on bio-based products has also turned to the use of corn-derived materials to develop a more sustainable deicer option than salt-based solutions.

However, before the IHRB sought bio-based solutions, it first had to understand the impact of using salt as a deicer, a product first used experimentally in the early 1950s (Iowa DOT 2008b). A series of projects in the late 2000s led by now-retired UI researcher Wilfrid Nixon investigated the effectiveness and impacts of salt-based deicers.

The first effort, completed in 2007 (TR-471), established a set of specification tests to help agencies select deicing products and ensure that they meet performance standards. The second project, completed in 2008 (TR-488), provided agencies with a method to determine the costs of using various mixtures of salt brine and calcium chloride brine. The final project, completed in 2009 (TR-472), sought to minimize the corrosion impacts of deicers on maintenance trucks.

However, the project found that “uncertainties on the performance in the field of corrosion inhibitors” meant that agencies should not select deicers “on the basis of their potential to reduce corrosion due to inhibitors” (TR-472).

The findings opened the door to opportunities for deicer alternatives.

An initial endeavor into agricultural-based deicing products, completed in 2010 and led by the CP Tech Center’s Peter Taylor and John Verkade, found promise in a mixture containing 80% glycerol and 20% sodium chloride (TR-581).

More recently, former North Dakota State University (NDSU) and current Arizona State University (ASU) researcher Ravi Yellavajjala has had success developing an innovative corn-based deicer that has “lower freezing point depression, enhanced ice melting capacity, and corrosion inhibition properties” (TR-754).

“We’re always looking to add new options to our toolbox of roadway treatments. Based on the lab testing results, corn-based deicers offer some interesting performance advantages that are worthy of continued research and testing,” said Craig Bargfrede, Iowa DOT Winter Operations Administrator (Iowa DOT 2021c).

IHRB executive secretary Vanessa Goetz noted that the potential of this new product goes beyond winter maintenance operations.

"The IHRB invested $40,000 initially to see how corn and soybean polyols can be used in reducing the need for salt, which showed that they can help reduce the freezing point of salt brine, making it more efficient," Goetz said. "And during that initial research project, they inadvertently stumbled upon the anti-corrosive properties of these corn polyols."

Because of the success of the initial investment, the IHRB funded another project led by Yellavajjala (TR-788) that focused more on the "stumbled-upon" properties for both deicing purposes and potentially other transportation applications.

"We found that these polyols also mitigate deicer corrosion in our subsequent tests," said Yellavajjala, who performed the work for TR-754 and TR-788 while at NDSU. "Just adding 1% by weight [of corn-based polyols] is sufficient to reduce deicer-induced corrosion in automobiles and bridges by more than 70%."

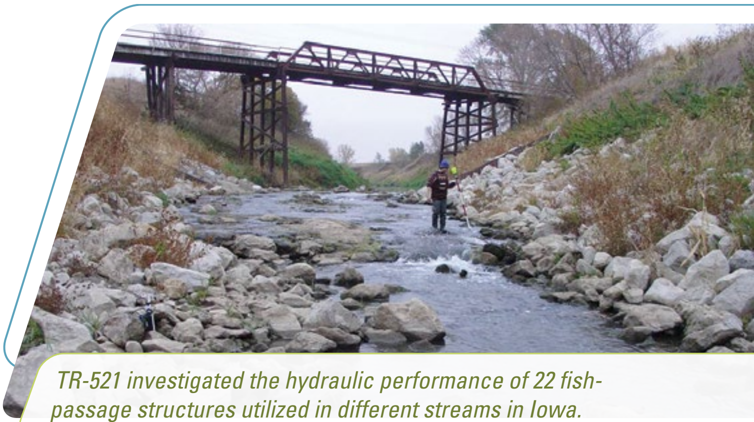
"This study provided winter maintenance professionals with practical solutions that can be put into practice immediately," read a 2024 impact brief on the project (Iowa DOT 2024i). "Future research could further explore the optimal application methods for coating the rebar, determine the coating's shelf life, and evaluate the products' effectiveness under real-world conditions."

Yellavajjala's current work on corn-based polyols is continuing to make improvements to the ice-melting capacity of the materials developed and tested in previous phases (TR-814).

"Our motto for this research is 'using local resources to tackle local problems'," he said.

Goetz said that this more recent research, like earlier lignin-based research, is also exploring whether the product could be used as a good dust suppressant for gravel roads or as a base stabilizer.

"So, who knows where the project will be 10 years from now?" she added.



TR-521 investigated the hydraulic performance of 22 fish-passage structures utilized in different streams in Iowa.

One answer to the potential impact of the deicer research, and all of the sustainability-focused IHRB projects during the past 25 years, was predicted by Williams in TR-557: "'Green pavements' could possibly have the same impact on the construction materials industry as ethanol has had on the energy sector."

Changes to the State of the Practice

Studies related to sustainability serve in the long-term as solutions that align current practices with national expectations. Their importance, as stressed by IHRB researchers, is immeasurable. An example of this is the IHRB-funded research bettering Iowa's wetlands (TR-500, TR-526) and fish-passage structures (TR-521), which has helped Iowans understand environmental considerations within the context of current trends in research and practice.

Additionally, Muste's research has gone on to aid state, county, and municipal engineers in the selection of the best management practices for preventing unwanted erosion and sedimentation at roadway construction sites during and after construction (TR-464, TR-485).

"These types of projects are rewarding because they facilitate access to robust technical solutions through interactive interfaces that are stripped by language barriers when posing questions about real problems on individual or community grounds," he added.

The move toward environment-based research entails exploring solutions to already existing problems but doing so in a way that "improves the long-term sustainability of the transportation network in Iowa," as Lee wrote in his TR-624 report on the development of quality standards for asphalt mixtures with high RAP contents.

"The goal is to create value for society," Williams said in regard to his own IHRB-funded research. "So, another goal would be to see our research go into practice."

Lee, who has worked with Williams on several IHRB-funded research projects over the past 25 years, has turned his focus to preservation and sustainability, which encompasses his work in TR-658. This work, building off of the Phase I study in TR-624, sought to further monitor and characterize the high-RAP mixtures that he and his team developed for testing.

Laboratory tests and field performance studies of asphalt mixtures with high RAP contents ultimately help pavement engineers design asphalt mixtures with optimum RAP contents and increase the use of RAP materials while enhancing the long-term performance of pavements in Iowa.

"We want to increase these kinds of practices and keep them at the forefront," he said. "Our goal is to increase the RAP contents [in Iowa pavements] and see how well they will perform over time."

To solve outstanding problems—from deteriorating roads to subpar deicing agents—IHRB research has been conducted with an eye toward adapting current practices and positioning them for future success.

"[Over the years] there have been some big shifts when it comes to sustainable practices," Williams said. "We have to be candid about the challenges, and sometimes it's just luck."

In TR-656, lignin-based BCPs were sprayed on a gravel road subgrade to gain insight into soil stabilization benefits.

"And sometimes it's about understanding what can give us a better advantage," Ceylan added regarding his own research with sustainable materials.

Ceylan's work on TR-582 and TR-656 evaluated the use of biofuel co-products (BCPs) for geo-material stabilization with the goal of providing a cost-effective and sustainable solution to strengthening transportation infrastructure systems on secondary roads.

"Successful implementation will enhance the state's leadership in contributing to the long-term sustainability of agricultural-based industries in Iowa," Ceylan wrote in his 2019 report for TR-656.

"Sustainability is so important, and so is good engineering," Ceylan reiterated regarding his IHRB-funded work on sustainable materials. "It forces us to think about performance and what kind of practices we are doing now that aren't sustainable in the long term."

The implementation of new standards in winter maintenance through sustainable deicing materials came to the forefront in 2007 with Nixon's work on noncorrosive deicing materials and corrosion reduction treatments for deicing salts (TR-471) and in 2008 with his work on calcium chloride versus sodium chloride as deicing chemicals (TR-488).

"The use of chemicals is a critical part of a proactive winter maintenance program. However, ensuring that the correct chemicals are used is a challenge," he wrote in his report for TR-488. "On the one hand, budgets are limited, and thus price of chemicals is a major concern. On the other, performance of chemicals, especially at lower pavement temperatures, is not always assured."

It is through IHRB research that efforts have been made to lessen the impact of the state's winter maintenance programs and provide more effective and sustainable treatments for local agencies.

Taylor and Verkade followed this theme to study an agricultural-based deicing product for the IHRB in 2010 (TR-581), while Yellavajjala later assessed a corn-based deicer product in a series of IHRB projects starting in 2020 (TR-754, TR-788, TR-814).

In sum, options are necessary to determine the right course of action for our transportation system, and IHRB research has consistently provided the outlet for assessing crucial alternatives. When it comes to sustainable solutions that could help solve both state and national deterioration and durability problems, as Ceylan said, "IHRB research keeps Iowa on the map."

CHAPTER 9

INNOVATIVE PROJECTS

IHRB contributions led to some national bridge innovations, like the UHPC I-girder in Wapello County, the first instance of UHPC use on a bridge deck overlay in the United States.

Importance and Stakes

Innovation, by definition, means introducing new techniques or establishing successful ideas to create new value. In the realm of transportation, that often manifests through applied research with the goal of improving lives.

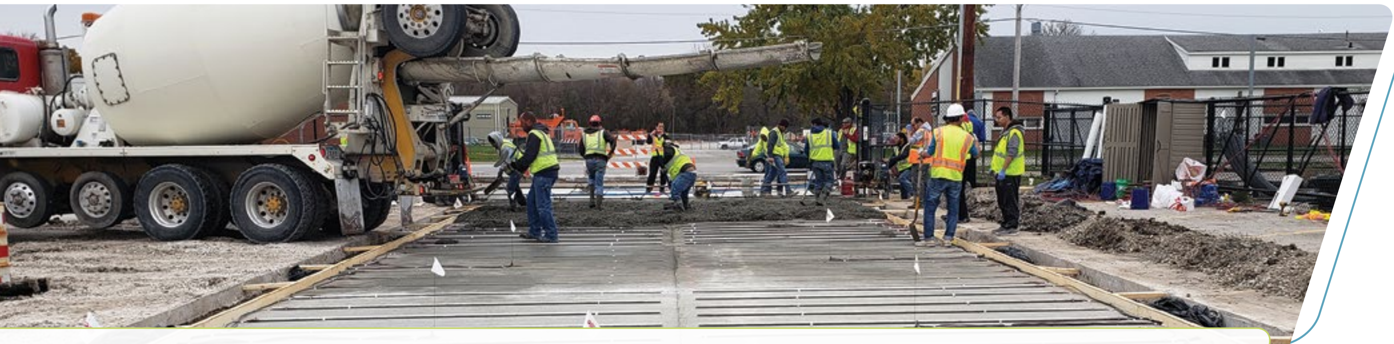
From its first meeting in 1950, the IHRB has undertaken innovative work on projects designed to improve the efficiency and safety of Iowa's road systems. Many of those projects have received national attention, and many have resulted in methods that were developed into standard practices (Isenberg 1999).

Fast-forwarding to today, the IHRB continues to fund value-driven projects, but the emphasis on innovation is even stronger. This has been the case since 2002, when the board was incorporated into the Iowa DOT's newly established Research and Technology Bureau.

This change presented an opportunity for the IHRB to build innovation into its four methods for identifying projects: (1) creation of a strategic program using an open and collaborative process, (2) consideration of projects of merit (not previously identified), (3) continuation of previous projects, and (4) consideration of pilot projects for novel or innovative ideas.

The IHRB wanted to encourage innovation and longer-range technological advances in the field of transportation. And to support this aim, the board encouraged individuals or groups to submit proposals requesting seed funding for projects that were innovative or explored longer-range advances in various aspects of highway transportation.

According to Vanessa Goetz, the current State Research Program Manager at the Iowa DOT's Research & Analytics Bureau, a total of $200,000 to $250,000 is set aside for innovative projects out of an annual operating budget of $3M to $3.5M, with $40,000 to $60,000 of seed funding typically allotted for each innovative project.



TR-724 demonstrated a full-scale field implementation of an ECON heated pavement system as an alternative to conventional snow removal operations.

Defined thematically as "high-risk, high-reward" in nature, these projects are often basic research that leads to new fundamental insights that—in time—can result in substantive advances to the design, construction, instrumentation and monitoring, modeling, or management of highway-related projects.

"These projects may be big risk, but if they are proven, they could provide a big reward," Goetz echoed in her description of the program. "And they could potentially have a big impact on the way we do business in the transportation industry."

From the use of eggshell waste as a bio-cement material (TR-810), scientific innovations in microsurfacing and slurry seal mixture design (TR-755), and self-heating electrically conductive concrete (ECON) (TR-724) to the development of self-cleaning box culverts (TR-545, TR-619, TR-719, TR-596) and innovative solutions for slope stability reinforcement in Iowa soils (TR-489), there have been numerous examples in recent decades that show the impact of innovative research.

"Many transportation stakeholders benefit from our innovative projects—from our local agencies to national and international partners," Goetz added. "Typical applied research projects may have more immediate results, but participating in innovative research continues to benefit transportation decades after that initial investment."

The goal of supporting innovative projects is in line with the board's vision: "Improve lives through innovative transportation research."

Through the years, these projects have addressed the important and fundamental issues facing transportation in Iowa. And while they were not necessarily expected to lead to results of immediate use in highway engineering, they did produce results holding promise for further useful development.

For example, TR-759, led by former InTrans researcher John Shaw, looked at "un-ticketing," a program for rewarding and reinforcing safe driving behavior. The results were a promising look into what could be accomplished in Iowa's communities. Shaw's team also produced a guidebook that could be used to help law enforcement agencies and other community leaders implement similar projects.

"There is no easy measurement of success," Goetz said. "[The board] is taking a chance by allowing innovation to flourish and by having an open mind and a willingness to invest."

The IHRB also serves as the STIC for Iowa as part of a federal incentive program, a role that supports the costs of standardizing innovative practices. Through this program, the FHWA currently awards up to $125,000 to the state each year. Goetz notes that the IHRB, through its role as Iowa's STIC, provides the 20% match required by the FHWA to remove the financial burden for stakeholders seeking to implement innovations utilizing these funds.

"The business of the board prior to the STIC was all state funded, so there was no relationship between the highway research board program and our federal partners. But with the addition of the STIC, we now have a great relationship with the FHWA, and it has allowed us to reap the benefits of collaboration by utilizing the funding sources available."

Because Iowa's STIC is responsible for AID grants from the U.S. DOT, approximately $7M worth of innovation funding has been applied for and received since 2014, commented Goetz.

"I think research and collaboration can help everyone get where they need to go," said Sandra Larson, former Iowa DOT Research and Technology Bureau director, regarding her work spearheading the research program during her tenure. "Collaboration is the glue that holds it all together. It takes everyone looking for new ideas."

Project Highlights

Although the seed funding for innovative projects is small, the high stakes involved mean that it may take years of research—and multiple phases with increased funding—to fully appreciate the impact of the initial project.

For example, while seed investments may only result in lessons learned on what does and doesn't work, there's always the chance that full funding of related innovative research (e.g., TR-639, TR-720) could result in something like a $5.3M pilot plant making bio-based polymers 12 years after the initial project (ISU News Service 2015).

"The IHRB participated from the beginning [of that innovative project] with seed funding to demonstrate that using bio-sources could create an alternative to petroleum-based asphalt," Goetz said. "All of that research led by R. Christopher Williams culminated in Iowa State having a biorefinery plant and a whole program around the research."

A processing facility located at Iowa State's BioCentury Research Farm produces bio-polymers from soybean oil.

InTrans Director Shauna Hallmark added, "It isn't just the seed funding. It's the board's whole process of investing, in being willing to try something innovative."

Like Williams' bio-based polymer work, the corn-based deicer projects described in the Sustainability chapter (TR-754, TR-788) started out as an innovative project idea funded by the board for its potential. And from the initial seed funding, the product has demonstrated its potential as both a sustainable deicer and an innovative anti-corrosive agent and dust suppressant. The results are expected to be patented by ASU.

"The idea for developing a new deicer emerged after noticing cracks and rust spots forming on my two-year-old home's driveway," said ASU researcher Ravi Yellavajjala, who led the projects. "We focused on keeping costs low, ensuring wide availability, and [ensuring] compatibility with standard deicing equipment."

He added, "Corn-derived polyols fit this bill and have improved ice melting capability significantly."

Sustainable Pavements

The IHRB continues to devote funding to innovative projects focused on the use of additional sustainable materials and recycled industrial byproducts, even when the full impacts have not yet been seen.

Research by AMPP Director R. Christopher Williams has had major demonstrable results, but bio-based asphalt polymer is far from the only area of innovative asphalt-related research that the board has funded.

While with the AMPP, then InTrans researcher Ashley Buss investigated innovations in asphalt emulsions that also led to significant findings.

One of the research projects that she led as PI explored the use of asphalt emulsions in sustainable pavement construction, preservation, and rehabilitation (TR-708C), and another project (TR-755) built off of those findings to look into pavement preservation treatments that utilize quick-setting asphalt emulsions, including microsurfacing and slurry seal.

"When implemented successfully, microsurfacing and slurry seals can be cost-effective treatments for increasing pavement life. In addition, their rapid curing allows a road to be opened to traffic in as little as one hour after treatment application," read a summary of the 2019 project's benefits (TR-755).

In the area of subgrade soils, another InTrans researcher, Halil Ceylan, began investigating the use of eggshell waste as a soil stabilizer in 2022. The Iowa Egg Council estimates that about 70% of the 16 billion eggs produced in Iowa each year are in liquid form, meaning around 11 billion eggshells end up in landfills that could potentially be used elsewhere (TR-810).

"Iowa is the number one state in the country in terms of egg production. If our state isn't going to use the leftover eggshells for geomaterial stabilization, who else is?" Ceylan said. "We specifically picked the topic because it's more likely to be cost-effective and implementable at a large scale with us being in such close proximity to the eggshell waste."

This innovative project found that eggshell powder, consisting of nearly 95% calcium carbonate, presents an environmentally friendly opportunity to repurpose agricultural waste into beneficial construction materials that improve soil engineering properties. The project is expected to continue with a large-scale evaluation in a second phase.

Ceylan is also leading two other innovative projects, related to heated pavements using ECON technology, that have the potential to reduce the use of environmentally unfriendly deicing chemicals, reduce snowplow miles, and improve pedestrian safety. Though the initial funding for this research came from the Federal Aviation Administration, which was interested in using the technology for airport pavements (TR-724), the IHRB has continued to investigate its use in pedestrian-heavy areas such as parking lots and bus stops (TR-789).

A bus stop in Iowa City was chosen to serve as the test site for this innovative ECON technology (TR-789). Iowa City Public Works Director Ron Knoche, who is also an IHRB member, said the selection of that particular site was simply a case of "right place, right time," in that he happened to mention an upcoming bus stop project with Ceylan while Ceylan was looking for a place to demonstrate the ECON technology.

While the project came together serendipitously, it hasn't been without its share of difficulty. "It's been pretty challenging. Because the project is so innovative and new, there's no electrical code on its use, and it has required a variance," Knoche said. "But I think we're at the point now where the technology will be included in the next National Electrical Code update, which will allow for implementation across the country."

Through the efforts of the IHRB, in collaboration with the Iowa DOT, the 2026 National Electrical Code is anticipated to include a new section to accommodate electrically conductive pavements.

Bridge Innovations

Thanks in large part to the IHRB, Iowa has long been a national leader in bridge innovations.

"Some of the national innovations regarding bridges started in Iowa. The Iowa DOT's bridge bureau and the IHRB were a big part of that," Larson said. "And it continues and thrives today."

Early interest in, and support for, UHPC led Iowa to have the first UHPC I-girder (Wapello County), the first precast PI girder (Buchanan County), and the first UHPC overlay (Buchanan County) in the United States (Larson 2023, TR-683).

"UHPC has tremendous properties with respect to strength and durability," said Jim Nelson, director of the Bridges and Structures Bureau. "Finding the best uses for it can help us reduce the long-term costs of our bridge infrastructure. UHPC is a material the Iowa DOT is very interested in, and this will be an area of research that will continue to be of interest."

A recent example of this innovative vein of research is a project led by Iowa State researcher Jay Shen that characterized the material properties of geopolymer-based UHPC (TR-708A). The goal was to determine the new material's ability to replace traditional portland cement in UHPC mixes.

The results suggested that the new material can be made using locally available concrete materials and that, with further development, geopolymer-based UHPC has the "potential to be a more cost-effective and environmentally friendly option" for future bridge construction and repair.

Beyond UHPC, other recent state-of-the-art bridge research has explored an innovative box beam connection (TR-743), ultrasound techniques to evaluate and preserve structures (TR-757), and the use of cold gas dynamic spraying to repair steel structures (TR-758).

The latter two projects are still in the "potential" phase, but the former project, led by InTrans researcher Brent Phares, included a field demonstration in Washington County to exhibit the new design and evaluate its performance in the short and long term.

Washington County Engineer Jacob Thorius said the box beam bridge fit several of the county's needs in terms of providing a long-lasting structure that could be built quickly to limit closure time when replacing an existing bridge.

"The box beams allowed us to speed up construction by having the typical field cure time happen ahead of time at the pre-caster's yard instead of on site during the road closure. Since the beams also served as the deck/base of the road, we were able to swing them in place shortly after the old bridge was removed, tie them together in a couple of days, and then rock the bridge surface, all of which helped reduce the impact to the public," Thorius said.

TR-743 demonstrated the field implementation of an innovative longitudinal joint design for box girder bridges.

He added, "Hopefully, other pre-casters can find ways to build these structures more efficiently, and thus lower their cost, so they can be used as an alternative for replacing bridges quickly."

By the time the project wrapped in 2023, the bridge had been in service for two years, and the innovative joint design—which includes a unique rebar configuration and Type K cement—remained in good condition. The final report offers other counties a "how-to" for constructing box girder bridges featuring the new joint design (TR-743).

Collaboration Is the Key to Innovation

Because of the lessons that the IHRB learned from its own efforts to cohere (e.g., the adoption of a Business Plan in 2001), the board has spent decades understanding the importance of collaboration. Just as the board came to understand that a project that benefits state roads may have the same or similar application on city streets and county highways, it found that by pooling resources, perhaps even more benefits could be leveraged.

TR-759 explored opportunities to reward and reinforce safe driving behavior.

TR-708A studied the material properties of a cost-effective and environmentally-friendly geopolymer-based UHPC.

One example noted by Goetz and Hallmark is the collaboration that occurred as part of a University Transportation Center (UTC) grant led by InTrans between 2013 and 2019. Under this arrangement, UTC and IHRB funds were combined to leverage additional dollars for four innovative "high-risk, high-reward" projects (TR-708).

As the summary report for the UTC grant notes, "Thinking outside the box on how to fund innovative solutions to transportation needs was an innovation in itself" (InTrans 2019). By matching the IHRB's investment, the UTC effectively doubled the available dollars for the four projects funded under the unique collaboration.

"I thought it was interesting that they were willing to invest in something that might not have any payoff, but they were willing to take the risk and show they're supportive of innovative projects," said Hallmark, who led the UTC grant. "They want to push the boundary when they can, but they're also good stewards of the funds."

In addition to the previously mentioned projects that were part of this collaboration, which studied geopolymer-based UHPC material properties (TR-708A) and explored the use of asphalt emulsions in sustainable pavements (TR-708C), a third project focused on advances in pavement infrastructure (InTrans 2019).

That project (TR-708B) studied the advantages, challenges, and feasibility of using a hybrid, semi-flexible, semi-rigid concrete—called a casting cement asphalt mixture (CCAM)—for highway pavements, bridge decks, and overlays. The mixture had shown promise in warmer European and Asian climates but had not been previously studied in the United States.

The fourth project funded through the UTC and IHRB collaboration, led by InTrans researcher Jing Dong-O'Brien, looked presciently into our more tech-focused future by investigating the energy efficiency of connected and autonomous vehicles (CAVs) in a mixed fleet (TR-708D).

"This study developed special cruise control systems to make CAVs more energy-efficient," Dong-O'Brien said. "For gasoline CAVs, the cruise control system helps them slow down and speed up smoothly to save fuel. For electric CAVs, the cruise control system helps maintain high regenerative braking efficiency to recover more energy from braking."

Another innovative IHRB project that involved some outside-the-box thinking and collaboration of a different type had Shaw connect with law enforcement agencies in an effort to improve safety. Though collaboration with law enforcement on transportation safety efforts is not unheard of, the "un-ticketing" project was unique (TR-759).

This "upside-down approach to speed compliance" required the buy-in of local law enforcement agencies, whose officers would need to not only ticket violators but also expend extra effort taking down information on compliant drivers during routine traffic patrols.

Those drivers were entered into one of six drawings—one drawing every two weeks during the study period—and the winners were mailed prizes for their good driving behavior.

"I think most of us respond positively to being encouraged, and I think sometimes we spend too much [time] worrying about the people that are doing the bad things and not worrying about the great people that are doing all the positive things on the roadway," Cerro Gordo County Sheriff Kevin Pals told the local Mason City television news station (KIMT3 2023) about the collaborative project.

Ultimately, the contest produced inconclusive changes in traffic speeds but increased positive attitudes toward road safety.

"The un-ticketing project was probably one of the more unique things that the board has tried," Hallmark said. "I think it's very cool that they were willing to fund that effort and see what would happen."

Changes to the State of the Practice

"To move transportation forward requires us to continually evaluate our practices and make changes to improve the way we do business," said Peggi Knight, director of the Iowa DOT's Research and Analytics Bureau. "By focusing our research in areas like safety, mobility, innovation, and durability, we can ensure a more robust and long-lasting transportation system. And the IHRB's focus on innovation has led the way by instilling a willingness to fund basic research of ideas that have yet to be explored."

Making changes to transportation policies and practices is a slow road, but, according to both Larson and Goetz, it is often the early work—the concepts and ideas—that kickstarts change and improvement.

That's why innovative projects like the previously mentioned TR-758 are important. Behrouz Shafei, an InTrans researcher, found in 2021 that cold spraying could help solve an issue faced by DOTs across the nation—maintaining an inventory of corroding steel structures.

The research showed the potential for cold spraying to improve the repair and retrofit of steel structures, especially in bridges, by providing a durable treatment that can be applied simply and quickly using a portable device.

"The way to really grow the knowledge and grow the applications for these innovations is through greater collaboration—even beyond Iowa's borders," Larson said. "The Iowa DOT has been doing that for a really long time and continues to this day to be a real leader nationally in sharing information and looking at the challenges and seeking solutions."

Speaking on the initial success of innovative projects over the past 25 years, Goetz added, "[The board] sees the benefits to innovative work."

These benefits were on display in Ceylan's two innovative projects on heated pavements. His 2021 research on an ECON heated pavement system (TR-724) has since transformed the state of the practice regarding the inherent electrical resistance of concrete, and he is currently exploring the use of the same innovative technology at a bus stop in Iowa City as part of another project (TR-789).

The latter project is still in progress, but the ECON technology demonstrated in the former research has already been recognized by AASHTO as a high-value research project and focus technology (InTrans 2022).

"The new ECON heated pavement technology represents a significant advancement in our approach to maintaining safe and accessible transportation infrastructure," said Knight. "By preventing snow and ice accumulation, it could potentially eliminate the use of traditional deicing methods in targeted areas. This technology could be implemented in a range of applications, from airports and high-traffic roadways to areas where pedestrian slips and falls from ice are a hazard.

The ECON projects have also required us to think outside the civil engineering box and engage with experts like Underwriters Laboratory [now UL Solutions] and the people working on the National Electrical Code to develop new code language to accommodate this technology."

For each of the four projects funded under TR-708 (TR-708A, TR-708B, TR-708C, and TR-708D), the developed innovation was similarly responsive to the needs of the transportation community. From exploring the properties of hybrid concrete (TR-708B) to estimating the energy efficiency of CAVs in a mixed fleet (TR-708D), the research benefited the state of the practice, even if only in small ways at first.

For example, Buss's project on asphalt emulsions (TR-708C) served as a starting point for multiple tests and trials that can be run on specially engineered emulsions. And the models created under Dong-O'Brien's CAV project (TR-708D) proved the potential benefits of a mixed traffic stream and led to valuable findings on energy consumption.

Additionally, Shen's research on a geopolymer-based UHPC was only the beginning of further explorations of the material in future bridge projects (TR-708A).

But, Goetz noted, "Even the projects that didn't go anywhere, there were lessons learned, and there is value in that."

"Sometimes new ideas don't pan out, but there is always opportunity in failure," added Knight. "But when new ideas work, they can be transformative."

Though the hope for any project is that it will seed future research, the knowledge base continues to grow regardless of the outcome.

"The Iowa DOT has been a national leader in innovation, and our Iowa Highway Research Board program has funded research that then went on to change the way the nation builds and manages its transportation system," said Knight.

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ABBREVIATIONS

3D	Three-dimensional
AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ABC	Accelerated bridge construction
AC	Asphalt concrete
AI	Artificial intelligence
AMPP	Asphalt Materials and Pavements Program
APT	Air permeameter test
APWA	American Public Works Association
BCP	Biofuel co-product
BEC	Bridge Engineering Center
BECAS	Bridge Engineering Center Assessment Software
BMP	Best management practice
BST	Bituminous surface treatment
CAV	Connected and autonomous vehicle
CCAM	Casting cement asphalt mixture
CIR	Cold in-place recycling
CP Tech Center	National Concrete Pavement Technology Center
CTRE	Center for Transportation Research and Education
DEM	Digital elevation model
DOT	Department of transportation
ECON	Electrically conductive concrete
EDC	Every Day Counts
E-L-T	Equipment Life-Cycle Cost Analysis Tool
ERL	Electronic reference library
FHWA	Federal Highway Administration
FRC	Fiber-reinforced concrete
GIS	Geographical information system

GPS	Global Positioning System
GRAMS	Granular Roads Asset Management System
HMA	Hot-mix asphalt
HPC	High-performance concrete
IBRD	Innovative Bridge Research and Deployment
IC	Internal curing
ICEA	Iowa County Engineers Association
ICPA	Iowa Concrete Paving Association
IHRB	Iowa Highway Research Board
IIHR	Iowa Institute of Hydraulic Research
I.M.	Instructional memorandum
InTrans	Institute for Transportation
Iowa PWSB	Iowa Public Works Service Bureau
Iowa State	Iowa State University
IPAT	Iowa Pavement Analysis Techniques
IPCR	Implementation Project Closure Report
IRI	International roughness index
ITE	Institute of Transportation Engineers
JPCP	Jointed plain concrete pavement
LCCA	Life-cycle cost analysis
LRFD	Load and Resistance Factor Design
LTAP	Local Technical Assistance Program
LVR	Low-volume road
LWFA	Lightweight fine aggregate
MEMS	Microelectromechanical sensors and systems
MEPDG	Mechanistic-Empirical Pavement Design Guide
MUTCD	Manual on Uniform Traffic Control Devices for Streets and Highways
NAPA	National Asphalt Pavement Association

NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
NCWTS	National Center for Wood Transportation Structures
NHS	National Highway System
NPDES	National Pollutant Discharge Elimination System
OODAS	Object-oriented design and specification
PCC	Portland cement concrete
PCI	Pavement condition index
PDE	Pavement Drainage Estimator
PI	Principal investigator
PMIS	Pavement Management Information System
PROSPER	Program for Sustainable Pavement Engineering and Research
RAM	Recycled asphalt material
RCB	Reinforced concrete box
RFP	Request for proposal
RISAT	Road Infrastructure-Superload Analysis Tool
SHM	Structural health monitoring
SMV	Slow-moving vehicle
SP&R	State Planning and Research
STIC	Statewide Transportation Innovation Council
SUDAS	Statewide Urban Design and Specifications
TPMS	Transportation Program Management System
TRB	Transportation Research Board
UHPC	Ultra-high performance concrete
UI	University of Iowa
UNI	University of Northern Iowa
UPV	Ultrasonic pulse velocity
US	United States
USGS	U.S. Geological Survey
UTC	University Transportation Center
WMA	Warm-mix asphalt
WSD	Working Stress Design

APPENDIX A

CHAIR AND VICE CHAIR OF THE IOWA HIGHWAY RESEARCH BOARD: 2001–2024

Year	Chair	Vice Chair
2001	John Adam	—
2002	Wade Weiss	Lowell Greimann
2003	Rob Ettema	Greg Parker
2004	Greg Parker	Larry Jesse
2005	Larry Jesse	Jon Ites
2006	Jon Ites	Rob Ettema
2007	James Alleman	Jeff Krist
2008	Jeff Krist	Jim Berger
2009	Jim Berger	Brian Moore
2010	Jay Waddingham	Doug Schnoebelen
2011	Doug Schnoebelen	John Joiner
2012	Ron Knoche	Ahmad Abu-Hawash
2013	Ahmad Abu-Hawash	Kevin Mayberry
2014	Kevin Mayberry	Terry Wipf
2015	Terry Wipf	Sarah Okerlund
2016	Sarah Okerlund	Ahmad Abu-Hawash
2017	Ahmad Abu-Hawash	Wade Weiss
2018	Wade Weiss	P. Hanley
2019	Allen Bradley	Ronald Knoche
2020	Ronald Knoche	Dave Claman
2021	Dave Claman	Andrew McGuire
2022	Andrew McGuire	David Sanders
2023	David Sanders	Rudy Koester
2024	Rudy Koester	James Hauber

APPENDIX B

IOWA HIGHWAY RESEARCH PROJECTS: 1999–2024

Dates indicate the years in which the projects were initiated.

1999 (since July)

- 440. Field and Laboratory Evaluation of Precast Concrete Bridges
- 441. IA Reference Manual for Traffic Control Devices and Pavement Markings

2000

- 140. (140A) Collection and Analysis of Stream Flow Data
- 401. Embankment Quality - Phase III
- 442. Systematic Identification of High Crash Locations
- 443. Evaluation of Rammed Aggregate Piers for Highway Applications in Iowa Soils
- 444. Demonstration Project Using Railroad Flatcars for Low-Volume Road Bridges
- 445. Development of Bridge Load Testing Process for Load Evaluation
- 446. Technology Transfer of As Built and Preliminary Surveys Using GPS, Soft Photogrammetry, and Video Logging
- 447. A Computer Program for the Hydraulic Design of Culverts
- 448. Foamed Asphalt Technology Workshop and Demonstration

2001

- 394. Transportation Program Management System - Phase IV
- 449. Determination and Evaluation of Alternative Methods for Managing and Controlling Highway Related Dust
- 450. Identification of Laboratory Techniques to Optimize Superpave HMA Surface Friction Characteristics
- 451. Investigation into Improved Pavement Curing Materials and Techniques - Phase I & II
- 452. Alternative Solutions to Meet the Service Needs of Low-Volume Bridges in Iowa
- 453. Low Water Stream Crossings in Iowa
- 454. Durable, Cost Effective Pavement Marking Materials - Phase I
- 455. Handbook of Simplified Practice for Traffic Studies
- 456. Measuring Main-Channel Slopes for Major Rivers in Iowa
- 457. Development of a Manual Crack Quantification and an Automated Crack Measurement
- 458. Field Testing of Abrasive Deliver Systems in Winter Maintenance
- 459. Reuse of Lime Sludge from Water Softening
- 460. Living Snow Fences
- 461. Fly Ash Soil Stabilization of Non-Uniform Subgrade Soils
- 462. Tree and Brush Control for County Road Right-of-Way
- 463. Field Performance Study of Past Iowa Pavement Research: A Look Back
- 464. Erosion Control for Highway Applications - A Critical Review of Published Literature
- 466. Evaluation of Unbonded Ultrathin Whitetopping of Brick Streets
- 467. Investigation of the Modified Beam-in-Slab Bridge System
- 468. Technology Transfer Program for the Iowa Highway Research Board (IHRB)

2002

- 140. (140B) Collection and Analysis of Stream Flow Data
- 469. Reduction of Concrete Deterioration by Ettringite Using Crystal Growth Inhibition Techniques - Part II - Field Eval of Inhibitor Effectiveness
- 470. Development of a Method to Determine Pavement Damage Due to Detours and Haul Roads
- 471. Evaluation of Non-Corrosive Deicing Materials and Corrosion Reducing Treatments for Deicing Salts
- 472. Investigation of Materials for the Reduction and Prevention of Corrosion on Highway Maintenance Equipment
- 473. Rehabilitation of Concrete Pavements Utilizing Rubblization and Crack and Seat Methods
- 474. Development of a Mix Design Process for Cold-In-Place Rehabilitation Using Foamed Asphalt
- 475. Synthesis of Best Practices for Increasing Protection and Visibility of Highway Maintenance Vehicles

- 476. PCVAL: A Computer Program for Valley Stage-Discharge Curves and Bridge Backwater Calculations
- 477. Total Cost of Transportation Analysis - Phase II (HR-388 - Phase I)
- 478. Evaluation of Composite Pavement Unbonded Overlays - Phase 3 (Installation and Maintenance of Weigh-In-Motion Detection System on Iowa Hwy 13 in Delaware Co.)
- 479. Investigation into Improved Pavement Curing Materials and Techniques - Part II (Phase III)
- 480. Investigation of the Long-Term Effects of Concentrated Salt Solutions on Portland Cement Concrete
- 481. Identification of the Best Practices for the Design, Construction, and Repair of Bridge Approach Sections
- 482. Determination of the Optimum Base Characteristics for Pavements
- 483. Evaluation of Hot-Mix Asphalt Moisture Sensitivity Using the Nottingham Asphalt Test Equipment
- 484. Materials and Mix Optimization Procedures for PCC Pavements
- 485. Erosion Control for Highway Applications - Phase II: Development and Implementation of a Web-Based Expert System for Erosion and Sediment Control Measures
- 486. Development of Abutment Design Standards for Local Bridge Designs
- 487. Development of Object-Oriented Specifications for IADOT and Urban Standards
- 490. Stringless Portland Cement Concrete Paving

2003

- 488. Economics of Using Calcium Chloride vs. Sodium Chloride for Deicing/Anti-icing
- 489. Innovative Solutions for Slope Stability Reinforcement and Characterization in Iowa Soils
- 491. Development of Winter Performance Measures for Highway Winter Maintenance Operations
- 492. Embankment Quality Phase IV - Application to Unsuitable Soils
- 493. Performance Evaluation of Steel Bridges - Phase II
- 494. Statistical Analysis of Highway Needs Condition Data: Manual vs. Automated
- 495. Field Evaluation of Compaction Monitoring Technology
- 497. Manual of Iowa Drainage Law
- 498. Field Testing of Railroad Flat Car Bridges
- 499. Effectiveness of Electrochemical Chloride Extraction for the Iowa Avenue Pedestrian Bridge
- 500. Evaluation of the Compensatory Wetland Mitigation Program in Iowa
- 502. Evaluation of Long-Term Field Performance of Cold In-Place Recycled Roads
- 503. Utility Cut Repair Techniques - Investigation of Improved Utility Cut Repair Techniques to Reduce Settlement in Repaired Areas
- 504. Extensions to the Iowa Culvert Hydraulics Software - The Design of Energy Dissipators
- 505. Improving PCC Mix Consistency & Production by Mixing Improvements
- 506. Determination and Evaluation of Alternate Methods for Managing and Controlling Highway-Related Dust, Phase II - Demonstration Project
- 507. Thin Maintenance Surfaces Phase III - Municipal Streets and Low-Volume Rural Roads
- 508. Design Guide and Construction Specifications for NPDES Site Runoff Control
- 509. AASHTO 2002 Pavement Design Guide Implementation Plan - Phases I and II

2004

- 140. (140C) Collection and Analysis of Stream Flow Data
- 474. Validation of the Mix Design Process for Cold In-Place Rehabilitation Using Foamed Asphalt
- 496. Development of Standard Plans for the Design of Single Span Pretensioned, Prestressed Concrete Beam Bridges with Concrete Abutments
- 501. Optimization and Management of Materials in Earthwork Construction
- 510. Laboratory Study of Structural Behavior of Alternative Dowel Bars
- 511. Design and Construction Procedures for Concrete Overlay and Widening of Existing Pavements
- 512. Measuring Pavement Profile at the Slipform Paver
- 513. Decision Support Model for Assessing Archaeological Survey Needs for Bridge Replacement Projects in Iowa
- 514. Development of a Manual of Practice for Roadway Maintenance Workers
- 515. A Guide for Monitoring and Protecting Bridge Waterways Against Scour
- 516. Measurement of Seasonal Changes and Spatial Variation in Pavement Subgrade Support Properties - A Link to Pavement Performance
- 517. Guidelines for Safety Treatment of Roadside Culverts
- 518. Monitoring Wind-Induced Vibrations/Stresses in a High Mast Lighting Tower
- 519. Developing Flood-Frequency Discharge Estimation Methods for Small Drainage Basins in Iowa

- 520. Evaluation of Dowel Bar Retrofits for Local Road Pavements
- 521. Field Investigation of Hydraulic Structures Facilitating Fish Abundance & Passage through Bridges in Western Iowa Streams
- 522. Investigation of Steel Stringer Bridges: Substructures and Superstructures
- 524. Review of Inconsistencies Between SUDAS and Iowa DOT Specifications
- 525. Design Guide for Improved Quality of Roadway Subgrades and Subbases
- 526. Feasibility of Cooperative Development of Wetland Mitigation Projects
- 527. Guidelines for Removal of Traffic Control Devices in Rural Areas

2005

- 140. (140D) Collection and Analysis of Stream Flow Data
- 528. Development of a New Process for Determining Design Year Traffic Demands
- 529. Design and Evaluation of a Single Span Bridge Using Ultra-High Performance Concrete
- 530. Integral Bridge Abutment-to-Approach Slab Connection
- 531. Effective Shoulder Design and Maintenance
- 532. Evaluation of Transverse Joint Forming Methods in PCC Pavement
- 533. Evaluation of Design Flood Frequency Methods for Iowa Streams
- 534. Design Procedures and Field Monitoring of Submerged Barbs for Streambank Protection
- 535. Reuse of Lime Sludge from Water Softening and Coal Combustion Byproducts
- 536. Implementation of the Water Quality Control BMPs & Design & Specifications Manuals in the Iowa Stormwater Runoff Control Interactive Manual
- 537. Field Experiments of Current Concrete Pavement Surface Characteristics Practices: Iowa Data Collection and Analysis
- 538. Using Scanning Lasers for Real-Time Pavement Thickness Measurement
- 539. Instrumentation and Monitoring of Precast, Post-Tensioned Bridge Approach Pavement
- 540. Developing Guidance for Use of Lighting on Rural and Urban Roadways in Iowa
- 541. The Effects of Headcut and Knickpoint Propagation on Bridges in Iowa
- 542. Development of Continuous Concrete Slab Bridge Standards
- 543. Development of Three Span Prestressed Concrete Beam Bridge Standards
- 546. Revision to the SUDAS Traffic Signal Design Guide
- 547. Investigation of Electromagnetic Gauges for Determination of In-Place HMA Density
- 548. Investigation of the Impact of Rural Development on Secondary Road Systems
- 549. Roadway Design Standards for Rural and Suburban Subdivisions
- 550. Performance Evaluation of Rubblized Pavements in Iowa

2006

- 140. (140E) Collection and Analysis of Streamflow Data
- 523. Appropriate Traffic Calming Techniques for Small Iowa Communities
- 545. Development of Self-Cleaning Box Culvert Designs
- 551. Local Agency Pavement Marking Plan
- 552. Field Evaluation of Timber Preservation Treatments for Iowa Highway Applications
- 553. Examination of Curing Criteria for Cold In-Place Recycling
- 554. Performance & Evaluation of Concrete Pavement Granular Subbase
- 555. Evaluation of Hot-Mix Asphalt Moisture Sensitivity Using the Nottingham Asphalt Test Equipment
- 556. Feasibility Investigation of Segmentally Precast Bridge Piers for Accelerated Construction
- 557. Evaluation of Lignin Derived from Agricultural Co-Products as an Antioxidant in Asphalt
- 558. Design and Performance Verification of Ultra-High Performance Concrete Piles for Deep Foundations
- 559. Improved Method for Determining Wind Loads on Highway Sign and Traffic Signal Structures
- 560. Clear Zone - A Synthesis of Practice and Benefits of Meeting the Ten-Foot Clear Zone Goal on Urban Streets
- 561. Precast Concrete Elements for Accelerated Bridge Construction
- 562. Monitoring Wind-Induced Vibrations/Stresses in a High Mast Lighting Tower
- 563. The Effects of Implements of Husbandry Farm Equipment on Pavement Performance
- 564. Adding Scour Estimation to the Iowa Bridge Backwater Software
- 565. Implementation of Recommendations into SUDAS Specifications (Phase II of TR-524)
- 566. Investigation of Utility Cut Repair Techniques to Reduce Settlement in Repair Areas
- 567. Development of Stage-Discharge Relations for Ungaged Bridge Waterways

2007

- 140. (140F) Collection and Analysis of Streamflow Data
- 568. Modified Sheet Pile Abutments for Low-Volume Bridges
- 569. Quantitative Mapping of Waterways Characteristics at Bridge Sites
- 570. Identification of Practices, Design, Construction, and Repair Using Trenchless Technology
- 571. GIS-Based Decision and Outreach Tools for Aggregate Source Management
- 572. Improving Safety for Slow-Moving Vehicles on Iowa's High-Speed Rural Roadways
- 573. Development of LRFD Design Procedures for Bridge Piles in Iowa
- 574. Structural Design Construction & Evaluation of a Prestressed Concrete Bridge Using Ultra-High Performance Concrete Pi Girders
- 576. Investigation of Electromagnetic Gauges for Determination of In-Place Density of HMA Pavements - Phase II
- 577. Evaluation of Rumble Stripes on Low-Volume Rural Roads in Iowa
- 578. Development of Mix Design Process for Cold In-Place Recycling Using Emulsion - Phase 3
- 579. Low Cost Strategies to Reduce Speed and Crashes on Curves
- 581. Development of an Improved Agricultural-Based Deicing Product

2008

- 140. (140G) Collection and Analysis of Streamflow Data
- 239. (HR-239) Load Ratings for Standard Bridges - Phase IV
- 580. Pavement Markings and Safety
- 582. Biofuel Co-Product Uses for Pavement Geo-Materials Stabilization
- 583. Development of LRFD Procedures for Bridge Pile Foundations in Iowa Volume II: Field Testing of Steel Piles in Clay, Sand, and Mixed Soils and Data Analysis
- 584. Development of LRFD Procedures for Bridge Pile Foundations in Iowa Volume III: Recommended Resistance Factors with Consideration of Construction Control and Setup
- 585. National Agriculture Image Program Participation
- 586. Pavement Thickness Design for Local Roads in Iowa
- 587. Crack Development in Ternary Mix Concrete Utilizing Various Saw Depths
- 588. Update Bridge "J" Standards
- 589. Updating U.S. Precipitation Frequency Estimates for the Midwestern Region
- 590. Cold In-Place Recycling (TR-553) Phase II - Measuring Temperature, Moisture, Deflection, and Distress for the Test Section
- 591. Stabilization Procedures to Mitigate Edge Rutting for Granular Shoulders
- 592. Bridge Rails and Approach Railing for Low-Volume Roads in Iowa
- 593. Infrastructure Impacts on Iowa's Changing Economy
- 594. Development of Non-Petroleum Based Binders for Use in Flexible Pavements
- 595. Autonomous Measurements of Bridge Pier and Abutment Scour Using Motion-Sensing Radio Transmitters
- 596. Insights into the Origin and Characteristics of the Sedimentation Process at Multi-Barrel Culverts in Iowa
- 597. Wet Reflective Pavement Marking Demonstration Project
- 598. Development of Updated Specifications for Roadway Rehabilitation Techniques
- 602. Part I - Updating Portions of the Three Span Prestressed Concrete Beam Bridge Standards to LRFD Specifications
- 603. Part II - Updating Portions of H-Standard Three Span Prestressed Beam Bridges, T-Pier and Pile Bent Pier Update to LRFD
- 604. Field Testing and Evaluation of a Demonstration Timber Bridge
- 605. Evaluation of the Buena Vista IBRD Bridge: A Furthering of Accelerated Bridge Construction in Iowa

2009

- 140. (140H) Collection and Analysis of Streamflow Data
- 575. Embedded Micro-Electromechanical (MEMS) Sensors & Systems for Monitoring Highway Structures & for Infrastructure Management
- 599. Investigation of Warm-Mix Asphalt Using Iowa Aggregates
- 601. Roadway Lighting and Safety - Phase II (TR-540) Monitoring, Quality, Durability, and Efficiency
- 606. Iowa Public Employees Leadership Academy (LTAP)
- 607. Review of Inconsistencies Between SUDAS & Iowa DOT Specifications
- 608. Assessment of Iowa County Roadway Financing Needs, Phases 1–4
- 609. Curing Criteria for Cold In-Place Recycling - Phase III
- 610. On-The-Spot Damage Detection Methodology for Highway Bridges During Natural Crisis
- 611. Wireless Sensor Networks for Infrastructure Monitoring
- 612. Wind Loads on Dynamic Message Cabinets and Behavior of Supporting Trusses

- 614. Structural Characterization of a UHPC Waffle Bridge Deck and Its Connections
- 615. Connection Details and Field Implementation of UHPC Piles - Phase II: Use of Ultra-High Performance Concrete in Geotechnical and Substructure Applications

2010

- 140. (140I) Collection & Analysis of Streamflow Data
- 613. Study of the Impacts of Implements of Husbandry on Iowa Bridges
- 616. Timber Abutment Piling and Back Wall Rehabilitation and Repair
- 617. An Adaptive Field Detection Method for Bridge Scour Monitoring Using Motion-Sensing Radio Transponders (RFIDs)
- 618. Parallel Wing Headwalls for Single RCBs (LRFD)
- 619. Development of Self-Cleaning Box Culvert Design - Phase II
- 620. Update of RCB Culvert Standards to LRFD Specifications
- 621. Geosynthetic Reinforced Soil for Low-Volume Bridge Abutments
- 622. Maintenance and Design of Steel Abutment Piles in Iowa Bridges
- 623. Quality Control/Quality Assurance Testing for Joint Density and Segregation of Asphalt Mixtures
- 624. Development of Quality Standards for Inclusion of High Recycled Asphalt Pavement Content in Asphalt Mixtures
- 625. Improving Accuracy of Deflection & Camber Predictions for Prestressed Concrete Bridge Girders
- 626. Optimization of Snow Drifting Mitigation & Control Methods for Iowa Conditions
- 627. Risk Mitigation Strategies for Operations and Maintenance Activities

2011

- 629. Revision to the SUDAS Traffic Signal Standards - Phase II
- 630. Evaluation and Guidance on Effective Traffic Calming and Traffic Control in Small Rural Communities
- 631. Automation of DEM Cutting for Hydrologic/Hydraulic Modeling
- 632. Low Cost Rural Road Surface Alternatives
- 633. Investigation into Shrinkage of High Performance Concrete Used for Iowa Bridge Decks and Overlays
- 634. Pilot Construction Projects for Granular Shoulder Stabilization
- 635. Warm-Mix Asphalt Phase II - Evaluation of WMA Quality Assurance Testing Protocols
- 636. Bridge Damage Detection: Integration of Structural Health Monitoring System Concepts and Components – A Statewide Collaboration
- 638. Western Iowa Missouri River Flooding – Geo-Infrastructure Damage Assessment, Repair and Mitigation Strategies
- 639. Development of Bio-Based Polymers for Use in Asphalt
- 640. Optimizing Pavement Base, Subbase, and Subgrade Layers for Cost and Performance on Local Roads
- 641. Reflective Crack Mitigation Guide for Flexible Pavements

2012

- 628. Alkali Content in Fly Ash – Measuring & Testing Strategies for Evaluating Compliance
- 637. Development of a Wireless MEMS Multifunction Sensor System and Field Demonstration of Embedded Sensors for Monitoring Concrete Pavements
- 642. Pilot Project for a Hybrid Road-Flooding Forecasting System on Squaw Creek
- 643. Evaluating Roadway Subsurface Drainage Practices
- 644. Development and Integration of Advanced Development of Cost-Effective Timber Bridge Repair Techniques for Minnesota Project
- 645. Development and Integration of Advanced Timber Bridge Inspection Techniques for NBIS
- 646. Development of Bridge Inspection, Load Rating, & Maintenance Manuals
- 647. Methods for Removing Concrete Decks from Bridge Girders
- 648. Evaluation and Testing of a Light-Weight Fine Aggregate Concrete Bridge Deck in Buchanan County, Iowa
- 649. Two One-Day Workshops on the Application of Load and Resistance Factor Design of Driven Piles in Iowa
- 650. Development of Non-Petroleum Based Binders for Use in Flexible Pavements - Phase 2

2013

- 140. (140L) Collection and Analysis of Streamflow Data
- 651. Iowa Pavement Asset Management Decision-Making Framework
- 652. Analysis of Statewide Pavement Marking Program (Previously Pavement Marking and Grooving)
- 653. Assessment of Non-Destructive Testing Technologies for Quality Control/Quality Assurance of Asphalt Mixtures
- 654. Development of a Subgrade Drainage Model for Unpaved Roads

- 655. Updating the Iowa Culvert Hydraulics and Iowa Bridge Backwater Software
- 656. Biofuel Co-Product Use for Pavement Geo-Materials Stabilization - Phase II, Comprehensive Laboratory Evaluation & Characterization and Field Demonstration
- 657. Evaluation of Low-Cost Signalized Intersection Red Light Running Countermeasures in Medium to Large Communities in Iowa
- 658. Development of Quality Standards for Inclusion of High Recycled Asphalt Pavement Content in Asphalt Mixtures - Phase 2
- 659. Development of Asphalt Dynamic Modulus Master Curve Using Falling Weight Deflectometer (FWD) Measurements
- 660. Investigation of Negative Moment Reinforcing in Bridge Decks
- 661. Evaluate the Need for Longitudinal Median Joints in Bridge Decks on Dual Structures
- 662. Evaluating Roadway Subsurface Drainage Practices – Phase II
- 663. Short Span Prefabricated County Bridge Standards
- 664. Low Cost Rural Surface Alternatives: Demonstration Project
- 665. Mitigation of Sedimentation at Multi-Box Culverts
- 666. Investigation of Field Corrosion Performance and Bond/ Development Length of Galvanized Reinforcing Steel
- 668. Impact of Curling and Warping on Concrete Pavement
- 669. Statistical Summary of Selected Iowa Streamflow Data through September 30, 2013
- 670. Iowa DOT Library Services, Collection, & Technology Assessment
- 706. County Use of the BridgeWatch

2014

- 140. (140M) Collection and Analysis of Streamflow Data
- 667. Validation of Gyratory Mix Design in Iowa
- 671. Performance Monitoring of Boone County Expo Pavement Sections - Phase III
- 672. Autonomous Sensing Skin for Detection and Localization of Fatigue Cracks
- 673. Design and Performance Verification of a Bridge Column/Footing/Pile System for Accelerated Bridge Construction (ABC)
- 674. Evaluation of Otta Seal Surfacing for Low-Volume Roads in Iowa
- 675. Assessment of PCC Concrete Setting Time and Joint Sawing
- 676. Impacts of Internally Cured Concrete Paving on Contraction Joint Spacing
- 677. Embankment Quality and Assessment of Moisture Control Implementation
- 678. Flood-Estimation Comparisons for Small Drainage Basins in Iowa
- 679. Upgrading Bridge Rails on Low-Volume Roads in Iowa
- 680. Laboratory and Field Evaluation of a Composite Glue-Laminated Girder to Deck Connection
- 681. Context Sensitive Designs: Testing of Multi-Performance Level Box Beam Standards
- 682. Standard for Single Span Prefabricated Bridges - Phase III
- 684. Laboratory and Field Evaluation of an Alternative UHPC Mix and an Associated UHPC Bridge
- 688. Equipment Purchased for the Library
- 689. County Engineers to Low-Volume Road Conference

2015

- 140. (140N) Continuing Investigation of the Water Resources of the State of Iowa through Collection and Analysis of Streamflow and Related Hydraulic Data for the Design of Highway Bridges and Culverts
- 685. Feasibility of Gravel Road and Shoulder Recycling
- 686. Guidance on Traffic Sign Effectiveness, Installation, and Removal
- 687. Effect of Wind-Induced Unsteady Vortex Shedding, Diurnal Temperature Changes, and Transit Conditions on Truss Structures Supporting Large Highway Signs
- 690. Phase II for TR-663 - Investigation into Shrinkage of High Performance Concrete Used for Iowa Bridge Decks and Overlays - Phase II Shrinkage Control and Field Investigation
- 691. Cost-Competitive Timber Bridge Designs for Long-Term Performance
- 692. Investigation of Stream-Channel and Watershed Delineations and Basin-Characteristic Measurements Using LiDAR Data for Small Drainage Basins in Iowa Located Within the Des Moines Lobe Landform Region
- 693. Development of Quality Standards for Inclusion of High Recycled Asphalt Pavement Content in Asphalt Mixtures - Phase 3
- 694. Temporary Traffic Control Handbook for Local Agencies
- 695. Evaluation of Rural Intersection Treatments
- 696. Installation Guidance for Centerline and Edgeline Rumble Strips in Narrow Pavements
- 697. Prevention and Restoration of Early Joint Deterioration in Concrete Pavements
- 698. Concrete Overlay Performance on Iowa's Roadways
- 699. Real-Time Flood Forecasting and Monitoring Systems for Highway Overtopping in Iowa

2016

- 683. Bridge Workshop - Use of Ultra-High Performance Concrete for Bridge Deck Overlay
- 700. Prevention of Longitudinal Cracking in Iowa Widened Concrete Pavement
- 701. Evaluation of the Use of Link Slabs in Bridge Projects
- 702. Transportation Research Board Education for City Engineers
- 703. Update Depth of Cover Tables for Concrete and Corrugated Metal Pipe
- 704. Performance Based Evaluation of Cost-Effective Aggregate Options for Granular Roadways
- 705. Evaluation of the Performance of a Short Span T-Beam Bridge in Buchanan County
- 708. Innovative Project Hybrid Concrete for Advancing Pavement Performance
- 708. Organization of the 2016 Innovative Projects Program
- 709. Effectiveness of Pavement Preservation Techniques
- 710. Partially Grouted Revetment for Low-Volume Road Bridges
- 711. Investigation of Exterior Girder Rotation and the Effect of Skew During Deck Placement
- 712. Evaluate, Modify and Adapt the Concrete Works Software for Iowa's Use
- 713. Load Rating of Standard Bridges for Special Hauling Vehicles
- 714. Guide to Life-Cycle Data and Information Sharing Workflow for Transportation Assets
- 717. Use of Polymer Overlays or Sealers on New Bridges

2017

- 715. Beam End Repair for Prestressed Concrete Beams
- 716. Construction of New Substructure Beneath Existing Bridges
- 717. Use of Polymer Overlays or Sealers on New Bridges
- 718. Evaluation of Alternative Abutment Piling for Low-Volume Road Bridges
- 719. Development of Self-Cleaning Box Culvert Design - Phase 3
- 720. Development of Bio-Based Polymers for Use in Asphalt - Phase 2
- 721. Low-Cost Rural Surface Alternatives - Phase III
- 722. Increase Service Life at Bridge Ends Through Improved Abutment and Approach Slab Details and Water Management Practices
- 723. Implementation of the Negative Moment Reinforcing Detail Recommendations
- 724. Self-Heating Electrically Conductive Concrete Demonstration Project
- 725. Low-Cost Rural Surface Alternatives Phase IV - Frost Depth Monitoring and Prediction
- 726. Modernization of Iowa Transportation Program Management System
- 727. Optimizing Maintenance Equipment Life Cycle for Local Agencies
- 728. Role of Coarse Aggregate Porosity on Chloride Intrusion in HPC Bridge Decks
- 729. Development of Granular Roads Asset Management System
- 730. Advanced Testing and Characterization of Iowa Soils and Geomaterials
- 731. Improving Concrete Patching Practices on Iowa Roadways
- 732. Develop and Improve Selection Methodology for Safety Improvements at Public Highway-Railroad Grade Crossings
- 733. 2018 Iowa Secondary Roads Research Support
- 734. Load Rating for Short Span Prefabricated Bridge County Standards
- 735. Holding Strategies for Low-Volume State Routes - Phase II
- 736. Performance Evaluation of Recent Improvements of Bridge Abutments and Approach Backfill
- 739. Limitations for Semi-Integral Abutment Bridges

2018

- 737. Next Generation Life Cycle Cost Analysis Tool for Bridges in Iowa
- 738. Shrinkage and Temperature Forces in Frame Piers
- 740. Development of Iowa Pavement Analysis Technique
- 741. Asset Management, Extreme Weather, and Proxy Indicators
- 742. Validation of Gyratory Mix Design in Iowa - Phase II
- 743. Field Demonstration of an Innovative Box Beam Connection
- 744. Transfer of the Iowa DOT Culverts Web-Tool Prototype to Iowa DOT Mainframe
- 745. Development of Operations Management System for Iowa Secondary Road Departments
- 746. Field Implementation of Internally Cured Concrete for Iowa Pavement Systems - TR-676 Phase II
- 747. Use of Waste Quarry Fines as a Binding Material in Unpaved Roads
- 748. Characterizing the Behavior of a Machine-Placed UHPC Bridge Deck Overlay

- 749. Impact of Curling and Warping on Concrete Pavement Systems - Phase II
- 750. Comparing the Design and Use of Different Types of Grade Control at Culverts
- 751. 2019 Iowa Secondary Roads Research Support
- 752. Implementation of Recommendations for Eliminating Longitudinal Median Joints in Wide Bridges
- 753. Otta Seal - Phase II
- 754. Corn-Based Deicers
- 755. Scientific Innovations in Microsurfacing and Slurry Seal Mixture Design
- 756. Feasibility Study of 3D Printing of Concrete for Transportation Infrastructures
- 757. Exploration of Ultrasound for the Evaluation and Preservation of Structures
- 758. Use of Cold Gas Dynamic Spraying for Repair of Steel Structures
- 759. Un-Ticketing: An Upside-Down Approach to Speed Compliance
- 760. Reducing Uncertainties in Snow Fence Design: Development of Methods for Estimation of Snow Drifting and the Snow Relocation Coefficient
- 761. Feasibility of an Iowa Urban Service Bureau
- 762. Development of Pavement Structural Analysis Tool for Iowa Local Roads
- 764. Use of Concrete Grinding Residue as a Soil Amendment
- 765. Evaluation of Penetrating Sealers for Concrete
- 766. Evaluation of Galvanized and Painted - Galvanized Steel Piling - TR-766
- 769. Coarse Aggregate Deterioration in Granular Surfaces and Shoulders
- 811. Updates to Short Span Prefabricated Bridge County Standards

2019

- 763. Design of Drilled Shafts in Iowa - Validation and Design Recommendations
- 767. Fiber Reinforced Concrete in Bridge Decks
- 768. Design and Detailing Requirements for Columns Under Collision
- 770. Development of Quality Standards for Inclusion of High Recycled Asphalt Pavement Content in Asphalt Mixtures.
- 771. Performance Evaluation of Very Early Strength Latex Modified Concrete (LMC-VE) Overlay - Phase II of TR-290
- 772. Performance Evaluation of Polyester Polymer Concrete Overlays Continuation Proposal 0 TR-717 - Phase II
- 773. Development of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Iowa Bridges
- 774. Cold In-Place Recycling Project Selection and Guidance for Iowa Roadways
- 775. Late Life Low Cost Deck Overlays RFP IHRB-18-07
- 776. Concrete Box Culvert Earth Pressure Monitoring
- 777. Development of a Smartphone-Based Road Performance Data Collection Tool
- 778. 2020 Iowa Secondary Roads Research Support
- 779. Evaluation of Performance of A709 Grade QST 65 Steel
- 780. Advanced Testing and Characterization of Iowa Soils and Geomaterials - Matching Proposal
- 781. Development of Approaches to Quantify Superloads and Their Impacts on Iowa Road Infrastructure System
- 783. Use of Organosilanes to Mitigate the Impact of Freeze-Thaw Damage to the Granular Roadways in Iowa

2020

- 782. Guide to Remediate Bridge Deck Cracking
- 784. Iowa's Pavement Preservation Guide
- 785. Load and Resistance Factor Rating of Iowa DOT Standard Bridges
- 786. 2021 Iowa Secondary Roads Research Support
- 787. Utilization of Ground Tire Rubber for Energy Efficient Pavements
- 789. Implementing a Self-Heating, Electrically Conductive Concrete Heated Pavement System for the Bus Stop Enhancement Project in the City of Iowa City
- 791. Bridges Designed for Minimum Maintenance

2021

- 788. Mitigation of Chloride-Induced Corrosion through Chemisorption
- 790. Alternative Funding Approaches for Iowa Roads
- 792. Assessing the Flood Reduction Benefits of On-Road Structures
- 793. Superabsorbent Polymers in Concrete to Improve Durability
- 794. Iowa Public Works Service Bureau
- 795. Next Generation Life-Cycle Cost Analysis Tool for Bridges in Iowa - Phase II

- 796. Iowa Granular Road Structural Design Tool
- 797. Feasibility of Granular Road and Shoulder Recycling - Phase II: Gradation Optimization for Improved Performance
- 798. Impact of Legalized 25-Kip Axle Loads for Self-Propelled Implements of Husbandry on Iowa Bridges
- 800. Helical Pile Foundation Implementation for Bridge Structures
- 801. Accelerated Bridge Construction (ABC) Methods for Pile-Footing-Column Systems Using Lightweight Precast Members

2022

- 799. Base Stabilization of Iowa Granular Roads Using Recycled Plastics
- 802. Beam End Repair for Prestressed Concrete Beams - Phase II
- 803. Accelerated Bridge Construction (ABC) Methodology for Integral Abutments
- 805. Design of Self-Cleaning Solutions for Mitigating Sedimentation at Twin- and Single-Box Culverts
- 806. Ultra-High Performance Concrete Repair of Steel Bridge Girder Ends
- 807. Beneficial Use of Iowa Waste Ashes in Concrete through Carbon Sequestration
- 808. A Sustainable Air-Entraining and Internal Curing Agent
- 809. Introducing Smart Materials in Granular Roadway and Pavement Foundation Systems for Mitigating Freeze-Thaw Damage
- 810. Use of Iowa Eggshell Waste as Bio-Cement Materials in Pavement and Gravel Road Geo-Material Stabilization
- 812. Development of County Bridge Standards for Single Short Span Cast-in-Place (CIP) Slab Bridges
- 815. Advancing the Design of Flexible Ancillary Structures
- 816. Field Performance of Fiber-Reinforced Concrete Overlays
- 817. Central Iowa Expo Pavement Project: Performance Assessment
- 818. Development of Guidance for Roadway Cross Section Reconfiguration Decisions

2023

- 813. An Economical and Sustainable Dust Suppressant for Gravel Roads
- 814. Concentration Preserving Deicing Solutions for Higher Ice Melting
- 819. New and Updated Statewide Historic Bridge Survey
- 820. (ISU) Performance Monitoring of Two-Course Bridge Deck Utilizing Ultra-High Performance Concrete
- 820. (WJE) Performance Monitoring of Two-Course Bridge Deck Utilizing Ultra-High Performance Concrete
- 821. County Bridge Standards for Single Span Concrete Slabs – Final Design (Phrase 2)
- 822. Evaluation of RePLAY for Mainline, Shoulders, and Rumbles - Phase II Study: Proprietary Bio-Based Fog Sealer and Rejuvenator Reapplication in Clinton County
- 823. Effectiveness and Guidance of Aggressive Rehabilitation of Gravel Roads
- 824. Develop and Field Test Non-Proprietary Ultra-High Performance Concrete for New Bridge Decks
- 825. Iowa Highway Research Board 75 Year Anniversary History
- 826. Development of Quality Standards for Inclusion of High Recycled Asphalt Pavement Content in Asphalt Mixtures - Phase V
- 827. Effect of Vibration on Concrete Mixtures
- 828. Low Cost Safety Strategies for Unpaved Rural Roads

2024 (through June)

- 829. Use of Roller Compacted Concrete for Paved Shoulders
- 830. Best Practices for Joint Sawing
- 831. Qualitative Relationship Between Increased Legal Loads & Reduced Bridge Service Life
- 832. Implementation of AASHTOWare BrR Program for Rating Iowa Bridges

IOWA HIGHWAY RESEARCH BOARD

The Iowa Highway Research Board (IHRB) is an advisory board responsible for assisting the Iowa Department of Transportation (DOT) and the state's cities and counties in the development and continuation of an effective program of research and development in highway transportation. Board membership includes representatives of Iowa's city and county government highway agencies, the Iowa DOT, and Iowa's public universities.

The IHRB was established in 1949 to provide guidance and oversight for the use of the primary, secondary, and municipal road research funds. Years later, the IHRB is still fulfilling that role, overseeing about 20 new projects each year involving transportation issues in Iowa. The value earned from this research is continually returned to Iowa taxpayers multifold through cost savings of innovations, improved safety, and the implementation of proactive technologies.

Since its founding, one of the keys to the board's success is the collaborative nature of the advisory group. Over the past 25 years, IHRB members have seen nearly 400 projects completed, with funds of around $60 million. The IHRB encourages submission of research ideas that consider all aspects of transportation and related infrastructure through research, innovation, implementation, and technology transfer efforts.

The scope of this book covers IHRB research and advancements from 2000 to 2024 and highlights significant IHRB research projects during that time. The projects are divided into eight chapters (Rural Road Safety, Low-Volume Roads, Pavement Preservation, Concrete Pavements, Bridges, Standards and Specifications, Sustainability, and Innovative Projects), each demonstrating the impact and necessity of the IHRB and its contributions over the years.

IHRB celebrating 75 years

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ISBN 979-8-218-71968-5
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