Modified Asphalt Research Center (MARC)
2nd Future Research Focus Workshop

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1. Executive Summary

The road infrastructure sector is undergoing significant transformation, driven by the increasing demands for enhanced performance, efficiency, and circularity in pavement design, construction, operation, and maintenance. As traditional methods struggle to meet these evolving expectations, there is a pressing need for innovation fueled by emerging technologies such as artificial intelligence (AI), advanced sensing techniques, and automation. These technologies offer the potential to revolutionize the field by streamlining processes, improving safety, and reducing environmental impacts.

Building on the success of the inaugural MARC workshop last year, which identified key challenges and research needs in pavement engineering, the MARC 2nd future research focus workshop, sought to further these discussions and explore new avenues for collaboration. This year's focus was on sustainable materials, and the use of cutting-edge technologies in pavement engineering field. The importance of integrating AI and data management to enhance decision-making and optimize pavement design and management was highly emphasized. By fostering collaboration among diverse stakeholders, the workshop aimed to generate innovative solutions that would lead to more efficient processes and improved outcomes in road infrastructure. Participants included stakeholders from academia, industry, and government, all dedicated to addressing the critical challenges facing the road infrastructure sector.

Through shared insights and expertise, the workshop facilitated the development of a forward-looking research agenda for MARC. This agenda aims to position the center as a leader in addressing the pressing challenges within the industry. Continued engagement and collaboration among all stakeholders are essential to realizing these objectives, ensuring that road infrastructure evolves in response to emerging opportunities and challenges.

2. Workshop Overview

The workshop took place on February 20th, 2025, at Room 213, Pyle Center, organized by the Modified Asphalt Research Center (MARC) at the University of Wisconsin-Madison (UW-Madison). The workshop was hosted by Dr. Hussain Bahia, Dr. Xiaopeng (Shaw) Li, Dr. Sikai (Sky) Chen, and Dr. Runhua Zhang.

2.1. Participants

Participants from academia, industry, and government sectors, along with numerous interested students from UW-Madison, registered to attend this workshop. Below is a list of the workshop attendees.

Name	Affiliation
Andrew Hanz	MTE Services Inc.
Ben Young	CRH Company

Benjamin Worel	Minnesota Department of Transportation
Bruno Carraro	CRH Company
Carl Johnson	Stark Pavement Corporation
Cheng Ling	CRH Company
Chengyuan Ma	University of Wisconsin-Madison
Dan Swiertz	Asphalt Materials Inc.
Deb Schwerman	Wisconsin Asphalt Paving Association
Derek Frederixon	MTE Services Inc.
Erik Lyngdal	Wisconsin Department of Transportation
Gang Liu	University of Wisconsin-Madison
Guocui Teng	University of Wisconsin-Madison
Hang Zhou	University of Wisconsin-Madison
Hangyu Li	University of Wisconsin-Madison
Hao Wang	Rutgers University
Hussain Bahia	University of Wisconsin-Madison
Josh Amundson	Behnke Materials Engineering, LLC
Keke Long	University of Wisconsin-Madison
Lijun Sun	University of Wisconsin-Madison
Michael Vrtis	Minnesota Department of Transportation
Rui Wang	University of Wisconsin-Madison
Ruitao Xie	University of Wisconsin-Madison
Runhua Zhang	University of Wisconsin-Madison
Sikai (Sky) Chen	University of Wisconsin-Madison
Siksha Swaroopa	University of Wisconsin-Madison
Weiran Han	University of Wisconsin-Madison
Xiaopeng (Shaw) Li	University of Wisconsin-Madison
Xiujuan Jane Zhang	University of Wisconsin-Madison
Yaowen Pei	University of Wisconsin-Madison

2.2. Proceedings Summary

The workshop commenced with Dr. David Noyce, Executive Associate Dean of the College of Engineering at UW-Madison, extending a warm welcome and delivering opening remarks to the attendees, setting the tone for a day filled with insightful discussions. Following this, Dr. Xiaopeng Li took the stage to present the MARC Review and Outlook, emphasizing that emerging technologies offer unprecedented opportunities in several key areas, including pavement design and testing, pavement construction, and pavement maintenance. His insights illuminated the transformative potential these advancements hold for the future of road infrastructure, inspiring attendees to embrace innovation in their practices.

Hosted by Dr. Runhua Zhang, the dialogue then expanded to include perspectives from transportation agencies and industry representatives, with presentations from Michael Vrtis (Research Project Engineer at Minnesota Department of Transportation), Erik Lyngdal (Chief Materials and Pavement Engineer for Wisconsin DOT), Daniel Swiertz (Director of Mix Design Laboratories (Materials Engineer) at Asphalt Materials, Inc.), Derek Frederixon (Project Manager at Mathy Construction Company), Deb Schwerman (Executive Director of the Wisconsin Asphalt Pavement Association), Cheng Ling (Director of Engineering & Sustainability at Pike Industries, A CRH Company) and Xiujuan Jane Zhang (Director, Advanced Materials Industrial Consortium, University of Wisconsin-Madison). The presentations also highlighted the urgent need for promoting pavement system circularity and sustainability and establishing pavement databases and leveraging and integrating AI, sensing, and automation techniques and tools into the traditional pavement engineering field.

Dr. Sikai Chen spearheaded a dynamic discussion session on gathering the major challenges

the industry is facing, identifying specific research areas for the development of MARC's new research agenda, and exploring collaboration opportunities and available resources to support research in these areas. This forum became a melting pot of ideas, with participants eagerly sharing their insights and aligning their visions with potential funding opportunities to craft forward-looking research scopes and collaboration models.

The workshop concluded with a comprehensive summary of the vision and plans of MARC by Dr. Li. The MARC upgrade plan includes a reorganization of the center structure, the establishment of an advisory board, a funding goal, and initiatives to hire coordinators, organize events, support travel, and conduct outreach and technology transfer activities. Then the workshop organizers guided attendees through a tour of the MARC and CATS Labs to briefly demonstrate the ongoing projects and exhibit the group's research capability to attendees.

3. Discussions and Key Insights

The discussion session was designed as an open brainstorming platform, encouraging participants to share their insights on the current challenges facing the industry. Attendees were invited to fill out an online survey to express their views on the most pressing issues and to propose research ideas aimed at addressing these challenges. This collaborative approach aimed to identify key areas where innovation is needed and explore potential solutions. Furthermore, participants discussed ways to foster collaboration with the MARC initiative, emphasizing the importance of partnership in tackling these challenges effectively. By leveraging collective expertise and creativity, the workshop aimed to generate actionable strategies that can drive meaningful advancements in the field. Based on participant feedback, four main topics emerged from the discussion are summarized as below.

Topic 1. Innovations in Material Selection and Design Using AI and Digitalization: The discussion on materials emphasized the integration of advanced technologies to enhance material selection and design processes. Participants highlighted the importance of utilizing AI and data-driven approaches to optimize material mixtures and structural designs, ensuring that the final products meet performance and sustainability standards. Establishing standardized data structures was deemed essential for improving compatibility and interoperability among diverse materials data sources. Additionally, the need to streamline project deliverables was discussed to enhance efficiency in material usage, while linking ongoing measurements of material properties to real-world performance assessments would provide valuable insights for future projects.

Topic 2. Optimizing Pavement Data Management for Collaborative Research and Insights: Data emerged as a critical focus, underscoring the necessity for robust data management practices in research and development. The participants advocated for the development of general data schemas to facilitate better integration and sharing of data across various platforms, enhancing collaboration among researchers. Standardizing data collection

methods was deemed vital to ensure the reliability and comparability of data across different projects, enabling more accurate analyses. Moreover, leveraging continuous lab and field measurements would enrich data pools, providing a comprehensive foundation for informed decision-making in material and structural design.

Topic 3: Harnessing AI for Predictive Modeling and Process Optimization Across Multiple Domains: The role of artificial intelligence in the research agenda was explored in depth, highlighting its transformative potential across various processes. Participants discussed leveraging AI algorithms for predictive modeling to enhance material performance and optimize design strategies. Integrating AI tools into traditional design workflows can significantly enhance learning from data, allowing researchers to make more informed choices. Additionally, the application of AI in automating data analysis and interpretation can lead to more efficient and insightful outcomes. Ensuring that AI solutions are user-friendly and accessible to both researchers and practitioners will be crucial for widespread adoption and impact.

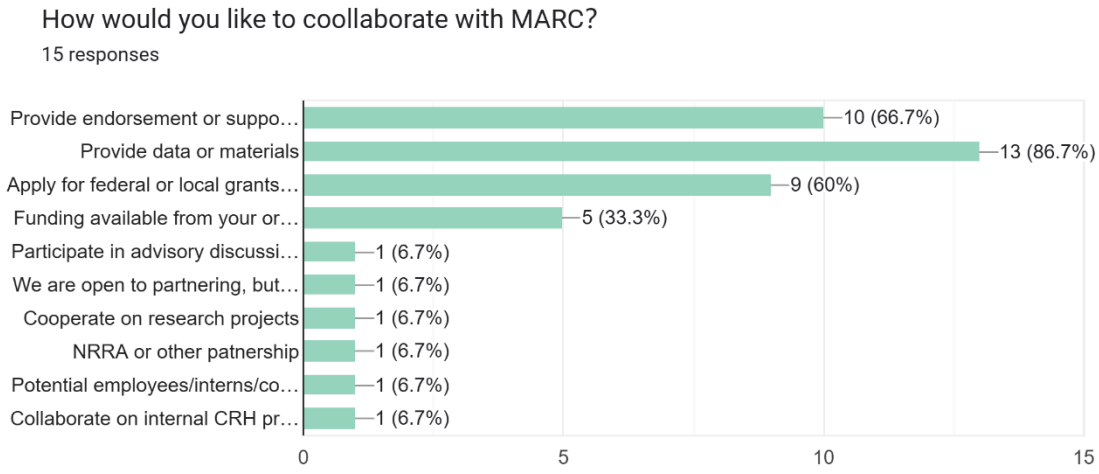
Topic 4: Automation's Impact on Streamlining Testing and Construction Efficiency: Automation was recognized as a key driver for enhancing efficiency and reducing costs in testing and construction processes. The discussion focused on developing autonomous systems for laboratory testing and material processing, which can minimize human error and streamline workflows. Participants emphasized the importance of automating construction and production equipment to improve consistency and reliability in operations. Furthermore, fostering workforce development by training personnel on new automated technologies and methodologies was seen as essential for successful implementation. Exploring innovative automation solutions for inspection processes would also enhance quality control, ensuring that materials and structures meet established standards.

Topic 5: Sustainability and Environmental Product Declaration (EPD): A crucial topic that emerged during the workshop was the emphasis on sustainability and the pivotal role of EPD in the pavement engineering sector. Participants emphasized the need for innovative and sustainable paving materials, and highlighted EPDs as vital tools for transparently communicating the environmental impacts of these materials. By integrating EPDs into the program, stakeholders can make informed decisions based on life-cycle assessments, fostering accountability and promoting the adoption of sustainable practices within industry. This focus on sustainability will be essential for MARC's future initiatives and collaborative efforts.

Topic 6: Advancing Workforce Development in Pavement Engineering: Workforce development emerged as a vital topic during the workshop, highlighting the need to equip the next generation of professionals with the skills and knowledge necessary to meet evolving road infrastructure industry demands. Participants discussed the importance of creating educational programs that emphasize emerging technologies, sustainable practices, and innovative materials, ensuring that students and professionals are prepared for future challenges.

Initiatives to enhance collaboration between academia and industry were also emphasized, with suggestions for internships, mentorship programs, and hands-on training opportunities that bridge the gap between theoretical knowledge and practical application. By fostering partnerships, stakeholders can create a robust pipeline of talent that is adept at navigating the complexities of modern road infrastructure.

Below is the survey on potential funding or resource opportunities from the workshop participants, which shows their interest in working with the MARC team to address the research needs.



4. Conclusions and Recommendations

Through identifying participants' needs and synthesizing insights shared during the discussion sessions, MARC is recommended to focus on the following new research directions:

1. **Advancing AI-Driven Innovations in Material Selection and Design:** There is a pressing need to explore the integration of AI and data-driven approaches in material selection and structural design. Research should focus on developing standardized data structures and tools that can optimize material mixtures while ensuring sustainability and performance. This will facilitate more efficient design processes and real-time assessments of material properties.
2. **Enhancing Collaborative Pavement Data Management Systems:** The discussions underscored the importance of robust data management practices. MARC should prioritize the development of general data schemas and interfacing tools that unify disparate data sources. This initiative will enhance collaboration among researchers and improve data sharing, ultimately leading to more reliable analyses and informed decision-making in pavement design, construction and maintenance.
3. **Expanding AI Applications for Predictive Modeling Across Various Domains:** The potential of AI to transform multiple processes was a key takeaway. Future research

should investigate the application of AI algorithms not only in material design but also in construction, maintenance, and inspection. This includes automating data analysis and optimizing workflows to drive efficiency and innovation throughout the entire lifecycle of materials and infrastructure.

4. **Implementing Automation for Improved Testing and Construction Efficiency:** Automation was recognized as crucial for enhancing efficiency in testing and construction. MARC should focus on developing autonomous systems for QA/QC testing and material processing. This should include training programs for the workforce to adapt to new technologies, ensuring that automated solutions lead to consistent quality control and streamlined operations.
5. **Prompting Sustainability and Circularity in Engineering Practices:** Participants emphasized the critical need for research focused on sustainability and circularity within the pavement engineering sector, and the importance of developing materials and processes that minimize environmental impact and promote resource efficiency. Future research should explore innovative methods and environmentally responsible solutions for recycling and repurposing materials, enhancing the life cycle of pavement systems, and fostering resilience in infrastructure development.
6. **Strengthening Workforce Development for a Sustainable Future:** To effectively address the evolving needs of modern road infrastructure, MARC must invest in comprehensive workforce development initiatives. This includes establishing educational programs that emphasize sustainable practices, emerging technologies, and practical training opportunities through partnerships with industry stakeholders. By implementing targeted training programs and mentorship opportunities, MARC can cultivate a skilled workforce equipped to drive innovation and ensure the long-term success of the industry.

Identifying and securing funding is crucial for advancing these research areas. During the workshop, several potential funding or resource opportunities were investigated, spanning governmental, private sector, and academic sources. MARC researchers are encouraged to explore the following resources and opportunities:

1. Federal Funding Proposals: Develop proposals for federal funding opportunities, particularly through agencies like FHWA and USDOT.
2. University Intellectual Property: License university intellectual property and utilize shared facilities for research and development.
3. State-Level Stakeholder Engagement: Engage with pooled funds or state-level agencies that may have a vested interest in the research areas.
4. Flexible Funding Sources: Leverage flexible funding options from organizations like NRRA, CAPRI, WHRP, and other transportation pooled funds for

collaborative projects.

5. Partnership with Behnke Materials Engineering, LLC (BME): Collaborate with BME for field collection of materials, field and laboratory testing, and assistance with final reporting.
6. Access to Performance Data: Utilize available Indian pavement performance data and material specifications to inform research.
7. Trade Associations and Business Partnerships: Explore collaborations with trade associations and business partnerships to enhance research initiatives.
8. Data Access Initiatives: Establish initiatives to improve access to relevant data for research purposes.
9. Funding from CRH: Investigate funding opportunities from CRH for projects aligned with their interests.
10. Formal and Informal Partnerships: Foster both formal and informal partnerships within the research community and industry stakeholders.
11. Pooled Fund Opportunities: Look into pooled fund opportunities, such as those from NRRA, that focus on local issues and have "call for innovation" programs.
12. Leadership Access: Gain access to leadership team within CRH and the broader partner ecosystem to facilitate collaborations and project development.

By leveraging these resources and opportunities, MARC can effectively advance its research agenda and foster innovation in the field. To realize the potential of AI, sensing, and automation in transforming the existing paradigms of road infrastructure design, construction, operation, and maintenance, a collective effort from all stakeholders is essential. MARC calls on government agencies, industry partners, academic institutions, and funding bodies to engage in Collaborative Research and Knowledge Sharing.

5. Transition from MARC to SHRC

To better respond to the rapidly evolving challenges and opportunities in pavement engineering, the Modified Asphalt Research Center (MARC) has officially transitioned into the Smart Highway Research Center (SHRC) starting this June (2025), with formal approval from the University of Wisconsin–Madison. This transformation marks a strategic expansion of the center's identity and focus, from a sole emphasis on modified asphalt materials to a broader, interdisciplinary vision aligned with the future of smart and sustainable infrastructure. SHRC now actively pursues research and innovation across three major thrust areas: (1) Artificial Intelligence & Data Science; (2) Autonomy in Testing, Construction, and Maintenance; (3) Circularity, Sustainability & Low-energy Transportation Infrastructure.

The management structure has been updated accordingly to support this expanded mission:

- Dr. Hussain Bahia, Professor Emeritus, continues to serve as the Director, focusing on long-term strategy and external partnerships.

- Dr. Xiaopeng (Shaw) Li, Professor at CEE, is the Executive Director, responsible for day-to-day operations and strategic program development.
- Dr. Runhua Zhang, Scientist and Lecturer, works as Associate Director for Infrastructure, leading efforts in sustainable pavement materials, recycling and rejuvenating, and system resiliency design.
- Dr. Sikai (Sky) Chen, Assistant Professor, serves as Associate Director for AI & Data Science, spearheading research in machine learning, generative AI, and intelligent pavement modeling systems.
- Additionally, Dr. Xiaopeng Li leads the Autonomy Program, which focuses on robotic testing, autonomous construction systems, and advanced inspection technologies.

This leadership framework ensures that each strategic area is guided by domain experts with active research portfolios, positioning SHRC to pursue high-impact federal grants and deliver innovative solutions to real-world infrastructure challenges.

This transformation from MARC to SHRC signals a bold commitment to shaping the next era of road infrastructure. The vision of SHRC is to become a national leader in smart, sustainable, and AI-enabled highway systems by transforming how pavement infrastructure is designed, constructed, maintained, and managed. Its mission is to:

- Advance cutting-edge technologies that integrate AI, automation, and sustainability into highway infrastructure.
- Develop and standardize robust digital pavement data ecosystems to support predictive decision-making.
- Collaborate with government, industry, and academia to ensure real-world implementation and workforce development.
- Educate the next generation of engineers to tackle infrastructure challenges through innovation and cross-disciplinary knowledge.

6. Next Steps

Continued Research Directions and Collaborations: MARC/SHRC will leverage its platform to foster collaborations across various sectors, actively seeking funding opportunities for research in pavement materials, database, automation, and artificial intelligence. This effort will aim to develop innovative solutions for the technical challenges faced in road infrastructure.

Establishment of Working Groups: MARC/SHRC will form diverse Working Groups targeting critical areas such as Research Thrusts, Data & AI Infrastructure, and Workforce Development & Training Programs. These groups will focus on advancing specific themes, enhancing data management practices, and developing training initiatives to address the evolving needs of the industry.

Formation of an Advisory Board & Planning Board Meetings: In 2025, MARC/SHRC plans to establish an advisory board consisting of experts from academia, industry, and

government. This board will provide strategic guidance and facilitate knowledge exchange, ensuring that MARC/SHRC's initiatives align with current industry needs and future directions. A formal agenda will also be developed for advisory board meetings, featuring member recognition, state DOT updates, budget reviews, and discussions on major funding competitions. This structured approach will enhance communication and decision-making within the board.

Periodic Workshops and Online Forums: Regular workshops and online forums will be organized to promote ongoing dialogue among researchers, practitioners, and policymakers. These events will serve as platforms for sharing advancements, discussing emerging challenges, and identifying opportunities for joint ventures.

Tentative Data for Next Year's Workshop: Our next MARC/SHRC workshop is tentatively scheduled for May 2026.

Appendix

MARC 2nd Workshop Flyer

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2nd Future Research Focus Workshop

Purpose of the Workshop

This workshop aims to initiate discussions on emerging opportunities and challenges in road infrastructure. It will focus on setting a new research agenda, identifying potential resources, and fostering collaboration among stakeholders. The goal is to investigate existing challenges in road infrastructure and propose new solutions. This could include developing sustainable materials and construction techniques to reduce environmental impact, and leveraging automation and AI to upgrade or transform the design and management of road infrastructure systems (e.g., creating efficient and reliable virtual platforms for design and optimization, and developing automated construction and maintenance technologies).

Agenda (see more details in the next page)

8:30 - 8:40 am	Welcome and Opening Remarks
8:40 - 9:00 am	Update from MARC Team
9:00 - 10:00 am	Presentations from state DOTs
10:00 - 10:30 am	Break
10:30 - 12:15 pm	Presentations from Industry Companies
12:15 - 1:15 pm	Lunch
1:15 - 1:30 pm	Group Photo (All Attendees)
1:30 - 3:30 pm	Research Needs and Collaboration Discussion Session; Development of MARC Future Collaboration and Advisory Board
3:30 - 4:00 pm	Break
4:00 - 5:00 pm	Tour of Center Labs

Key Topics

- Low-carbon transportation material and alternative asphalt.
- The impact of AI and automation in transforming material testing and structural design.
- Optimizing traffic operations and enhancing roadway construction and maintenance.
- Strategies for monitoring and predicting smart traffic and pavement performance.
- Innovations in automating road construction and maintenance.

Attendees

The workshop will host stakeholders from the Federal Highway Administration (FHWA), state Departments of Transportation (DOTs), industry partners, and academic researchers.

Registration

https://forms.gle/DTqeaxC7LhMJxs8e6

Parking (covered by UW-Madison): Lot 6 Helen C. White Garage, 600 N Park St, Madison, WI

Lodging: Wisconsin Union Hotel, Hilton Garden Inn, Hampton Inn, Hyatt Place Madison/Downtown

Date: February 20, 2025

Location: Room 213, Pyle Center, 702 Langdon Street, Madison WI

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