Workshop Synopsis

Advancing Sustainable Solutions for Cement and Concrete Pavement Materials

Hyatt Regency O'Hare Chicago

May 9-10, 2022

Background

A one-and-one-half day workshop was conducted May 9-10 at the Hyatt Regency O'Hare Chicago, hosted by the FHWA Concrete Pavement Materials and Sustainable Pavement Programs and supported and organized by the National Concrete Pavement Technology Center (CP Tech Center). The workshop was facilitated by Migdalia Carrion (FHWA) and Robert Spragg (FHWA). FHWA invited individuals involved in the concrete pavement industry representing academia & research, cement & concrete industries, engineering consulting firms, and transportation agencies (FHWA, state DOTs, and a port authority). Attendance list is presented in Appendix 1.

Summary

FHWA Opening Remarks

LaToya Johnson (FHWA, Team Leader - Pavement Design & Performance) and Gina Ahlstrom (FHWA, Team Leader- Pavement Materials) kicked-off the workshop by providing the background and purpose of the workshop. It is widely recognized that the carbon footprint of portland cement, and subsequently concrete pavements, is a target area for embodied carbon reduction. Efforts have been underway to reduce the carbon footprint of concrete pavement for a number of years, but those efforts have not typically been well-coordinated nor systematically measured or benchmarked. FHWA is focusing efforts on measuring the carbon footprint of concrete paving with an ultimate objective of delivering a coordinated program that serves to advance *sustainable pavement systems*[1]. The cement industry is specifically highlighted in the Administrations Long-Term Strategy[2], which contributes to the urgency.

The purpose of this workshop was to bring stakeholders together – industry, agency, consultants, and academia – to assess where each group is positioned with regard to sustainability, what their prospective plan is moving forward, and most importantly, how we can collaborate on this issue.

With infrastructure investment increasing, along with a heightened awareness of contribution of greenhouse gas emissions, the stakeholder groups at this meeting have the opportunity to demonstrate to other federal government agencies, leadership of the US DOT and Biden-Harris Administration, and the public how our material and industry practices can result in more sustainable pavements when measured against a 2005 pavement[3].

[1] FHWA-HIF-15-002. Towards Sustainable Pavement Systems: A Reference Document.

[2] The Long-Term Strategy of the United States, Pathways to Net-Zero Greenhouse Gas Emissions by 2050 (whitehouse.gov)

[3] Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability | The White House

A 2009 through 2022 timeline highlighting the vision of the Sustainable Pavements program and the continued work on that vision to culminate in the 2022 Climate Challenge[4] was presented. At the federal level there is a strong focus on cement production because the large volume of production leads to the industry being a highly ranked contributor to national GWP emissions[5]. To date, FHWA has supported the advancement of lower embodied materials and developed tools to understand the life cycle.

Stakeholder Cohort Reports

Consultant Cohort (AP Tech, NCE, Larry Sutter) – Tom VanDam reporting

Consultants are reactive, responding to their client's needs. There is not a big demand from clients for consultants to perform sustainability-related work. Sustainability can be complicated, but clients want simplicity. Costs and value rule with clients. Consultants will figure out how to do whatever their clients request, but agency project managers and engineers must be educated as to what is needed and expected. Training and education needs are abundant.

State DOT Cohort (Co., Mo., Mn., Il., PANYNJ) – all made brief presentations

Colorado has enacted legislation to collect EPD project information until 2025, then a policy will be implemented based upon the benchmarks. PANYNJ has developed and implemented a "Clean Construction Program" that requires EPD submission, or negative proof, alongside of mix designs submitted for approval. The program has partnered with a local academic team to develop a formula for quantifying the A1 GWP of concrete mixes for historical mixtures and current placement while the local EPD market grows. This allows PANYNJ to push ahead with potential specification changes to incorporate A1 GWP limits based on historical uses while EPDs become more common in their region. Missouri focuses on better designs and saving money, not emissions, although better designs and cost effectiveness do result in lower emissions. Sustainability is not on their radar. Illinois is not focusing on carbon reduction, but employs recycling, PLCs, and other carbon reducing strategies due to the economics of these measures. There is proposed Buy Clean type of legislation for low embodied carbon concrete. Minnesota is discussing fuel consumption legislation and a pay item for EPD development to track embodied carbon.

Industry Cohort (NRMCA, PCA, ACPA, Holcim) – Brian Killingsworth reporting

NRMCA started addressing this issue 20 years ago, and established a committee focused on sustainability in 2007. NRMCA members have reduced their national average carbon footprint 21% in the past 7 years. From the full life cycle perspective, use phase impacts, especially on the network level, should be considered. PCA has produced a carbon neutrality roadmap, emphasizing actions across the supply chain are needed in order to meet near-term, mid-term, and long-term strategies to reach carbon neutrality by 2050. EPA has restrictions on what alternative fuels can be burned in a kiln that present a challenge.

Academic Cohort (OR State, OK State, MIT, MTU, UNC-Charlotte, UC-Davis) – Tyler Ley reporting

A few big picture strategies exist: Optimize the use of concrete; reduce the clinker factor of concrete; make it long-lasting. Sustainability is not possible without durability. Enable and encourage innovation – do this by asking for what you want and let the project team figure out a way to get there (akin to performance spec). There exist computer tools to optimize for sustainability metrics and to help people understand where to start if they have no ideas. Lifecycle impacts cannot be ignored – excess vehicle fuel consumption, the role of durability, and carbon

[4] https://www.fhwa.dot.gov/pavement/sustainability/
[5] https://www.epa.gov/system/files/documents/2022-04/fastfacts-1990-2020.pdf

uptake are few effects that were highlighted. Focus on strategies that really move the needle –analysis incorporating both LCA and LCCA that compares cost effectiveness is one way to prioritize. Find education funding to support talking about sustainability and give people a reason to learn about it. Prioritize research, development, and implementation considering real-world constraints.

Brainstorm – Key Strategies to Advance Sustainable Concrete Pavements

Participants were invited to post their ideas to advance lower carbon footprint concrete pavement systems in the following areas:

- Cradle-to-Gate (Material Production)
- Construction
- Use and End-of-Life
- Key Messaging
- Enabling

Technology Readiness Level (TRL) Survey

Twelve items were distilled from the brainstorming exercise. The group voted on the perceived TRL of each group using the Scale shown in Appendix 2. Topics and average ratings are as follows, with the entire distribution shown in Appendix 3:

- Evaluation procedure for non-conventional materials (5.0)
- Implementation of Portland Limestone Cement (8.5)
- Implementation of PEM (6.7)
- Global Warming Potential (GWP) using EPDs/LCA (7.2)
- Developing GWP benchmark based on EPDs/LCA (5.7)
- Remove cement content limits from specifications (7.4)
- Two-lift concrete pavement (6.9)
- Removing or modifying pavement opening requirements (6.4)
- Increase frequency of diamond grinding (6.9)
- Incorporation of embodied carbon into Pavement Management Systems (4.5)
- Recycled concrete aggregate (8.3)
- Alternative fuels (hauling vs. cement production) (6.8)

Sound Bites from Related Discussion

EPDs are less complex and less expensive than impressions might give. $5k for a two-year subscription and some groups are performing EPDs every month with up-to-date data.

While there exists a few different EPDs tools, there is a general consensus among them as long as they use similar background data sets. There was a recent harmonization effort to compare these tools.

Portland Limestone Cements (PLCs) are being rolled out across the US, but there is some engineering that needs to be done for a plant to fully make the switch.

Material evaluation process using new materials can follow the framework outlined in ASTM C1709.

There is urgency in developing and implementing an accepted means to achieve measurable and documented lower embodied carbon in paving concrete. The foundation measurements should be based on EPDs.

Industry and FHWA should work towards development of a carbon reduction guidance document. This document and its implementation could model the effort and activities similar to the program for development and implementation PEM.

There are immediate measures agencies and contractors can employ to lower embodied carbon in concrete paving; using PLCs, using SCMs, optimizing mixtures, employing PEM type specifications, eliminating minimum cement requirements, optimizing project and pavement design. These strategies can currently be implemented and quantified.

Following the “cradle-to-gate” carbon reduction efforts, the entire life cycle, particularly the use phase, needs to be developed as an overall carbon reduction plan with the goal of working towards attaining “net zero carbon” in concrete paving systems.

Longer term considerations through a life cycle assessment (LCA) will provide a more comprehensive measurement of sustainability of concrete pavements. Use phase considerations include things such as: longer life pavements, operational fuel savings through maintained smoothness and reduced rolling resistance, carbonation or “carbon uptake”, fewer traffic disruptions for maintenance and rehabilitation, and carbon sequestration.

More education and support for shadow projects.

Key Messages

A series of Key Messages were developed following the brainstorming and technical discussions.

- Cement is a large emitter of carbon emissions due to volume, and concrete is a highly versatile and critical material for highway infrastructure.
- There are opportunities to improve the sustainability of concrete pavements throughout the pavement life cycle while ensuring pavements meet and exceed performance requirements.
- Academia, agencies, industry, and consultants are collaborating to carry-out research, development, implementation, and technology-transfer (education) efforts to advance pavement sustainability.
- We have begun quantifying embodied and operational emissions throughout the life cycle. There are research, data, training, and education needs that must be addressed to improve and standardize this quantification.
- There are practical, quantifiable, and implementation ready approaches to reduce environmental impact, such as PLC, use of EPDs, and optimization of mixture designs.
- To reduce carbon emissions and increase awareness that promotes change in traditional practices, we need to:
    - Enhance protocols to evaluate emerging technologies and practices;
    - Expand education and training programs;
    - Engage stakeholders;
    - Provide incentives.

- Sustainability decisions should address societal, environmental, and economic impacts to deliver stated performance.
- Barriers to stakeholders' buy-in should be identified and overcome to increase the pace of change.
- Talk about our successes to a wider audience.

Next Steps:

- FHWA, Industry, and Academia will begin to use these Key Messages and highlight how our activities are working to advance these points.
- FHWA will facilitate a discussion on data needs and data structure to facilitate their use in our LCA Pave tool.
- FHWA will develop task groups to work on a few key topics and to develop a framework for their advancement. Preliminarily, the Concrete Pavement Materials Program will develop task groups to address the topics of Durability and Carbonation. Similarly, the Sustainable Pavements Program will develop a task group to explore Excess Vehicle Fuel Consumption.
- FHWA would like to keep this group together as part of a new feedback effort. A follow-on meeting is tentatively planned for November 2022 or January 2023.

If you have next steps that you, your agency, or your group please feel free to share them with Robert.Spragg@dot.gov. We will start to incorporate those when we talk on this topic.

Appendix 1: Attendees

Attendees Advancing Sustainable Solutions for Cement and Concrete Materials			
	Gina Ahlstrom	FHWA	gina.ahlstrom@dot.gov
	Migdalia Carrion	FHWA	migdalia.carrion@dot.gov
	Michelle Helsel	FHWA	michelle.helsel.ctr@dot.gov
	LaToya Johnson	FHWA	latoya.johnson@dot.gov
	Amlan Mukherjee	FHWA	amlan@mtu.edu
	Milena Rangelov	FHWA	milena.rangelov.ctr@dot.gov
	Robert Spragg	FHWA	robert.spragg@dot.gov
DOT Agencies			
	Hailey Goodale	Colorado DOT	hailey.goodale@state.co.us
	James Krstulovich	Illinois DOT	james.krstulovich@illinois.gov
	Curt Turgeon	Minnesota DOT	curt.turgeon@state.mn.us
	Brett Trautman	Missouri DOT	brett.trautman@modot.mo.gov
	Dorian Bailey	PANYNJ	dbailey@panynj.gov
	Peter Bacas	Paul Carp. Assoc with PANYNJ	pbacas@panynj.gov
Academia			
	Randy Kirchain	MIT	kirchain@mit.edu
	Larry Sutter	MTU	llsutter@mtu.edu
	Tyler Ley	Oklahoma State	tyler.ley@okstate.edu
	Jason Weiss	Oregon State	jason.weiss@oregonstate.edu
	John Harvey	UC-Davis	jtharvey@ucdavis.edu
	Tara Cavalline	UNC-Charlotte	tlcavall@uncc.edu
Industry			
	Amy Brooks	ACPA	abrooks@crcllc.com
	Laura O'Neill Kaumo	ACPA	loneill@acpa.org
	Al Innis	LafargeHolcim	allison.innis@gmail.com
	Brian Killingsworth	NRMCA	bkillingsworth@nrmca.org
	Jim Mack	NRMCA	jamesw.mack@cemex.com
	Michelle Wilson	PCA	mwilson@cement.org
Engineering Consultants			
	Kurt Smith	ApTech	ksmith@appliedpavement.com
	Tom Van Dam	NCE	tvandam@ncenet.com
CP Tech Center			
	John Adam	CP Tech Center	jfadam@iastate.edu
	Sharon Prochnow	CP Tech Center	prochnow@iastate.edu

Appendix 2: TRL Assessment Criteria

(double click to open embedded PDF)

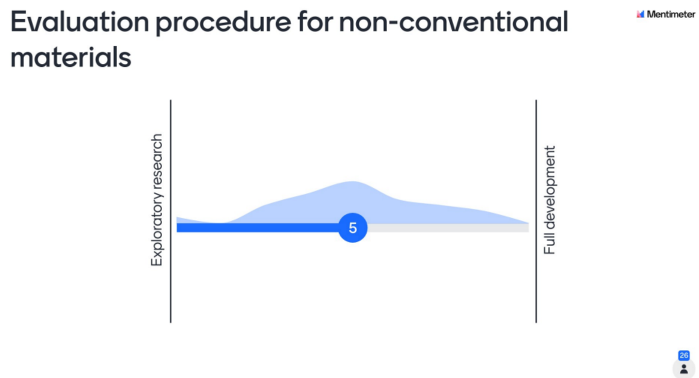
Technology Readiness Level

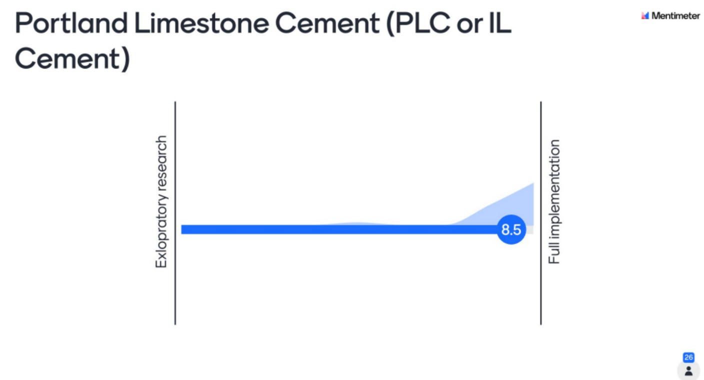
Adapted from FHWA's *Technology Readiness Level Guidebook* (FHWA-HRT-17-047).

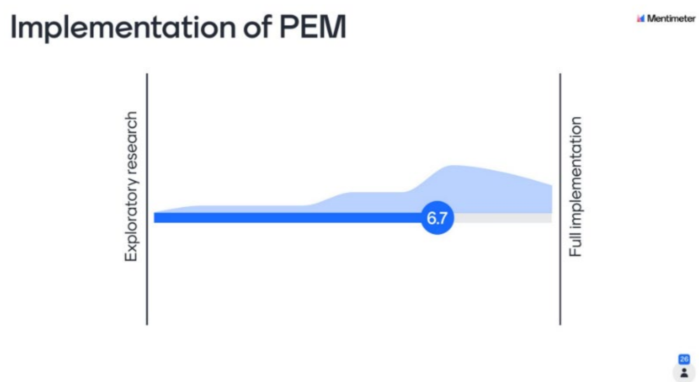
RESEARCH	1	Basic principles and research	Do basic scientific principles support the concept? Has the technological approach been developed?
RESEARCH	2	Application formulated	Are potential applications identified? Are system components at least partly described? Do preliminary analyses or experiments confirm that the application might meet the user need?
RESEARCH	3	Proof of concept	Are performance metrics established? Is feasibility fully established? Do experiments or modeling and simulation validate performance predictions?
RESEARCH	4	Components validated in laboratory environment	Are end-user requirements documented? Does an integration plan exist and is component compatibility demonstrated? Were individual components successfully tested in a laboratory environment (a fully controlled test environment where a limited number of critical functions are tested)?
RESEARCH	5	Integrated components demonstrated in a laboratory environment	Are external and internal interfaces documented? Are operational requirements developed? Is component integration demonstrated in a laboratory environment (i.e., fully-controlled setting)?
DEPLOYMENT	6	Prototype demonstrated in relevant environment	Is the operational environment fully known (i.e., user community, physical environment, and relevant input characteristics)? Was the prototype tested in a realistic environment outside the laboratory? Does the prototype satisfy all operational requirements when confronted with realistic problems?
DEPLOYMENT	7	Prototype demonstrated in operational environment	Are available components representative of production components? Is the fully integrated prototype demonstrated in an operational environment (i.e., real-world conditions, including the user community)? Are all interfaces tested individually under stressed and anomalous conditions?
DEPLOYMENT	8	Technology proven in operational environment	Do all system components function compatibly with each other and with the operational environment? Is the technology proven in an operational environment? (i.e., does it meet target performance measures?) Was a rigorous test and evaluation process completed successfully? Does the technology meet its stated purpose and functionality as designed?
DEPLOYMENT	9	Technology refined and adopted	Is the technology deployed in its intended operational environment? Is information about the technology disseminated to the user community? Is the technology adopted by the user community?

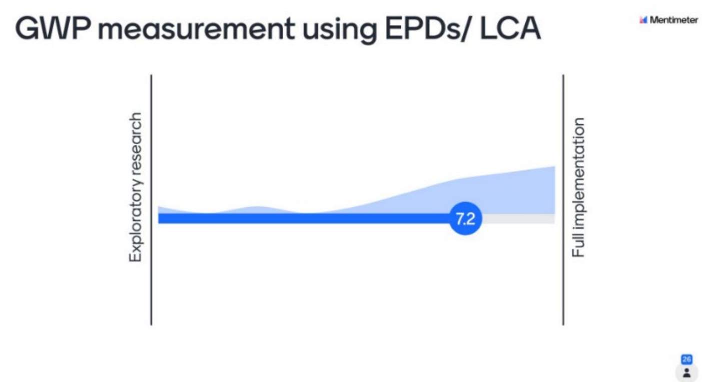
U.S. Department of Transportation
Federal Highway Administration

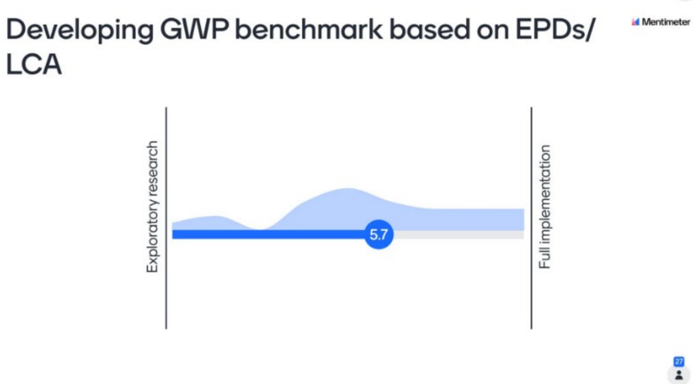
Appendix 3: TRL Assessment Distributions

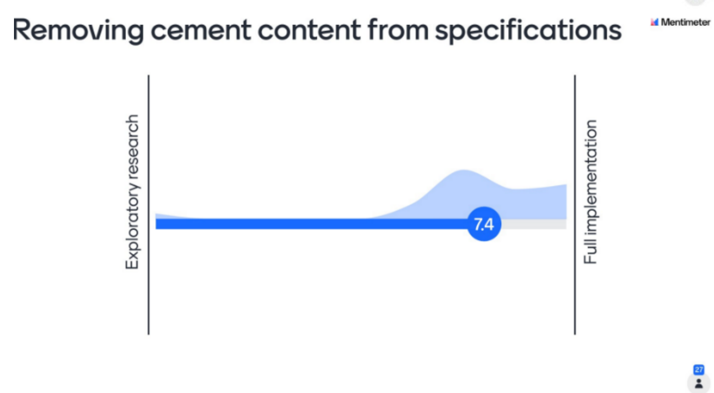


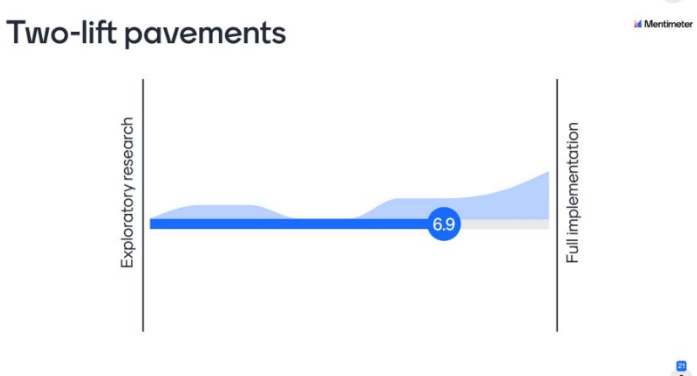


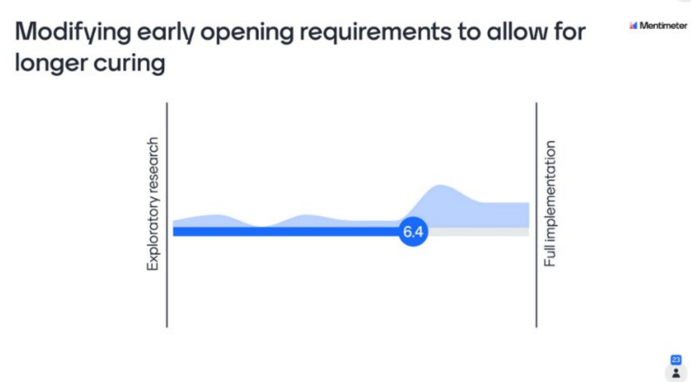






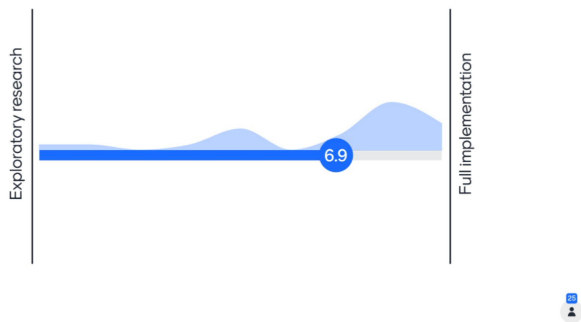






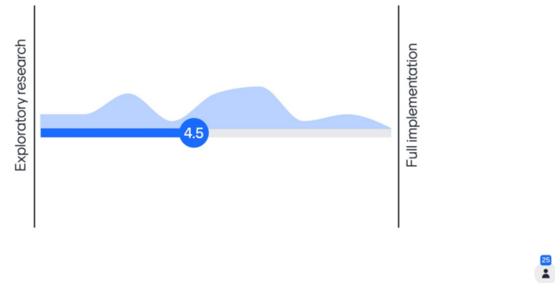
Increasing frequency of diamond grinding

Mentimeter



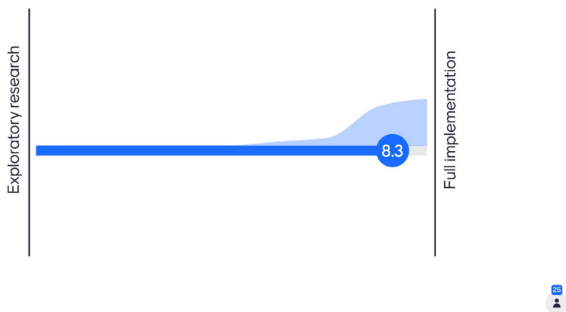
Incorporation of embodied carbon and PVI into PMS

Mentimeter



Recycled concrete aggregate

Mentimeter



Use of alternative fuels

Mentimeter