## **Concrete Pavement & Materials** Technical Feedback Group



## Advancing Sustainable Solutions – Workshop # 2

Austin Texas | November 17-18, 2022

### SUMMARY ITEMS

**CP&M TFG Moving Forward** - Continue to meet roughly every 6 months. Keep collaborating. Next meeting in May/June 2023. Suggestions for the next meeting site included MnRoad Test Track area (MN), Tuscaloosa (AL), Seattle (WA), Charlotte (NC), Charleston (SC), or Outer Banks (NC). A hub that is easy to get into and out of is preferred.

**Education and Tech Transfer** – Education about sustainability, EPDs, etc. is still needed. Stakeholders must be engaged, and educated about what this (sustainability, low carbon, EPDs etc.) is... and how we implement it? Also, we need to clearly communicate why it is important, so we can get buy-in from all stakeholders – from executive level to engineering staff. Resilience and cost effectiveness could be a pathway, given the political reality around climate change and sustainability. Also, CA and CO have instituted programs that appear to be working well. We may want to learn more details of these programs to help inform how one might implement nationwide.

Specific education and tech transfer needs include:

- Continued emphasis on resources about PEM and PLC (both important for sustainability)
- Develop Tech Brief/one-page document on the key elements for using EPD's such as Environmental impact comparison, performance comparison, vendor selection and design selection.
- Develop Tech Brief about Use Phase impacts such as Excess Fuel Consumption from deflection and roughness, albedo effects (related to Radiative Forcing) and Carbon Uptake from carbonization.
- Pavement ME Design Tools Needs improvement in durability/performance predictions as new materials and performance models come into the market. Weak in durability predications. Need to push new technology towards implementation, in place recycling not included, IRI model too simplistic. A one stop-shop model is needed.
- LCAPave should be updated to include use-phase impacts.

**AASHTO Guide for Decreasing Concrete's Embodied Carbon Content** – Presented framework was well received. Supportive of continued development. Acknowledged that it is a large undertaking. May need to pare down scope to focus on most important factors. Are other resources needed in addition to this guide?

Green Public Procurement – FHWA will explore how other countries have integrated this into their practices.

**Construction Impacts** – Can we identify and quantify the benefits of such items as lane-closures/construction stages to reduce GHG emissions? Some resources exist (e.g. CA4PRS). Should they be updated to include sustainability impacts?

**IRA Incentives/grants** – For the \$2B Buy Clean initiative (under the IRA) grant eligibility is determined by the EPA. CPM TFG could be a resource for EPA on this since we may have more knowledge in the concrete area specifically. Challenges with establishing low carbon grant eligibility using EPDs include factors such as the limitations of EPDs, lack of comparability of EPDs, and lack of availability of PCRs for mobile plants. Details about this program will be available in coming months. One notable suggestion for how to implement the \$2B grant program: In the next year take the first \$100 Million of the \$2B in IRA to fund 100 small pilot projects, spread across 20 agencies, using ternary blended cements with 50% clinker replacement, and test & publish.

#### **Research Items Discussed:**

- Need to develop PCR to accommodate paving concrete (mobile plants). Do we need more generic PCRs as well?
- Recycling practices by DOTs Last study done a few years ago. What are states doing now? AASHTO COMP has a List Serve which could be used for this.
- Carbonation Draft a clear statement for RNS or Synthesis. Ask states as part of the recycled study listed above or as a separate one. Also, NIST is leading an effort on this and the group is waiting to see that work product before pursuing additional work in this area.

#### Main TFG thoughts about what to prioritize to move sustainability solutions forward:

- Invest in education. Emphasis on what sustainability, low carbon, EPDs etc. are, and why this is all important. Important to get buy-in. Encourage collaboration.
- Leverage the Use Phase (PVI). Build and maintain stiff and smooth pavements. Incorporate use-phase impacts in LCAPave.
- Accelerate deployment via risk sharing! Provide incentives large enough to alleviate risk. Provide funds is a good way to implement.
- Implementing fast will be critical to success. Increase the pace of change! Urgency is important. Provide data and publish case studies.
- Also: Removing barriers to fuels at clinker stage. Materials usage, reduce waste to zero. Update specs. Start doing it now. Implement test pavements to gather data and validate models. Optimize mixes that meet performance. Emphasize smooth and rigid pavements. Regulate CO<sub>2</sub> as an air pollutant.

## **MEETING NOTES**

#### Day 1 (11/17/2022)

#### Welcome and Opening Remarks

Leif Wathne - Leif opened the meeting stating it was an informal workshop to allow for feedback and input to FHWA from all.

Welcome from FHWA – Gina Ahlstrom welcomed everyone and appreciated being in Austin. She stated this was the 2<sup>nd</sup> meeting on this topic since the last workshop in May 2022 in Chicago. There was a concrete technology feedback group but covid presented some challenges. The main topic is sustainability, they will keep that vision with this smaller group. This will be a cohesive group/team moving forward. Where can research take us? Using a team approach with people from different backgrounds and perspectives. We will have a common platform moving forward. She appreciates all for attending.

Welcome from TX - Andy Narajo (TX) – Andy welcomed everyone to Austin. They are a large user of concrete pavements with 16,000 lane-miles of CRCP and 2000 lane-miles of JCP. They are big users of SCM's and are actively looking for alternative options. They are looking to increase durability and resiliency without legislative mandates.

Self-Introductions - Self-Introductions were made with those attending stating their name, employer, expertise, what they hoped to learn and hobbies. This varied among the group with public agencies, industry, consultants and academia. The expertise varied as well. All wanted to learn more about sustainability and wanted to help. Leif stated we are here to advance sustainable solutions and to provide information to FHWA for this. He hopes to leave with actionable items for this.

#### FHWA Opening Remarks – Robert Spragg

Robert provided opening remarks stating what the group will do such as discuss topics, initiatives and programs of interest to FHWA, discuss national issues and needs, be a forum for input with a cross-section of various individuals hosting meetings that are open. They will not be an advisory group, not direct FHWA programs or activities, not provide a consensus opinion and not be charged with developing documents or standards. He gave the group's mission, to focus on program level challenges and opportunities concerning the performance and sustainability of concrete pavements, and it will be a forum for discussion and to provide input to FHWA.

The first meeting was held in May 2022 with a smaller group representing a varied background. In the US we use 109 M Metric tons of cement per year. It is a critical material and we need sustainability throughout its life cycle. We are looking for on-going collaborations to advance pavement sustainability. We can quantify emissions throughout its life cycle and have practical approaches to do this. We need to utilize emerging technologies, expand education, engage stakeholders and provide incentives. Decisions should address societal, environmental, and economic impacts. We need to identify barriers and promote our successes.

FHWA heard the message to advocate for the low hanging fruit (PEM and PLC), promote education, life cycle assessment on emissions is important, and provide money for demonstration projects.

The workshop objectives are to:

- Learn about ongoing efforts
- Communicate FHWAs posture and direction to key stakeholders

• Advance strategies across the pavement life cycle into quantifiable practical and implementation ready approaches to reduce climate impacts.

FHWA's current position is to provide sustainable pavements through pavement design, materials, QA, construction, pavement managements and preservation/rehabilitation. Decisions should address the social, environmental and economic impacts. They need to meet the CO<sub>2</sub> targets of 20% reduction from the 2005 baseline by 2030 and 100% by 2050. Industry can help with this by identifying pathways to accomplish this and identify barriers and needs. FHWA needs stakeholders engagement and feedback to accomplish this.

He discussed tailpipe (from vehicles) vs embodies emissions (from materials production and construction). This brought about a slew of comments regarding tailpipe emissions, EPDs, message needed to get out, horizontal vs vertical construction, life-cycle costs, performance necessary, use of IL cements, costs, data, and measuring changes vs. risk.

The DOT has a new policy memorandum on this – Buy Clean Initiative that will assess and address the embodied carbon emissions that come from transportation projects. Highway projects could be eligible for funding under a Carbon Reduction Program under some carbon reduction requirement (yet to be identified). Federal money of \$2B will be available until September 2026 to reimburse or provide incentives to lower embodied GHG emissions. This is as determined by EPA, a regulatory agency. It was asked if EPA was invited to this meeting. They were not directly but FHWA has been in discussion with them. FHWA wants one voice to EPA and hope to get that back. They have been invited to some meetings. They are looking to target embodied emissions in the A1-A3 category initially.

DOT's recent activities include the COOP Agreement with the CP Tech Center, supporting the AID-PT Program, utilize TF groups, PEM (guide and P&B for resistivity and plastic tests), a QA Manual, Recycling efforts, updating the concrete pavement preservation guide, harvesting fly ash, overlays, real-time smoothness equipment loan and technical support, SCMs, 2005 Concrete benchmark, Technical Support Teams, MNRoad Cell 32 and Iowa Case Study. In education they have a Sustainability Course NHI-131134, held a webinar on Buy Clean Policies and EPDs, a MnDOT workshop on Public Bidding and EPDs, and a 2022 PCR Guidance Toolkit.

They will investigate how other countries have integrated Green Public Procurement into their practices. The NCHRP recently awarded \$350k for QA and Sustainability.

Financially FHWA contributed \$300k to MnRoad, \$7.1M for the Climate Challenge to 25 states and 2 local agencies in the area of education, process implementation, benchmarking and fundamental research. They have the Center for Acceleration Innovation (<u>www.fhwa.dot.gov/edc</u>) that stated (in part) that EPDs will transform the procurement process on GHG in a transparent manner to reduce environmental burdens throughout the project deliver process. This initiative will help agencies, etc. in applying EPDs.

A PLC Technote - 1. suppliers driving the transition, 2. opportunity to address questions and 3. provide case studies.

A Pooled Fund (<u>www.pooledfund.org/Details/Solicitation/1542</u>) approved in March 2022 of \$10k will get you \$250,000 & 100 hrs of Technical Assistance to advance a new practice. This is open to many items but could be PEM or BMD (balanced mix design for asphalt).

For items of low hanging fruit are Type IL cement (also known as PLC), PEM mixtures. They initiated the P3C – Performance Centered Concrete Construction pooled fund on actions to increase performance of concrete

between the batch plant and opening to traffic.

For LCA it is more than embodied carbon. They have SP-TWG topic subgroups to look at data for EPDs and goals for Use Phase. LCA Pave Support is a new tool to help in paving activities.

#### **Cohort Updates -Leif Moderating**

#### Agency Report – Andy (TX), Brett (MO), Peter (PANY), Hailey (CO)

Texas consumes 150-200,000 tons of fly ash yearly at 20-35% replacement, sometimes up to 50% SCM replacement. Maximum cementitious is 520 #/CY and optimize gradations to reduce it to 400#/CY in some cases. They all recycled crushed concrete as aggregates. The moved to compressive strength for traffic opening. In 2024 they will increase SCM replacement to 50%, 70% for mass placements and will allow natural pozzolans. They have a number of research projects and have submitted a Climate Challenge proposal.

Missouri is looking for fly ash replacements. They have a Climate Challenge project on concrete and asphalt for EPDs. They will attend the ACPA annual meeting and try to get the word out on EPDs. They hold a quarterly meeting on PEM, etc. Cradle to Gate now but cannot compare asphalt to concrete.

PANYNJ has a Concrete Embodies Carbon project to determine the scope of emissions by quantifying embodies carbons. This included a review of concrete from past years. In 2018 400# of Portland cement (300# for mass pours) was set. This showed a reduction of GWP of 25-30%. A draft specification is ready for this.

Colorado showed a timeline of activities in this area from the 1980's. Some highlights are use of fly ash in the 1980's, use of PLC and increasing limestone use in the 2000's, increase slag percentage in the 2010s along with using PEM mixtures. They have been using recycled aggregate for over 20 years. Legislation has been passed that requires collecting EPDs for projects in cement and concrete, asphalt and asphalt mixtures, and steel. This collection (so far of 32 projects) will help to further develop maximums in the future. EPD specifications and protocols are on the CDOT webpage. They received a Climate Challenge award. They also will conduct more research and hold outreach sessions.

Problems identified by PANYNJ include the Definition of Low Embodied Carbon Concrete. What is the criteria? SCM usage? The second is Mix Specific EPDs. PANYNJ receives concrete from many different sources. How do mobile batch plants fit in? The 3<sup>rd</sup> is there is No Set Methods of GWP Limit Setting. This is difficult due to different sources and different areas. The 4<sup>th</sup> is for Precast concrete, in that it for a specialty item without a lot of industry support to quantify. CO mentioned the lack of accountability for EPD submittals, limited personnel, communication to others outside of the agency, lack of knowledge, lack of impact and data quality and need for PCR improvements.

#### Challenges

- Lack of accountability for EPD submittals
- Limited personnel to perform QA activities
- Communication with suppliers not part of industry associations

#### Industry Report – NBC, NRMCA, ACPA, WRI, CRSI, ESCSI, EIG, PCI, PTI, PCA - Brian (NRMCA)

From 2016 to 2021 there has been a 11.3% reduction in GWP and that PLC is 8.3% lower than OPC in 2021. Blended cement share has increased to 25% from less than 5% in the past year alone. Good data needs to be used for EPDs and we need to be transparent. The PCA Roadmap has 5 value chains of Clinker, Cement, Concrete, Construction and Carbonation, and have made great progress. The contractor's commitment is located at BuildingGreen.com with options to take for Good, Better or Best in different areas, one being carbon reduction. They coordinate with the FHWA Sustainable Pavement Goals (see below) to provide guidance to get true data, establish benchmarks, support carbon reduction and provide incentives to name a few, for Goal #1. We need to optimize designs, embrace sustainability strategies, diamond grind every 10 years, and be resilient to climate change.

FHWA Sustainable Pavements Goal #1 - Where missions cross, what can be done together?

- Develop guidance for states on how to collect and use EPD data
- Develop guidance on establishment of benchmarks
- Support the use of material carbon budget in lieu of mix specific limits
- Provide incentives to use innovative materials and methods on pilot projects

Goal #2 - Improving sustainability thru innovations in Pavement asset management systems

Goal #3 - Implementation and Quantification of Environmental Performance Metrics.

- Support extending PCR life cycle stages to include cradle to grave
- Industry efforts related to concrete PCR
- Develop guidance of pavement design optimization that integrates LCCA

Project specific pavement design lowers cost and environmental impact

Goal #4 - Implementation of Social and Equity metrics in Pavement systems

- Optimizing carbonating
- Use phase dominates
- Improvement pavement resilience regarding climate change

Recommended actions include work with EPA to define and set benchmarks, implement stage analysis in LCA tools, Include full life-cycle in PCR, assess/update LCI datasets, set project CO<sub>2</sub> goals, address impediments to innovation, and incorporate resilience concepts into design and asset management. ACPA report/plan is done and will be distributed at the annual meeting. It has 5 categories: 1) carbon reduction, 2) jobsite wellness, 3) waste management, 4) water managements and 5) material selection

#### Academia Report – Tyler, Tara, Randy, Armen, Hessam, Moe, John and Somayeh

The group reported there is a lot to do but we must not be afraid to make decisions. You will get rapid feedback and can change course. "Don't let perfect be the enemy of good" by Voltaire. How can EPDs be collected to establish functional equivalence. We must compare apples to apples since the variation can be as much as 50%. We should create a one-pager on key elements needed for using EPDs in environmental comparisons, performance comparisons, vendor selection and design selection. Action – create a one-page document on the key elements for using EPD's such as Environmental impact comparison, Performance comparison, Vendor selection and Design selection.

In the Use Phase deflection and IRI have an impact as well as albedo effects and naturally occurring recarbonization. There are many studies of PVI (fuel consumption). Briefs could be created on Excess Fuel Consumption, Radiative Forcing from Albedo and Carbon Uptake.

Pavement ME Design Tools needs improvement in durability predictions as new materials and performance models come into the market. Very weak in durability predications. Need to push new technology towards

implementation, in place recycling not included, IRI model too simplistic and we need to build a one stop shop model.

We can recycle up to 100% if barriers (availability of materials, hesitation to do something new, other perceived barriers) are removed. FHWA can help by promoting the benefits of recycling, survey states on best practices and distribute. This would lower the risk for many projects. We should have RCA as an EDC initiative. Use the Tarantula Curve for recycling.

Caltrans Pavement Tools Integration of Data Definitions and Models (attachment 4a) were shown along with the Pavement Engineering and Database Interactions. Trust in the tools that we have.

Focus on the system and not individual projects for efficiency and savings. Look at freight volumes, safety needs, poor/fair roadways and bridges, and congestion to allocate your resources. Use these metrics to achieve a score for future work. Freight is responsible for 7% of emissions. A dedicated truck corridor similar to rail lines (ATC – Autonomous Truck Corridor)? Benefits could be great! FHWA could help by providing case studies for system level management and fund exploration grants for innovative approaches.

PLC can save 8M tons of CO<sub>2</sub> when implemented. 30% of kilns produce this now. FHWA can help by asking what a DOT is most interested in, organize DOTs by region, use local FHWA forces to promote this and create a plan for each state or region. They can provide guides, case studies and training support. Mitigate risks to the state in implementing new technology. Incentivize by providing more funding when criteria is met. FHWA should help and not mandate (unless it is legislated).

# Consultant Report – Sutter Engineering IIc, NCE, Applied Pavement Technology and theRightenvironment – Larry Sutter and Tom Van Dam

The Consultants goals are the same as everyone else's is. We can help you, the FHWA and states with this. Consultants can provide specialized knowledge, can support all parties, can provide training and other support, can do R&D and be altruistic. Extreme events are happening with more frequency. We need to change to reduce GHG emissions. No action will lead us to a 4.5 degree C increase by 2100, current INDC action to 3.5 and we need to follow a 2 degree pathway. Sustainability is a new dimension in construction. Key things will change in 2050 from 2022 such as using less clinker in cement, less cement in concrete and less concrete in construction by using less cement, SCMs, alternative cementitious materials, mixture optimizations and alternative designs. Less obvious changes will be in construction and contracting. Sustainability must be integrated into the project. If you pay for it, you will get it. Discussions like this are needed but we need more action. We need to strengthen the LCA infrastructure, have more demonstration projects, and support innovation by underwriting RISK. We need new tests and implementation. Consultants cannot change it. There must be education and push the information out.

General Discussion followed focusing on what can we learn from failures, we need information sharing. There are challenges but we are in this together

#### What do we mean by Life-Cycle Carbon Reduction? Randy Kirchain (MIT)

A life-cycle approach should be used to evaluate impacts from materials production, design & construction, use and end-of-life. There are embodied carbon as we as operational carbons. Cement production drives the impacts for concrete. Embodied impacts vary greatly by area. The use phase can have the majority of GHG emissions in a pavement cycle. The amount varies greatly with roughness, area, season, vehicle speed, albedo, carbonation, and traffic amount. Key observations are use phase impacts can be far larger than embodied; use phase of excess fuel consumption, albedo and carbonation; and Use Phase can be larger or smaller than materials, but it is usually

influential. You should think of a multiplier effect over time.

#### Update on AASHTO Standard Guide for Reducing Embodied Carbon – Felag and Wathne

Robert Spragg opened by saying this is an effort to help states and industry develop low embodied carbon content in concrete while maintaining performance. This effort will show how we can lower embodied carbon content in concrete by providing strategies. It allows states to move forward wherever they are on this effort

Mark presented on the CP Tech Center work on developing a guide for this. A guide was recommended since this would be a series of options or instructions that offer direction without recommending a specific course of action. Pros are that it aligns with what we are doing as opposed to a Practice and easier to ballot. Cons are that it may be overlooked or underused if not in the Materials Book. We cannot compromise engineering performance. Binder System approaches include lower cement content, use supplementary cementitious materials, use blended cements, use alternative cements or other approaches. Admixtures could also be used to lower the embodied carbon content. Aggregate system approaches include using durable aggregates, blending marginal aggregates, targeting quality aggregates based on need, minimizing transportation and using artificial or recycled aggregates, or other approaches. Mixture system approaches include proper proportioning, proportioning for use, using PEM, improve durability by using other R 101 requirements, optimizing aggregate gradations, carbon injection and other approaches. Reporting will be with and without EPDs. Timeline is mostly out of our control but 4 months to send to AASHTO then 12 months to publication (March 2024). This can vary greatly. Talk then do, then do again if necessary.

#### Breakout Group Discussion #1 – EMBODIED – Wathne

[FHWA wants thoughts on two questions. 1. General comments on approach - first thoughts. 2. Hypothetical: if I take this and design new mix... and it meets performance spec goals. How do I demonstrate that it meets low carbon standard? Rules of thumb? How do we actually do this...? IF you design a mix under a low carbon grant.... How do you demonstrate that it meets the threshold without an EPD. Waiver process?]

An AASHTO document is a good way for states to vet information and get buy-in. It allows 'entry' wherever you are in this effort. QA could be included as a strategy. Some of the points may not be complementary (i.e., if you increase or decrease an item it may limit your movement for another). Off-setting strategies, should evaluate as a whole. We may need more than a guide. Do we have enough data for EPDs for different mixes?

#### Breakout Discussion #2 - CONSTRUCTION - Wathne

[Are there opportunities: Full closure vs phased closures. Overnight closure vs "weekend+" closures. Construction Equipment. Others? How/to whom do we need to communicate these?]

There are opportunities for lower costs, safety and environmental impacts with full closures (weekend closures). Alternative bidding was met with mixed results. We can put a \$ cost on social impacts, delay costs for incentives. We need to communicate to public, etc. on traffic control plans and closures. Get feedback. Transfer fleets to clean energy allowing time to do so. Keep IRI down, pavements smooth. Educate contractor's on smoothness and quality. Limit waste generated during construction.

#### General First Day Closing Comments on Demonstration Projects – Wathne

A general discussion followed about demonstration projects of the past and we need to do similar projects now. FHWA is doing that with the current monies available. What do we want to include in demonstration projects and what decisions need to be made to accept those that get funded and those that do not. Monitoring would have to be done. CA has a system to do this.

### Day 2 (11/18/2022)

#### Welcome and Recap of Day 1 - Spragg / Wathne - General Comments

We need the scope on the education issue. Education is important with outreach. Most people don't know what we are talking about. Hear input on this. Center of Excellence of ACI could help in Certification? LEED? Some basic knowledge. What are EPDs? Agencies have staff knowledgeable, but they have other work to do. Nutrition labels are important! Training side, TC3 group set up training modules? Starting point for DOT's. Information may be already out there. How do we implement?

CA (482 cities and 52 counties) faced the education issue. They met with the League of Cities, etc. for 2 years and got buy in to explain, not sell. Used gas tax money to set up an improvement/resource center for outreach. This online, self-paced certification program was for 80 hours. They trained 1300 people in 2 years through universities. CO set up a similar interactive course providing resources. It took awhile. Great feedback to clarify needs.

Tell industry EPDs mandatory in 3 years. Will comply. Demand for PLC going up. MO was approached early regarding IL cement. They incorporated into their specifications. No plants switched over initially. Education helpful. Smaller outlets need guidance.

For Alternate bidding EPDs we may not know product at the time of bidding. How to incorporate? Fuel tax – electric – change revenue stream.

#### Update on FHWA PVI Study – Kiran (PPT)

Impact of pavements on vehicle fuel consumption – Surface Characteristics (Roughness and Texture) and Structural Characteristics. Roughness impacts by energy dissipation represented by IRI (international Roughness Index). Impact of pavement texture affects tire and tread deflections. Mean Texture Depth or Mean Profile Depth (MPD). Compliant pavements deflect more under load. Pavement deflection moduli or other indices. Critical conditions for PVI factors – Roughness (higher volumes, speed), Texture (traffic volumes) and Structural Response (heavy traffic, low speeds and higher temps).

TFHRC study – Objectives – Review models, availability of models, and recommend approaches for using the models. Objectives not to compare pavement types, not which models are the best or not to conduct field experiments. Different Surface Characteristics Models – NCHRP 1-45, MIT Roughness Induced, NRC Phase II, MIRIAM, UIUC Roughness-Speed Impact and FHWA Updated HERS. Each models consider, calculates and VOC outputs differently. For these all have IRI, some rolling resistance and most IFC (Instantaneous Fuel Consumption).

Structural Response PVIsr Models – MIT Deflection Induced, OSU Excess Vehicle Fuel (Model 1) and MSU Structural Rolling Resistance Model. Considers, calculates and VOC Outputs - all have and layer thickness, properties and deflection; dissipated energy; and EFC.

Case Study Objectives – Evaluate models, demonstrate application, assess consistency and compatibility, provide a better understanding and evaluate sensitivity to various conditions. Case studies – 1 – Models, 2 – Design scenarios, 3 – Evaluation of Impact and 4 – Network level evaluation of EFC and VOC. There was an increase in fuel consumption with increased roughness or texture. Fuel consumption increases as trucks go slower. For the PVIpsc there were some variations in results. PVI psc Models – NCHRP 1-45, MIRIAM, UIUC, New HERS and MIT Roughness Induced Models. Studies Flexible and Rigid Pavements for IFC and EFC. Some

variation in results.

General Comments - Texture is a significant factor, more than expected. Roughness too. Can model be used by state agencies? Trucks are more sensitive to speed.

Comparison of Estimated Fuel Savings – Estimated improvements of measures would give you an estimated fuel savings. Measures are (roughness, texture, curvature, gradient, speed, etc.). Findings are models can be used to estimate factors and has general agreement.

General Comments - The availability and quality of data is important and a challenge for longer analysis periods. IRI an economic model started in Brazil. Results were linear with the delta being important. Roughness will go down more than 50, probably from 200 to 90 or 80, 150 to 60. T

#### Breakout Discussion #3 - USE PHASE - Leif

Questions -

- PVI Study... how to account for this? Where would we include it. Next steps?
- Material Durability For a novel material how can a LCA reflect this for better durability. Timing of actions.
- Long life materials 75 years or more? How can we ensure concrete pavements perform as long-life materials? What kind of supporting documentation would support this determination?
- RNS on Carbonation

While discussing what we would be talking about in a breakout session many comments and questions were brought up. While doing this it was suggested to not have a breakout session but continue the good discussion as shown below:

#### Use Phase – LCA – General Comments

Designing by PEM may be different from standard design. How do we account for it since we don't have full LCA picture? PEM provides assurance. We will get there by using it. Incentives since you can show a longer life. Use LCCA and LCA. Plug values into models then evaluate. Go to accelerated testing for modeling. All analysis problematic. Some unplanned but know when planned maintenance is needed. Performance based models. May not reflect if same IRI. Structural design models could be into IRI but may not be captured. We are much more knowledgeable than in the past. 60% construction quality important. Accept level of risk.

#### **Use Phase – Materials – General Comments**

Need a PCR for materials. How do they compare? Assume same analysis periods. We need information on Novel materials, non-hydraulic cements or geopolymers. PLC has been used for many years. What about removing good materials due to change in roadway alignment? Pavements are more than materials...design to handle traffic. Can't rely on empirical formulas. How do we get enough assurance about materials. Test and keep applying. Some tests treat materials unfairly. Make sure criteria account for new materials. Strength, attacks by chemicals, etc. We know a lot. Testing at different times or temperatures.

#### Use Phase – 75 Year Requirement – General Comments

We have it for bridges but not pavements. Risk needs to be minimized and this can be done. There are questions but we can make it last!

#### Use Phase - RNS – Carbonation RNS – Spragg – General Comments

What is the outcome of the research? If carbonation is important how can we incorporate into a tool or

analysis procedure. Grinding, crushing, etc. We need to make sure we do not double count. For a Synthesis you would need about 40 states that have information on a topic. For a RPS you need to define what your product is, what is your outcome along with a clear direction to get there. Could you look at LTPP SPS sites for this? Different ages have different answers. Models are out, you need field validation. Pathways for end of life. Need conceptual framework for it. What would be the purpose? Carbonation into LCA. Useful carbonation to get in. PH value can predict. Some studies are available on carbonation. Put into LCA pave. Define a robust system for approval. Carbonation broad, some research. NIST is conducing work in this area. Group seemed content with seeing deliverables from NIST before pursuing additional work.

#### Use Phase Impact – What should be included/meaningful? CO2 footprint – Leif – Listing

PVI – Context specific (traffic, trucks - higher, temp?) – Roughness and Structural Response
Albedo – Radiative forcing...human thermal comfort. Extreme heat events.
Construction work zone
Carbonation – In service, end of life.
Social Impacts – Delay costs
B2-5 – Maintenance and Rehab impacts (embodied from materials and user delay costs/emissions).
PCR for pavements – EPDs for pavement?
Maintenance Impacts

Notes: Check European Models. Need tools or models to know how to account for these impacts. The use phase being incorporated in the LCA document is the most important thing we can be doing. We need a PCR for pavements.

# Around the Horn discussion: If you were King for a Day, what would you do (where would you put your energy) to lower the CO2 impact of pavement? (Individual thoughts abbreviated)

- Budget on education contractor, etc. What is sustainability, low carbon, EPDs etc.... and HOW do we do this? WHY it is important? How do we get BUY IN (resilience and cost effectiveness can be a pathway) Make people want to embrace this! Embrace we are at a tipping point. Encourage collaboration
- Leverage the Use Phase (PVI) Build and maintain stiff and smooth pavements. Incorporate in LCA pave
- Accelerate deployment (of these technologies) and risk sharing! Provide incentives large enough to alleviate risk. Provide funds is a good way to implement. Provide funding to replace.
  - In the next year take the first \$100 Million of the \$2B in IRA to fund 100 small pilot projects, spread across 20 agencies, using ternary blended cements with 50% clinker replacement, and test & publish it all.
- Do it quicker, share risk, move faster. Increase the pace of change! Urgency is important. Learn by reading, publish data. Case studies..
- Removing barriers to fuels at clinker stage
- Materials usage, reduce waste to zero.
- Update specs. Start doing it now.
- Implement test pavements to gather data and validate models.
- Optimize mixes. Optimize mixes that meet performance. Smooth and rigid. Target money,
- Make CO<sub>2</sub> an air pollutant

#### Path Forward

Spragg – Thank you everyone for coming! We learned a lot. Hope you all did the same. Worthwhile endeavor. Also thank the bridge folks for joining! Action items to do. Some pathways. Continue discussion. Thank you to Texas for hosting.

Next meeting: Probably similar format. Six months, May or June 2023. Suggestions for the next meeting site included MnRoad Test Track area (MN), Tuscaloosa (AL), Seattle (WA), Charlotte (NC), Charlestown (SC), or Outer Banks (NC). A hub that is easy to get into and out of.

Meeting Adjourned at 11:30am, 11/18/2023.