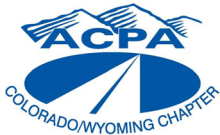


# Environmental Product Declarations (EPDs)

## An Update on the Colorado DOT's Benchmarking Efforts

Angela Folkestad, P.E.

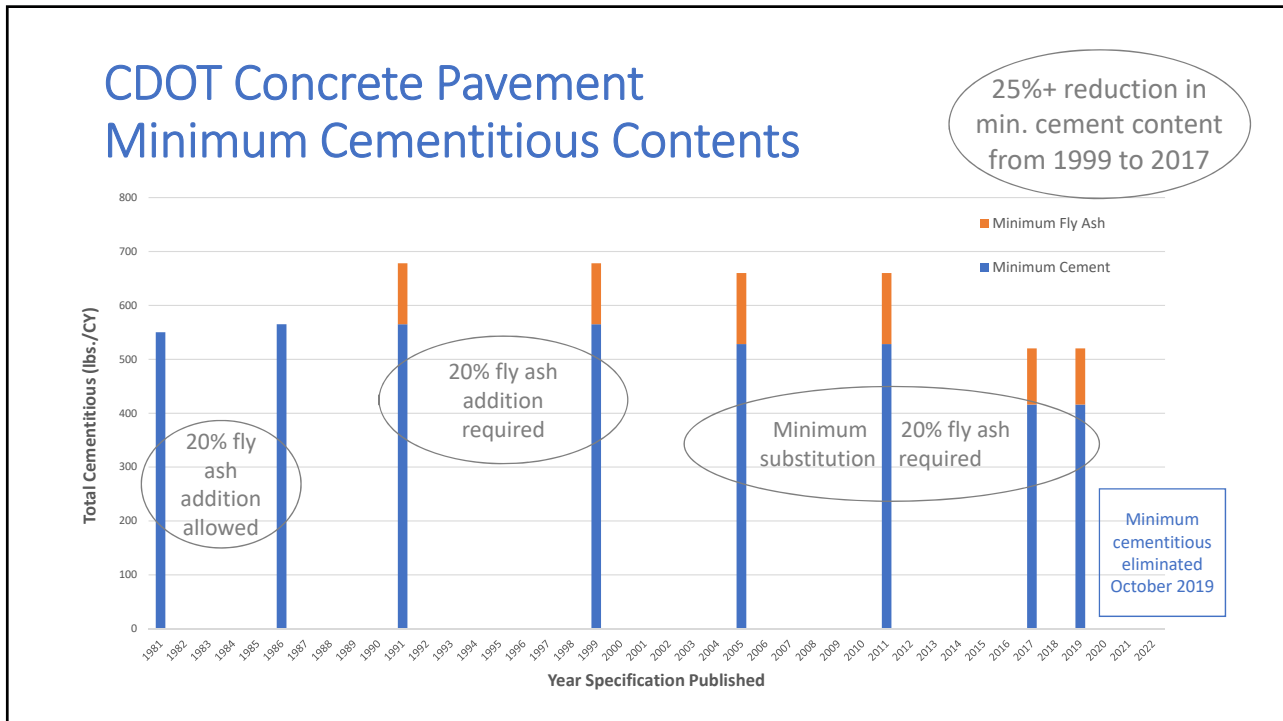
CO/WY Chapter – American Concrete Pavement Association



## CDOT & Industry Have Been Proactive for Years

- Pavement Design – Adoption of Pavement ME
- Materials Selection and Mixture Design Specifications
  - Aggregates
  - Cementitious Materials





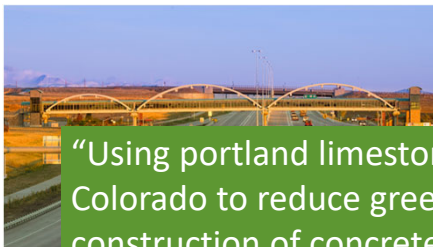
# CDOT Specifications – PLC allowed since 2008

- ASTM C1157 GU used initially
- ASTM C595 Type II introduced in fall 2014



1<sup>st</sup> CDOT Paving Project w/ PLC  
US 287 (Ports to Plains route) in eastern CO

# PLC Allowed in CDOT Specs since 2008



“Using portland limestone cements for over 10 years allows Colorado to reduce greenhouse gas emissions in the construction of concrete pavements with no compromise in quality and long-term performance.”

Eric Prieve, CDOT Concrete & Physical Properties Engineer

**CP ROAD MAP**  
Moving Advancements Into Practice™  
MAP Brief October 2018

Best practices and emerging technologies that can be used to build better, greener concrete paving.

**Portland-Limestone Cement after 10 Years in the Field**

**Introduction**

In 2005, the first commercial plant of PLC in the United States was operational and sold under the ASTM C1157 performance-based specification for its cement.

Portland-Limestone cement is not simply a blend of portland cement and limestone. It is a carefully engineered material designed to meet the demands of the concrete's performance. It is a cementitious material that is stronger than ordinary portland cement and has a finer particle size distribution. The fine limestone particles act as nucleation sites

to 10% compared to ordinary portland cement (OPC).

In 2005, the first commercial plant of PLC in the United States was operational and sold under the ASTM C1157 performance-based specification for its cement.

**History of Performance**

PLC has been used by the ready-mix concrete industry. PLC has been used in thousands of cubic yards of concrete for commercial and residential projects.

**CEMENT TESTING**

Of the most extraordinary things about ASTM C1157 portland-limestone cements is how ordinary they are. Compared to ASTM C150 (Type I) portland cements, they have similar strength gain characteristics, can be used under identical environmental conditions, are in-situ comparable during mixing and placement, and have the same durability characteristics.

The only major difference between the two cements is what is missing. The energy and carbon dioxide footprint of a portland-limestone cement is lower than that of a portland cement. Because

environmental and sustainable design continue to gain in significance as resources grow scarce, the use of energy-efficient and environmentally sound materials is an integral part of design and construction. As a result of its relatively low cost, low embodied energy, and high strength, portland-limestone cements are the most widely used building materials on the planet.

This article discusses testing conducted by an independent laboratory of new ASTM C1157 portland-limestone cements produced by Holcim (US) Inc. in Colorado and Utah and several projects constructed using these cements to illustrate how extraordinarily ordinary these cements are.

**Clinker part of clinker**

In view of the manufacture of portland cements as CO<sub>2</sub> intensive? There are two primary sources of CO<sub>2</sub> inherent in the manufacturing



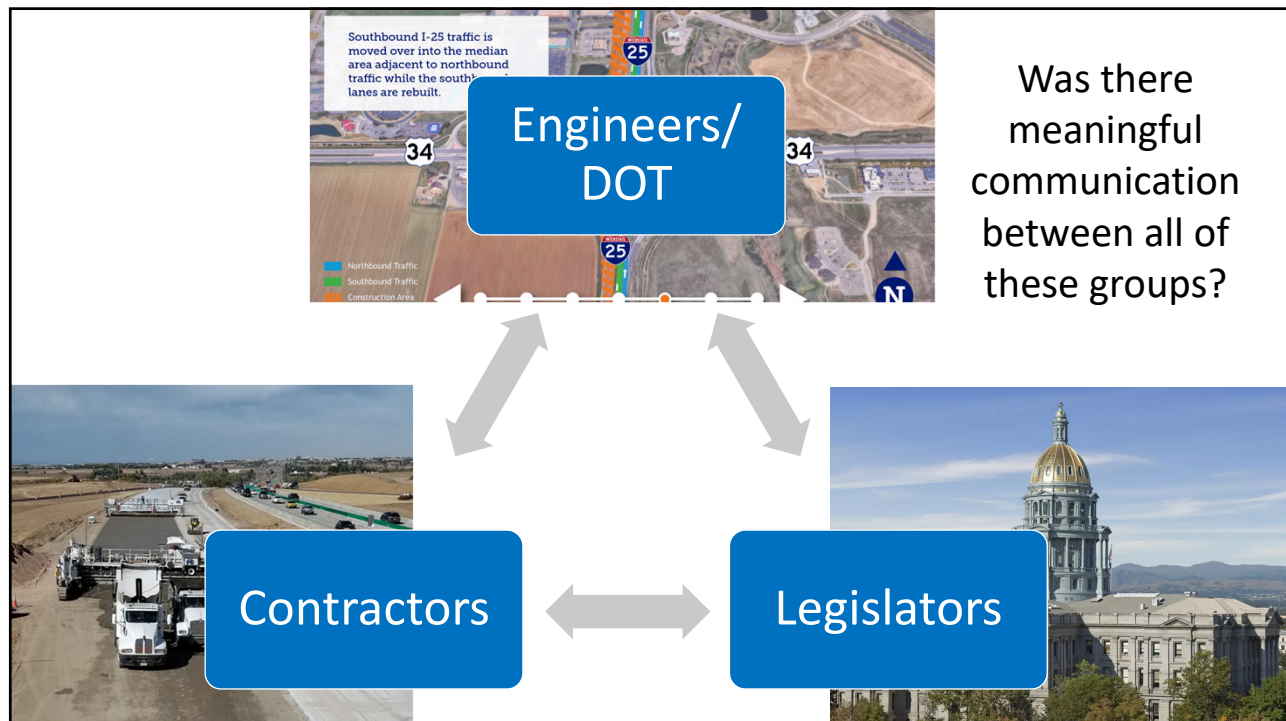
1,500+ Lane-Miles of Concrete Pavement w/ PLC

## What was being accomplished with these changes?

- Improved durability
- Lower materials cost
- Encourage Innovation
- Lower environmental impact
- Prevents excessive over-design
- Smoother pavements

*Intentional or not, we were headed on the path toward...*

Performance Engineered Mixtures (PEM)!



## THE DENVER POST

### Denver among top 10 worst U.S. cities for hazardous air pollution, 2 new studies say

EPA tallies show Denver residents inhaled elevated pollution on more than 260 days a year for the past two years



In this Wednesday, March 6, 2019, photograph, the skyline is shrouded as pollution fills the air over Denver.

David T. Cook, The Associated Press

By BRUCE FINLEY | bfinley@denverpost.com | The Denver Post  
January 30, 2020 at 6:02 a.m.

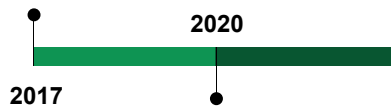
Source: The Denver Post, January 30, 2020

***“People also are breathing bad air regularly in other cities along Colorado’s Front Range, from Colorado Springs to Fort Collins, according to Environmental Protection Agency records.”***

***“And climate warming is expected to intensify air pollution, federal scientists warn, because heat speeds the formation of ground-level ozone and boosts the frequency and severity of wildfires, which infuse more particles into smog.”***

## Buy Clean Colorado: Background

**Buy Clean California Act Passed**



**SB 20-159 Introduced**

The Colorado legislative bill sponsor used the Buy Clean California Act as a basis and renamed to Buy Clean Colorado Act.

*Graphic Source: Colorado Department of Transportation*

## What was the impetus for EPD legislation?



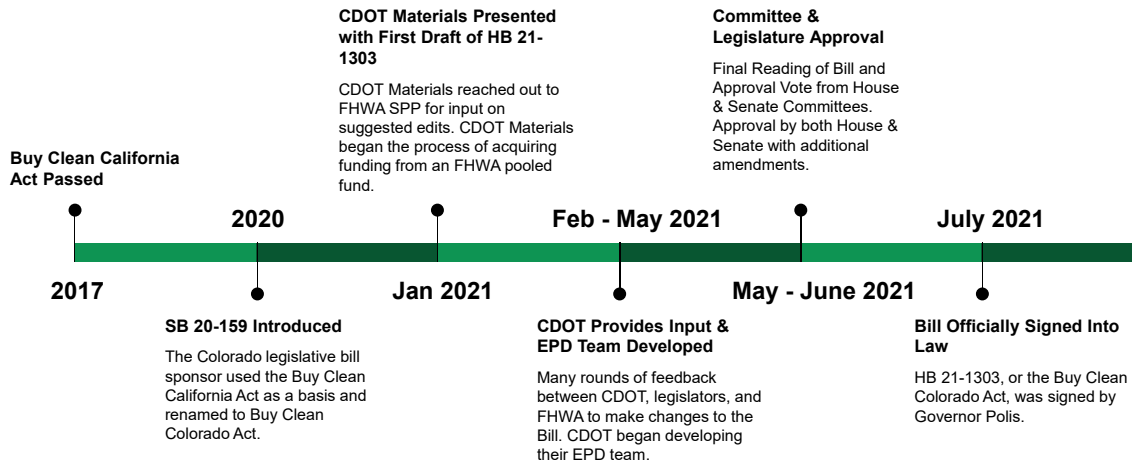
## Our Challenge...



≠



## Buy Clean Colorado: Background



Graphic Source: Colorado Department of Transportation

## Buy Clean Colorado: Working with Legislature

CDOT worked several months with bill sponsor from proposal through acceptance by legislative committee. CDOT gathered input from the FHWA Sustainable Pavements Program and other Agencies to **shape the bill**.

- Changes CDOT Materials requested:
  - Divide the bill into 2 sections: vertical construction & horizontal construction
  - Allow more time to collect EPDs for benchmarking before establishing limits
- Final Content:
  - Based on CDOT's feedback, bill divided into separate sections for vertical and horizontal construction

Content Source: Colorado Department of Transportation

## Buy Clean Colorado

- HB 21-1303 incorporated into Colorado Revised Statutes in July '21
  - 24-92-117 – Office of the State Architect
  - 24-92-118 – Colorado Department of Transportation
- Requires CDOT to collect EPDs per ISO 14025 on eligible projects for certain eligible materials including:
  - Asphalt and Asphalt Mixtures
  - Cement and Concrete Mixtures
  - Steel
- CDOT must use collected EPDs to develop a policy establishing maximum Greenhouse Gas emissions for each eligible material
- EPD submittal requirements detailed in “Buy Clean Colorado” Specification

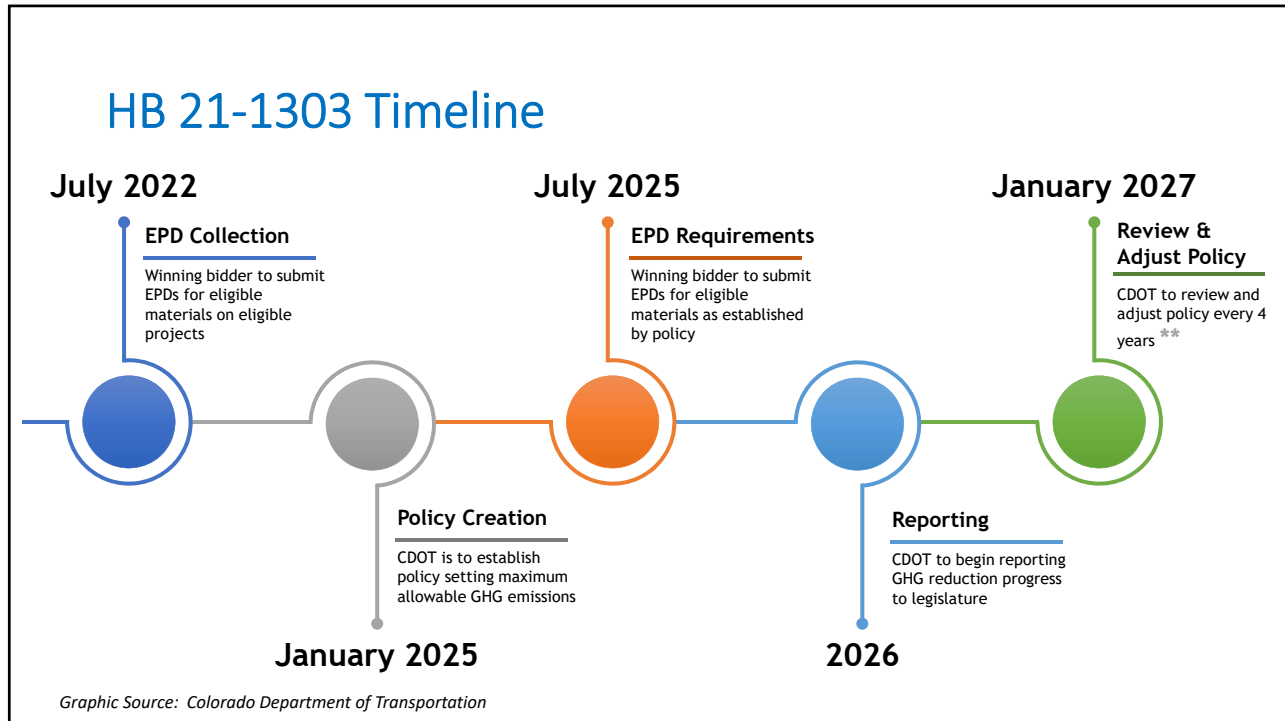
## HB 21-1303: Potential Benefits

Implementation of this EPD program will provide the following potential benefits:

- Partnership with the statewide [Colorado Greenhouse Gas \(GHG\) Pollution Reduction Roadmap](#)
- Alignment with CDOT's [GHG Pollution Reduction Proposed Standards](#)
- Compliance with HB 21-1303 by reducing GHG of CDOT projects over time
- Supply CDOT with information to make more informed and environmentally responsible decisions
- Collaboration with material suppliers and contractors to quantify and potentially reduce their environmental impacts
- Transparency to the public that CDOT is moving towards more sustainable infrastructure

*Content Source: Colorado Department of Transportation*





## CDOT's New EPD Specification

June 2, 2022

REVISION OF SECTION 101 and 106  
ENVIRONMENTAL PRODUCT DECLARATIONS

**Sections 101 and 106 of the Standard Specifications shall include the following:**  
**Add the following definitions to Subsection 101.02:**

**Environmental Product Declaration:** An environmental declaration providing quantified environmental data using pre-determined parameters and, where relevant, additional environmental information. ISO14025 refers to these as a Type III Environmental Declaration.

**Product Category:** A group of products that can fulfill equivalent functions (ISO14025).

**Product Category Rule:** A set of specific rules, requirements, and guidelines for developing Type III environmental declarations for one or more product categories (ISO14025).

**Section 106 shall include the following:**

**106.13 Environmental Product Declaration (EPD) Materials Submittal Requirements:**

The Contractor shall submit an Environmental Product Declaration (EPD) for the following materials to be utilized on this project.

- (1) Asphalt and Asphalt Mixtures,
- (2) Cement and Concrete Mixtures,
- (3) Steel.

The EPD submittal shall be per the Environmental Product Declarations Protocol document as published in the Appendix of the CDOT Field Materials Manual relevant to the project. The EPD Protocol Document shall be considered a Contractual Document for this project.

All costs associated with the development of and submittal of an EPD and any other work associated will not be paid for separately but shall be included in the relevant bid item, or constituent material prices.

- All details included in CDOT's Field Materials Manual
- \$3M minimum project cost
- Defines bid items requiring EPD submittal & relevant quantity limits
- Addresses portable batch plants

## CDOT Bid Items Currently Requiring EPDs

Table 1. Bid Items Requiring EPD Submittal

Item Number Category	Item Description	Included Item Number / Range	Interpretation
206	Structure Backfill (Flow-Fill)	206-00065	EPD submittal required for the flow-fill (concrete) design.
310	Hydraulic Cement	310-00900	EPD submittal required for the cement.
403	Asphalt Mixtures (HMA/SMA/WMA)	403-09210 through 403-96660	EPD submittal for each asphalt mixture design and plant location required. If 411 - Asphalt Cement is paid separately, it shall be included in the 403 EPD submittal item. For portable Plant EPD Guidance, see footnote.
412	Portland Cement Concrete Pavement (PCCP)	412-00200 through 412-01500; 412-06000; 412-06060	Separate EPD submittals for concrete, dowel bar, and reinforcing steel items are required. For portable Plant EPD Guidance, see footnote.
503	Drilled Shafts	503-00012 through 503-00102	Separate EPD submittals for concrete and reinforcing steel items are required.
504	Walls (Cast in Place)	Cast in place 504 items containing concrete, reinforcing steel, or both.	Separate EPD submittals for concrete and reinforcing steel items are required.
601	Concrete (All Classes)	601-01000 through 601-05900	Separate EPD submittals are required for each class of concrete and mix design for each supplier.
602	Reinforcing Steel	602-00000 through 602-00025	Separate EPD submittals are required for each mill supplying steel.

604	Inlets/Drainage Structures (Cast in Place)	604-00305 through 604-19515; 604-20000 through 604-39035	Separate EPD submittals for concrete and reinforcing steel items are required.
606	Guardrail and Bridgerail (Cast in Place)	606-00710 through 606-00944	Separate EPD submittals for concrete and reinforcing steel items are required.
608	Concrete Sidewalk & Bikeway	608-00000 through 608-00012; 608-00020 through 608-00040; 608-00350 through 608-00500	EPD submittal required for concrete, or asphalt mixtures.
608	Bituminous Sidewalk & Bikeway	608-01000 through 608-01500	EPD submittal required for concrete, or asphalt mixtures.
609	Curb and Gutter	609-20000 through 609-71000	EPD submittal required for concrete.
610	Median Cover Material	610-00010 through 610-00040	EPD submittal required for concrete, or asphalt mixtures.

Concrete Related Bid Items

## CDOT Bid Item Quantity Limits

Table 2. Bid Item Quantity Limits

Item Number Category	Item Description	Quantity Limits	Unit
206	Structure Backfill (Flow-fill)	50	CY
310	Hydraulic Cement	150	Ton
403	Asphalt Mixtures (HMA/SMA/WMA)	500	Ton
412	Portland Cement Concrete Pavement (PCCP)	1,000	SY
601	Structural Concrete (All Classes)	50	CY
602	Reinforcing Steel	15,000	LB
608	Concrete Sidewalk & Bikeway	250	SY
608	Bituminous Sidewalk & Bikeway	500	Ton
609	Curb and Gutter	1,000	LF
610	Median Cover Material	4,000	SF

Concrete Related Bid Items

## Status of EPD Collection: Summary

- 56 projects advertised (through early January) that contain EPD specification & are eligible for EPD collection
- CDOT received 29 EPDs & expecting more submissions soon
- Additional categories to be added:
  - Structural Steel
  - Precast & Prestressed concrete



Content Source: Colorado Department of Transportation

## CDOT EPD Resources

- EPD Specification
- EPD Protocol Document
- EPD Quantity Conversion SS
- EPD Submission Form & Training
- Reference Documents
- Presentations & Workshops
- Conference Agendas
- White Paper

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**Environmental Product Declarations (EPD)** Contact Us  
CDOT\_EPDP@state.co.us

**Requirements**

- **EPD Specification** - Revision of Sections 101 and 106 - Environmental Product Declarations.
- **EPD Protocol Document** - Appendix D of the 2023 Field Materials Manual.
- **EPD Quantity Conversion Spreadsheet, Version 1 (Rev. 8-17-2022)** - This Tool can be used by project personnel to determine the materials eligible for EPD submissions based on bid item number and quantity. It also reports the bid item quantity in the EPD Declared Unit, which is a required value in the EPD submission form.

**EPD Declared Unit Requirements Table**

Material	Declared Unit (Metric)
Asphalt	Metric ton
Concrete	Cubic meter
Reinforcing Steel	Metric ton
Cement	Metric ton

**EPD Submission Form**

- [EPD Submission Form](#)
- [EPD Submission Form Introduction video](#)
- [Submission Form Training](#)

<https://www.codot.gov/business/designsupport/materials-and-geotechnical/epd>

## Expected Changes Coming Soon...

### **Bid items to be added**

- Steel pilings
- Walls (expand to include precast)
- Slope & ditch paving
- Structural steel
- Reinforced concrete pipe/end sections/culverts
- Inlets/drainage structures (expand to include precast)
- Guardrail & Bridgerail (expand to include precast)
- Prestressed concrete structures
- Drainage pipes

## Future Requirements...

- Additional bid items
- Uncertainty factors may be applied to GWP values shown in EPDs to account for non-facility specific data used when developing them
- Ongoing outreach with industries producing and placing eligible materials
- Additional materials may be added
  - Cold-rolled steel elements (such as guardrail & corrugated metal pipe)

## Example EPDs for CDOT Class P (Paving) Concrete (Not collected through CDOT program)

ENVIRONMENTAL IMPACTS	
Global Warming Potential (kg CO <sub>2</sub> -eq)	342
Ozone Depletion Potential (kg CFC-11 eq)	2.86E-02
Acidification Potential (kg SO <sub>2</sub> eq)	1.41
Eutrophication Potential (kg N eq)	0.33
Photochemical Oxidant Potential (kg O <sub>3</sub> eq)	2.2
Alkali Depletion, non-fuel (kg Si eq)	6.96E-01
Alkali Depletion, fuel (kg Si eq)	0.01
Total Heavy Metals (kg)	1.92
Consumption of Freshwater (m <sup>3</sup> )	1.92E-01

- CDOT B/D/P
- Impacts for 1 m<sup>3</sup>
- 4,500 psi @ 28 days
- **GWP: 342 kg CO<sub>2</sub>-eq**
- EPD Program: NRMCA
- 3<sup>rd</sup> party verifier: Sustainable Solutions Corp.
- LCA & EPD Developer: Climate Earth

ENVIRONMENTAL IMPACTS	
Global Warming Potential (kg CO <sub>2</sub> -eq)	298
Ozone Depletion Potential (kg CFC-11 eq)	6.26E-02
Acidification Potential (kg SO <sub>2</sub> eq)	0.33
Eutrophication Potential (kg N eq)	0.33
Photochemical Oxidant Potential (kg O <sub>3</sub> eq)	2.2
Alkali Depletion, non-fuel (kg Si eq)	6.96E-01
Alkali Depletion, fuel (kg Si eq)	0.01
Total Heavy Metals (kg)	1.92
Consumption of Freshwater (m <sup>3</sup> )	1.92E-01

ISO 21500:2017 Sustainability in Building Construction — Environmental Declaration of Building Products, serves as the core PCR for Concrete. NSF International, August 2021 v2.1 serves as the sub-category PCR.

Sub-category PCR review was conducted by Thomas P. Gloria - Industrial Ecology Consultants

Independent verification of the declaration, according to ISO 14025:2006.  Internal  External

Third party verifier Thomas P. Gloria (t.gloria@industrial-ecology.com) - Industrial Ecology Consultants

For additional explanatory material  
 Manufacturer Representative: Dana Robinson (dana.robinson@burnco.com)  
 Software Tool: CarbonCLARITY Suite, EPD Generator - Verification  
 LCA & EPD Developer: Climate Earth (support@climateearth.com)

## Next Steps: FHWA Climate Challenge

**CDOT was granted \$312,000 & intends to use on the following projects:**

**Project 1:** Continued support for compliance with HB 21-1303 (future industry outreach, improvements to EPDs and PCRs).

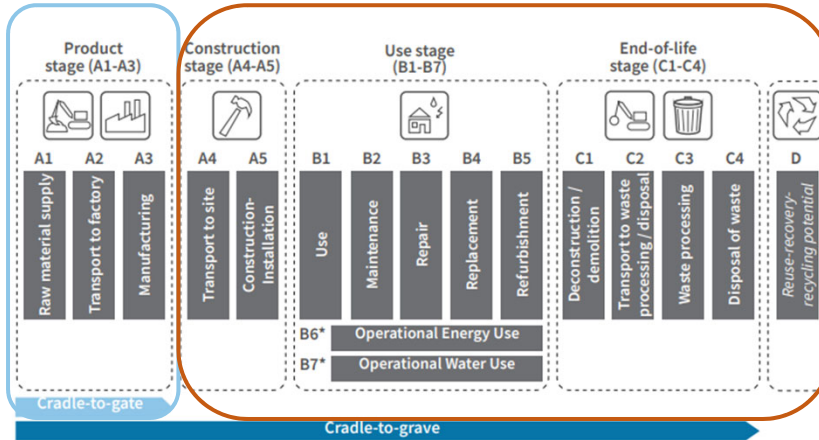
**Project 2:** Data analyses and methodology to establish GWP limits based on EPD data CDOT collects between now and 2025 (how to categorize materials, how to identify outliers and handle uncertainty, and developing documentation of this process) - In collaboration with CU Boulder.

**Project 3:** Beyond A1-A3 (gaining familiarity with lifecycle thinking and the LCA Pave tool).



Content Source: Colorado Department of Transportation

## EPDs Measure Cradle to Gate Impacts



Substantial portion of impacts are not captured through EPDs

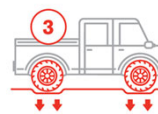
\*Operational carbon stages that are typically excluded from life cycle assessments focused on embodied carbon.

Figure 1. Life cycle stages for building products, based on EN 15978:2011 and ISO 21930:2017.

Graphic Source: Carbon Leadership Forum (CLF)

## Beyond A1-A3: Reducing Gate to Grave Impacts

- Pavement preservation/restoration
- Concrete overlays as preservation
- Pavement Vehicle Interaction (PVI)
  1. Roughness – bumpy or smooth
  2. Texture – abrasiveness/traction
  3. Deflection – bending of pavement
- Albedo - measure of solar energy reflected by earth's surface



<p style="font-size: 24px; font-weight: bold; margin: 0;">Concrete Pavement's Role in a Sustainable, Resilient Future</p> <p style="font-size: 12px; color: #0099cc; margin: 5px 0 0 0;">Version 1.1</p> <div style="text-align: center; margin-top: 20px;">  <p style="font-size: 8px; margin: 0;">ACPA AMERICAN CONCRETE PAVEMENT ASSOCIATION</p> </div>	<div style="background-color: #005596; color: white; padding: 5px; font-weight: bold; font-size: 16px; margin-bottom: 10px;">Table of Contents</div> <p><b>Section One: Introduction to Sustainability and Resilience</b> ..... 4</p> <p>What is Sustainability? ..... 4</p> <p>The Resilience Relationship ..... 5</p> <p>Roadmap to Carbon Neutrality ..... 6</p> <p>The Importance of Life Cycle Thinking ..... 7</p> <p><b>Section Two: Economic Sustainability and the Role of Robust Materials Competition</b> ..... 9</p> <p><b>Section Three: Environmental Sustainability of Concrete Pavements</b> ..... 11</p> <p>Optimizing Pavement Designs for a Reduced Carbon Footprint ..... 11</p> <p>Reducing Cement's Carbon Footprint with Blended Cements ..... 12</p> <p>Reducing Concrete's Carbon Footprint with Performance-Engineered Mixtures ..... 13</p> <p>Use Phase Impacts ..... 14</p> <p>The Role of EPDs in Sustainability (sidebar) ..... 14</p> <p>Pavement Vehicle Interaction ..... 15</p> <p>Albedo and Highly Reflective Surfaces ..... 16</p> <p>Maximizing Radiative Forcing Impacts ..... 17</p> <p>Minimizing Urban Heat Islands ..... 18</p> <p>Carbon Dioxide Absorption ..... 18</p> <p>Additional Strategies to Improve Concrete Pavement's Environmental Sustainability ..... 19</p> <p>Recycling ..... 20</p> <p><b>Section Four: Society and Concrete Pavements</b> ..... 21</p> <p>Rideability and Improved PVI ..... 21</p> <p>Health and Safety ..... 21</p> <p><b>Section Five: Conclusion</b> ..... 22</p> <p>Bibliography ..... 23</p>
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Questions?

Angela Folkestad, P.E.

CO/WY Chapter – ACPA

AFolkestad@pavement.com

Huge thanks to Hailey Goodale for providing presentation content & insights!  
Please reach out to her directly with additional questions.

Hailey Goodale, EIT

Colorado Department of Transportation (CDOT)

Hailey.Goodale@state.co.us