
NATIONAL CONCRETE CONSORTIUM
SH13 CO Overlay
Picture Source: ACPA
Environmental Product Declarations (EPDs)
Concrete Industry Perspective
ACPA
NRMCA
PCA


Infrastructure and Sustainability
Current Initiatives Driving Material Transparency
ACPA
NRMCA
PCA

Federal Buy Clean Initiative

- White House **Buy Clean Actions** Announced September 15th, 2022.
  - Administration Goal: Net-zero emissions by 2050 and a 50-52% reduction by 2030.*
  - Prioritize the Federal Government's purchase of steel, concrete, asphalt and flat glass that have lower levels of emissions.
  - Expand lower-carbon construction materials used in federally-funded projects.
  - Convene states to partner on Buy Clean.
  - Increase data transparency through supplier reporting to track and reduce emissions.
  - Launch pilot programs to advance federal procurement of clean construction materials.
  - Expand the Buy Clean Task Force to eight more federal agencies (total of 17 now).

*Economy-wide from 2005 levels (announced April 22, 2021).

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U.S. DOT Buy Clean Initiative

The US Department of Transportation policy statement (issued September 15th, 2022),

"…the U.S. Department of Transportation will launch a Buy Clean Initiative that will assess and address the embodied carbon emissions that come from the engineering, design, construction, procurement, maintenance, and disposal of transportation projects"

1. the Department will explore the use of Environmental Product Declarations, which are transparent, verified reports used to communicate the environmental impacts of construction materials. Standardized reporting would help industry to confidently move forward in investing in the production of clean and reliable materials.
2. the Department will develop a Buy Clean policy based on those reports, to ensure that materials purchased with taxpayer dollars are serving the best interests of the American people, while also supporting job creation in sustainable industry.
3. the Department will prioritize education and research on embodied carbon emissions to ensure that we continue to drive down the emissions that come from the materials and processes used in transportation infrastructure.

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1. **Lower Carbon Procurement Pilot (June 2022):** Increase utilization of environmental product declarations (EPDs) and encourage the acquisition of products and materials with low embodied carbon emissions.
2. **FHWA Climate Challenge (August 2022):** Grant funding to reduce the lifecycle emissions associated with the design, construction, and maintenance of pavements. (40 submissions from 25 states)
3. **U.S. DOT Embodied Carbon Working Group:** Support efforts to ensure all U.S. DOT modal administrations are prioritizing Buy Clean.

H.R.3684 - Infrastructure Investment and Jobs Act (2021)

- **Water:** Deliver clean water to all American families and eliminate the nation's lead service lines.
- **Roads & Bridges:** Repair and rebuild our roads and bridges with a focus on climate change mitigation, resilience, equity, and safety.
- **Transit:** Improve transportation options and reduce greenhouse emissions through investment in public transit.
- **Airports & Ports:** Upgrade airports and ports to improve competitiveness, create more and better jobs at these hubs, and reduce emissions.
- **Rail:** Invest in passenger rail to create safe, efficient, and climate-friendly alternatives for moving people and freight.
- **Electric Vehicles:** Build a national network of electric vehicle (EV) chargers.
- **Power:** Upgrade power infrastructure to deliver clean, reliable energy and deploy cutting-edge energy technology to achieve a zero-emissions future.
- **Resiliency:** Make our infrastructure resilient against the impacts of climate change, cyber-attacks, and extreme weather events.
- **Pollution:** Tackle legacy pollution by cleaning up Superfund and brownfield sites, reclaiming abandoned mines, and capping orphaned oil and gas wells.

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H.R.5376 - Inflation Reduction Act of 2022

- $5.8B allocated for an advanced manufacturing fund intended to help speed decarbonization at industrial plants (SEC. 50161).
  - Disbursed through grants and loans.
  - Also expands eligibility for tax credits for installing emissions-reduction equipment at plants.
- $5.5B allocated across federal agencies — including $2 billion to the Federal Highway Administration (FHWA) — to procure low-carbon materials for transportation and other projects (SEC. 60506).
- $250M allocated to the Environmental Protection Agency (EPA) to help manufacturers develop Environmental Product Declarations (SEC. 60112).
- $100M allocated for EPA, FHWA, and GSA to develop and carry out a program for construction materials to identify and label construction materials and products that have substantially lower levels of embodied greenhouse gas emissions (SEC. 60116).

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State and Local Buy Clean Legislation

- California (AB 262)
- Colorado (HB21-1303)
- Minnesota (Buy Clean Study & Buy Clean/Buy Fair Pilot Program)
- Oregon (HB 4139A)
- Washington State (2021-23 Biennium Budgets & Buy Clean/Buy Fair Pilots)
- City of Austin, TX (Climate Equity Action Plan)
- City of Portland, OR (Procurement Services; Low Carbon Concrete)
- Others…

Sustainability Primer

Some Background Information

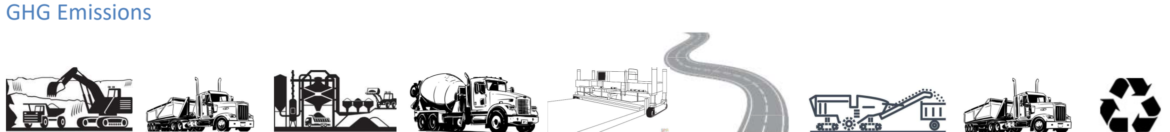
ACPA NRMCA PCA

Embodied and Operational (Use) GHG Emissions

Concrete Pavement Life-Cycle

A1	A2	A3	A4	A5	B1 - B7	C1	C2	C3 - C4
Embodied	Embodied	Embodied	Embodied	Embodied	Embodied Use	Embodied	Embodied	Embodied
Extract and process raw materials	Transport all materials to concrete plant	Manufacture concrete	Transport to paving project	Construct pavement	Use and maintain the pavement	Remove pavement or recycle in-place	Haul away waste materials	Landfill or recycle / reuse

GHG Emissions



Time

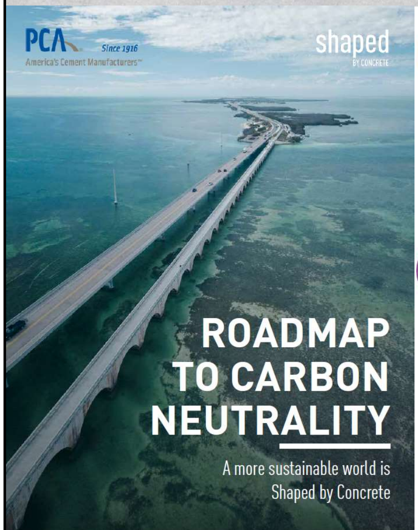
Cradle-to-Gate (Life-Cycle Stages A1-A3)

Cradle-to-Grave (Life-Cycle Stages A1-C4)

Based on an illustration by Stacy Smedley (www.climategifs.com)

14 Count on CONCRETE PAVE AHEAD DURABLE. SUSTAINABLE. CONCRETE. shaped BY CONCRETE

Roadmap to Carbon Neutrality: Cement & Concrete



CLINKER – Key chemically reactive ingredient

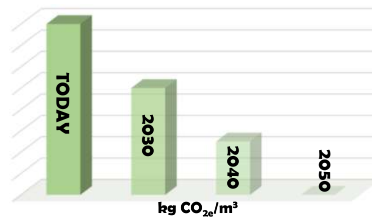
CEMENT – The binder

CONCRETE – Critically useful material to society

CONSTRUCTION – Service life / use phase impacts

CARBONATION – Concrete is a CO_2 sink

NEAR-TERM – **MID-TERM** – **LONG-TERM**



Reducing Concrete's Embodied Carbon Emissions (In-Use to Near-Term)

- **Optimized Pavement Designs & Rehabilitations**
  - Use of Pavement ME and other innovative methods (e.g., short or long [jointless] slab designs, concrete o/l, FDR).
- **Use of Type IL Cement**
  - Portland-limestone cement containing more than 5% but less than or equal to 15% by mass of limestone.
- **Alternative & Blended Cements / Clinkers**
  - The use of low CO_2 clinker and blended cements.
- **Supplementary Cementitious Materials (SCMs)**
  - Fly Ash, Slag, other pozzolans to reduce the amount of cement in the concrete.
- **Aggregate Optimization**
  - Use well graded mixes to reduce paste and improve workability & durability. On-site concrete recycling.
- **Enhanced Carbonation**
  - Technologies to use CO_2 emissions (e.g., injected CO_2).

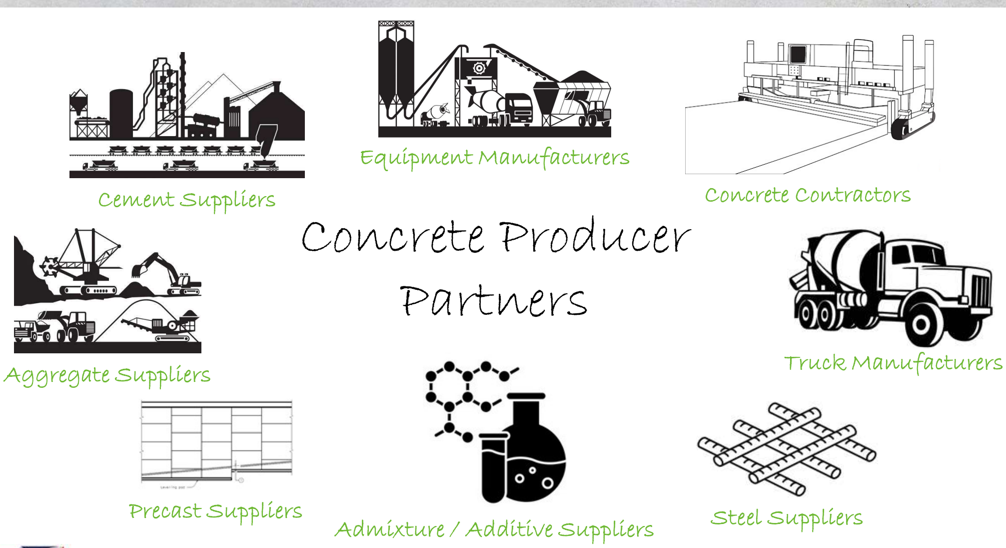
Optimizing concrete mixes using these tools allows the Industry to create low carbon ready-mix concrete

Reducing Concrete's Embodied Carbon Emissions (Mid- to Long-Term)

- **Increase Use of Alternative Fuels at Cement Plants**
  - Utilize transformative fuels and technologies: hydrogen, plasma heating, oxyfuel/oxy-calcination, electric calcination, agriculture and sorted disposed waste…
- **Zero or Low Emissions During Cement and Concrete Manufacturing and Transportation**
  - Move to renewable energy sources and alternative fuels (e.g., hydrogen) or electric power for transportation.
- **Development of New Cements**
  - Use low CO_2 clinker and blended cements, new binders, etc.
- **Carbon Capture Utilization & Storage**
  - Further develop technologies to capture, store, and use CO_2 emissions (e.g., underground storage, enhanced carbonation cement and aggregates, etc.).

Optimizing concrete mixes using these tools allows the Industry to create low carbon ready-mix concrete

Industry Partnering: Working Together to Meet Sustainability Goals



Type III ISO 14025 Environmental Product Declaration (EPD)

Summary Page

This Environmental Product Declaration (EPD) reports the impacts for 1 m^3 of ready mixed concrete mix, meeting the following specifications:

- ASTM C94: Ready-Mixed Concrete
- UNSPSC Code 30111505: Ready Mix Concrete
- CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction
- CSI Division 03-30-00: Cast-in-Place Concrete

COMPANY
BURNCO Colorado
301 Centennial Dr.
Milliken, CO 80543

PLANT
Jeffco Plant
10888 CO-93
Golden, CO 80403

EPD PROGRAM OPERATOR
National Ready Mixed Concrete Association
900 Spring St
Silver Spring, MD 20910

NRMCA CERTIFIED EPD

NRMCAEPD:20029

DATE OF ISSUE
10/02/2021 **(valid for 5 years until 10/02/2026)**

ENVIRONMENTAL IMPACTS

Declared Product:
Mix 45FN31C2C • Jeffco Plant
Description: CDOT CLASS B/D/P LOW SLUMP
Compressive strength: 4500 PSI at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	345
Ozone Depletion Potential (kg CFC-11-eq)	8.20E-6
Acidification Potential (kg SO_2-eq)	1.01
Eutrophication Potential (kg N-eq)	0.39
Photochemical Ozone Creation Potential (kg O_3-eq)	22.4
Abiotic Depletion, non-fossil (kg Sb-eq)	7.02E-5
Abiotic Depletion, fossil (MJ)	710
Total Waste Disposed (kg)	102
Consumption of Freshwater (m^3)	3.24

Product Components: natural aggregate (ASTM C33), Portland cement (ASTM C150), batch water (ASTM C1602), fly ash (ASTM C618), admixture (ASTM C494), admixture (ASTM C260)

Additional detail and impacts are reported on page three of this EPD

ISO 21930:2017 Sustainability in Building Construction — Environmental Declaration of Building Products: serves as the core PCR
PCR for Concrete, NSF International, February 2019 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 Cara Vought (cara@sustainablesolutionscorporation.com) • Sustainable Solutions Corporation

For additional explanatory material
Manufacture Representative: Dana Rotkovich (dana.rotkovich@burnco.com)
Software Tool: CarbonCLARITY Suite, EPD Generator • Verification
LCA & EPD Developer: Climate Earth (support@climateearth.com)

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Life Cycle Assessment (LCA Page)

LIFE CYCLE ASSESSMENT

SYSTEM BOUNDARY

This EPD is a cradle-to-gate EPD covering the product stages (A1-A3) only

PRODUCTION Stage (Mandatory)			CONSTRUCTION Stage		USE Stage					END-OF-LIFE Stage			
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4

CUT-OFF

Items excluded from system boundary include: production, manufacture, and construction of manufacturing capital goods and infrastructure; production and manufacture of production equipment, delivery vehicles, and laboratory equipment; personnel-related activities (travel, furniture, and office supplies); and energy and water use related to company management and sales activities that may be located either within the factory site or at another location.

ALLOCATION PROCEDURE

Allocation follows the requirements and guidance of ISO 14044.
The product category rules for this EPD recognize fly ash, silica fume and slag as waste products recovered materials and thus the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a concrete material input.
Jeffco Plant is a truck (transit) mixing plant. 30% of all mixing truck(fleet) energy has been allocated to module A3.

LIFE CYCLE INVENTORY (LCI)

This EPD was calculated using industry average cement data. Cement LCA impacts can vary depending upon manufacturing process, efficiency and fuel source by as much as 50% for some environmental impact categories. Cement accounts for as much as 89% of the impacts of the concrete mixes included in this EPD and thus manufacturer specific cement impacts could result in variation of as much as 44%.

PRIMARY SOURCES OF LCI DATA

- **Admixture (air-entraining):** EFCA EPD, Europe 2015
- **Admixture (plasticizing):** EFCA EPD, 2015
- **Aggregate (natural):** US-EI (2016): "Gravel, round, at mine/US", 2001
- **Cleaning Chemicals:** Ecoinvent 3.4: 50% Citric acid and 50% Phosphoric acid, industrial grade, without water, in 70% solution state, market for/GLO, 2017
- **Diesel:** USLCI: "Diesel, combusted in industrial equipment/NREL/US", 2007
- **Electricity (WECC):** Ecoinvent 3.4: " Electricity, medium voltage, market for, cut-off", 2015
- **Fly ash:** byproduct of coal combustion; no upstream manufacturing impacts
- **Natural gas:** USLCI: "Natural gas, combusted in industrial boiler/NREL/US", 2007
- **Non-Hazardous Solid Waste:** US-EI (2016): Disposal, municipal solid waste, 2008
- **Oils, Lubricants and Greases:** Ecoinvent 3.4: Lubricating oil, GLO, market for, cut-off, 2011
- **Portland cement:** Portland Concrete Association, Industry Average EPD, 2021
- **Rail transport:** USLCI: "Transport, train, diesel powered NREL/US", 2007
- **Truck transport:** USLCI:"Transport, combination truck, long-haul, diesel powered/tkm/RNA", 2010
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Detail Page

DECLARATION OF ENVIRONMENTAL INDICATORS DERIVED FROM LCA

Impact Assessment	Unit	A1	A2	A3	Total
Global warming potential	kg CO_2-eq	312	20.2	12.6	345
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11-eq	7.55E-6	8.40E-10	6.47E-7	8.20E-6
Eutrophication potential	kg N-eq	0.35	0.02	0.02	0.39
Acidification potential of soil and water sources (AP)	kg SO_2-eq	0.62	0.26	0.13	1.01
Formation potential of tropospheric ozone (POCP)	kg O_3-eq	11.7	7.17	3.47	22.4
Resource Use					
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb-eq	6.68E-5	-	3.41E-6	7.02E-5
Abiotic depletion potential for fossil resources (ADPfossil)	MJ	225	285	200	710
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ	49.5	0.00E+0	6.72	56.2
Renewable primary resources as material, (RPRM)*	MJ	0.00E+0	-	0.00E+0	0.00E+0
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ	1,466	285	205	1,956
Non-renewable primary resources as material (NRPRM)*	MJ	3.99	-	0.00E+0	3.99
Consumption of fresh water	m^3	3.20	-	0.04	3.24
Secondary Material, Fuel and Recovered Energy					
Secondary Materials, (SM)*	kg	114	-	0.00E+0	114
Renewable secondary fuels, (RSF)*	MJ	17.9	-	0.00E+0	17.9
Non-renewable secondary fuels (NRSF)*	MJ	172	-	0.00E+0	172
Recovered energy, (RE)*	MJ	0.00E+0	-	0.00E+0	0.00E+0
Waste & Output Flows					
Hazardous waste disposed*	kg	4.29E-3	-	0.00E+0	4.29E-3
Non-hazardous waste disposed*	kg	102	-	0.02	102
High-level radioactive waste*	m^3	8.20E-4	-	3.08E-9	8.20E-4
Intermediate and low-level radioactive waste*	m^3	4.37E-6	-	1.04E-7	1.48E-7
Components for reuse*	kg	0.00E+0	-	0.00E+0	0.00E+0
Materials for recycling*	kg	1.71	-	8.23E-3	1.72
Materials for energy recovery*	kg	0.00E+0	-	0.07	0.07
Recovered energy exported from the product system*	MJ	0.00E+0	-	0.00E+0	0.00E+0
Additional Inventory Parameters for Transparency					
Emissions from calcination and uptake from carbonation*	kg CO_2-eq	158	-	-	158

* Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.
- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete. Use caution when interpreting data in these categories.

EPDs are comparable only if they comply with ISO 21930 (2017), use the same, sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

REFERENCES

ISO 21930:2017 Sustainability in Building Construction — Environmental Declaration of Building Products
ISO 14044:2006/Amd 1:2017/Amd 2:2020 Environmental Management — Life Cycle Assessment — Requirements and Guidelines

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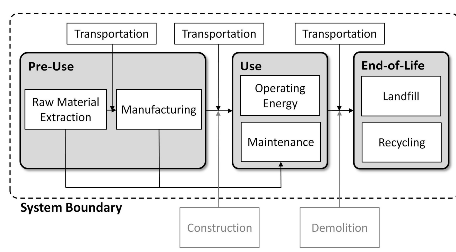
GWP Gases: CO_2, methane, nitrous oxide, CFCs, HFCs, HCFSs, PFCs, SF_6

Product Category Rules (PCR)

- Instructions on how and what to report via the EPD
  - Product studied
  - Functional unit
  - System boundaries
  - Life cycle stages included
  - Impacts reported



Concrete Industry EPD Process

1. Submitting Company Selects a Program Operator.
2. Choose Product and Related Product Category Rule (PCR) and Gather Data per PCR.
3. Conduct Life-Cycle Assessment (LCA) by In-House Staff or LCA Consultant.
4. Conduct Independent Review of LCA.
5. Develop Draft EPD by In-House Staff or LCA Consultant.
6. Submit the LCA Report and Draft EPD to Program Operator for Initial Verification.
7. Program Operator Engages Independent Verifier Who Reviews the LCA Report and Draft EPD.
8. Program Operator Certifies EPD for Submitting Company.

Common EPD Program Operators for Concrete

Program Operator	LCA / EPD Practitioner
NSF	MASTER® BUILDERS SOLUTIONS
NRMCA	Athena Sustainable Materials Institute & climate earth
ASTM	Athena Sustainable Materials Institute & climate earth

Concrete Product Category Rule (PCR) – Revision History

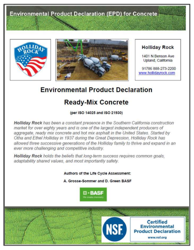
Version	Date issued
Version 1 (published by Carbon Leadership Forum)	November 2012
Version 1.1 (published by Carbon Leadership Forum)	December 2013
Version 2 (published by NSF International)	February 2019
Version 2.1 (published by NSF International)	August 2021 Valid through February 22, 2024

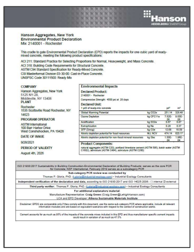
Version 2.x (published by NSF International) August 2022(?) Consideration of Mobile Mixers

Concrete PCR Revisions: Consideration of Mobile Batch Plants

- PCR Committee recently voted to include a one-year deviation:
  - Informative annex to the PCR;
  - Allows for data collection and analysis of data from portable mixing equipment;
  - Data would be basis for paving project EPDs using mobile batch plants.
- Committee will evaluate need to add language specific to paving vs. building mobile batch plant impacts.
  - Subcommittee could be assigned and propose expanded language, if necessary.
- Roller Compacted Concrete Paving Industry
  - Seeking clarification whether deviation is applicable to continuous (pugmill) mixers.

Concrete Environmental Product Declarations





- **~40,000* product specific EPDs have been published by concrete producers since 2013 in U.S. and Canada (~43,000+* globally)**
  - **Largest number published by any industry**
  - Concrete GWP Values (from EC3 Tool):
    - Conservative (Baseline set @ 80th percentile): 362 $kgCO_{2e}/yd^3$
    - Average ("Typical" @ Arithmetic Mean & Std Dev): 299 $kgCO_{2e}/yd^3 \pm 26.7\%$
    - Achievable ("Low-Carbon" set @ 20th percentile): 232 $kgCO_{2e}/yd^3$

GWP benchmarks should be established locally and by mix type.

*Based on Embodied Carbon in Construction Calculator (EC3) Tool Published by Building Transparency which is very comprehensive but not exhaustive.

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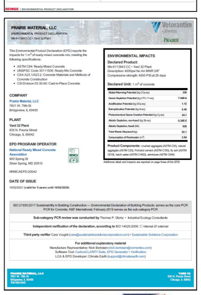
Illinois, Minnesota, Ohio Concrete EPDs



- **Currently 360* concrete EPDs Published for IL, MN, OH (zero for MI in EC3)**
  - Concrete GWP Values (from EC3 Tool):
    - Conservative (Baseline set @ 80th percentile): 389 $kgCO_{2e}/yd^3$
    - Average ("Typical" @ Arithmetic Mean & Std Dev): 295 $kgCO_{2e}/yd^3 \pm 40.8\%$
    - Achievable ("Low-Carbon" set @ 20th percentile): 191 $kgCO_{2e}/yd^3$

GWP benchmarks should be established locally and by mix type.

*based on Embodied Carbon in Construction Calculator (EC3) Tool Published by Building Transparency which is very comprehensive but not exhaustive.

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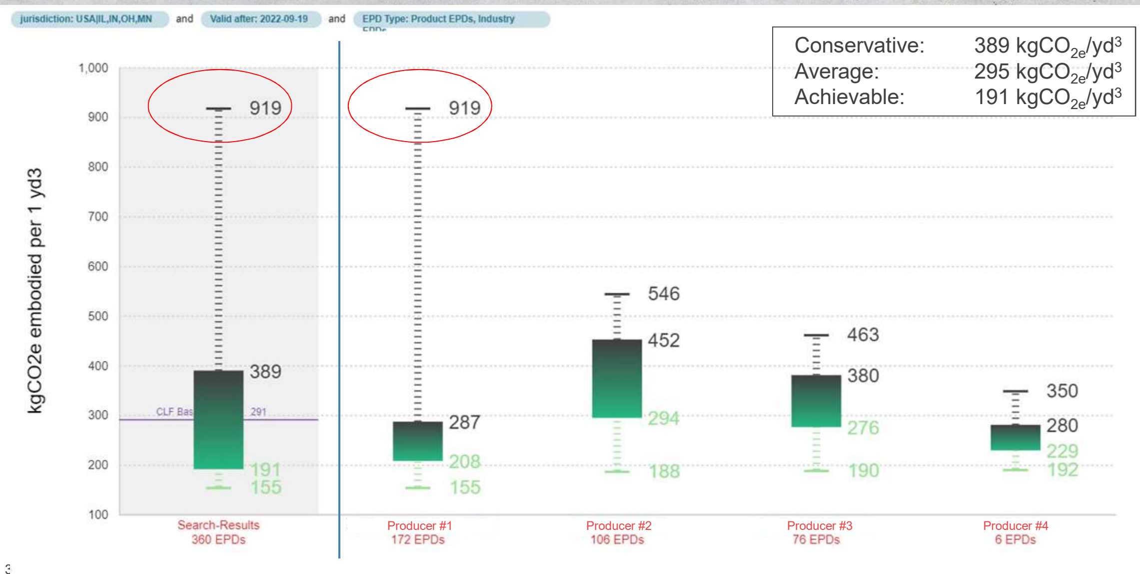
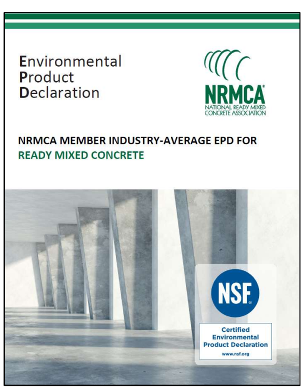
Illinois, Minnesota, Ohio Concrete EPDs



Industry Wide Environmental Product Declaration



https://www.nrmca.org/wp-content/uploads/2020/02/NRMCA_EPD10294.pdf

- Ready Mixed Concrete Industry Wide EPD (v3.2) Jan 2022 – Nov 2024
- From NRMCA Member Data (100+ Companies & ~2,000 Plants)
- Concrete GWP Values from IW EPD (calculated at ↑strength & ↓SCM ranges):

Industry Average EPD (Published January 3rd, 2022)										
28-day f'c, psi	Minimum	Maximum	0% FA/SL	20% FA	30% FA	40% FA	30% SL	40% SL	50% SL	50% FA/SL
Conventional Concrete GWP (per yd^3)										
0 - 2,500	136.6	213.7	213.7	184.7	169.1	152.6	168.0	152.8	137.5	136.6
2,501 - 3,000	150.7	238.1	238.1	205.2	187.4	168.8	186.1	168.9	151.7	150.7
3, 001 - 4,000	182.5	293.3	293.3	251.7	229.1	205.5	227.5	205.6	183.7	182.5
4,001 - 5,000	220.3	358.5	358.5	306.6	278.6	249.0	276.5	249.2	221.8	220.3
5,001 - 6,000	231.5	377.4	377.4	322.6	293.0	261.7	290.8	262.0	233.1	231.5
6,001 - 8,000	266.9	438.9	438.9	374.4	339.5	302.6	336.9	302.9	268.9	266.9
Lightweight Aggregate Concrete GWP (per yd^3)										
0 - 3,000	303.0	426.4	426.4	367.2	335.2	360.0	305.7	340.8	303.0	321.6
3,001 -4,000	343.6	491.2	491.2	424.0	385.0	414.7	348.2	390.3	343.6	362.5
4,001 - 5,000	373.6	547.6	547.6	468.5	422.4	455.3	380.1	427.5	373.6	394.4

Supplementary Cementitious Material (SCM) Ranges:
0-19% Fly Ash and/or Slag, 20-29% Fly Ash, 30-39% Fly Ash, 40-49% Fly Ash, 30-49% Slag, 40-39% Slag, ≥ 50% Slag, ≥ 20% Fly Ash and ≥ 30% Slag

- **NRMCA members decreased their carbon footprint by 21% in 7 years**

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NRMCA Member Regional LCA Benchmark Report

Region	28-Day Compressive Strength, psi								
	2,500	3,000	4,000	5,000	6,000	8,000	3,000LW	4,000LW	5,000LW
	Global Warming Potential (per yd^3)								
National	183.5	200.6	235.6	279.0	294.6	341.3	376.4	412.9	449.8
Eastern	183.3	201.5	240.2	289.0	305.3	360.5	395.4	437.9	480.1
Great Lakes Midwest	177.6	194.8	231.4	277.6	293.1	345.3	381.6	421.6	461.3
North Central	184.2	201.9	238.8	284.7	301.5	351.8	372.1	410.7	451.7
Pacific Northwest	180.0	199.8	242.0	295.2	311.9	372.7	396.2	439.7	483.4
Pacific Southwest	196.5	213.5	247.3	288.9	306.4	349.0	382.2	417.5	453.9
Rocky Mountains	177.5	194.6	229.8	273.4	289.6	336.7	369.8	406.5	443.5
South Central	172.4	187.7	218.6	257.2	272.2	312.8	357.7	390.2	424.5
South Eastern	188.9	204.6	236.5	275.5	292.1	332.2	365.6	398.7	429.4

Table B1-NRMCA U.S. National Benchmark Mix Designs (per cubic yard)

Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	354	394	475	576	610	719	394	475	556
Fly Ash	lbs	62	69	83	101	107	126	69	83	97
Slag Cement	lbs	17	19	23	28	30	35	19	23	27
Mixing Water	lbs	305	305	305	315	341	341	308	308	308
Crushed Coarse Aggregate	lbs	1,126	1,115	1,083	1,029	1,061	1,018	0	0	0
Natural Coarse Aggregate	lbs	553	547	531	505	521	499	0	0	0
Crushed Fine Aggregate	lbs	169	167	162	154	159	152	161	149	136
Natural Fine Aggregate	lbs	1,282	1,270	1,233	1,171	1,208	1,159	1,225	1,130	1,035
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	980	990	1,000
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,867	3,886	3,895	3,878	4,037	4,049	2,178	2,168	2,159

- Published July 2022 (v3.2)
- Region Specific Mixtures For:
  - 6 Conventional Concrete Mixtures &
  - 3 Lightweight Concrete Mixtures

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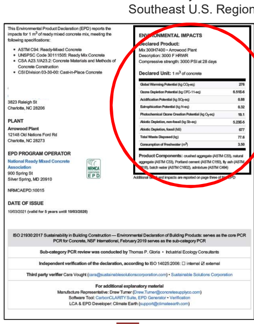
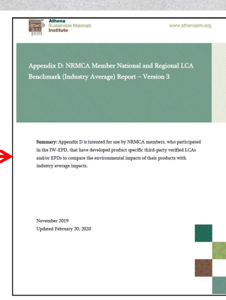
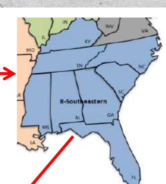
Optimization - Compare to Benchmark

3,000 psi
w/Fly Ash
Southeast U.S. Region







DECLARATION OF ENVIRONMENTAL INDICATORS DERIVED FROM LCA

Impact Assessment	Unit	A1	A2	A3	Total
Global warming potential	kg CO_2-eq	244	23.8	7.84	276
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11-eq	6.30E-6	1.00E-9	2.05E-7	6.51E-6
Eutrophication potential	kg N-eq	0.28	0.02	0.02	0.32
Acidification potential of soil and water sources (AP)	kg SO_2-eq	0.51	0.29	0.08	0.88
Formation potential of tropospheric ozone (POCP)	kg O_3-eq	9.39	7.50	2.17	19.1

Table E9-South Eastern LCA Results (per cubic yard)

Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	209.17	226.87	262.74	306.52	325.03	370.15	387.10	424.12	458.62
ODP	kg CFC11e	5.93E-06	6.35E-06	7.23E-06	8.28E-06	8.77E-06	9.87E-06	1.42E-05	1.52E-05	1.60E-05
AP	kg SO2e	0.77	0.82	0.92	1.04	1.10	1.22	1.90	2.01	2.11
EP	kg Ne	0.29	0.31	0.35	0.40	0.42	0.47	0.68	0.72	0.76
SFP	kg O3e	16.72	17.73	19.81	22.27	23.53	26.13	25.96	28.09	30.07
ADPf	MJ, NCV	1,307.52	1,399.79	1,588.77	1,819.92	1,925.67	2,162.96	2,802.91	3,003.82	3,188.41
ADPe	kg Sbe	2.15E-04	2.25E-04	2.47E-04	2.72E-04	2.87E-04	3.14E-04	2.61E-04	2.83E-04	3.05E-04
FFD	MJ Surplus	117.28	122.52	133.49	147.02	154.16	167.89	200.31	211.88	222.96

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EPD Software Tools

- EPDs developed utilizing pre-verified EPD software becoming more prevalent.
  - Athena
  - Climate Earth
  - GCCA / Quantis
  - One-Click LCA

Concrete Industry EPD Process

1. Submitting Company Selects a Program Operator.
2. Choose Product and Related Product Category Rule (PCR) and Gather Data per PCR.
3. Conduct Life-Cycle Assessment (LCA) by In-House Staff or LCA Consultant.
4. Conduct Independent Review of LCA.
5. Develop Draft EPD by In-House Staff or LCA Consultant.
6. Submit the LCA Report and Draft EPD to Program Operator for Initial Verification.
7. Program Operator Engages Independent Verifier Who Reviews the LCA Report and Draft EPD.
8. Program Operator Certifies EPD for Submitting Company.

Reproducibility and Alignment of LCA Models

- Concrete PCR v2 requires verification and validity of an EPD
- Two (of five) conditions state:
  - EPD calculations by software systems should be verified using similar procedures as verifying and EPD.
  - When EPDs are aligned to an industry average, there should be consistency of results between product specific EPDs and industry average.
    - Use same LCA software version and background data, or
    - *test representative samples of the regionally specific industry average benchmark data and include report of the maximum percent difference.*

Reproducibility and Alignment of LCA Models

Appendix A: Summary of Reproducibility Results

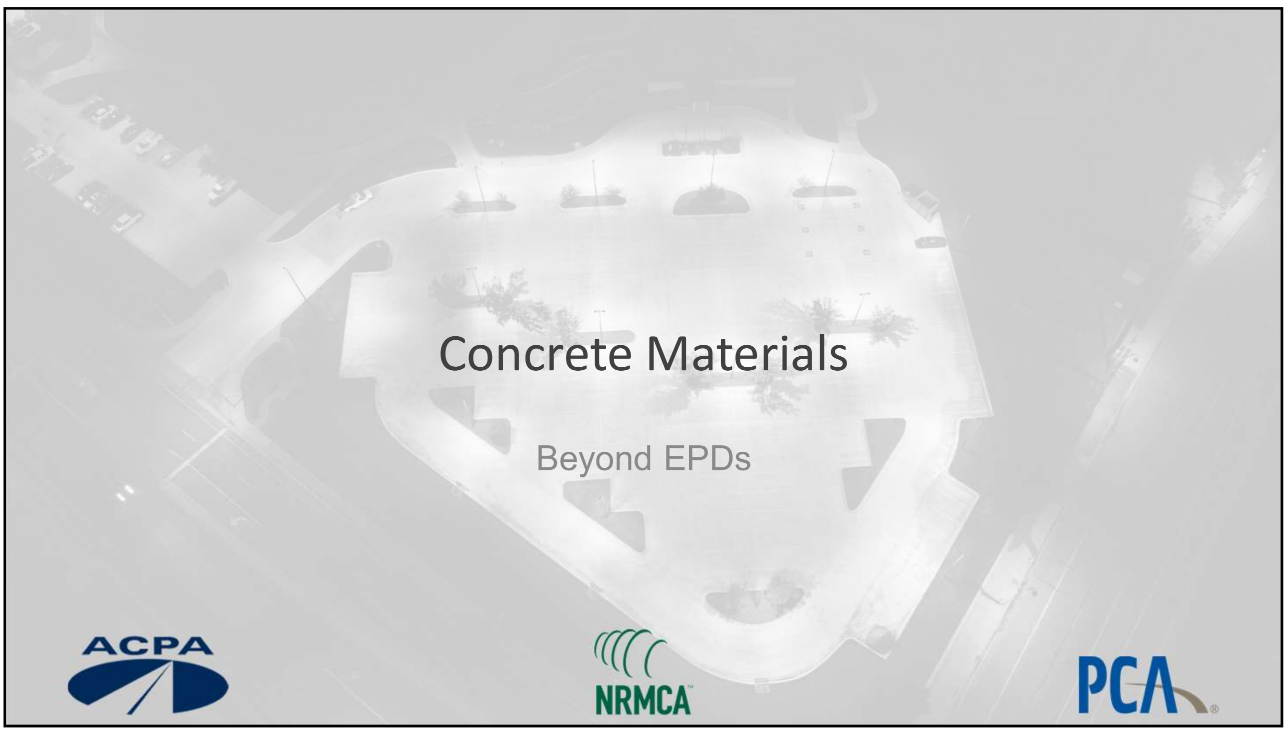
Results of alignment for the NRMCA Eastern Region Benchmark.

April 2021

Impact category	ABB	Athena	Climate Earth	Unit	Results		Difference
		Method Used	Method Used		Athena	Climate Earth	
Global warming	GWP	TRACI 2.1 V1.02	TRACI 2.1 v 1.04	kg CO2 eq	202.80	201.02	-0.88%
Ozone depletion	ODP	TRACI 2.1 V1.02	TRACI 2.1 v 1.04	kg CFC-11 eq	6.18E-06	5.98E-06	-3.28%
Eutrophication	EP	TRACI 2.1 V1.02	TRACI 2.1 v 1.04	kg N eq	0.29	0.2799	-2.79%
Acidification	AP	TRACI 2.1 V1.02	TRACI 2.1 v 1.04	kg SO2 eq	0.74	0.7245	-2.17%
Smog	SFP	TRACI 2.1 V1.02	TRACI 2.1 v 1.04	kg O3 eq	15.20	14.959	-1.57%

EPD Misunderstandings, Misconceptions, and Misuses and Other Considerations

- Comparing EPDs across categories is tempting but improper.
- Life-cycle inventory data quality is critical for accurate analysis and EPD results.
- EPDs can lead to a “how low can we go” mentality, unintentionally affecting other properties.
- There is more to environmental stewardship than green house gas emissions.
- Producer-contractor collaboration may not be fully realized when only considering EPDs.
- Whole pavement EPD would provide for better decision making.
- Individual EPDs do not account for uncertainty, but a collection of within category EPDs can.
- There are costs that could potentially inhibit some producers from bidding on projects.



Strategies BEYOND the Embodied Footprint

- Prioritizing means reducing our embodied carbon – in cement and in concrete – right now.
- The industry has embraced EPDs to benchmark and measure progress.
- <u>The industry has made huge strides already… optimizing mixtures (PEM), reducing cement content, SCMs, PLC, ternary blends, etc.</u>
- However… embodied carbon is only a PORTION of the carbon footprint.

How Concrete Properties Can Lower Use Phase CO_2

- **Durability and Resilience**
  - Concrete's durability reduces future rehabilitation and reconstruction activities.
  - Concrete's strength and resiliency allows it to better withstand natural disasters and their aftermath.
- **Improved Fuel Efficiency**
  - Fuel consumption of trucks on concrete is improved because concrete pavements are stiffer and stay smoother longer.
- **Highly Reflective**
  - Concrete's light color lowers lighting requirements and UHI impacts; and increases Radiative Forcing that can offset 20% to 40+% of concrete CO_2 used to make the pavement (dependent on thickness)
- **Increased Carbonation**
  - Re-carbonation absorbs ~10-11% of the CO_2 emitted in the A1-A3 phase and 25% of the total potential CO_2 that could be sequestrated.

Resilience and Sustainability:
Not having to rebuild after natural disasters saves CO_2

I-10 South of Beaumont, TX During Hurricane Harvey 2017
Source: Logan Wheat

Infrastructure Decision Making: Considering Sustainability and Resilience

Planning/Goals	Design	Procurement	Operation
Use scoring systems (i.e., INVEST) to evaluate a project's potential environmental impact and set specific sustainability goals.	Use whole pavement, full life cycle to understand a project's cradle-to-grave cost and environmental impacts and select designs with the lowest impacts.	Use environmental product declarations (EPDs) to set benchmarks and procure materials that meet sustainability goals.	Use life cycle cost and environmental modeling for asset management treatment optimization and selection. Network analyses will provide the largest CO_2 reductions.

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Thank You

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ACPA NRMCA PCA