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NEU's monthly webinars are part of our commitment to education on sustainable practices and climate adaptive strategies

Utilizing ACI Code 323 – Low-Carbon Concrete: Real World Implementation and Examples



Nathan W. Forrest, P.E. ENV SP
California Nevada Cement Association

February 26th, 2026

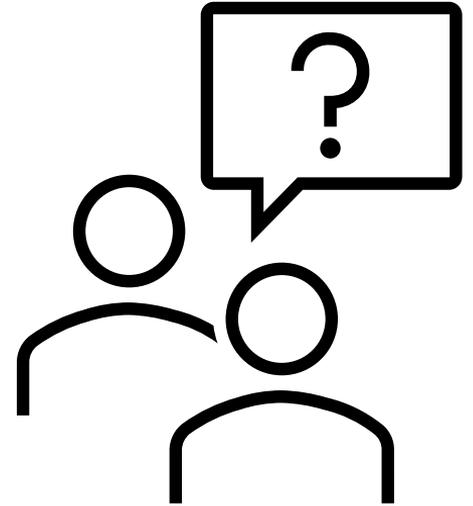
www.neuconcrete.org



An ACI Center of Excellence
for Carbon Neutral Concrete

Presentation Notes

- Find presentation slides and post event recording at:
 - <https://www.neuconcrete.org/events-and-education>
- Attendees are in listen only mode
- Certificates will be emailed following presentation
- Ask questions via the Q&A dialog box in the zoom platform



Disclaimer

As with all concrete mixtures, trial batches should be performed to verify concrete properties. Results may vary due to a variety of circumstances, including temperature and mixture components, among other things.

You should consult your materials, cement, and concrete professionals for design assistance. Nothing contained herein shall be considered or construed as a warranty or guarantee, either expressed or implied, including any warranty of fitness for a particular purpose.

Today's Speaker



Nathan W. Forrest, P.E. ENV SP

Technical Director, California Nevada Cement Association

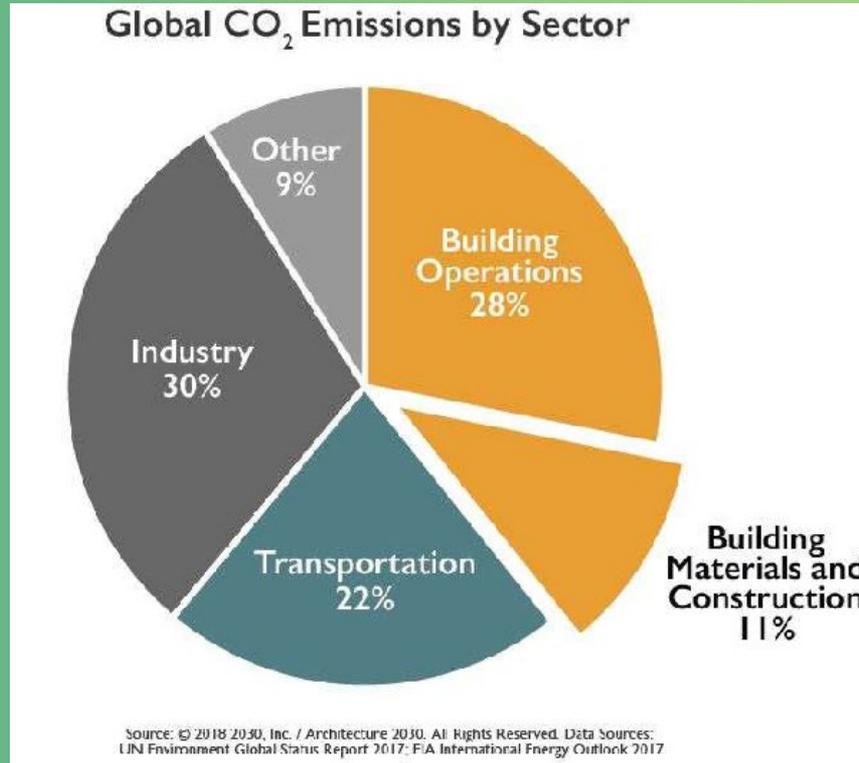
Nathan is a distinguished licensed Civil Engineer with over 25 years of expertise in the design and construction of residential, commercial, highway, bridge, and drainage projects. His extensive experience spans complex infrastructure development, where he has successfully led projects that enhance durability, efficiency, and sustainability in the built environment. As the Technical Director at the California Nevada Cement Association (CNCA), he leads innovation in low-carbon concrete technologies. Nathan is a recognized authority in the use of Blended Cements, Low-Carbon Concrete materials, codes, and specifications, and has played a pivotal role in major projects throughout California.

Agenda

- The need for low carbon concrete
- Where the carbon comes from
- Motivation for ACI Low-Carbon Concrete Code
- Code development process and timeline
- ACI CODE-323 overview
- Measuring carbon in concrete
- Project example
- What's next for industry?
- Q&A

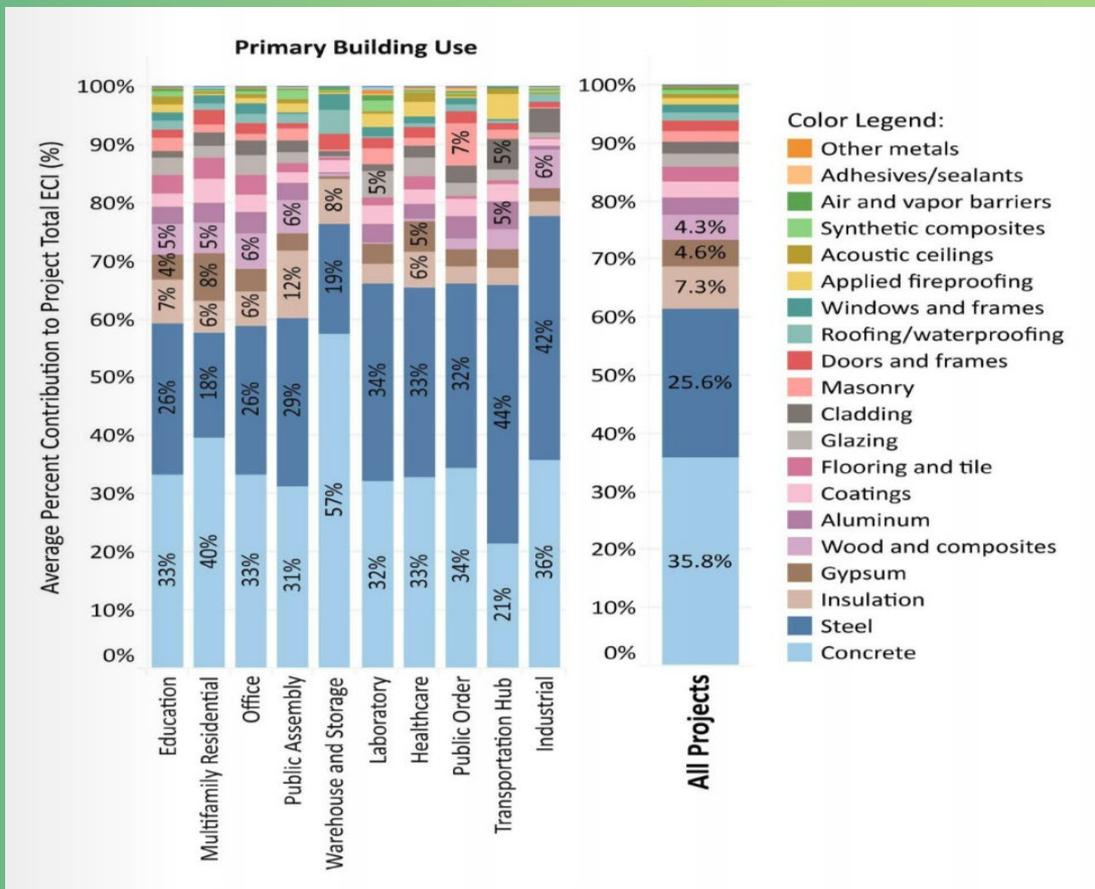
WHY DO WE NEED LOW CARBON CONCRETE?

- Building materials and construction account for 11% of global CO₂ emissions
- Concrete production is responsible for:
 - ~8% of global CO₂ emissions
 - (~1% of US CO₂ emissions)



WHY DO WE NEED LOW CARBON CONCRETE?

Concrete is often responsible for more than 1/3 of the carbon footprint of new building construction



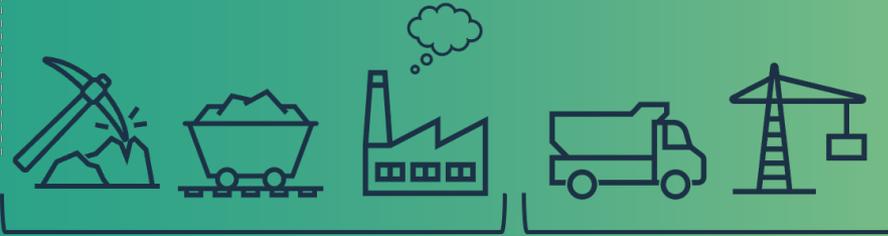
WHAT IS EMBODIED CARBON?

A measurement of the greenhouse gases that are released throughout the manufacture, transport, and installation of a product or material



WHAT IS EMBODIED CARBON?

Upfront Embodied Carbon



A1 – A3
Product

Includes:
Raw material sourcing, transport &
manufacture

A4 – A5
Construction

Includes:
Transport to site,
installation

Material Use/ Replacement



B1 – B7
Use

Includes:
Building maintenance, repairs,
replacement, refurbishment

Demolition/ Disposal



C1 – C4
End-of-life

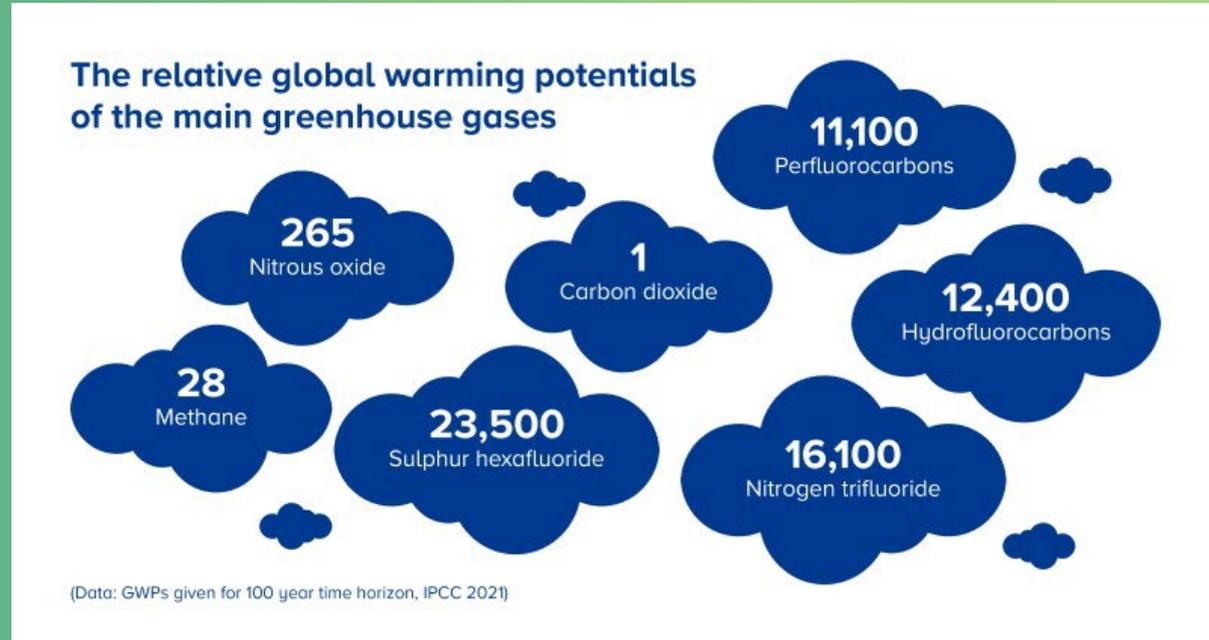
Includes:
Demolition, transport, waste
processing, disposal

GLOBAL WARMING POTENTIAL

Global warming potential (GWP) measures how much heat a greenhouse gas traps in the atmosphere relative to carbon dioxide (CO₂). It's a way to compare the relative warming impacts of different gases.

Expressed in Kg CO₂e/unit

Cement – Metric Ton
Concrete – CY or M³ (be careful)



WHERE DOES THE CARBON COME FROM?

Cement Manufacturing Process

excavate



grind



heat



mix



deliver



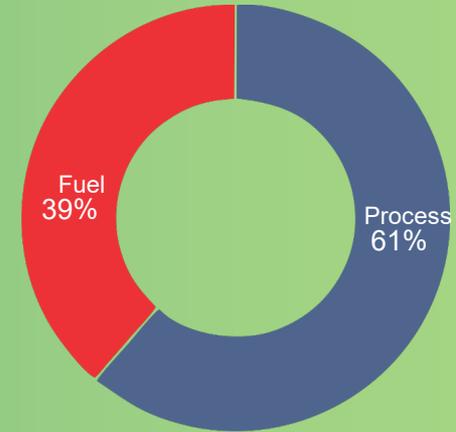
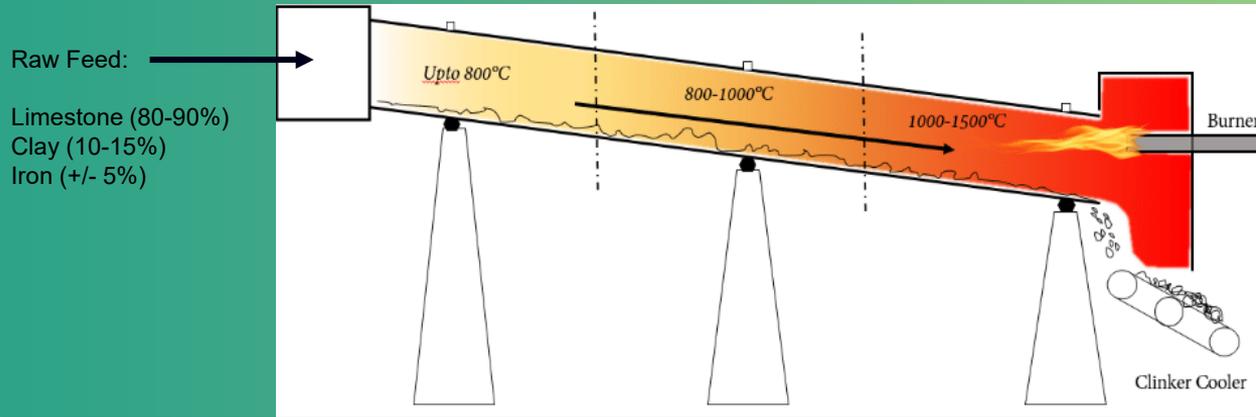




INSIDE AN OPERATING CEMENT KILN



PYROPROCESSING IN THE CEMENT KILN: TWO CARBON SOURCES



- Turning limestone into cement releases CO₂ (Limestone is CO₂ 44% by mass)
 - Process-related emissions (CaCO₃ → CaO + CO₂): +/- 61% of CO₂ emissions
- Thermal energy related emissions: Peak temperatures of 1400-1450 °C (2550-2650 °F) are required for calcining reaction: +/- 39% of CO₂ emissions
- Cement production emits +/- 0.92 tons of CO₂ per ton of U.S. cement produced



Grinding Cement

- ASTM C150 (AASHTO M85) Portland cements are +/- 92% clinker, 3% limestone, 5% gypsum

 - 922 kg CO₂e/MT – US Average

- ASTM C595 (AASHTO M240) Blended Cements also contain Portland cement clinker & gypsum, but add additional materials

 - 597-808 kg CO₂e/MT – CA Range

- The reduction in cement clinker results in 10 to 80% lower GHG footprint



Cement's Impact on Concrete's GWP

Contents by Mass

2-8% Air

15-20% Water

7-15% Cement

60-75%
Aggregate



Impact by GWP

5% Mixing Energy
1% Water

75-90% Cement

15% Aggregate



Motivation for code & TAC Guidance

- Other organizations have taken action to date without input from ACI

 - Marin County, California

 - ASHRAE

 - CLF, NRDC, NBI, RMI, etc.

 - CalGreen

 - Federal agencies (GSA, EPA, FHWA)



- Inconsistent policy action and ambiguity around term “low-carbon”

- ACI authorized code development in 2023 to take leadership role

 - Aggressive 1-year goal for first edition of code

 - Committee recruited in early 2023

- TAC Guidance on meaning of “low-carbon”

ACI 323 Committee

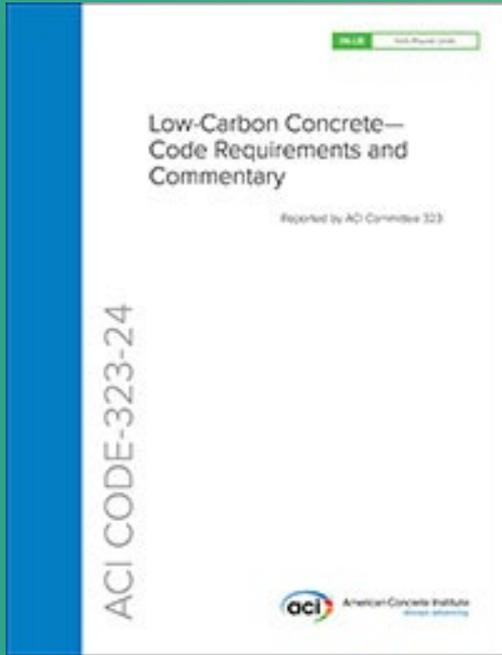


Photo courtesy Matthew Adams

Code development process and Timeline

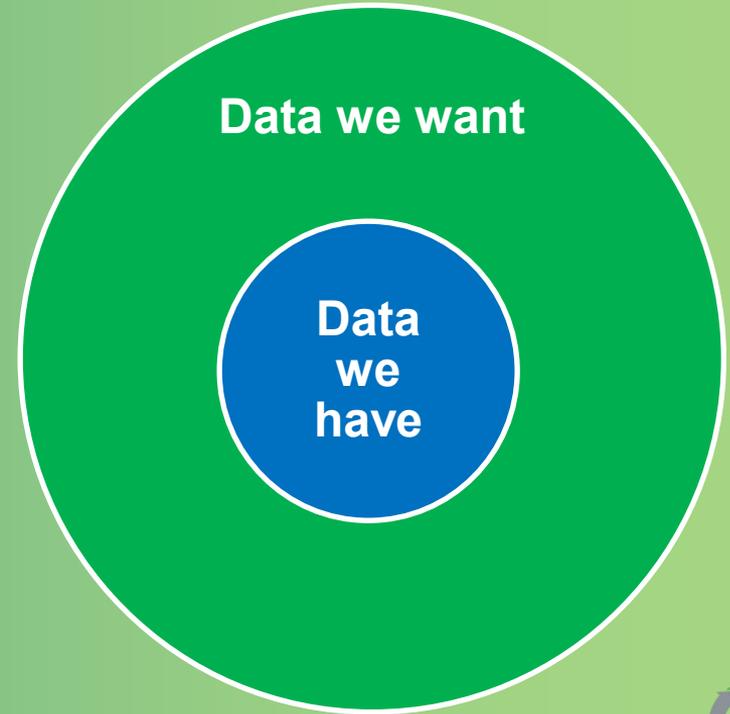
- April 2023 – First committee meeting at spring convention in San Francisco
- July 2023 – Full-day workshop at ACI HQ
 - Reviewed first draft concepts of code language
 - Arrived at a consensus on “low-carbon” as 85% of NRMCA or local benchmark
- August 2023 – First ballot of complete code and commentary
- October 2023 – Committee approved code at Boston convention, submitted to TAC
- January 2024 – TAC comments sent to committee
- February-March 2024 – TAC comments addressed
- March 31, 2024 – May 15, 2024 Public Comment
- October 2024 – Published

KEY TENANTS

- Scope, Purpose, and Exceptions
- Primacy of Life Safety, Durability, Serviceability [LDP flexibility]
- Project Size Tiers and Types
- No Prescription of Mix Designs
- Carbon Budget Approach
 - (No requirement for mix-by-mix compliance)
- Consideration of Regionality
 - (Uses local benchmarks or NRMCA regions if no local benchmarks are established)

CONSTRAINTS AND LIMITATIONS

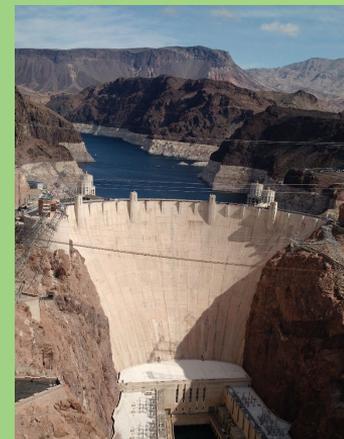
- Timeframe: ACI set goal of completion within the year 2024
- Codes are mandatory language documents
- Data we have now versus data we want
 - Impacts scope and exclusions in the code
 - More EPDs will help some
 - PCR revisions also needed



CODE OVERVIEW

CODE TABLE OF CONTENTS

- Chapter 1 – General
- Chapter 2 – Notation and Terminology
- Chapter 3 – Referenced Standards
- Chapter 4 – Concrete Mixture GWP
- Chapter 5 – Buildings
- Chapter 6 – Pavement and Hardscape
- Chapter 7 – Bridges
- Chapter 8 – Other Structures
- Appendix A – Regional GWP Benchmarks
- Appendix B – Examples and Documentation



Key provisions: Chapter 1 (General)

■ **Purpose:** Provide requirements for limiting GWP of concrete on a project. Can be applied to new construction, as well as repairs/alterations/additions. [1.3.1]

■ **Scope and Applicability**

■ “The provisions of this Code shall be in addition to those of the governing building or structural design code, standard, rule, or regulation.” [1.1.2]

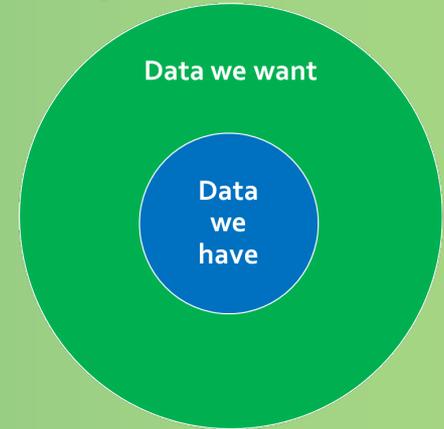
■ Cast-in-place concrete with specified compressive strength (f'_c) 2501 – 8000 psi [1.4.3]

■ The licensed design professional shall be permitted to specify more stringent requirements than those provided in this Code.” [1.4.5]

Key exclusions: Chapter 1 (General)

Code **does not apply** to:

- Concrete with $f'_c \leq 2500$ psi or > 8000 psi
- Precast concrete
- Auger cast concrete
- Shotcrete



Other **significant exceptions** (LDP and AHJ discretion):

- “This code... is not intended for use where compliance will compromise the required strength, stability, serviceability, durability, or integrity of the concrete structure.” [1.3.3]
- “GWP requirements of this Code shall be limited or excluded if the authority having jurisdiction or entity adopting this Code determines the requirements in Chapters 5 through 8 are not feasible.” [1.4.4]

Key provisions: Chapter 2 (Notation and Terminology)

■ Licensed design professional (LDP)

- (1) an individual who is licensed to practice structural design as defined by the statutory requirements of the professional licensing laws of the state or jurisdiction in which the project is to be constructed, and who is in responsible charge of all or part of the structural design.
- (2) the architect or engineer, licensed as described, who is responsible for the structural design of a particular project.

Key provisions: Chapter 3 (Referenced Standards)

- **3.2.1 International Organization for Standardization (ISO)**
 - **ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations – Principles and procedures**
 - **14040:2006 Environmental management – Life cycle assessment – Principles and Framework**
 - **ISO 14040:2006/Amd 1:2020 Environmental management – Life cycle assessment – Principals and framework**
 - **14044:2006 Environmental management – Life cycle assessment – Requirements and Guidelines**
 - **21930:2017 Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services**

Key Provisions: Chapter 4

- GWP requirements apply to concrete mixture materials (including fibers)
- Only “**upfront embodied**” GWP considered at this time (A1 to A3 LCA modules)
- LDP **specifies** appropriate GWP requirements for the project based on structure types in Chapters 5 through 8 and **verifies documentation** for the project.
- Acceptable documentation of GWP
 - Independent, third-party verified Product-specific EPD, LCA report, or LCA tool output
- **Carbon budget** (weighted average) approach for project → **flexibility**
- Consideration of **regionality** – GWP benchmarks by **strength class*** are set by adopting jurisdiction or entity. May use NRMCA regional benchmarks (Appendix A).
 - * Specified strength does not have to be at 28 days → **flexibility**

Key Provisions: Chapter 4

Carbon budget approach

CODE

4.4.1 The weighted average project GWP shall be calculated using Equation 4.4.1.

$$GWP_{project\ avg} = \frac{\sum_{i=1}^n GWP_{project\ i} \times Vol_i}{\sum_{i=1}^n Vol_i} \quad (4.4.1)$$

4.4.1.1 The individual GWP values used in Equation 4.4.1 shall meet the requirements of 4.3.

4.4.2 The weighted average benchmark GWP shall be provided as a weighted average of the classes of the total volume of concrete on the project using Equation 4.4.2.

$$GWP_{benchmark\ avg} = \frac{\sum_{i=1}^n GWP_{benchmark\ i} \times Vol_i}{\sum_{i=1}^n Vol_i} \quad (4.4.2)$$



Calculate the average GWP of your project, weighted by volume used.



Calculate the average GWP benchmark for your project across all, weighted by volume used.

Project types and tiers

Project Size	Chapter 5 Buildings (Gross Floor Area)		Chapter 6 Pavements and Hardscapes (Volume)		Chapter 7 Bridges (Deck Area)		Chapter 8 Other Structures (Volume)	
	Tier	Criteria	Tier	Criteria	Tier	Criteria	Tier	Criteria
Tier 1	BL1	≥ 50,000 ft ²	PH1	≥ 7,500 yd ³	BR1	≥ 25,000 ft ²	S1	≥ 7,500 yd ³
Tier 2	BL2	< 50,000 ft ² ≥ 5,000 ft ²	PH2	< 7,500 yd ³ ≥ 2,000 yd ³	BR2	< 25,000 ft ² ≥ 5,000 ft ²	S2	< 7,500 yd ³ ≥ 2,000 yd ³
Tier 3	BL3	< 5,000 ft ²	PH3	< 2,000 yd ³	BR3	< 5,000 ft ²	S3	< 2,000 yd ³

Compliance

- Structure of Chapters 5 through 8 is similar.
- Separate chapters facilitate use of different benchmarks for each project type.
- α = GWP reduction factor.
Set by adopting entity. Shall be 0.85 when using NRMCA regional benchmarks.

Project Size	GWP Limit	Compliance Documentation
Tier 1	$GWP_{\text{project avg}} \leq \alpha GWP_{\text{benchmark avg}}$	5.3.2, 5.3.3
Tier 2	None	5.3.2, 5.3.3
Tier 3	None	5.3.3

5.3.2 Documentation for building projects shall report the following:

- (a) $(GWP_{\text{project avg}} / GWP_{\text{benchmark avg}})$,
- (b) $GWP_{\text{project avg}}$
- (c) $GWP_{\text{benchmark avg}}$, and
- (d) $GWP_{\text{benchmark } i}$, $GWP_{\text{project } i}$, and Vol_i for every class of concrete on the project.

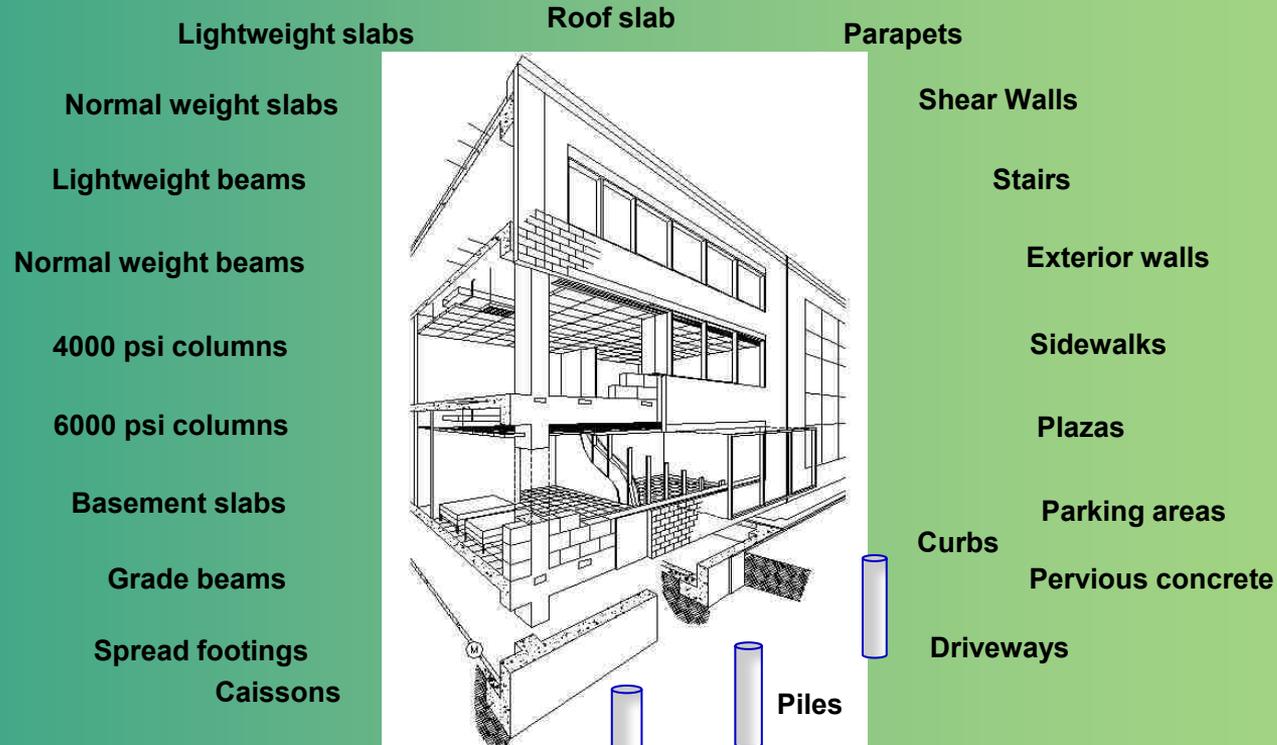
5.3.3 Building projects shall document all concrete mixtures used on the project with their corresponding use, specified compressive strength, exposure categories and any other performance requirements, and a summary of any strategies used to reduce the GWP of the concrete on the project.

HOW DO WE MEASURE CARBON?

Environmental Product Declarations (EPDs)



Each unique concrete mix is a product



Industry Average EPD

- Cradle to Gate (A1-A3) LCAs of 72 concrete mixes
- Lists impacts in 25 categories by compressive strength and SCM use
- CY and M³

Environmental Product Declaration



NRMCA MEMBER INDUSTRY-WIDE EPD FOR READY-MIXED CONCRETE





NSF
Certified Environmental Product Declaration
www.nsf.org

Table 1: Declared Product Range Classification

Specified Compressive Strength Range	SCM Range (%)	Product Name
0-2500 psi (0-17.24 MPa)	0-19% Fly Ash and/or Slag	2500-00-FA/SL
	20-29% Fly Ash	2500-20-FA
	30-39% Fly Ash	2500-30-FA
	40-49% Fly Ash	2500-40-FA
	30-49% Slag	2500-30-SL
	40-39% Slag	2500-40-SL
2501-3000 psi (17.25-20.68 MPa)	≥ 50% Slag	2500-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	2500-50-FA/SL
	0-19% Fly Ash and/or Slag	3000-00-FA/SL
	20-29% Fly Ash	3000-20-FA
	30-39% Fly Ash	3000-30-FA
	40-49% Fly Ash	3000-40-FA
3001-4000 psi (20.69-27.58 MPa)	30-39% Slag	3000-30-SL
	40-49% Slag	3000-40-SL
	≥ 50% Slag	3000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	3000-50-FA/SL
	0-19% Fly Ash and/or Slag	4000-00-FA/SL
	20-29% Fly Ash	4000-20-FA
	30-39% Fly Ash	4000-30-FA
	40-49% Fly Ash	4000-40-FA
	30-39% Slag	4000-30-SL
	40-49% Slag	4000-40-SL
	≥ 50% Slag	4000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	4000-50-FA/SL

Product Specific EPD

NATIONAL READY MIX

ENVIRONMENTAL PRODUCT DECLARATION

Mix S63C650S1 • Vernon Plant



This Environmental Product Declaration (EPD) reports the impacts for 1 m³ 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

National Ready Mix

15821 Ventura Boulevard, Suite 475
Encino, CA 91436

PLANT

Vernon Plant

2626 26th Street
Vernon, CA 90058

EPD PROGRAM OPERATOR

ASTM International

100 Barr Harbor Drive
West Conshohocken, PA 19428



DATE OF ISSUE

04/03/2020 (valid for 5 years until 04/03/2025)

ENVIRONMENTAL IMPACTS

Declared Product:

Mix S63C650S1 • Vernon Plant

Description: 1,4000PSIPLPLI

Compressive strength: 4000 PSI at 28 days

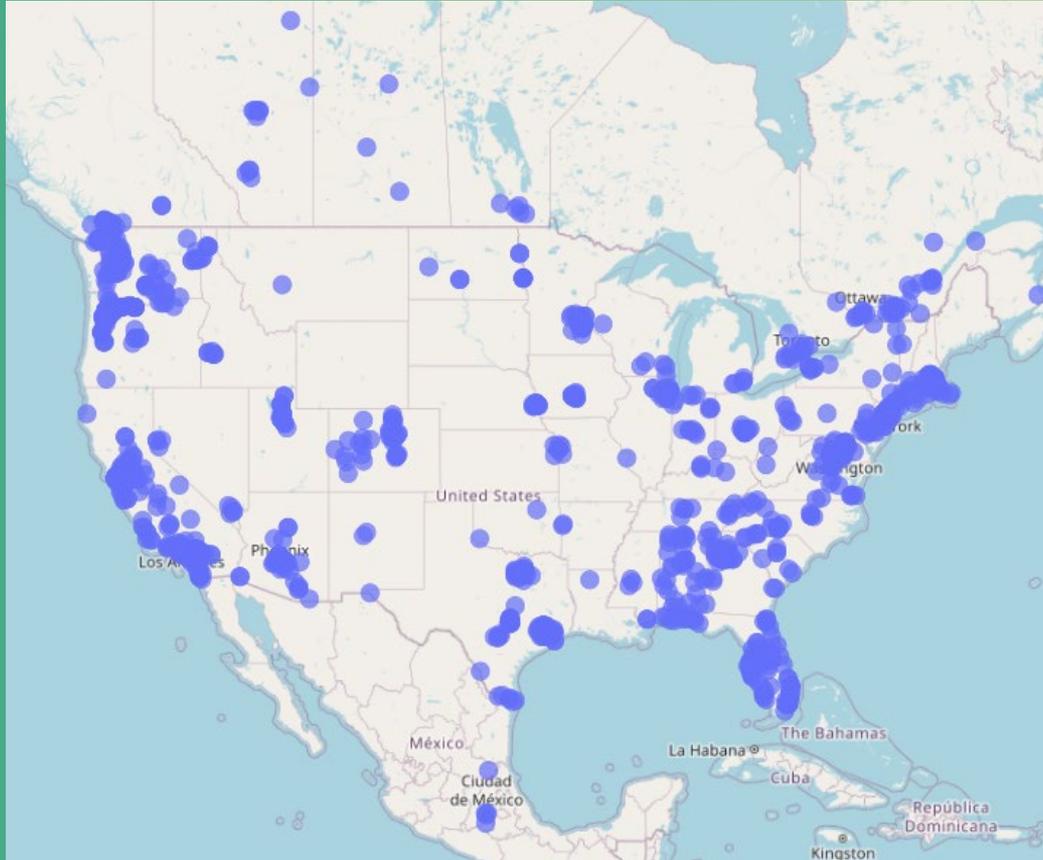
Declared Unit: 1 m³ of concrete

Global Warming Potential (kg CO ₂ -eq)	247
Ozone Depletion Potential (kg CFC-11-eq)	8.67E-6
Acidification Potential (kg SO ₂ -eq)	1.12
Eutrophication Potential (kg N-eq)	0.31
Photochemical Ozone Creation Potential (kg O ₃ -eq)	20.7
Abiotic Depletion, non-fossil (kg Sb-eq)	2.64E-6
Abiotic Depletion, fossil (MJ)	397
Total Waste Disposed (kg)	1.85
Consumption of Freshwater (m ³)	3.06

Product Components: natural aggregate (ASTM C33), slag cement (ASTM C989), Portland cement (ASTM C150), admixture (ASTM C494), batch water (ASTM C1602)

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

WHO HAS EPDS AVAILABLE?



<https://www.buildingtransparency.org/maps>

Appendix A: NRMCA Regional Benchmarks

2022 benchmark report (V3.2)

8 regions

Benchmarks for:

2501 – 3000 psi (Normal- and lightweight)

3001 – 4000 psi (Normal- and lightweight)

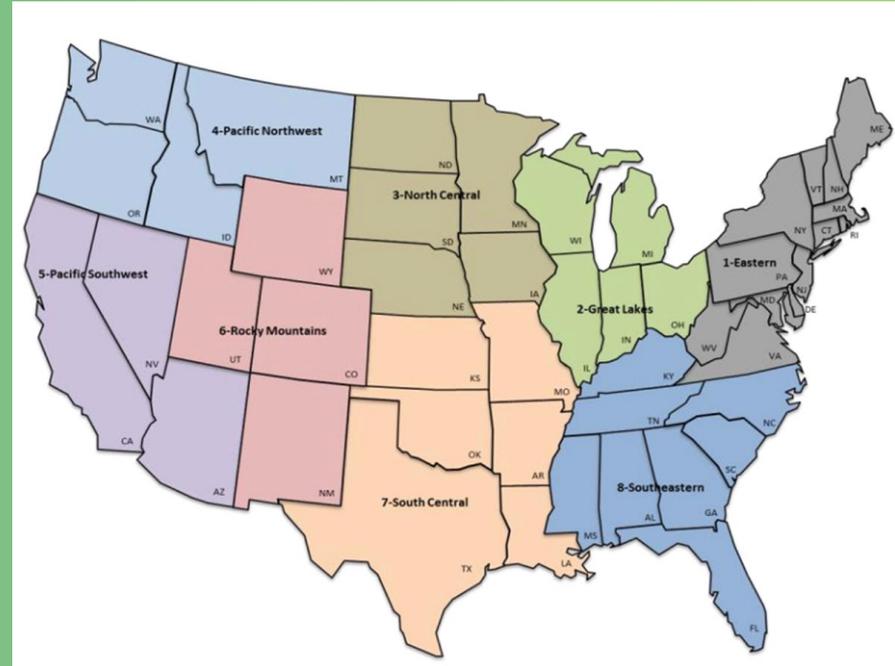
4001 – 5000 psi (Normal- and lightweight)

5001 – 6000 psi (Normalweight only)

6001 – 8000 psi (Normalweight only)

Use is permitted, but **preference** for adopting entity to set own benchmarks based on statistical analysis of local/regional data.

Use is limited to projects in contiguous U.S. (lower 48).



Project Examples:

■ 3 Projects:

- Small (Tier 3) – Starbucks Drive-Thru
- Medium (Tier 2) – Cast in Place Bridge
- Large (Tier 1) – Office Building

Small Project (Tier 3): Starbucks Drive Thru

- Denver, CO
- 255' long, 11' wide, 6" thick
 - (52CY)
- F2 Exposure:
 - 4,500psi, 0.45 max w/c
- S3 Exposure:
 - 4,500psi, 0.45 max w/c
 - Requires Pozzolan or Slag



Small Project (Tier 3): Starbucks Drive Thru

Table 6.3.1—Pavement and hardscape requirements by volume of concrete

Pavement and hardscape tier	Pavement and hardscape concrete volume	GWP limit	Minimum documentation requirement
PH1	$\geq 7500 \text{ yd}^3$	$GWP_{project\ avg} \leq \alpha GWP_{benchmark\ avg}$	6.3.2, 6.3.3
PH2	< 7500 and $\geq 2000 \text{ yd}^3$	None	6.3.2, 6.3.3
PH3	$< 2000 \text{ yd}^3$	None	6.3.3

6.3.3 Pavement and hardscape projects shall document all concrete mixtures used on the project with their corresponding use, specified compressive or flexural strength, durability requirements, and any other performance requirements, and a summary of any strategies used to reduce the GWP of the concrete on the project.

Small Project (Tier 3): Starbucks Drive Thru

Concrete mix design submittal and code compliance package to include:

- Concrete uses
- Strengths
- Durability Requirements
- Other Performance Requirements
- Mix Design
 - Material sources & gradations
 - Test results

AGGREGATE INDUSTRIES
West Central Region



CONCRETE MIX DESIGN SUBMITTAL

Contractor: Thoutt Brothers
Project Name: Fox Grove
Mix I.D.: 7456120.
Qualification: ACI 301-10 4.2.3.2.a
Intended Use: Hand

PROPORTIONS

		1	cu.yd. (SSD)
→	ASTM C150 Type I-II	526	LBS.
	ASTM C618 Fly Ash	132	LBS.
	ASTM C33 Coarse Aggregate	1732	LBS.
	ASTM C33 Fine Aggregate	1166	LBS.
→	ASTM Potable Water	270	LBS. 32.35 gal/cy
	ASTM C260 Air Entrainer	0.40	oz/cwt C+P 2.63 oz/cy
	ASTM C494 Type A Water Reducer	5.0	oz/cwt C+P 32.90 oz/cy
	ASTM C494 Type F High Range Water Reduc	2.0	oz/cwt C+P 13.16 oz/cy

PHYSICAL PROPERTIES

→	Slump:	3.00 - 5.00"
→	Air Content:	5.0 - 8.0%
→	w/c + p ratio:	0.41

COMPRESSIVE STRENGTH

→	$f'c =$	4,500 psi @ 28 days
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Production and delivery in accordance with ASTM C 94 Standard Specification for Ready-Mixed Concrete. Compressive strength performance is conditional with strict adherence to the current ASTM Standards relating to concrete, and the latest revisions of ACI 301 and 318.

Please direct inquiries to:
Stephen Herald
Quality Control Manager, Concrete
Phone: 303-777-3052
Fax: 303-744-2062
stephen.herald@aggregate-us.com

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for Carbon Neutral Concrete

Small Project (Tier 3): Starbucks Drive Thru

Summary of strategies to reduce the GWP of the concrete on the project:

The concrete mix and construction was optimized by:

- Replacing 20% of the cement with fly ash
- Sourcing locally: Obtain materials from local suppliers to reduce the carbon emissions associated with transportation

Medium Project (Tier 2): Bridge

■ Foothill Rd. Low Water Crossing in Cuyama, CA

■ 650' long, 36' wide deck – 23,400 S.F.



Medium Project (Tier 2): Bridge

Table 7.3.1—Bridge requirements by deck area



Bridge project tier	Deck area	GWP limit	Minimum documentation requirements
BR1	$\geq 25,000 \text{ ft}^2$	$GWP_{project\ avg} \leq \alpha GWP_{benchmark\ avg}$	7.3.2, 7.3.3
BR2	$< 25,000 \text{ ft}^2$ and $\geq 5000 \text{ ft}^2$	None	7.3.2, 7.3.3
BR3	$< 5000 \text{ ft}^2$	None	7.3.3

7.3.2 Documentation for bridge projects shall report the following:

- $(GWP_{project\ avg}/GWP_{benchmark\ avg})$
- $GWP_{project\ avg}$
- $GWP_{benchmark\ avg}$
- $GWP_{benchmark\ i}$, $GWP_{project\ i}$, and Vol_i for every class of concrete on the project

7.3.3 Bridge projects shall document all concrete mixtures used on the project with their corresponding use, specified compressive strength, durability requirements, and any other performance requirements, and a summary of any strategies used to reduce the GWP of the concrete on the project.

Medium Project (Tier 2): Bridge

4.3.2 “GWP values for each concrete mixture shall be documented in one of the following: an independent third party verified LCA report, an independent third-party verified product-specific EPD, or an independent third-party verified LCA tool.”

Example Facility-Specific Environmental Product Declaration:



NATIONAL READY MIXED CONCRETE COMPANY
 ENVIRONMENTAL PRODUCT DECLARATION
 Mix S63C455T13 - Vernon Plant



This Environmental Product Declaration (EPD) reports the impacts for 1 m³ of ready mixed concrete mix, for use in business-to-business (B2B) communication 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
[National Ready Mixed Concrete Company](#)
 15821 Ventura Boulevard, Suite 475
 Encino, CA 91436

PLANT
Vernon Plant
 2626 26th Street
 Vernon, CA 90058

EPD PROGRAM OPERATOR
[ASTM International](#)
 100 Barr Harbor Drive
 West Conshohocken, PA 19428

DATE OF ISSUE
 04/07/2025 (valid for 5 years until 04/07/2030)
 (Portable plant validity is limited to location specified)



ENVIRONMENTAL IMPACTS

Declared Product:
 Mix S63C455T13 • Vernon Plant
 Description: 1 4000PSI PU PL
 Compressive strength: 4000 PSI at 28 days

Declared Unit: 1 m³ of concrete (1 cyd)

Global Warming Potential (kg CO ₂ -eq)	203 (155)
Ozone Depletion Potential (kg CFC-11-eq)	1.31E-5 (1.00E-5)
Acidification Potential (kg SO ₂ -eq)	1.50 (1.15)
Eutrophication Potential (kg N-eq)	0.18 (0.14)
Photochemical Ozone Creation Potential (kg O ₃ -eq)	37.2 (28.5)
Abiotic Depletion, non-fossil (kg Sb eq)	2.16 (1.65)
Abiotic Depletion, fossil (MJ)	1,540 (1,178)
Total Waste Disposed (kg)	0.06 (0.04)
Consumption of Freshwater (m ³)	3.40 (2.60)

Product Components: natural aggregate (ASTM C33), type 1L cement (ASTM C595), slag cement (ASTM C989), batch water (ASTM C1602), admixture (ASTM C494)

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

Medium Project (Tier 2): Bridge

Concrete Uses, Volumes, and Strength Classes

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	COMPRESSIVE STRENGTH (psi)
1	CIDH Piles	700	4,000
2	Pile Caps	50	5,000
3	Bridge Deck	600	6,000
4	Approach Slabs	65	4,500
5	Barriers	215	3,500

Information from Designer

Medium Project (Tier 2): Bridge

Concrete Uses, Volumes, and Strength Classes + Benchmark GWPs

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	COMPRESSIVE STRENGTH (psi)	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO2e/YD3), NOTE 6
1	CIDH Piles	700	4,000	289
2	Pile Caps	50	5,000	307
3	Bridge Deck	600	6,000	349
4	Approach Slabs	65	4,500	289
5	Barriers	215	3,500	248



Information from
NRMCA

Medium Project (Tier 2): Bridge

Concrete Uses, Volumes, and Strength Classes, Benchmark GWPs + Project GWPs

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	COMPRESSIVE STRENGTH (psi)	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO2e/YD3), NOTE 6	MIX DESIGN GWP (FROM EPDs)
1	CIDH Piles	700	4,000	289	298
2	Pile Caps	50	5,000	307	315
3	Bridge Deck	600	6,000	349	340
4	Approach Slabs	65	4,500	289	335
5	Barriers	215	3,500	248	278



Information from Ready-Mix Producer

Medium Project (Tier 2): Bridge

Concrete Volumes & GWPs:

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	COMPRESSIVE STRENGTH (psi)	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO2e/YD3), NOTE 6	MIX DESIGN GWP (FROM EPDs)
1	CIDH Piles	700	4,000	289	298
2	Pile Caps	50	5,000	307	315
3	Bridge Deck	600	6,000	349	340
4	Approach Slabs	65	4,500	289	335
5	Barriers	215	3,500	248	278



Vol_i



$GWP_{Benchmark\ i}$



$GWP_{Project\ i}$

Medium Project (Tier 2): Bridge

Reporting: Project Average

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	COMPRESSIVE STRENGTH (psi)	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO ₂ e/YD ³), NOTE 6	MIX DESIGN GWP (FROM FPDs)
1	CIDH Piles	700	4,000	289	298
2	Pile Caps	50	5,000	307	315
3	Bridge Deck	600	6,000	349	340
4	Approach Slabs	65	4,500	289	335
5	Barriers	215	3,500	248	278

$$\begin{aligned}GWP_{project\ avg} &= Vol_1 \times GWP_1 + Vol_2 \times GWP_2 + Vol_3 \times GWP_3 \dots / \sum Vol \\ &= 700 \times 298 + 50 \times 315 + 600 \times 340 \dots / 700 + 50 + 600 \dots \\ &= \underline{312.9 \text{ kg CO}_2\text{e/CY}}\end{aligned}$$

Medium Project (Tier 2): Bridge

Reporting: Benchmark Average

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	COMPRESSIVE STRENGTH (psi)	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO ₂ e/YD ³), NOTE 6	MIX DESIGN GWP (FROM EPDs)
1	CIDH Piles	700	4,000	289	298
2	Pile Caps	50	5,000	307	315
3	Bridge Deck	600	6,000	349	340
4	Approach Slabs	65	4,500	289	335
5	Barriers	215	3,500	248	278

$$\begin{aligned} GWP_{\text{Benchmark avg}} &= Vol_1 \times GWP_{\text{Benchmark1}} + Vol_2 \times GWP_{\text{Benchmark1}} \dots / \sum Vol \\ &= 700 \times 289 + 50 \times 307 + 600 \times 349 \dots / 700 + 50 + 600 \dots \\ &= \underline{247.1 \text{ kg CO}_2\text{e/CY}} \end{aligned}$$

Medium Project (Tier 2): Bridge

Compliance: Report Ratio of Project to Benchmark Averages

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	COMPRESSIVE STRENGTH (psi)	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO2e/YD3), NOTE 6	MIX DESIGN GWP (FROM EPDs)
1	CIDH Piles	700	4,000	289	298
2	Pile Caps	50	5,000	307	315
3	Bridge Deck	600	6,000	349	340
4	Approach Slabs	65	4,500	289	335
5	Barriers	215	3,500	248	278

$$\begin{aligned} & \left(\frac{\text{GWP}_{\text{project avg}}}{\text{GWP}_{\text{benchmark avg}}} \right) \\ & = 312.9/247.1 \\ & = 1.27 \end{aligned}$$

Recall that a written description of strategies used to reduce GWP is also required for Tier 2 projects

Large Project (Tier 1): Office Building

Building project in California

60,000 ft²

5.3—Determination of requirements

5.3.1 Building projects shall comply with the requirements of Table 5.3.1, where α shall be 0.85 when Appendix A benchmarks are used. The authority having jurisdiction shall set α if they develop their own benchmarks as per 4.5.1.

Table 5.3.1—Building requirements by gross floor area

Building project tier	Building gross floor area	GWP limit	Minimum documentation requirements
BL1	≥ 50,000 ft ²	$GWP_{project\ avg} \leq \alpha GWP_{benchmark\ avg}$	5.3.2, 5.3.3
BL2	< 50,000 ft ² and ≥ 5000 ft ²	None	5.3.2, 5.3.3
BL3	< 5000 ft ²	None	5.3.3



Balian Architects

Large Project (Tier 1): Office Building

5.3.2 Documentation for building projects shall report the following:

- (a) $(GWP_{project\ avg} / GWP_{benchmark\ avg})$
- (b) $GWP_{project\ avg}$
- (c) $GWP_{benchmark\ avg}$
- (d) $GWP_{benchmark\ i}$, $GWP_{project\ i}$, and Vol_i for every class of concrete on the project

5.3.3 Building projects shall document all concrete mixtures used on the project with their corresponding use, specified compressive strength, exposure categories and any other performance requirements, and a summary of any strategies used to reduce the GWP of the concrete on the project.



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Large Project (Tier 1): Office Building

Tier: BL1 (full compliance & documentation required)

No local GWP benchmarks established

→ Use NRMCA Pacific Southwest Region: $\alpha = 0.85$

Table A.3.1e—Region 5 (Pacific Southwest) GWP benchmark values by class strength

Specified strength class (f_c') at 28 days, psi	Normalweight concrete $GWP_{benchmark}$ is kg CO ₂ e/yd ³ concrete	Lightweight concrete $GWP_{benchmark}$ is kg CO ₂ e/yd ³ concrete
2501 to 3000	214	383
3001 to 4000	248	418
4001 to 5000	289	454
5001 to 6000	307	Not applicable
6001 to 8000	349	Not applicable



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Large Project (Tier 1): Office Building

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	EXPOSURE CATEGORIES AND CLASSES	STRENGTH, f _c (KSI)	TEST AVG (DAYS)	CONC. WEIGHT	MAX W/C RATIO	MAX AGG. SIZE (IN)	TOTAL AIR CONTENT (%)
1A	DRILLED PIERS	450	F0, S1, W1, C1	3.00	56	NWC	--	1	--
1B	FOOTINGS	350	F0, S1, W1, C1	3.00	28	NWC	--	1	--
1C	HOLLOW SHELL PILES	150	F0, S0, W0, C0	3.00	56	NWC	--	3/4	--
2A	INTERIOR PIER CAPS, GRADE AND TIE BEAMS	200	F0, S0, W1, C1	3.00	56	LWC	--	3/4	--
2B	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS	250	F1, S1, W1, C1	3.50	56	NWC	0.55	3/4	5
2C	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS EXPOSED TO MOISTURE	350	F1, S1, W1, C0	3.50	56	NWC	0.50	3/4	5
3A	BASEMENT AND RETAINING WALLS	350	F1, S1, W1, C1	3.50	28	NWC	0.55	3/4	5
3B	BASEMENT AND RETAINING WALLS EXPOSED TO MOISTURE	250	F1, S1, W1, C1	3.50	28	NWC	0.50	3/4	5
4A	INTERIOR SLABS-ON-GRADE	650	F0, S0, W0, C0	4.50	28	NWC	--	1	3
4B	INTERIOR SUSPENDED SLABS	175	F0, S0, W0, C0	4.50	28	LWC	--	3/4	3
4C	INTERIOR INDUSTRIAL SLABS-ON-GRADE	1100	F0, S0, W0, C0	4.50	28	NWC	--	1	3

Large Project (Tier 1): Office Building

Summarized GWP Information
by concrete mix application
(from Ready-Mix supplier's
Environmental Product
Declarations)

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	MIX DESIGN GWP (FROM EPDs: (kg CO2e/YD3))
1A	DRILLED PIERS	450	175
1B	FOOTINGS	350	175
1C	HOLLOW SHELL PILES	150	175
2A	INTERIOR PIER CAPS, GRADE AND TIE BEAMS	200	325
2B	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS	250	200
2C	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS EXPOSED TO MOISTURE	350	200
3A	BASEMENT AND RETAINING WALLS	350	200
3B	BASEMENT AND RETAINING WALLS EXPOSED TO MOISTURE	250	200
4A	INTERIOR SLABS-ON-GRADE	650	280
4B	INTERIOR SUSPENDED SLABS	175	450
4C	INTERIOR INDUSTRIAL SLABS-ON-GRADE	1100	205

Large Project (Tier 1): Office Building

Comparison of GWP Values

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	MIX DESIGN GWP (FROM EPDs: (kg CO2e/YD3))	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO2e/YD3)
1A	DRILLED PIERS	450	175	214
1B	FOOTINGS	350	175	214
1C	HOLLOW SHELL PILES	150	175	214
2A	INTERIOR PIER CAPS, GRADE AND TIE BEAMS	200	325	370
2B	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS	250	200	248
2C	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS EXPOSED TO MOISTURE	350	200	248
3A	BASEMENT AND RETAINING WALLS	350	200	248
3B	BASEMENT AND RETAINING WALLS EXPOSED TO MOISTURE	250	200	248
4A	INTERIOR SLABS-ON-GRADE	650	280	274
4B	INTERIOR SUSPENDED SLABS	175	450	444
4C	INTERIOR INDUSTRIAL SLABS-ON-GRADE	1100	205	274

Large Project (Tier 1): Office Building

Comparison of GWP Values

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	MIX DESIGN GWP (FROM EPDs: (kg CO2e/YD3))	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO2e/YD3)	ACI 323 GWP LIMIT (85% of NRMCA REGIONAL AVERAGE GWP) (kg CO2e/YD3)
1A	DRILLED PIERS	450	175	214	181.9
1B	FOOTINGS	350	175	214	181.9
1C	HOLLOW SHELL PILES	150	175	214	181.9
2A	INTERIOR PIER CAPS, GRADE AND TIE BEAMS	200	325	370	314.5
2B	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS	250	200	248	210.8
2C	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS EXPOSED TO MOISTURE	350	200	248	210.8
3A	BASEMENT AND RETAINING WALLS	350	200	248	210.8
3B	BASEMENT AND RETAINING WALLS EXPOSED TO MOISTURE	250	200	248	210.8
4A	INTERIOR SLABS-ON-GRADE	650	280	274	232.9
4B	INTERIOR SUSPENDED SLABS	175	450	444	377.4
4C	INTERIOR INDUSTRIAL SLABS-ON-GRADE	1100	205	274	232.9

Large Project (Tier 1): Office Building

Comparison of GWP Values

CONC MIX TYPE	INTENDED USE	QUANTITY (CY)	MIX DESIGN GWP (FROM EPDs: (kg CO2e/YD3))	PAC. SW NRMCA REGIONAL AVERAGE GWP (kg CO2e/YD3)	ACI 323 GWP LIMIT (85% of NRMCA REGIONAL AVERAGE GWP) (kg CO2e/YD3)
1A	DRILLED PIERS	450	175	214	181.9
1B	FOOTINGS	350	175	214	181.9
1C	HOLLOW SHELL PILES	150	175	214	181.9
2A	INTERIOR PIER CAPS, GRADE AND TIE BEAMS	200	325	370	314.5
2B	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS	250	200	248	210.8
2C	EXTERIOR PIER CAPS, GRADE AND TIE BEAMS EXPOSED TO MOISTURE	350	200	248	210.8
3A	BASEMENT AND RETAINING WALLS	350	200	248	210.8
3B	BASEMENT AND RETAINING WALLS EXPOSED TO MOISTURE	250	200	248	210.8
4A	INTERIOR SLABS-ON-GRADE	650	280	274	232.9
4B	INTERIOR SUSPENDED SLABS	175	450	444	377.4
4C	INTERIOR INDUSTRIAL SLABS-ON-GRADE	1100	205	274	232.9
			957,500 kg CO2e	1132100 kg CO2e	962,285 kg CO2e

Large Project (Tier 1): Office Building

Summary of GWP Compliance:

$$\text{GWP}_{\text{benchmark avg}} = 1,132,100 \text{ kg CO}_2\text{e}/4,275 \text{ CY} = \underline{264.82} \text{ kg CO}_2\text{e}/\text{yd}^3$$

$$\text{GWP}_{\text{project avg}} = 957,500 \text{ kg CO}_2\text{e}/4,275 \text{ CY} = \underline{223.98} \text{ kg CO}_2\text{e}/\text{yd}^3 \quad (\text{Proj. weighted avg.})$$

$$\text{GWP}_{\text{project avg}} / \text{GWP}_{\text{benchmark avg}} = 223.98/264.82 = \mathbf{0.846}$$

0.846 ≤ 0.85: → COMPLIES! (Recall that $\alpha = 0.85$)

11 total mixes:

- 3 mixes exceeded 85% of benchmark (inc. 2 lightweight)

Recall that a written description of strategies used to reduce GWP is also required for Tier 3 projects

What's Next?

What's next for designers?

- Begin by requesting/requiring EPDs
- Develop specification language (or use ours) to reduce GWP in concrete
- Become familiar with ACI's resources for code compliance
 - Global Warming Potential Calculation Spreadsheet:



What's next for the Code? ACI 323-29

- Subcommittee A. General and Materials: Changes and updates to Notation and Terminology
- Subcommittee B. GWP Determinations: Calculation methodologies for setting GWP thresholds and tiering of GWP reduction requirements
- Subcommittee C. Benchmarking and Reduction: Updates to GWP benchmarking methods and GWP reduction values
- Subcommittee D. Systems: Updates to Chapters 5-8; identifying key items specific to each type of project
- Subcommittee E. Resilience: Develop an appendix focused requirements for resilient construction of concrete systems
- Subcommittee F. Whole Building: An approach that allows for the use of WBLCA as an alternative compliance path
- Subcommittee G. International and Educational: Changes that support international adoption of the Code 323. Identify educational needs to support adoption and deployment of Code 323 and develop educational tools as necessary

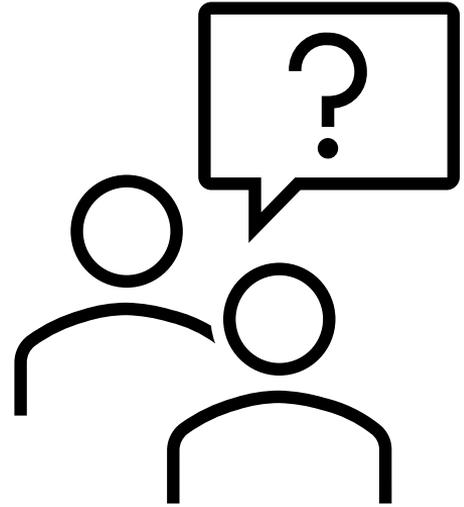
What's next for outreach and adoption?

- ACI Code Advocacy
 - Potentially IGCC (ASHRAE 189.1), Others?
- NEU – Documentation Tool, Training, and Outreach
- Adoption Support for Jurisdictions & Agencies:
 - Free Code Access
 - Alignment with decarbonization goals
 - Encourage use of local benchmarking



Questions?

- Ask questions via the Q&A dialog box in the zoom platform



NEU is Here to Help You!

Ask us about:

NEU's *The Low-Carbon Concrete Guide: Materials*. Strategies for reducing the carbon emissions of concrete with an emphasis on material/mixture decisions made at the project level. Available for purchase at the ACI Store. Scan the QR code!



NEU's Validation and Verification program. Provides third-party validation or verification of the environmental claims of both existing and innovative new products/technologies associated with low-carbon cement, concrete, and concrete products, following the requirements of international standards.

www.neuconcrete.org/validation-verification



Thank you!

NEU's next webinar will be on Thursday, Apr 23, 2026 1:00 PM Eastern Time

Simon Blotevogel with EcoCem Materials presents: Powering Low-Carbon Cement -
Unlocking the Potential of Electric Arc Furnace (EAF) Slag

Register today: https://us06web.zoom.us/webinar/register/WN_It0XIZWcThiFAMpHj7CgTw



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