NRMCA Concrete Carbon Calculator:

How to Reduce, Quantify, and Specify Carbon

NRMCA

BUILD WITH STRENGTH

PAVE AHEAD
DURABLE. SUSTAINABLE. CONCRETE.

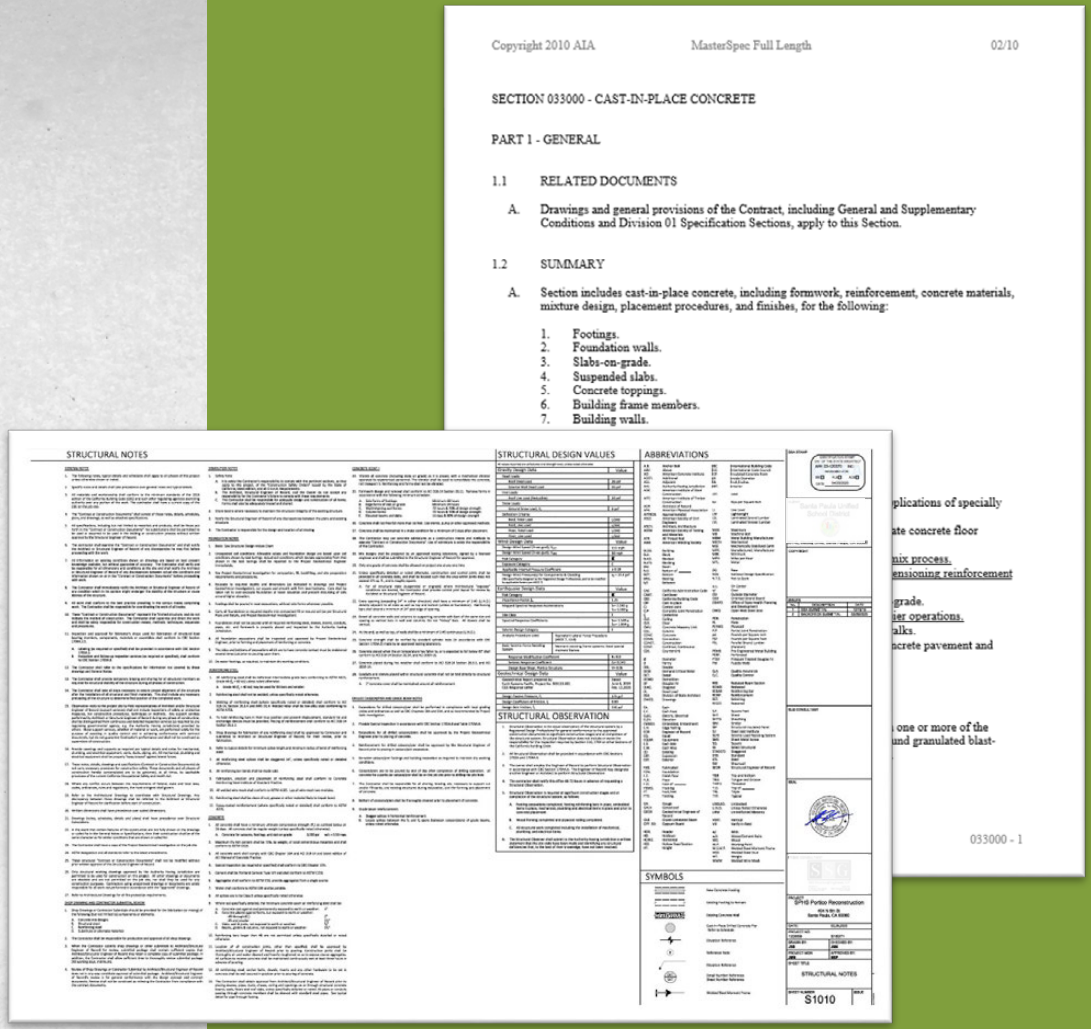
Division 03 Section 033000 Cast-In-Place Concrete

Step #1:

Performance-Based Improvements

Step #2:

Carbon Accounting and Targets



Step #1 – Performance Based Improvements

Goal:

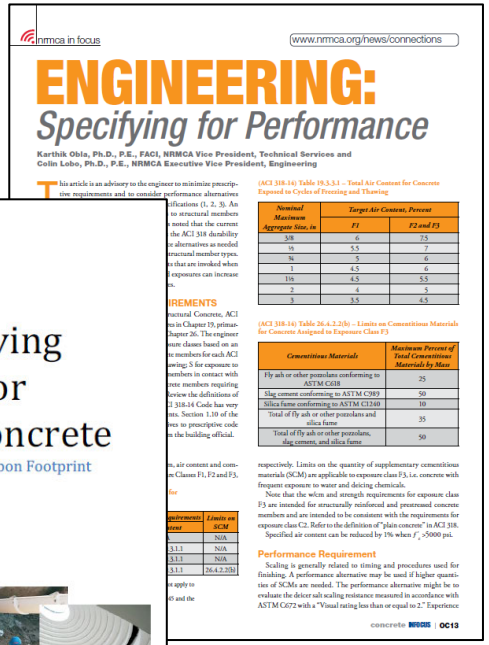
Prescription → Performance

Methods:

- Emphasize ACI 318 Exposure Classes
- Alt testing for durability/design
  - Shrinkage, MOE, RCP, ASR
- Expand acceptable materials
- Extended strength development

Results:

Efficient and Optimized Mix Designs



Performance Specs

They allow for sustainable mix designs, but don’t require it!

If you don’t ask for sustainability, it’s unlikely you’ll get it.

Step #2 – Carbon Accounting and Targets

Goal:

Trigger the use of low carbon materials

Methods:

- Collect EPDs
- Establish a Carbon Budget

Results:

- Procurement of low carbon concrete
- Flexibility for the contractor and producer
- Buffer for as-built conditions

Specifications for Sustainability

Member	Mix ID	Durability Exposure				Specified Strength, f'_c, psi	Max w/cm or Performance Alternative	Nom. max Aggregate, in.	Air Content	Slump/ Slump Flow	Chloride Limit	Temp. Limits	Max. GWP (kg/yd3 CO_2e)
		F	S	W	C								
Footings													250
Foundation Walls													250
Slabs-on-grade													250
Exterior slabs													
Suspended slabs (interior)													
Suspended slabs (exterior)													
Frame members													300
Columns (interior)													300
Columns (exterior)													300
Walls (interior)													250
Concrete toppings													250

Collaborative carbon budget **vs.** GWP limit per mix class

Preferred

Carbon Budget – Process

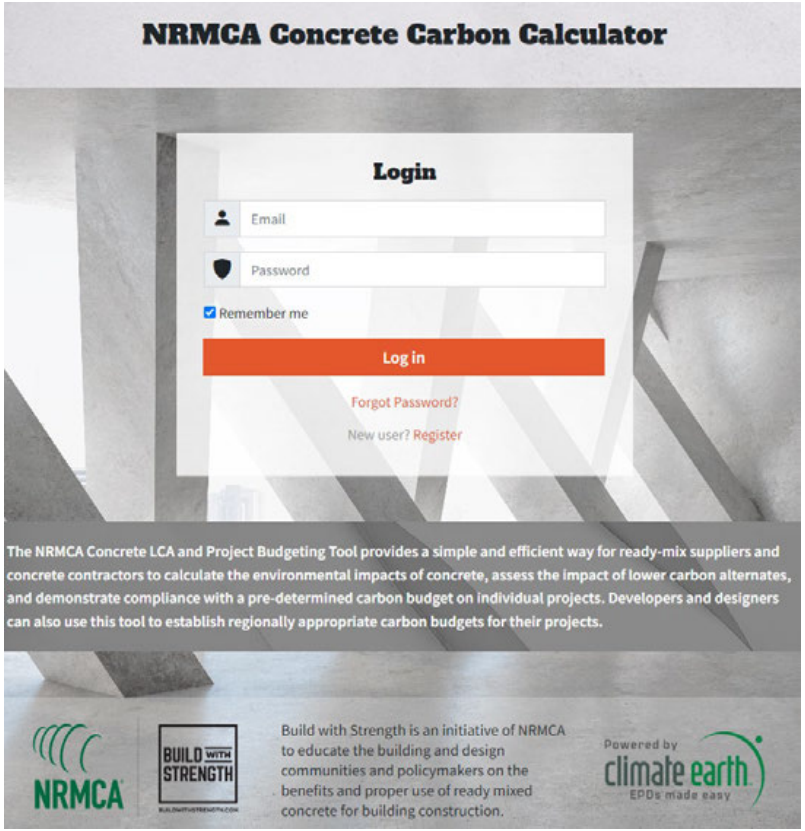
1. **Concrete Volume Takeoff + Compressive Strengths**
2. **Identify Benchmark Impacts or Targets Per Mix**
   - NRMCA Regional Benchmarks, GSA, CalGreen, etc.
3. **Identify Proposed Mix Design Impacts with Lower GWP**
   - NRMCA Industry Wide EPD Mixes – Varying Cementitious
   - Product Specific EPD Mixes from a Concrete Producer
   - Calculate Impact of Proposed Mix Proportions with NRMCA Tool
4. **Calculate and Compare Total Impact for Benchmark and Proposed Scenarios**
5. **Carbon Budget: Proposed Low Carbon Concrete Scenario + Buffer**
   - List in specs as a cumulative and/or weighted average target
   - See NRMCA Specification Guide

NRMCA Concrete Carbon Calculator

NRMCA's Carbon Tool can Simplify the Process

1. Automatically populates benchmark impacts
2. Calculates estimated carbon sequestration of the concrete through the life cycle of the structure
3. Generates a report documenting the anticipated reduction a low carbon concrete project can expect compared to the benchmark

Access at **https://nrmca.climateearth.com/**



What is a Carbon Budget?

- Project-wide goal instead of GWP limits per class of concrete
- Allows the contractor and producer to adjust mixes as needed to fit material, environmental, and schedule demands
- Larger reductions in foundations and other vertical members, smaller reductions in high early and fast-paced members
- Flexibility prevents coordination issues
- Same overall carbon reduction

Carbon Budget

TOTAL GWP: 4.30 x 10^6

VS

Individual Mix Limits

TOTAL GWP: 4.30 x 10^6

Shear Walls:
180 kg CO_2 eq/m^3

Columns:
190 kg CO_2 eq/m^3

Floors 2-18:
240 kg CO_2 eq/m^3

Floors B2-1:
225 kg CO_2 eq/m^3

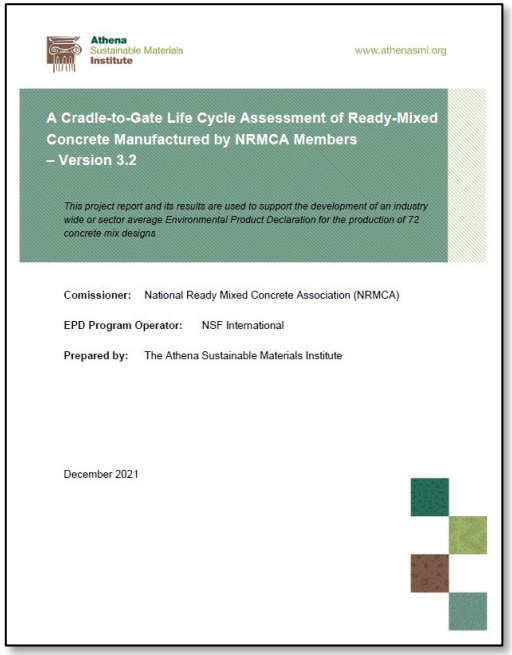
Basement Walls:
190 kg CO_2 eq/m^3

Foundation:
175 kg CO_2 eq/m^3

Establishing a Carbon Budget

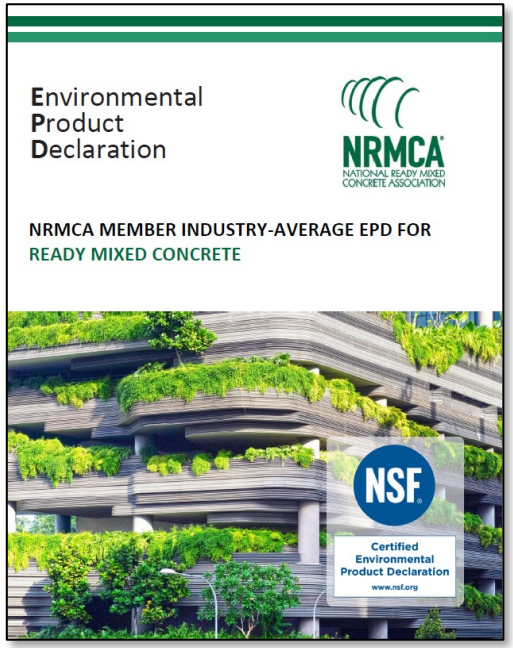
Structural Takeoff

Benchmark Project



VS

Proposed Project



Example Project

Structure:
18-Story
Residential Tower

Location:
Boston, MA

Concrete:
6 Primary Classes

Material:
Fly Ash and Slag
Available

Shear Walls: (yd^3) x (GWP) = Impact

Columns: (yd^3) x (GWP) = Impact

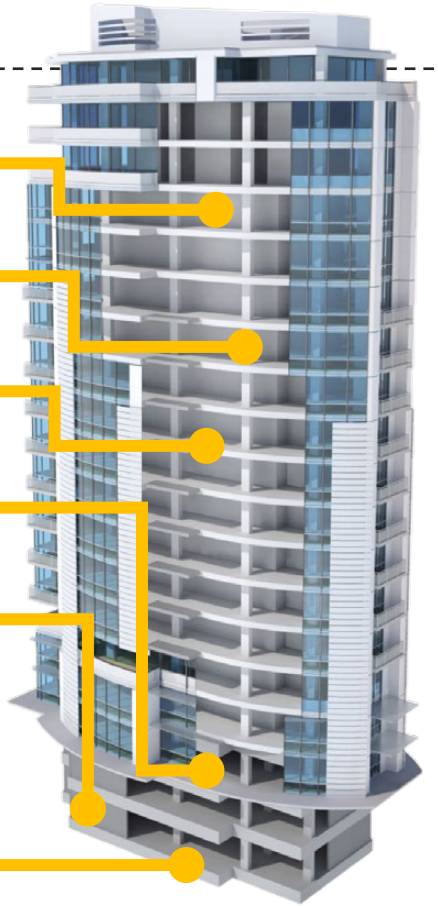
Floors 2-18: (yd^3) x (GWP) = Impact

Floors B2-1: (yd^3) x (GWP) = Impact

Basement Walls: (yd^3) x (GWP) = Impact

Mat Foundation: (yd^3) x (GWP) = Impact

TOTAL: Project Impact

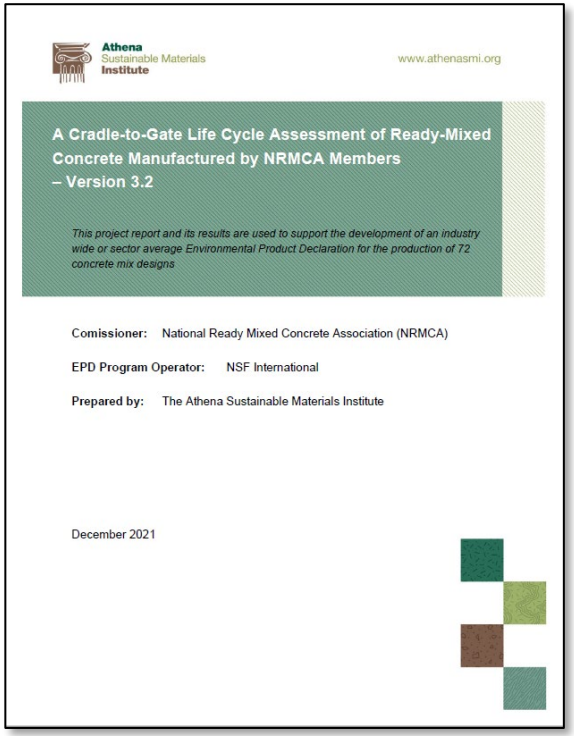


1. Estimating Quantities and Properties

Concrete Element	Concrete Volume (yd^3)	Benchmark Mixes (benchmark)*	Proposed Mixes (IW-EPD)*
Shear Walls	**7,630**	**6,000 psi**	**6,000 psi** 30% slag, 20% fly ash
Columns	**366**	**8,000 psi**	**8,000 psi** 40% fly ash
Floors 2-18	**4,533**	**5,000 psi**	**5,000 psi** 30% slag
Floors B2-1	**1,067**	**5,000 psi**	**5,000 psi** 40% fly ash
Basement Walls	**444**	**5,000 psi**	**5,000 psi** 30% slag, 20% fly ash
Foundation	**3,844**	**6,000 psi**	**6,000 psi** 40% slag, 30% fly ash

*Should be augmented with local data, knowledge, capabilities

2. NRMCA Benchmark Mixes



Athena Sustainable Materials Institute

www.athenasmi.org

A Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Manufactured by NRMCA Members – Version 3.2

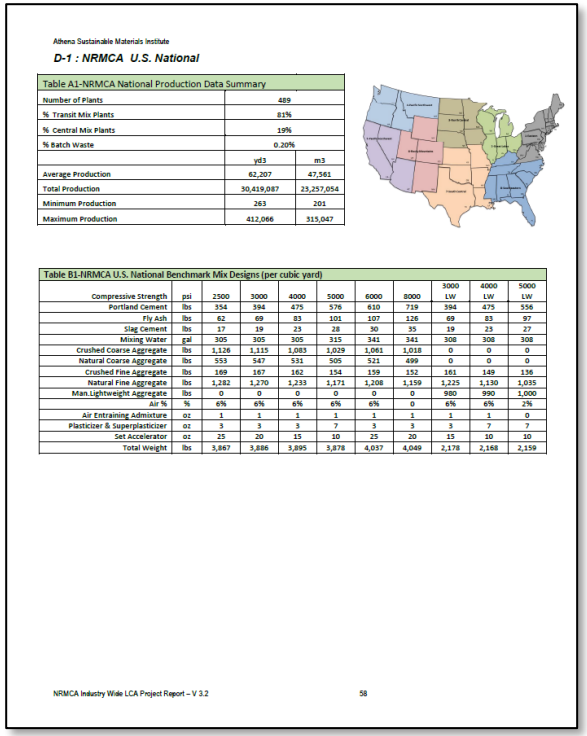
This project report and its results are used to support the development of an industry wide or sector average Environmental Product Declaration for the production of 72 concrete mix designs

Comissioner: National Ready Mixed Concrete Association (NRMCA)

EPD Program Operator: NSF International

Prepared by: The Athena Sustainable Materials Institute

December 2021



Athena Sustainable Materials Institute

D-1 : NRMCA U.S. National

Table A1-NRMCA National Production Data Summary		
Number of Plants	489	
% Transit Mix Plants	81%	
% Central Mix Plants	19%	
% Batch Waste	0.20%	
	yd3	m3
Average Production	62,207	47,561
Total Production	30,419,087	23,257,054
Minimum Production	263	201
Maximum Production	412,066	315,047

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	594	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	gal	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	4,057	4,049	2,178	2,168	2,159

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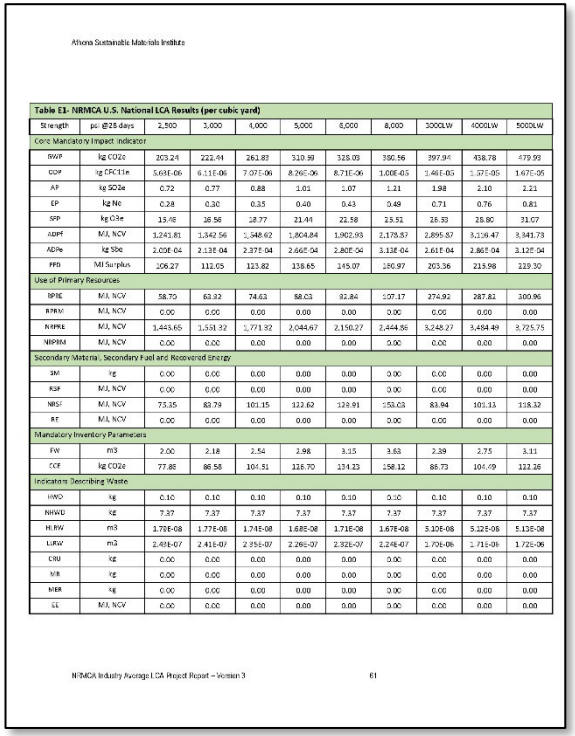


Athena Sustainable Materials Institute

Table E1- NRMCA U.S. National 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 Indicators										
GWP	kg CO2e	203.24	222.44	261.82	310.39	328.03	380.56	397.94	458.78	479.99
ODP	kg CFC11e	5.69E-06	6.11E-06	7.07E-06	8.26E-06	8.71E-06	1.00E-05	1.46E-05	1.57E-05	1.67E-05
AP	kg SO2e	0.72	0.77	0.88	1.01	1.07	1.21	1.98	2.10	2.21
EP	kg Ne	0.28	0.30	0.35	0.40	0.43	0.49	0.71	0.76	0.81
SFP	kg O3e	15.48	16.56	18.77	21.44	21.58	25.51	28.33	28.80	31.07
ADPF	MJ, NCV	1,241.81	1,342.56	1,548.62	1,804.84	1,902.93	2,178.87	2,895.87	3,126.47	3,341.73
ADPe	kg Sbe	2.09E-04	2.13E-04	2.37E-04	2.66E-04	2.80E-04	3.13E-04	2.61E-04	2.86E-04	3.12E-04
FPD	MJ Surplus	108.27	111.05	123.82	138.65	145.07	166.97	203.36	213.98	229.30
Use of Primary Resources										
RPRE	MJ, NCV	58.75	63.82	74.63	88.03	92.84	107.17	274.92	287.82	300.96
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,443.65	1,551.32	1,771.32	2,044.67	2,150.27	2,444.56	3,248.27	3,484.49	3,725.75
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	75.35	83.79	101.15	122.62	128.91	153.03	83.94	101.13	118.32
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	2.00	2.18	2.54	2.98	3.15	3.63	2.39	2.75	3.11
ODF	kg CO2e	77.86	86.58	104.51	126.70	134.23	158.12	86.73	104.49	122.26
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	1.70E-08	1.77E-08	1.74E-08	1.68E-08	1.71E-08	1.67E-08	5.10E-08	5.12E-08	5.13E-08
ILRW	m3	2.41E-07	2.41E-07	2.35E-07	2.26E-07	2.32E-07	2.24E-07	1.70E-06	1.71E-06	1.72E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NRMCA Industry Average LCA Project Report – Version 3 61

Download at **https://www.nrmca.org/sustainability**

2. NRMCA Benchmark Mixes

Shear Walls	7,630	6,000 psi	6,000 psi 30% slag, 20% fly ash

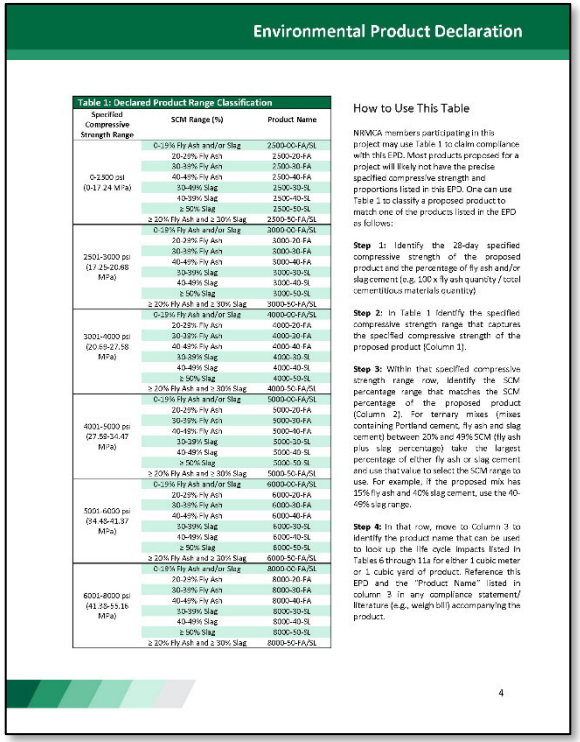
Results Table E2-Eastern LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	183.29	201.48	240.22	289.03	305.26	360.51	395.35	437.90	480.10
ODP	kg CFC11e	5.91E-06	6.36E-06	7.32E-06	8.52E-06	8.96E-06	1.03E-05	1.47E-05	1.58E-05	1.69E-05
AP	kg SO2e	0.67	0.71	0.81	0.93	0.98	1.12	2.10	2.22	2.33
EP	kg Ne	0.24	0.26	0.30	0.36	0.37	0.44	0.69	0.74	0.79
SFP	kg O3e	14.31	15.21	17.18	19.61	20.57	23.34	29.65	31.81	33.89
ADPf	MJ, NCV	400.61	412.16	442.07	482.50	503.70	548.75	2,225.23	2,290.96	2,344.41
ADPe	kg Sbe	1.28E-04	1.30E-04	1.36E-04	1.42E-04	1.48E-04	1.55E-04	1.71E-04	1.79E-04	1.87E-04

Note: This step is automated when using NRMCA's Concrete Carbon Calculator

2. NRMCA Benchmark Mixes

Concrete Element	Concrete Volume (yd^3)	Benchmark Mixes GWP (Eastern Region)	Proposed Mixes GWP (IW-EPD)*
Shear Walls	**7,630**	6,000 psi **305**	
Columns	**366**	8,000 psi **361**	
Floors 2-18	**4,533**	5,000 psi **289**	
Floors B2-1	**1,067**	5,000 psi **289**	
Basement Walls	**444**	5,000 psi **289**	
Foundation	**3,844**	6,000 psi **305**	

3. NRMCA Proposed Industry Wide EPD Mixes



Environmental Product Declaration

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
	50-99% Slag	2500-40-SL
	≥ 50% Slag	2500-50-SL
	≥ 20% Fly Ash and ≥ 20% Slag	2500-50-FA/SL
2501-3000 psi (17.25-20.68 MPa)	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
	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
3001-4000 psi (20.69-27.58 MPa)	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
4001-5000 psi (27.59-34.47 MPa)	0-19% Fly Ash and/or Slag	5000-00-FA/SL
	20-29% Fly Ash	5000-20-FA
	30-39% Fly Ash	5000-30-FA
	40-49% Fly Ash	5000-40-FA
	30-39% Slag	5000-30-SL
	40-49% Slag	5000-40-SL
	≥ 50% Slag	5000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	5000-50-FA/SL
5001-6000 psi (34.45-41.37 MPa)	0-19% Fly Ash and/or Slag	6000-00-FA/SL
	20-29% Fly Ash	6000-20-FA
	30-39% Fly Ash	6000-30-FA
	40-49% Fly Ash	6000-40-FA
	30-39% Slag	6000-30-SL
	40-49% Slag	6000-40-SL
	≥ 50% Slag	6000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	6000-50-FA/SL
6001-8000 psi (41.38-55.16 MPa)	0-19% Fly Ash and/or Slag	8000-00-FA/SL
	20-29% Fly Ash	8000-20-FA
	30-39% Fly Ash	8000-30-FA
	40-49% Fly Ash	8000-40-FA
	30-39% Slag	8000-30-SL
	40-49% Slag	8000-40-SL
	≥ 50% Slag	8000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	8000-50-FA/SL

How to Use This Table

NRMCA members participating in this project may use Table 1 to claim compliance with this EPD. Most products proposed for a project will likely not have the precise specified compressive strength and proportions listed in this EPD. One can use Table 1 to classify a proposed product to match one of the products listed in the EPD as follows:

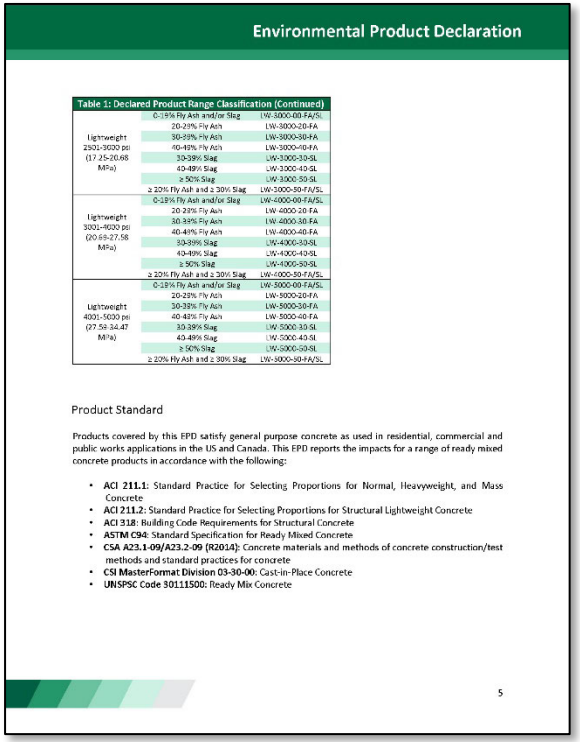
Step 1: Identify the 28-day specified compressive strength of the proposed product and the percentage of fly ash and/or slag cement (e.g. 100 x fly ash quantity / total cementitious materials quantity)

Step 2: In Table 1 identify the specified compressive strength range that captures the specified compressive strength of the proposed product (Column 1).

Step 3: Within that specified compressive strength range row, identify the SCM percentage range that matches the SCM percentage of the proposed product (Column 2). For ternary mixes (mixes containing Portland cement, fly ash and slag cement) between 20% and 49% SCM (fly ash plus slag percentage) take the largest percentage of either fly ash or slag cement and use that value to select the SCM range to use. For example, if the proposed mix has 15% fly ash and 40% slag cement, use the 40-49% slag range.

Step 4: In that row, move to Column 3 to identify the product name that can be used to look up the life cycle impacts listed in Tables 6 through 11a for either 1 cubic meter or 1 cubic yard of product. Reference this EPD and the "Product Name" listed in column 3 in any compliance statement/ literature (e.g., weigh bill) accompanying the product.

4



Environmental Product Declaration

Table 1: Declared Product Range Classification (Continued)

Lightweight 2501-3000 psi (17.25-20.68 MPa)	0-19% Fly Ash and/or Slag	LW-3000-00-FA/SL
	20-29% Fly Ash	LW-3000-20-FA
	30-39% Fly Ash	LW-3000-30-FA
	40-49% Fly Ash	LW-3000-40-FA
	30-39% Slag	LW-3000-30-SL
	40-49% Slag	LW-3000-40-SL
	≥ 50% Slag	LW-3000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	LW-3000-50-FA/SL
Lightweight 3001-4000 psi (20.69-27.58 MPa)	0-19% Fly Ash and/or Slag	LW-4000-00-FA/SL
	20-29% Fly Ash	LW-4000-20-FA
	30-39% Fly Ash	LW-4000-30-FA
	40-49% Fly Ash	LW-4000-40-FA
	30-39% Slag	LW-4000-30-SL
	40-49% Slag	LW-4000-40-SL
	≥ 50% Slag	LW-4000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	LW-4000-50-FA/SL
Lightweight 4001-5000 psi (27.59-34.47 MPa)	0-19% Fly Ash and/or Slag	LW-5000-00-FA/SL
	20-29% Fly Ash	LW-5000-20-FA
	30-39% Fly Ash	LW-5000-30-FA
	40-49% Fly Ash	LW-5000-40-FA
	30-39% Slag	LW-5000-30-SL
	40-49% Slag	LW-5000-40-SL
	≥ 50% Slag	LW-5000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	LW-5000-50-FA/SL

Product Standard

Products covered by this EPD satisfy general purpose concrete as used in residential, commercial and public works applications in the US and Canada. This EPD reports the impacts for a range of ready mixed concrete products in accordance with the following:

- **ACI 211.1:** Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
- **ACI 211.2:** Standard Practice for Selecting Proportions for Structural Lightweight Concrete
- **ACI 318:** Building Code Requirements for Structural Concrete
- **ASTM C94:** Standard Specification for Ready Mixed Concrete
- **CSA A23.1-09/A23.2-09 (R2014):** Concrete materials and methods of concrete construction/test methods and standard practices for concrete
- **CSI MasterFormat Division 03-30-00:** Cast-in-Place Concrete
- **UNSPSC Code 30111500:** Ready Mix Concrete

5

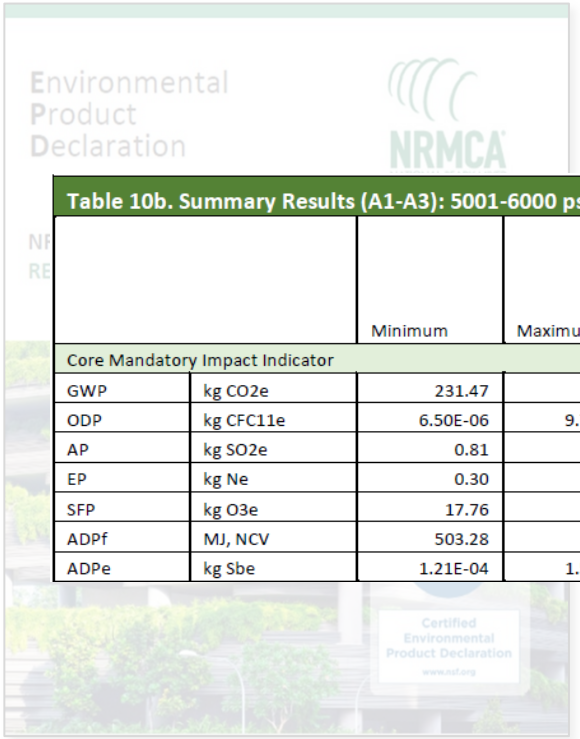
Download at **https://www.nrmca.org/sustainability**

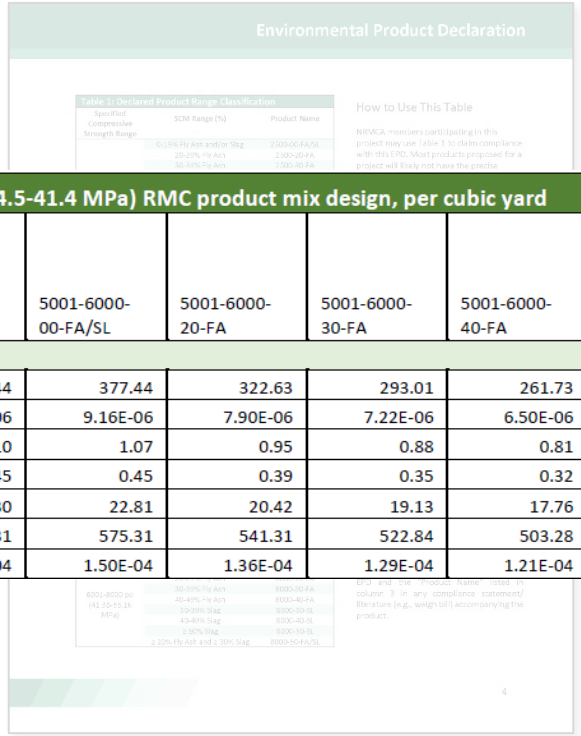
3. NRMCA Proposed Industry Wide EPD Mixes

Shear Walls	**7,630**	**6,000 psi**	**6,000 psi** 30% slag, 20% fly ash

5001-6000 psi (34.48-41.37 MPa)	0-19% Fly Ash and/or Slag	6000-00-FA/SL
	20-29% Fly Ash	6000-20-FA
	30-39% Fly Ash	6000-30-FA
	40-49% Fly Ash	6000-40-FA
	30-39% Slag	6000-30-SL
	40-49% Slag	6000-40-SL
	≥50% Slag	6000-50-SL
	≥20% Fly Ash and ≥30% Slag	6000-50-FA/SL

3. NRMCA Proposed Industry Wide EPD Mixes





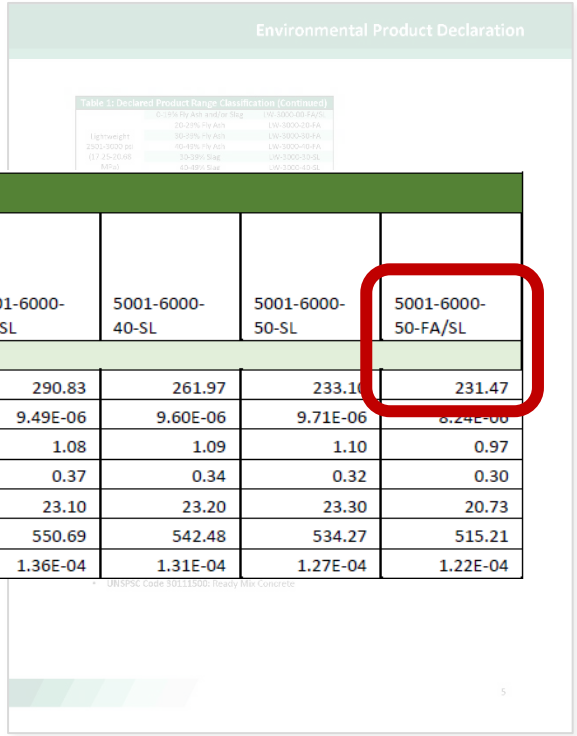


Table 10b. Summary Results (A1-A3): 5001-6000 psi (34.5-41.4 MPa) RMC product mix design, per cubic yard

		Minimum	Maximum	5001-6000-00-FA/SL	5001-6000-20-FA	5001-6000-30-FA	5001-6000-40-FA	5001-6000-30-SL	5001-6000-40-SL	5001-6000-50-SL	5001-6000-50-FA/SL
Core Mandatory Impact Indicator											
GWP	kg CO2e	231.47	377.44	377.44	322.63	293.01	261.73	290.83	261.97	233.10	231.47
ODP	kg CFC11e	6.50E-06	9.71E-06	9.16E-06	7.90E-06	7.22E-06	6.50E-06	9.49E-06	9.60E-06	9.71E-06	8.24E-06
AP	kg SO2e	0.81	1.10	1.07	0.95	0.88	0.81	1.08	1.09	1.10	0.97
EP	kg Ne	0.30	0.45	0.45	0.39	0.35	0.32	0.37	0.34	0.32	0.30
SFP	kg O3e	17.76	23.30	22.81	20.42	19.13	17.76	23.10	23.20	23.30	20.73
ADPf	MJ, NCV	503.28	575.31	575.31	541.31	522.84	503.28	550.69	542.48	534.27	515.21
ADPe	kg Sbe	1.21E-04	1.50E-04	1.50E-04	1.36E-04	1.29E-04	1.21E-04	1.36E-04	1.31E-04	1.27E-04	1.22E-04

Download at **https://www.nrmca.org/sustainability**

3. NRMCA Proposed Industry Wide EPD Mixes

Concrete Element	Concrete Volume (yd^3)	Benchmark Mixes GWP (Eastern Region)	Proposed Mixes GWP (IW-EPD)*
Shear Walls	**7,630**	6,000 psi **305**	30% slag, 20% fly ash **232**
Columns	**366**	8,000 psi **361**	40% fly ash **303**
Floors 2-18	**4,533**	5,000 psi **289**	30% slag **277**
Floors B2-1	**1,067**	5,000 psi **289**	40% fly ash **249**
Basement Walls	**444**	5,000 psi **289**	30% slag, 20% fly ash **220**
Foundation	**3,844**	6,000 psi **305**	40% slag, 30% fly ash **166****

* Should be augmented with local data, knowledge, capabilities

** Use NRMCA Tool to input mix proportions which uses Life Cycle Inventory (LCI) data to estimate impact

3. Alternate: Product Specific EPD Mixes

If available, can use for specific mixes from a specific manufacturer and location

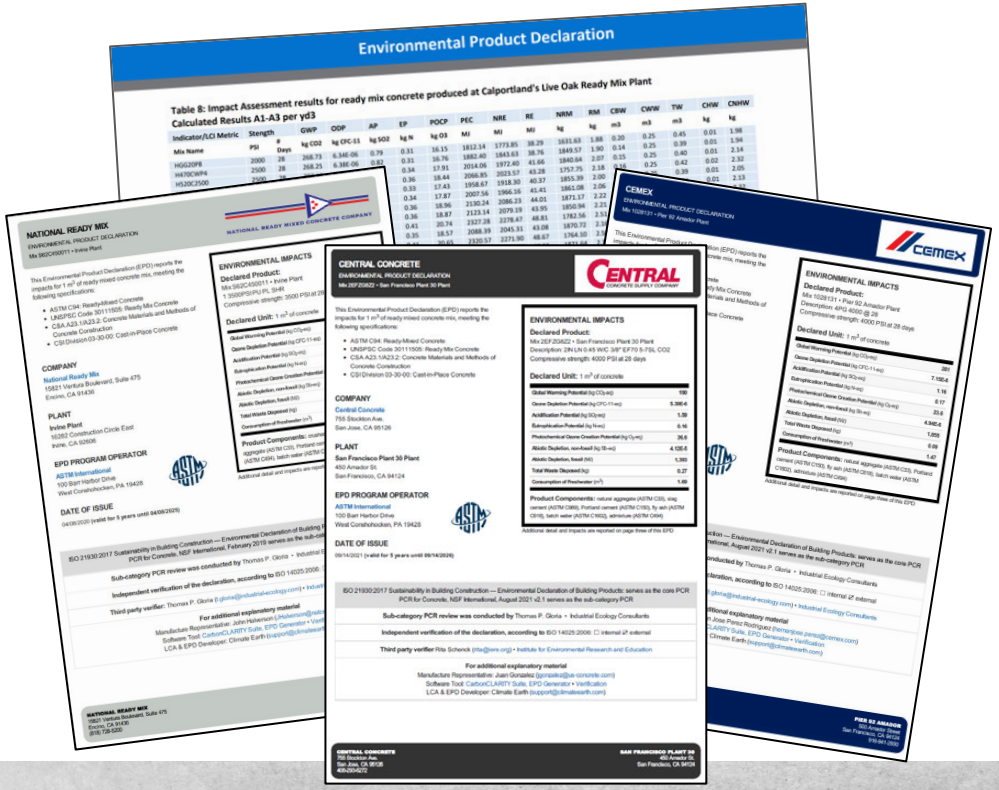
ENVIRONMENTAL IMPACTS

Declared Product:
Mix 2EFZG8Z2 • San Francisco Plant 30 Plant
Description: 2IN LN 0.45 W/C 3/8" EF70 5-7SL CO2
Compressive strength: 4000 PSI at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	190
Ozone Depletion Potential (kg CFC-11-eq)	5.39E-6
Acidification Potential (kg SO_2-eq)	1.59
Eutrophication Potential (kg N-eq)	0.16
Photochemical Ozone Creation Potential (kg O_3-eq)	36.6
Abiotic Depletion, non-fossil (kg Sb-eq)	4.12E-5
Abiotic Depletion, fossil (MJ)	1,393
Total Waste Disposed (kg)	0.27
Consumption of Freshwater (m^3)	1.69

Product Components: natural aggregate (ASTM C33), slag cement (ASTM C989), Portland cement (ASTM C150), fly ash (ASTM C618), batch water (ASTM C1602), admixture (ASTM C494)

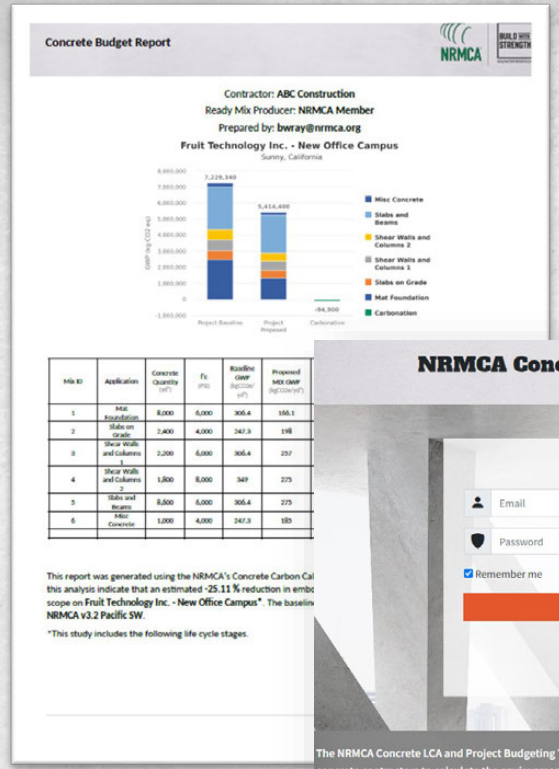


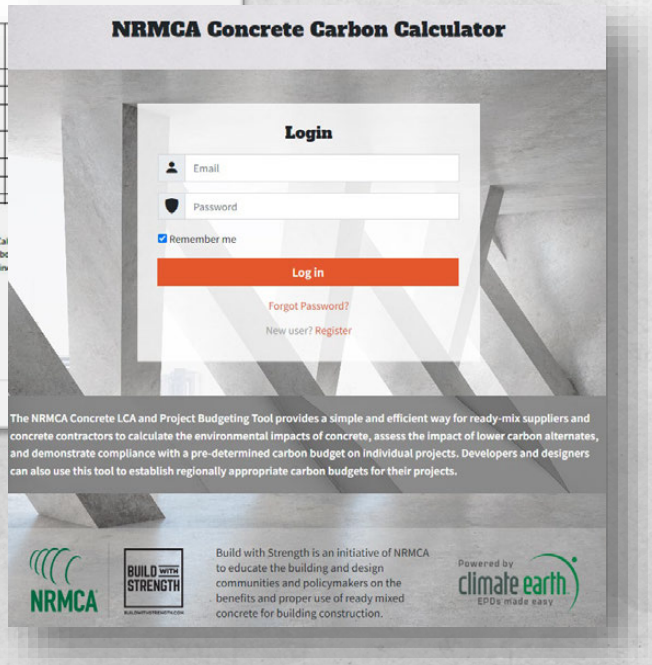
NRMCA Concrete Carbon Calculator

Producer

NRMCA

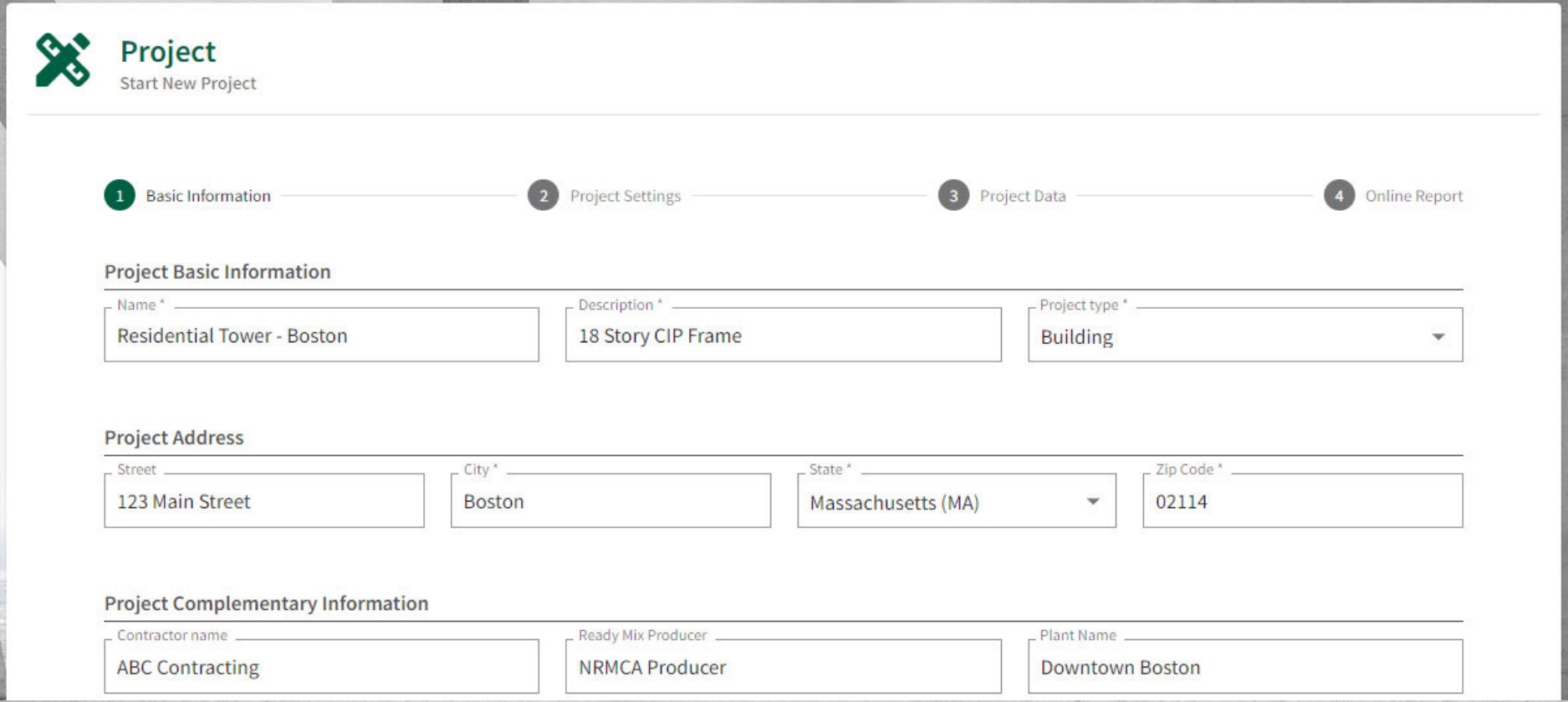
Designer



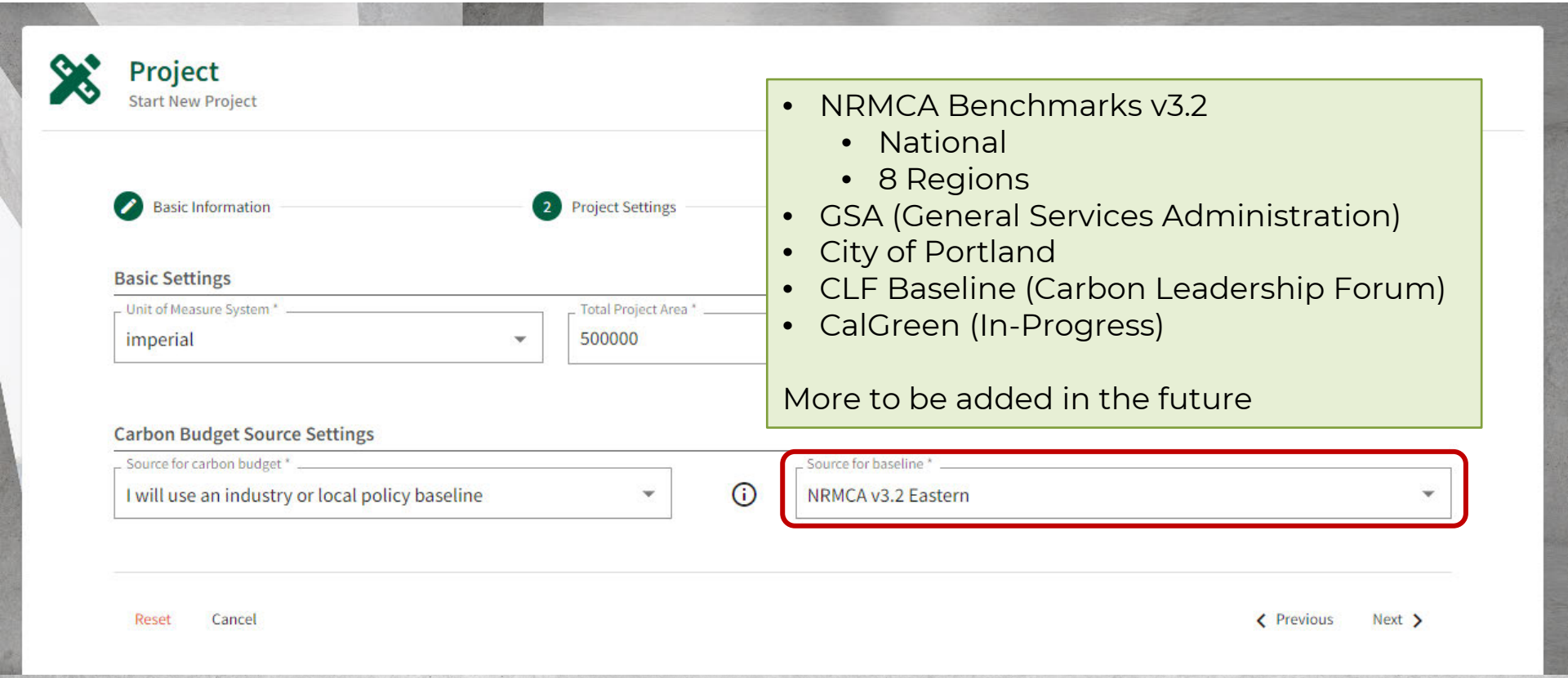


Access at **https://nrmca.climateearth.com/**

4. Compare Impacts: NRMCA Carbon Tool



4. Compare Impacts: NRMCA Carbon Tool



- NRMCA Benchmarks v3.2
  - National
  - 8 Regions
- GSA (General Services Administration)
- City of Portland
- CLF Baseline (Carbon Leadership Forum)
- CalGreen (In-Progress)

More to be added in the future

4. Compare Impacts: NRMCA Carbon Tool

Project
Edit Project

Basic Information — 2 Project Settings — 3 Project Data — Online Report

	Mix ID	Strength PSI	Mix Type	Application	Total Volume yd^3	Proposed Mix GWP $kgCO_2e/yd^3$	Carbonation Factor $kgCO_2e/yd^3$	Baseline GWP $kgCO_2e/yd^3$	Baseline GWP Budget $kgCO_2e/project$	Proposed Project GWP $kgCO_2e/project$	Total Achievable Carbonation $kgCO_2e/project$
	1	6000	Norm…	Shear Walls	7630	232	-7.6	305.3	2,329,439	1,770,160	-57,988
	2	8000	Norm…	Columns	366	303	-17.8	360.5	131,943	110,898	-6,515
	3	5000	Norm…	Floors 2-18	4533	277	-12.4	289	1,310,037	1,255,641	-56,209
	4	5000	Norm…	Floors B2-1	1067	249	-17.7	289	308,363	265,683	-18,886
	5	5000	Norm…	Basement V	444	220	-18.6	289	128,316	97,680	-8,258
	6	6000	Norm…	Foundation	3844	166.4	-0.7	305.3	1,173,573	639,642	-2,691
				TOTALS	17,884				5,381,671	4,139,704	-150,547

4. Compare Impacts: NRMCA Carbon Tool

For calculating impact of a proposed 70% SCM replacement in foundations

2 Project Settings — 3 Project D

Application	Total Volume yd³	Proposed Mix GWP kgCO2e/yd³	Carbonation Factor kgCO2e/yd³	Baseline GWP kgCO2e/yd
Shear Walls	7630	232	-7.6	305.3
Columns	366	303	-17.8	360.5
Floors 2-18	4533	277	-12.4	289
Floors B2-1	1067	249	-17.7	289
Basement V	444	220	-18.6	289
Foundation	3844	166.4	[illegible]	305.3
TOTALS	17,884			

Proposed Mix GWP for 'Mat Foundation'

Important information

This result is NOT an EPD. This GWP was calculated using the same LCI data sources as prescribed in Table A1 of the PCR for Concrete, NSF International, August 2021 v2.1. A3 is assumed to be 9.04 kg CO2eq/m3 per NRMCA's Benchmark Report v3.2. This GWP is strictly an estimate and is based on industry averages, regional data, and average transportation impacts and should be used for estimation purposes only. For more accurate results, it is recommended that a Type III Third-Party Verified Product Specific EPD be developed.

For a more accurate plant specific estimate, use your EPD tool provider's EPD estimator.

Material	Quantity per yd³	UoM
Batch Water	32	GAL
Portland Limestone Cement (Type IL)/ASTM C595 - Domestic	282	LB
Fly Ash	112	LB
Slag Cement/ASTM C989 - Imported	170	LB
Crushed Coarse Aggregate/ Crushed Fine Aggregate	1650	LB
Natural Fine Aggregate	1350	LB
Plasticizer and Superplasticizer	24	FL.OZ

Cancel Download Mix Design File Calculate

4. Compare Impacts: NRMCA Carbon Tool

For calculating the carbonation potential of each element.

ings — 3 Project Data — Online Report

Total Volume yd³	Proposed Mix GWP kgCO2e/yd³	Carbonation Factor kgCO2e/yd³	Baseline GWP kgCO2e/yd³	Baseline GWP Budget kgCO2e/project	Proposed Project GWP kgCO2e/project	Total Achievable Carbonation kgCO2e/project
7630	232	-7.6	305.3	2,329,439	1,770,160	-57,988
366	303	-17.8	360.5	131,943	110,898	-6,515
4533	277	-12.4	289	1,310,037	1,255,641	-56,209
1067	249	-17.7	289	308,363	265,683	-18,886
444	220	-18.6	289	128,316	97,680	-8,258
3844	166.4	-0.7	305.3	1,173,573	639,642	-2,691
17,884				5,381,671	4,139,704	-150,547

Carbonation Factor

Use type *

Reference Service Life (RSL) (years) *

Exposed surface (yd²/yd³) *

Exposure category *

Cement content (lb/yd³) *

Percent clinker in cement (%) *

Percent limestone in concrete (%) *

Percent silica fume in concrete (%) *

Percent fly ash in concrete (%) *

Cancel Calculate

4. Compare Impacts: NRMCA Carbon Tool

Concrete Budget Report

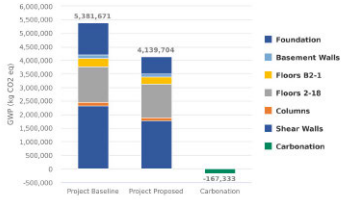
Contractor: **ABC Contracting**

Ready Mix Producer: **NRMCA Producer**

Prepared by: **bwray@nrmca.org**

Residential Tower - Boston

Boston, Massachusetts



Mix ID	Application	Concrete Quantity (yd³)	f'c (PSI)	Baseline GWP (kgCO2e/yd³)	Proposed MIX GWP (kgCO2e/yd³)	Total Project Baseline GWP (kgCO2e/project)	Total Project Proposed GWP (kgCO2e/project)	Difference from Baseline	Carbonation (kgCO2e/project)
1	Shear Walls	7,680	6,000	305.3	232	2,329,439	1,770,160	-24.01 %	-74,774
2	Columns	366	8,000	360.5	303	131,943	110,898	-15.95 %	-5,514.8
3	Floors 2-18	4,533	5,000	289	277	1,310,037	1,255,641	-4.15 %	-56,309.2
4	Floors B2-1	1,067	5,000	289	249	308,363	265,683	-13.84 %	-18,885.9
5	Basement Walls	444	5,000	289	220	128,316	97,680	-23.88 %	-8,258.4
6	Foundation	3,844	6,000	305.3	166.4	1,173,573.2	639,641.6	-45.50 %	-2,690.8
						5,381,671.2	4,139,703.6	**-23.08 %**	-167,333.1

This report was generated using the NRMCA's Concrete Carbon Calculator, powered by Climate Earth. The results of this analysis indicate that an estimated **-23.08 %** reduction in embodied carbon could be achieved for the concrete scope on **Residential Tower - Boston***. The baseline used to calculate this reduction is based on **NRMCA v3.2 Eastern**.

*This study includes the following life cycle stages.

Powered by: climate earth

Concrete Budget Report

PRODUCTION Stage (Mandatory)			CONSTRUCTION Stage		USE Stage					END-OF-LIFE Stage				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction	Transport to waste processing or disposal	Waste processing	Disposal of waste	Reuse, Recovery, Recycling Potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
X	X	X	-	-	-	-	-	-	-	-	-	-	-	X

Recommended Specification Additions:

Section 033000 - CAST-IN-PLACE CONCRETE

Part 1 - GENERAL

1. **- Related Documents**

A. The basis for designing concrete mixtures and demonstrating compliance with carbon budget targets shall be in accordance with:

1. National Ready Mixed Concrete Association (NRMCA) Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Manufactured by NRMCA Members – Version 3 (or later).
2. National Ready Mixed Concrete Association, NRMCA Member Industry Average EPD for Ready Mixed Concrete – Version 3 (or later).

2. **- Summary**

A. Embodied Carbon Footprint Goals

1. This project has a goal of reducing the embodied carbon footprint relative to a benchmark or typical project by **XX %**. To accomplish this goal, the **target carbon footprint reduction for concrete is 20% below the benchmark** established in the NRMCA Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Version 3 (or later). Specific targets for Global Warming Potential (GWP) are provided in Section 2, CONCRETE MIXTURES. It shall be permitted to propose innovative products and manufacturing processes for approval by the Engineer of Record. Proposed alternatives shall meet all performance criteria for strength, durability, and constructability, and achieve the re uired reduction in carbon footprint.

1.5 - Action Submittals

A. Embodied Carbon Footprint Submittals

1. Plant specific Environmental Product Declaration (EPD) for each concrete mixture proposed for the project accompanying each concrete mixture submittal
   a. It shall be permitted to substitute plant-specific EPDs with those listed in NRMCA Member Industry Average EPD for Ready Mixed Concrete if the proposed mixtures are similar to those listed and the concrete producer participated in providing data for the NRMCA Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete.
2. A calculation showing that the Global Warming Potential (GWP) of all the concrete supplied for the project shall be lower than the GWP target set in Section 2.

Powered by: climate earth

Concrete Budget Report

Recommended Specification Additions (continued):

1.7 - Quality Assurance

A. Ready Mixed Concrete Manufacturer Qualifications: A company manufacturing ready mixed concrete who complies with ASTM C94/C94M requirements for production facilities and equipment

1. Concrete shall be supplied from concrete plants with current certification under the NRMCA Certification of Ready Mixed Concrete Production Facilities, certification or approval by a state or highway agency or equivalent. Criteria of equivalent certification shall be included in the submittal.
2. Quality Control personnel with responsibility for concrete mixtures shall document qualifications demonstrating knowledge and experience with concrete technology and development of performance-based concrete mixtures. certified as an NRMCA Concrete Technologist Level 2, or equivalent. Details covered in equivalent certification program shall be documented in the submittal.
3. When requested, the manufacturer shall furnish a Quality Plan
4. Documentation that the concrete supplier participated in supplying data to the NRMCA Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete.

Part 2 - PRODUCTS

2.11 - Concrete Mixtures

A. Embodied Carbon Compliance

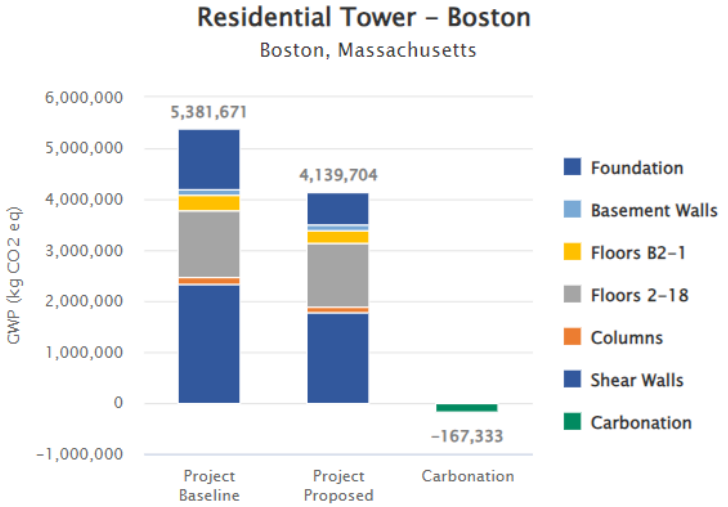
1. Provide documentation that the total GWP of all proposed concrete on the project is less than or equal to **5,785,000 kg of CO2 equivalents or a weighted average of 241 kgCO2e/yd3**.

Supporting Resources:

www.nrmca.org/sustainability www.BuildWithStrength.com

Powered by: climate earth

4. Compare Impacts: NRMCA Carbon Tool



Mix ID	Application	Concrete Quantity (yd³)	f'c (PSI)	Baseline GWP (kgCO2e/yd³)	Proposed Mix GWP (kgCO2e/yd³)	Total Project Baseline GWP (kgCO2e/yd³)	Total Project Proposed GWP (kgCO2e/project)	Difference from Baseline	Carbonation (kgCO2e/project)
1	Shear Walls	7,630	6,000	305.3	232	2,329,439	1,770,160	-24 %	-74,774
2	Columns	366	8,000	360.5	303	131,943	110,898	-16 %	-6,515
3	Floors 2-18	4,533	5,000	289	277	1,310,037	1,255,641	-4.2 %	-56,209
4	Floors B2-1	1,067	5,000	289	249	308,363	265,683	-13.8 %	-18,886
5	Basement Walls	444	5,000	289	220	128,316	97,680	-23.9 %	-8,258
6	Foundation	3,844	6,000	305.3	166.4	1,173,573	639,642	-45.5 %	-2,691
						5,381,671	**4,139,704**	**-23.1%**	**-167,333**

5. Establish Carbon Budget

Project	Project GWP (kg)	Weighted GWP (kg/yd^3)	GWP Reduction
Benchmark Mixes	5,382,000	301	0
Proposed with Fly Ash and Slag Mixes	4,140,000	232	- 23%
Establish Carbon Budget	4,300,000	240	- 20%*

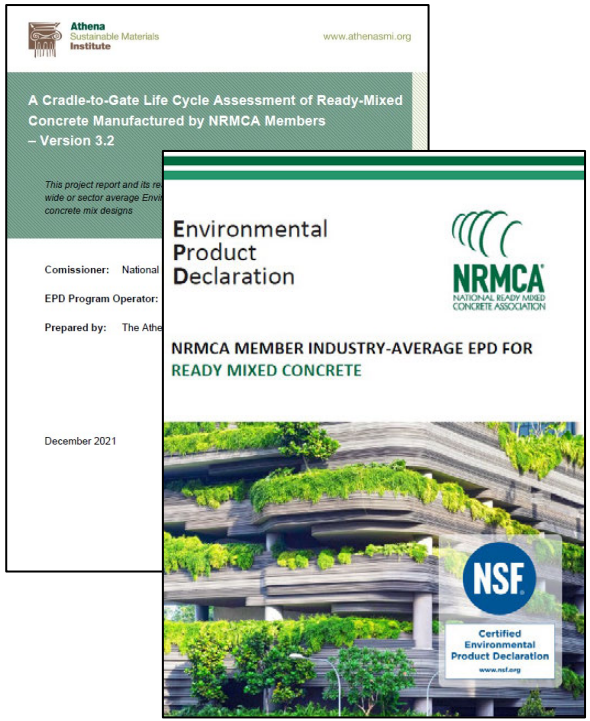
* Consider added buffer/tolerance

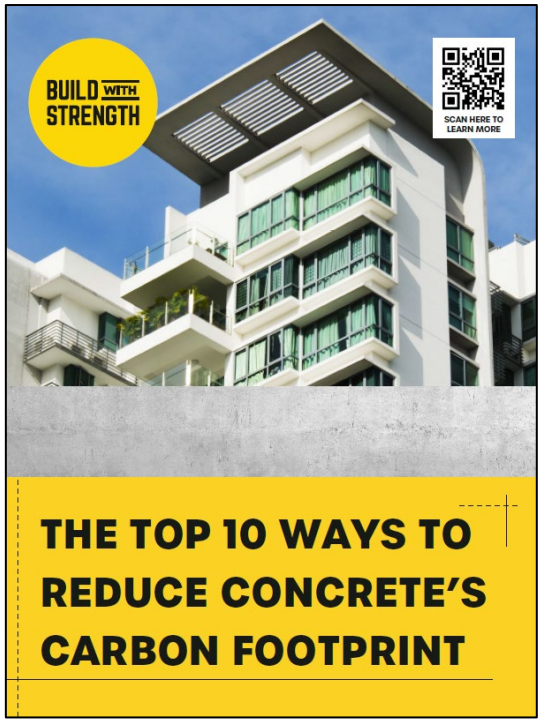
Set Targets for Carbon Footprint

Concrete Materials:

A. Supply concrete mixtures such that the total Global Warming Potential (GWP) of all concrete on the project is less than or equal to **4,300,000 kg** of CO_2 equivalents or a weighted average of **240 kgCO_2e/yd3**

Concrete Resources





www.nrmca.org/sustainability

www.BuildWithStrength.com