NRMCA Concrete Carbon Calculator:

How to quantify and specify carbon

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How to Quantify and Specify Carbon

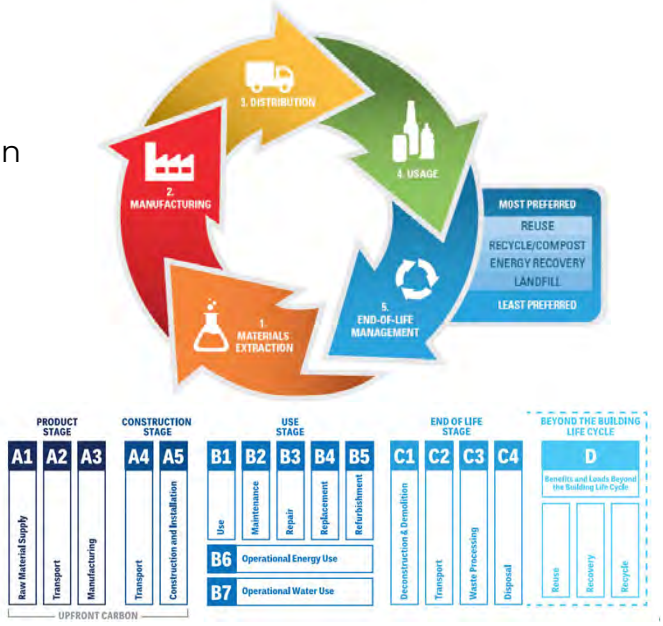
Historically:

- Prescriptive measures
  - "maximum cement content"
  - "minimum SCM content"
- Byproduct:
  - Not producer-specific solutions
  - Inefficient mix design
  - Increase in cost

How to Quantify and Specify Carbon

Present Day:

- Life Cycle Assessment
  - Benchmark vs. Proposed Low Carbon
  - Concrete-scope embodied carbon
    - → Project-wide Whole Building LCA
- Byproduct:
  - Quantifiable reductions
  - Producer specific solutions
  - Flexibility in execution



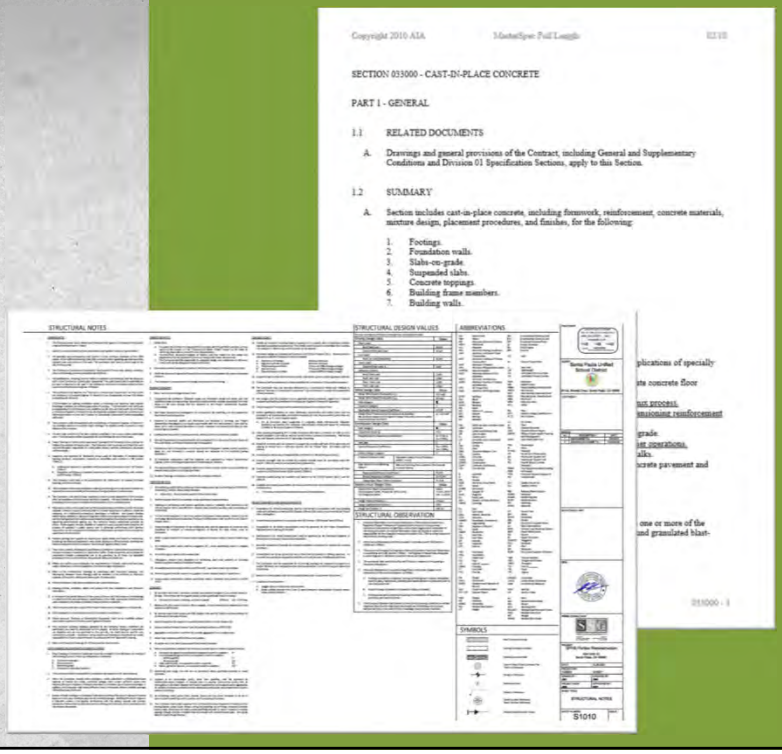
Division 03 Section 033000 Cast-In-Place Concrete

Step #1:

Performance-Based Improvements

Step #2:

Carbon Accounting and Targets


SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:

1. Footings.
2. Foundation walls.
3. Slabs-on-grade.
4. Suspended slabs.
5. Concrete toppings.
6. Building frame members.
7. Building walls.

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!

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 F	S	W	C	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)
Footings													250
Foundation Walls													250
Slabs-on-grade													250
Exterior slabs													
Suspended slabs (interior)													3 0
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

Specifications for Sustainability

Project Budget

TOTAL GWP: 4.30 x 10^6

VS

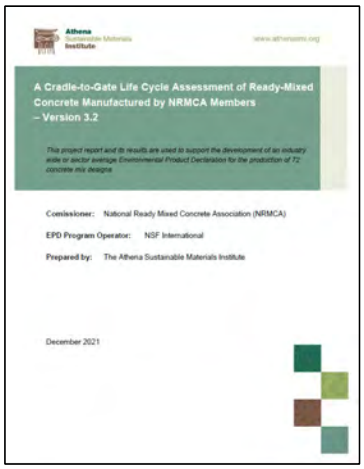
Individual Mix Limits

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

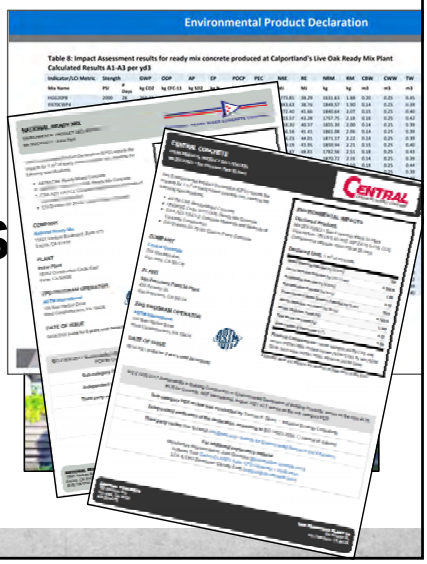
Establishing a Carbon Budget

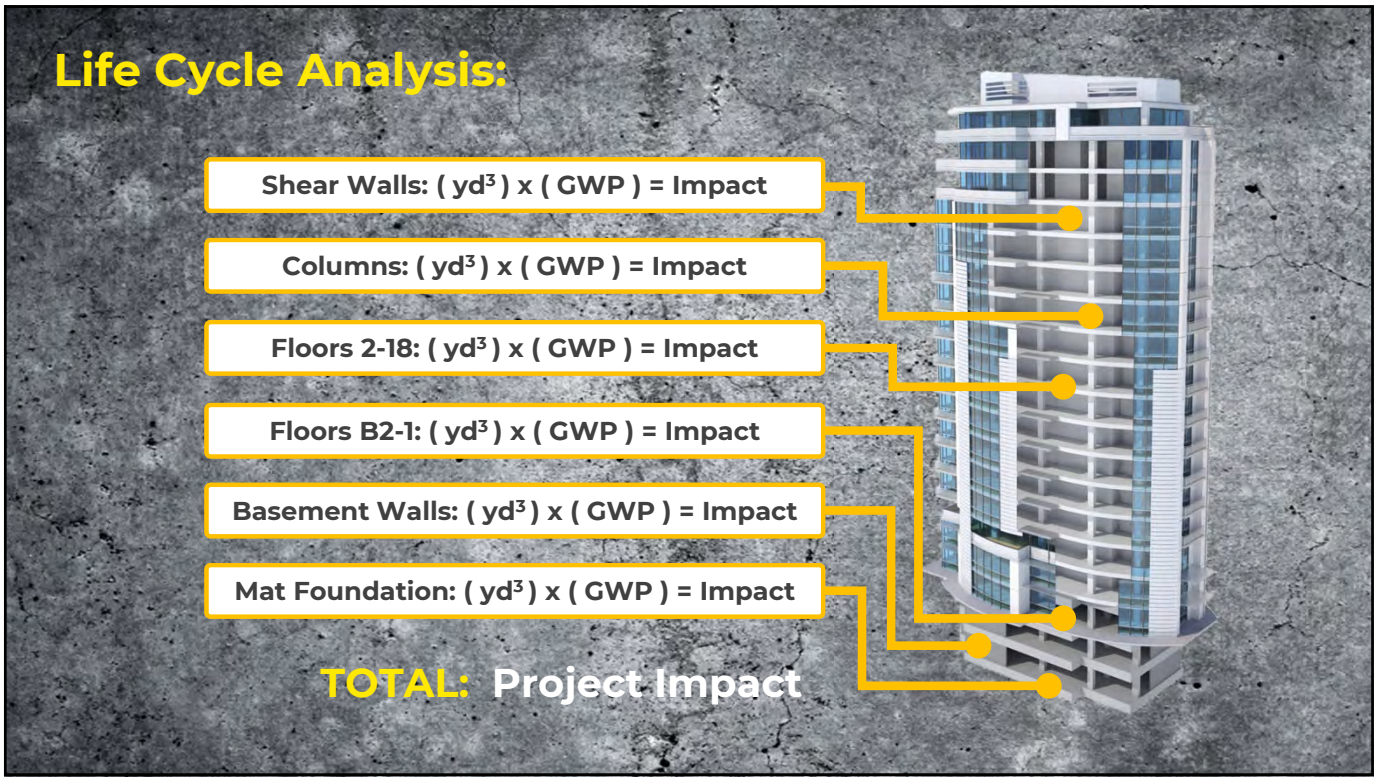
Benchmark Project



VS

Proposed Project





Estimating Quantities and Properties

Concrete Element	Concrete Volume (yd³)	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

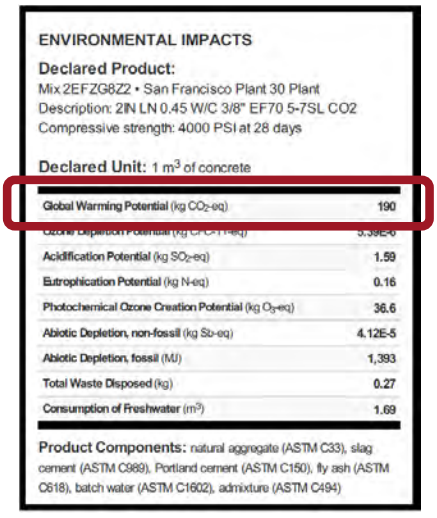
NRMCA Benchmark Mixes

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

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

Environmental Product Declaration (EPD)

3rd party verified & registered documents that communicate transparency



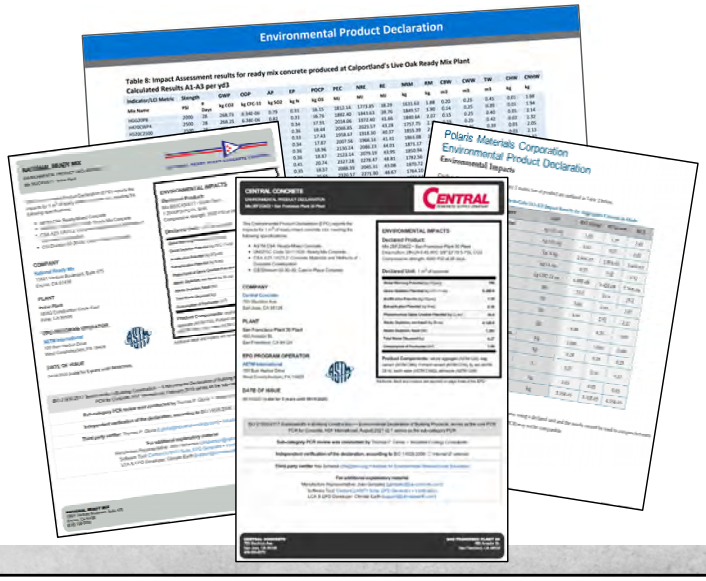
ENVIRONMENTAL IMPACTS

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 Proposed Industry Wide EPD Mixes

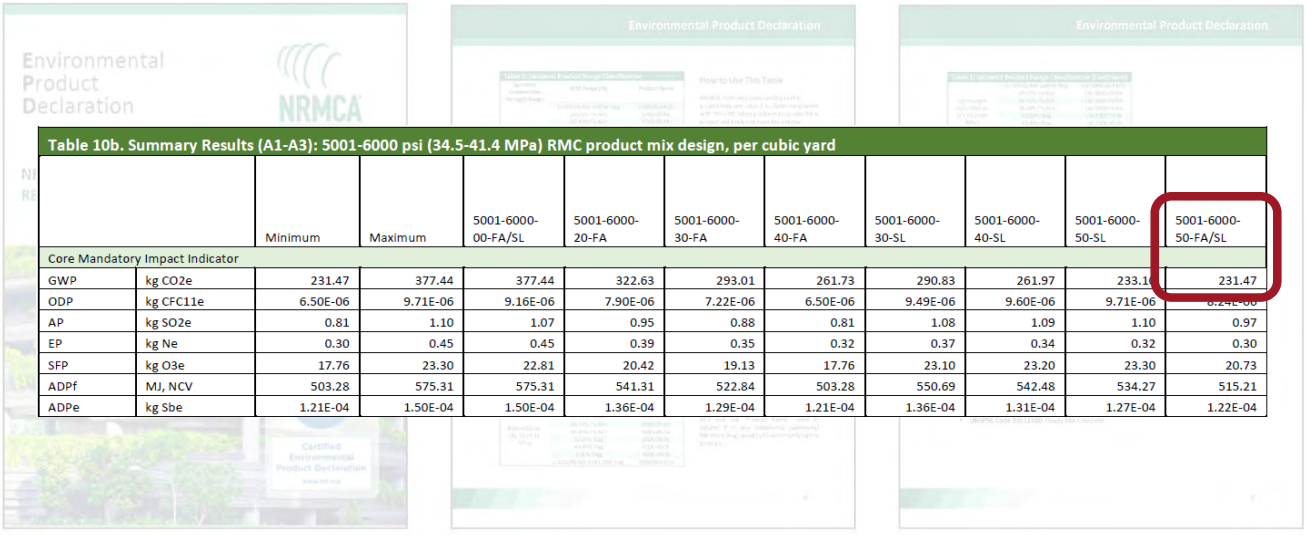


Table 10b. Summary Results (A1-A3): 5001-6000 psi (34.5-41.4 MPa) RMC product mix design, per cubic yard

		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	233.1	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

Identifying Global Warming Potential

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

*Should be augmented with local data, knowledge, capabilities

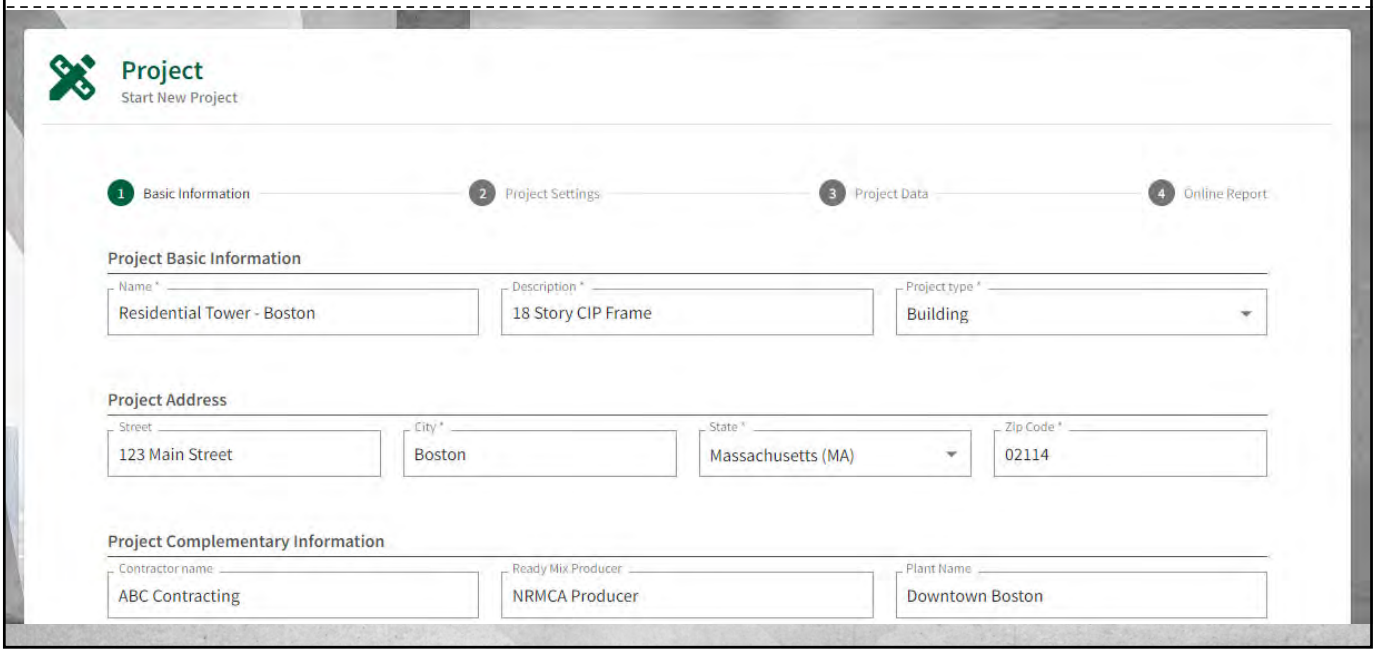
NRMCA Concrete Carbon Calculator

Producer

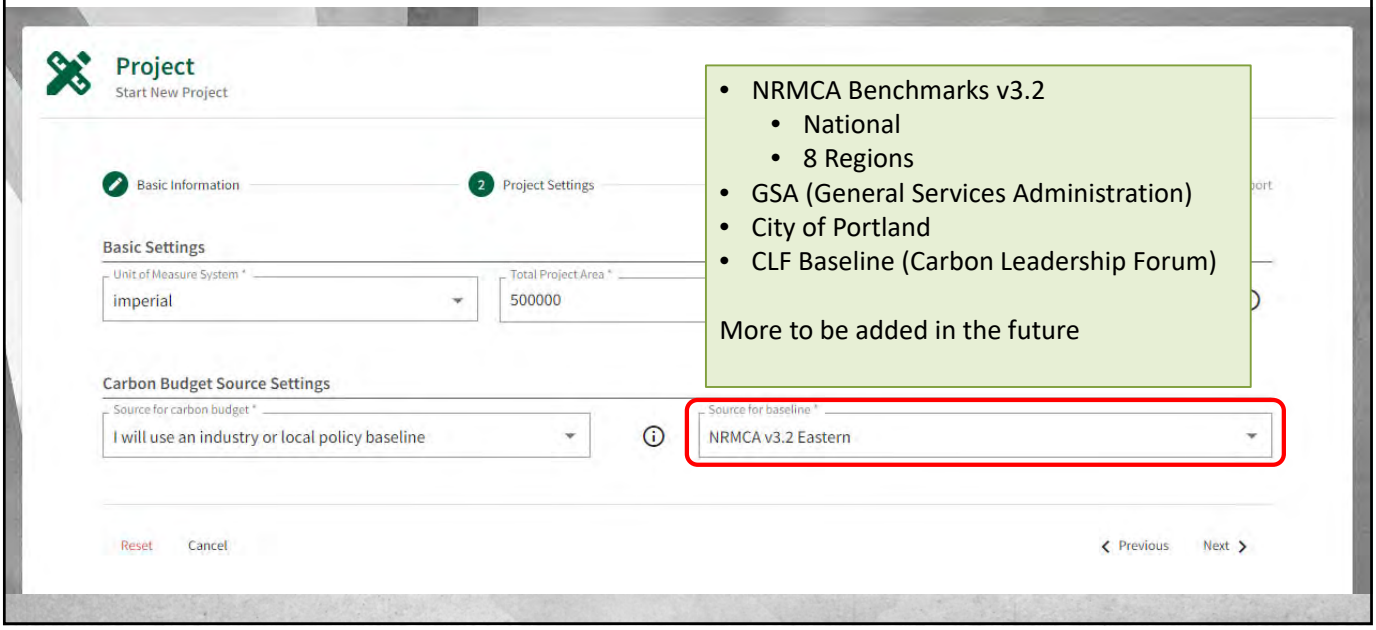
NRMCA Designer

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

NRMCA Carbon Tool



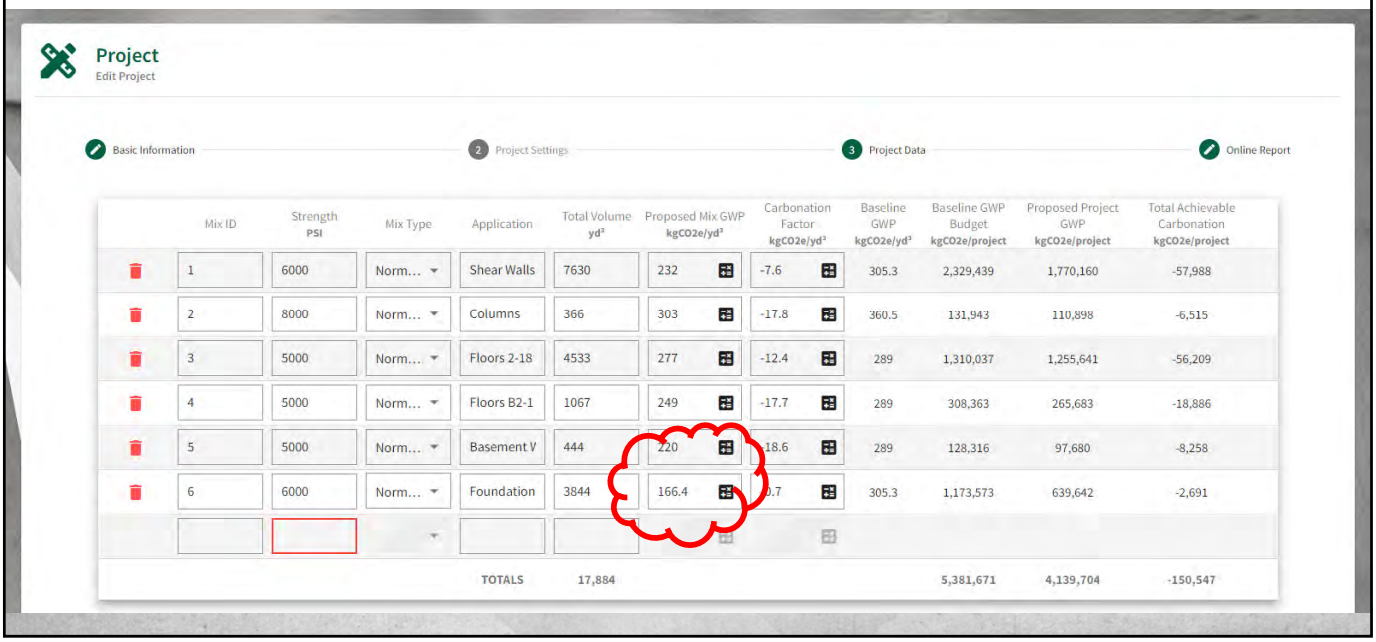
NRMCA Carbon Tool



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

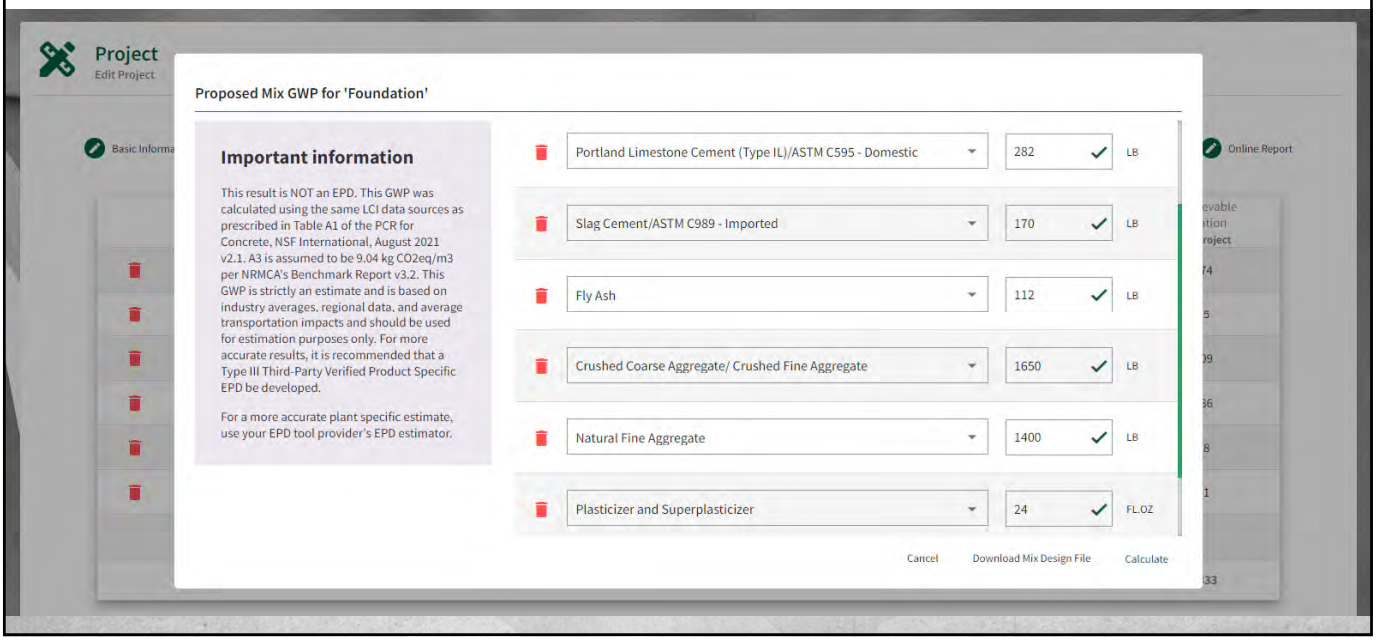
More to be added in the future

NRMCA Carbon Tool



Mix ID	Strength PSI	Mix Type	Application	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
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

NRMCA Carbon Tool



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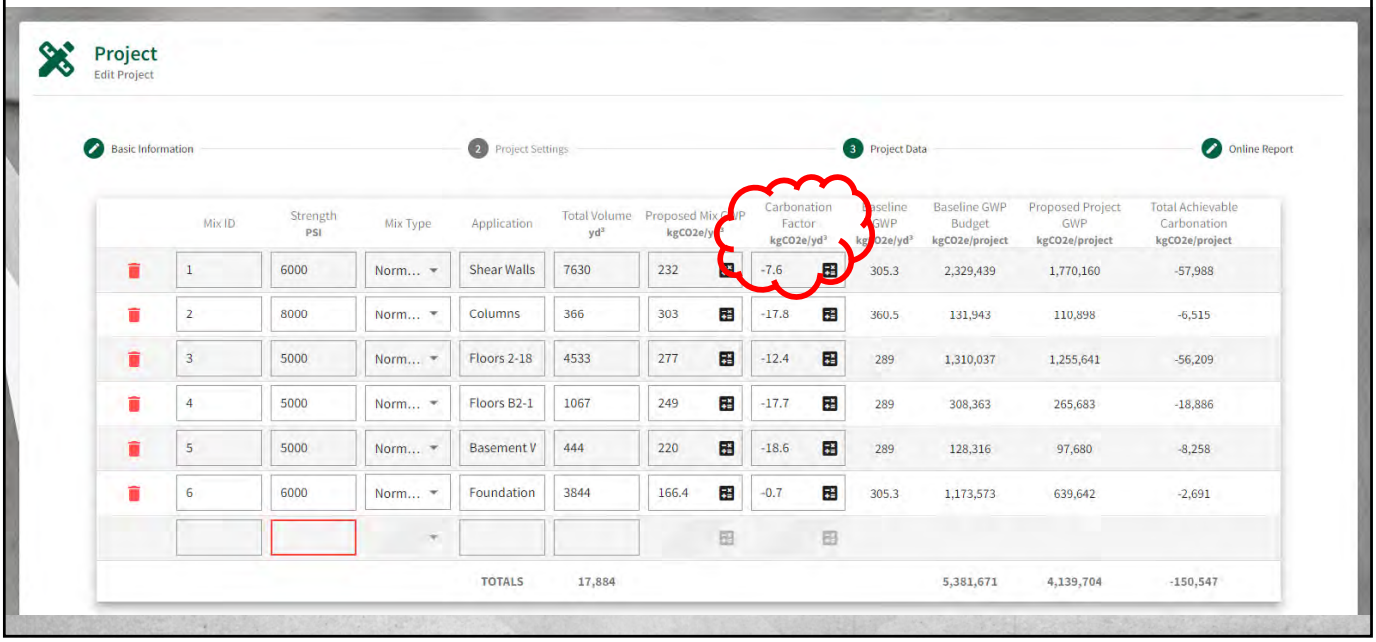

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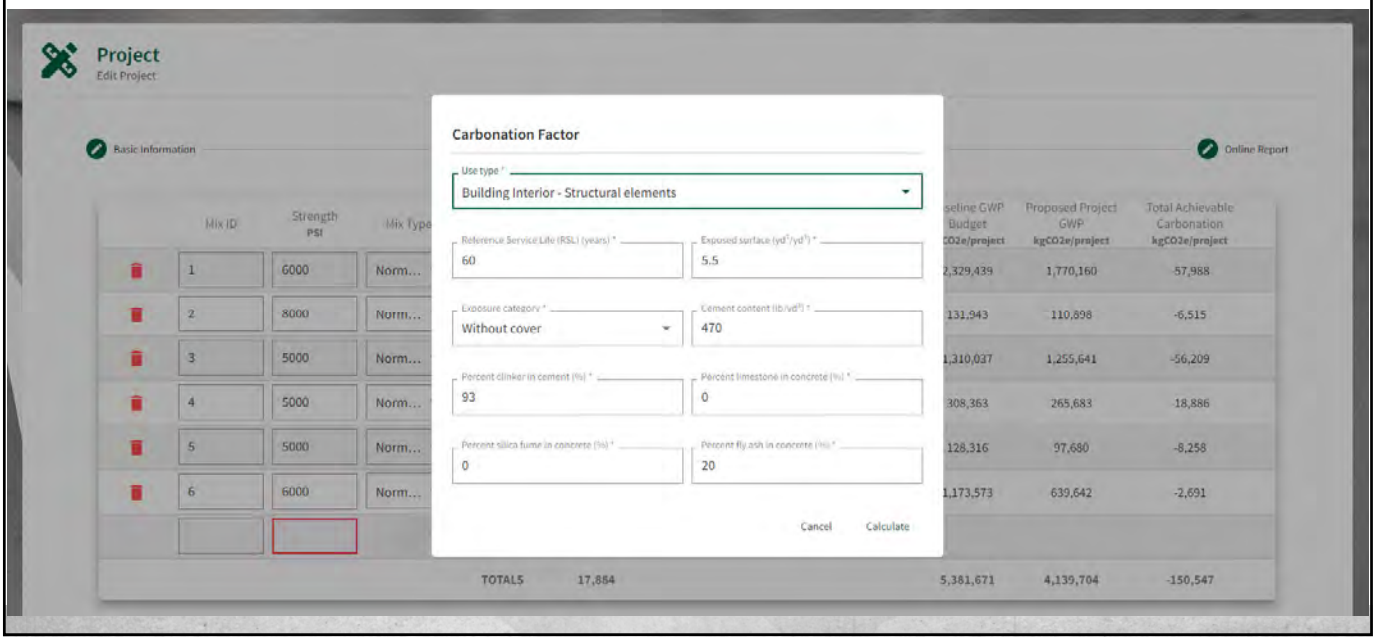

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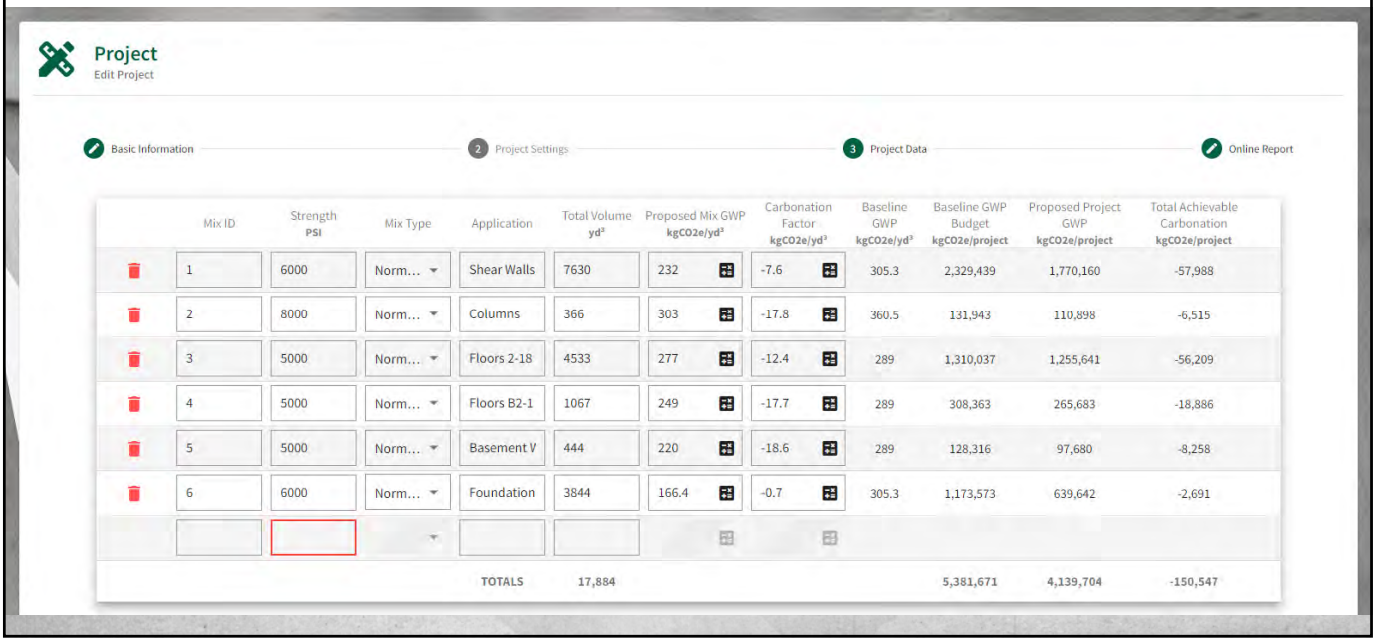

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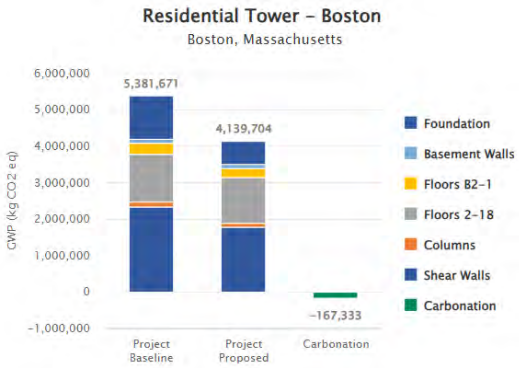

Mix ID	Application	Concrete Quantity (yd^3)	f'c (PSI)	Baseline GWP ($kgCO2e/yd^3$)	Proposed Mix GWP ($kgCO2e/yd^3$)	Total Project Baseline GWP ($kgCO2e/yd^3$)	Total Project Proposed GWP (kgCO2e/project)	Difference from Baseline	Carbonation (kgCO2e/project)
1	Shear Walls	7,630	6,000	305.3	232	2,329,439	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**

Final Results

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

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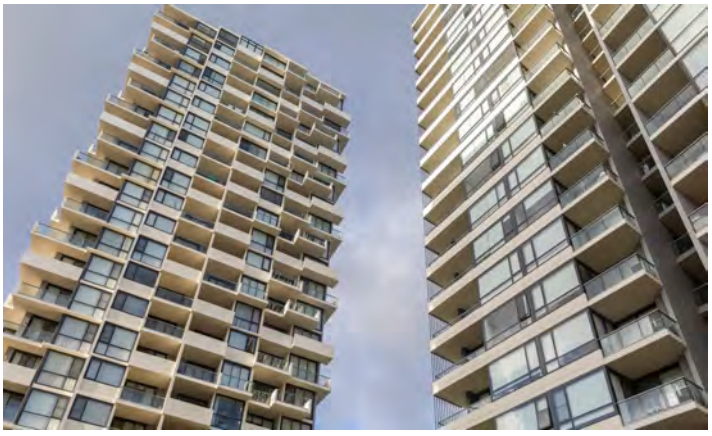
NRMCA BUILD WITH STRENGTH PAVE AHEAD DURABLE. SUSTAINABLE. CONCRETE.



Questions?
Thank You!