Slag Cement's Role in Sustainable Concrete

Slag School May 22, 2023
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Heidelberg Materials

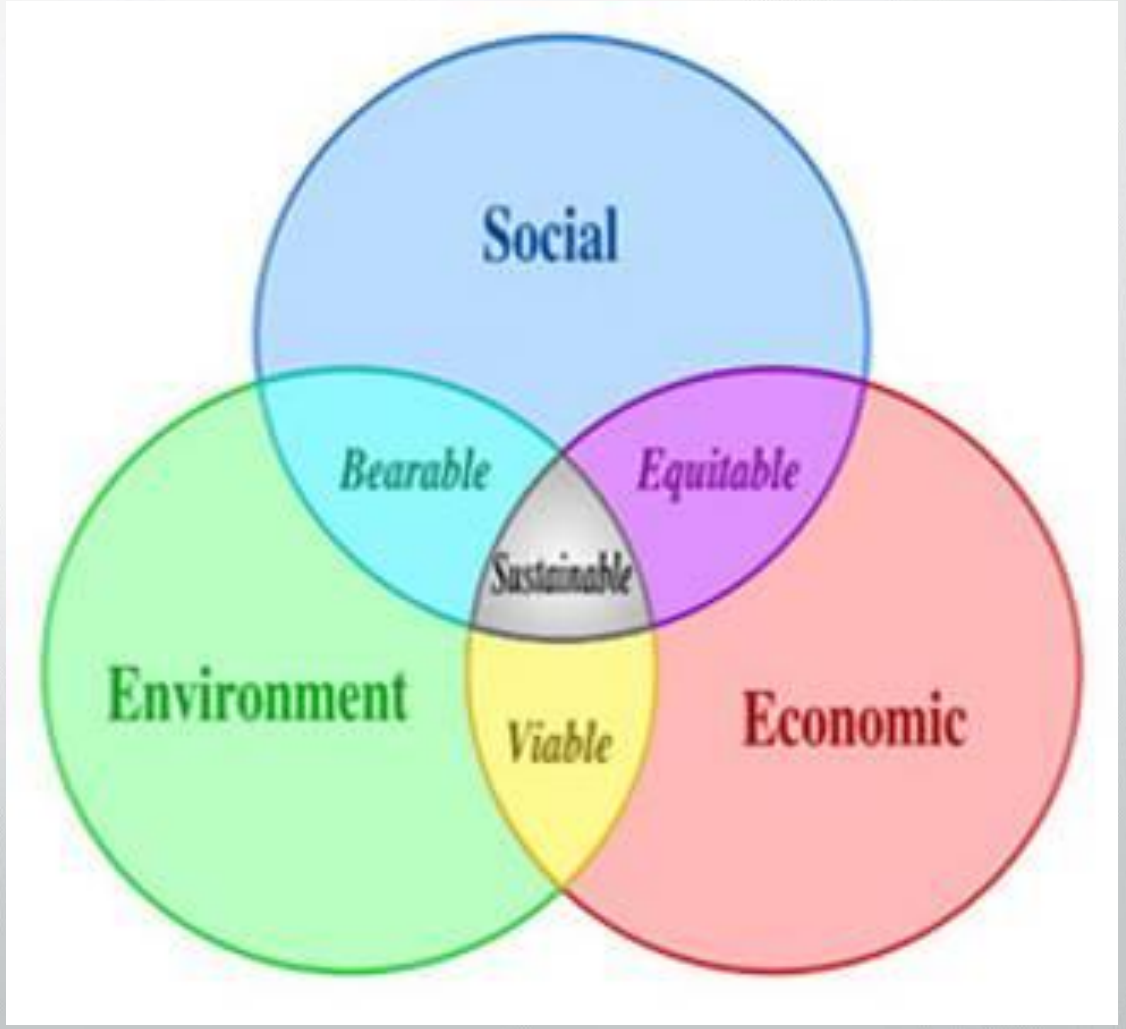
Sustainability Basics

"We do not inherit the earth from our ancestors; we borrow it from our children" Wendell Berry

The Triple-Bottom-Line

- Social
- Environmental
- Economic

… Sustainability is in the Overlap



Architectural and Engineering community were early adopters

Construction Practices & Building Design in…

- Material Impacts
- Health and Safety
- Resilience and Durability
- Longevity / Service Life
- Energy Performance
- Suitability for use
- Each

… Impact the Environment & Communities

Concrete meets sustainable criteria and is world's material of choice

After Water, Concrete is the Most Used Material on Earth

"Each year more than three tons of concrete are made and used for every person on the Globe…"

- Over 20 billion tons/year
- Demand is growing we are seeing
  - 40% +/- increase in building construction
  - Building stock will double in 30-years
  - To add 280 billion square feet by 2040

What makes a material more or less sustainable?

Sustainable Constituents	LCA Production Module A1
CO_2 / Energy Efficient Production	LCA Production Module A3
Durability and Resilience	LCA Use Stage, Modules B1 – B5
Long Service Life, Easily Recycled	LCA Use Modules B1 – B5 & End of Use Stages, Module C1-C4

Life Cycle Assessments (LCA)

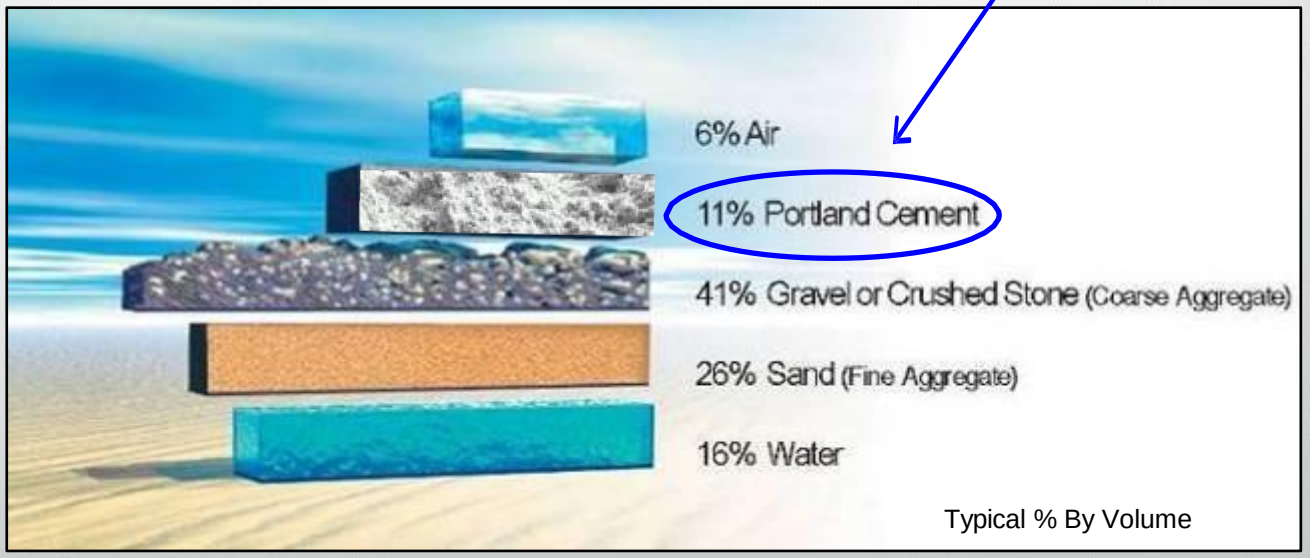
Production Stage			Construction Stage		Use Stage							End Of Life Stage			
Extraction And Upstream Production	Transport To Factory	Manufacturing	Transport To Factory	Installation	Use	Maitenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	Deconstruction / Demolition	Transport	Waste Processing	Disposal Of Waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
x	x	x	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Common Elements = Sustainable Material

Concrete uses common elements

- Rock aka coarse aggregate
- Sand aka fine aggregate
- Cement as a binder
- Optional SCMs
- Water
- Admixtures

Cement and Supplementary Cementitious Materials hold concrete together & give strength



Constituent Materials - Aggregate

~ 2/3 of the Concrete Mix

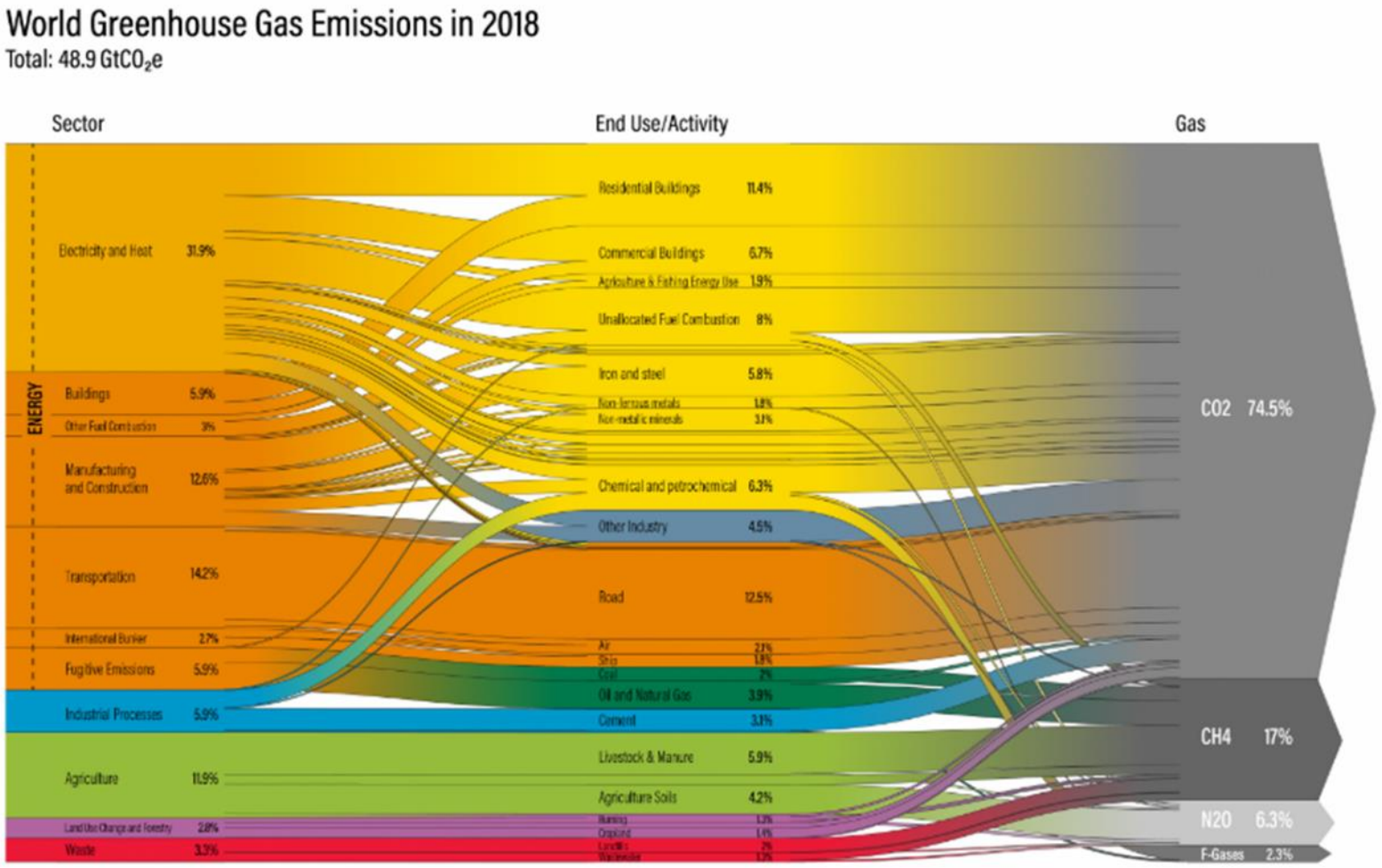
- Low Embodied Energy
- Little or No Mining Waste
- Easily Recycled
- Durable
- Local

Constituent Materials – Portland Cement

- Embodied Energy
  - Fossil Fuel Combustion
- Concrete's primary CO_2 source
  - ~ 60% from Calcining $CaCO_3 \rightarrow CaO + CO_2(g)$
  - ~ 40% from Fuel Combustion & Electrical
- With No Supplementary Cementitious Materials…
  Cement Can Represent 96% of Total Emissions

Photo by Larry Rowland

Global CO_2 emissions from cement



Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org

WORLD RESOURCES INSTITUTE

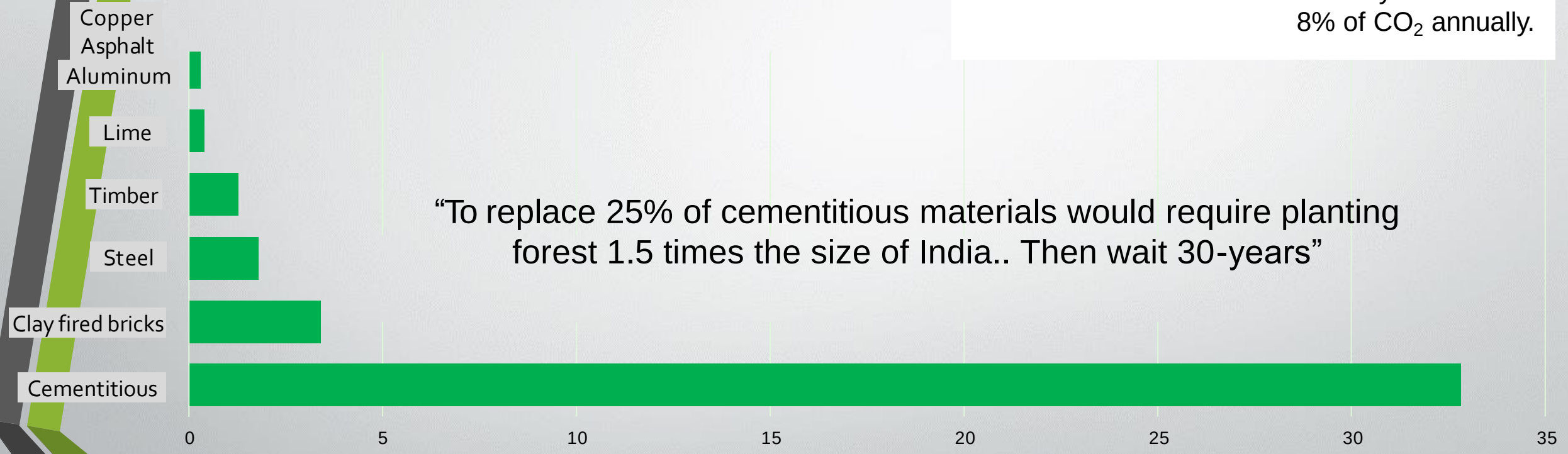
Cement's Impacts Well Documented

- Cement global GHG ~ 8% of CO_2
- Large emissions source globally
- Target due to high profile industry
- Carbon intensive process

Global CO_2 emissions from cement

Cementitious materials make up >50% of everything we produce.

It is for this reason they account for 8% of CO_2 annually.

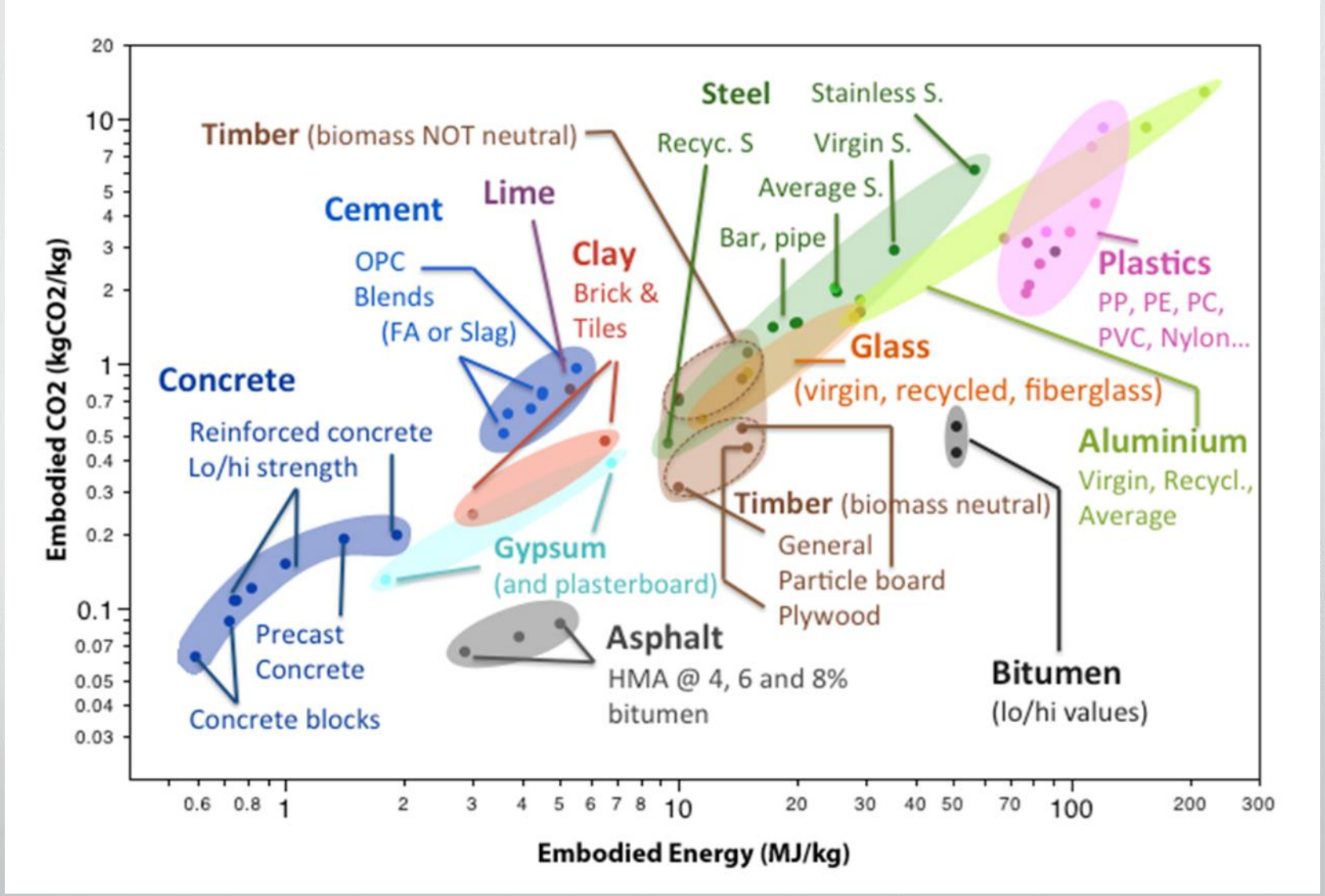


"To replace 25% of cementitious materials would require planting forest 1.5 times the size of India.. Then wait 30-years"

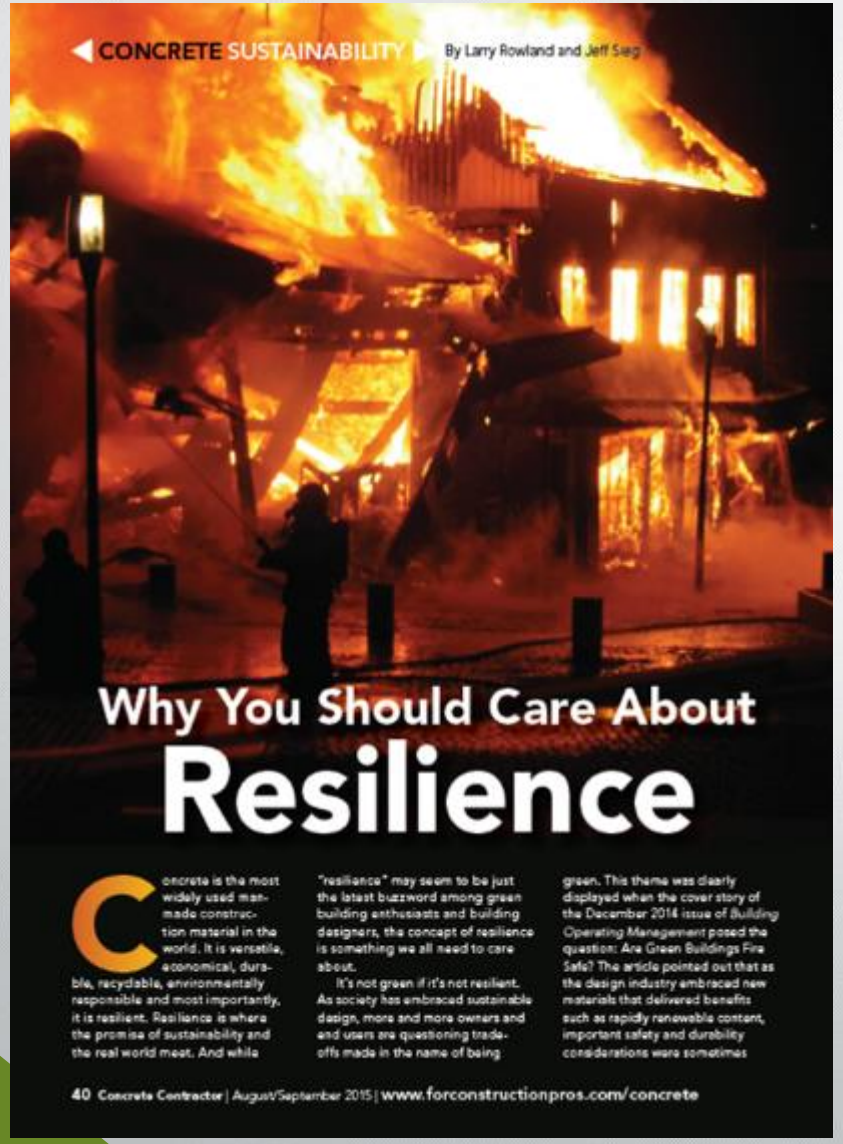
Slide adapted from LC3 presentation 3.31.2023 by Prof. Karen Scrivener

Global CO_2 emissions from cement

- Cement is a very sustainable material with relatively low environmental impacts.
- Concrete is the global sustainable building material of choice.



Concrete is Resilient



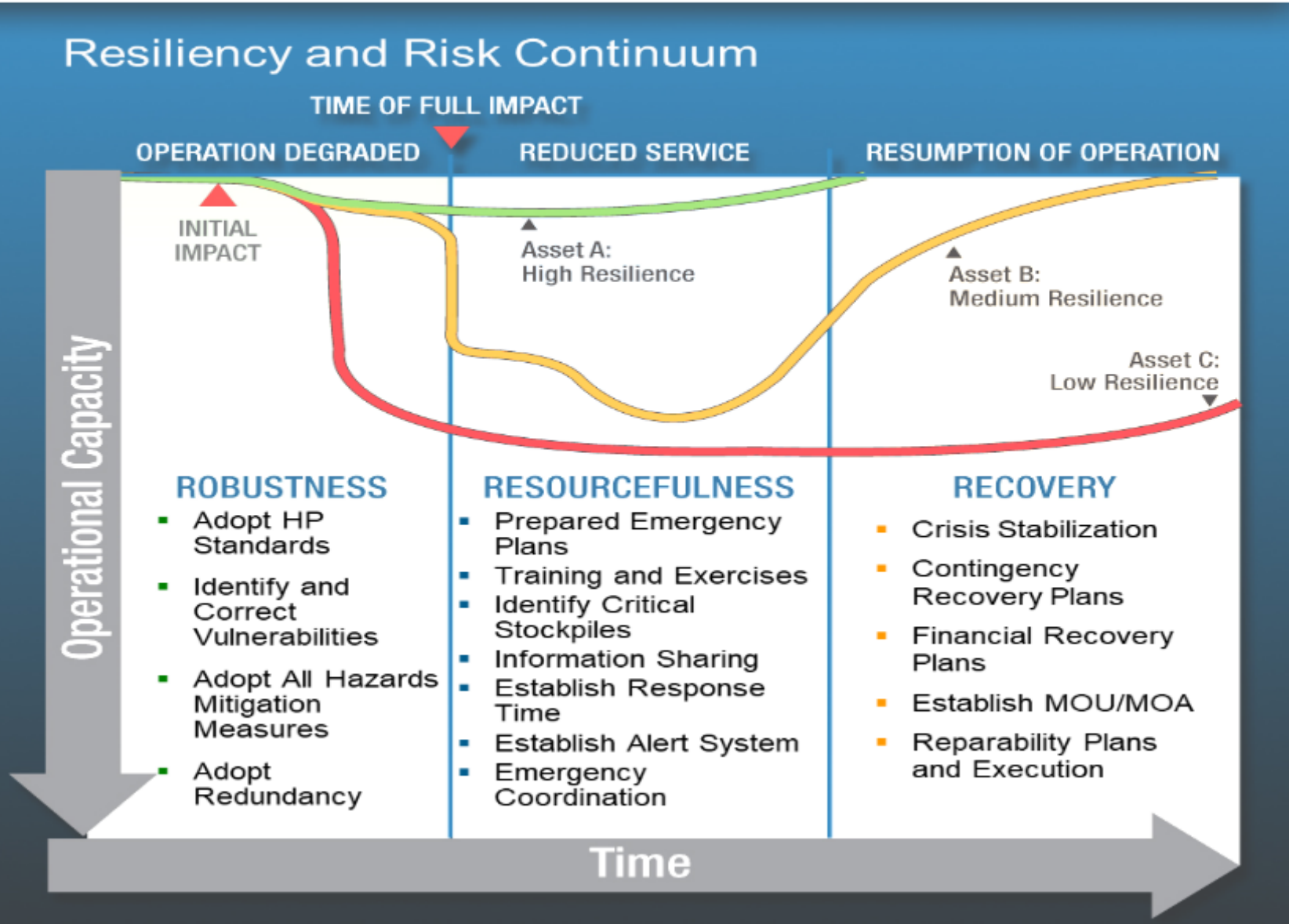
What do you want your home to be made of?

- Will it burn?
- Does it provide passive resistance to file?
- Is it pressurized water dependent
- Will it rot or be eaten by insects or mold?
- Will it blow away?
- Is it worth the risk?

HP Resilience Program Overview

Infrastructure resilience is the ability to reduce the effects of the magnitude and duration of disruptive events on the physical environment

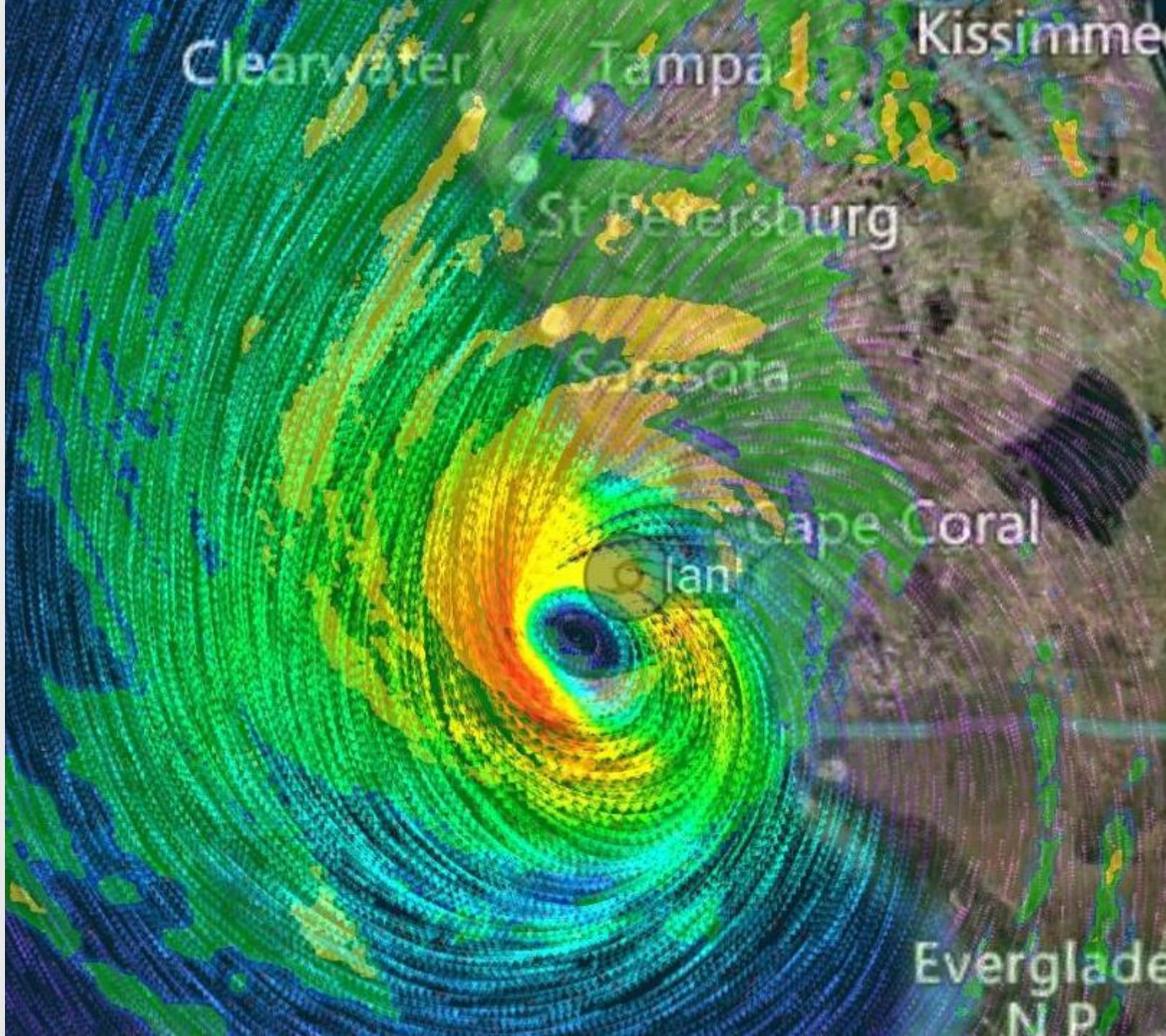
The effectiveness of a resilient enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event



Concrete…

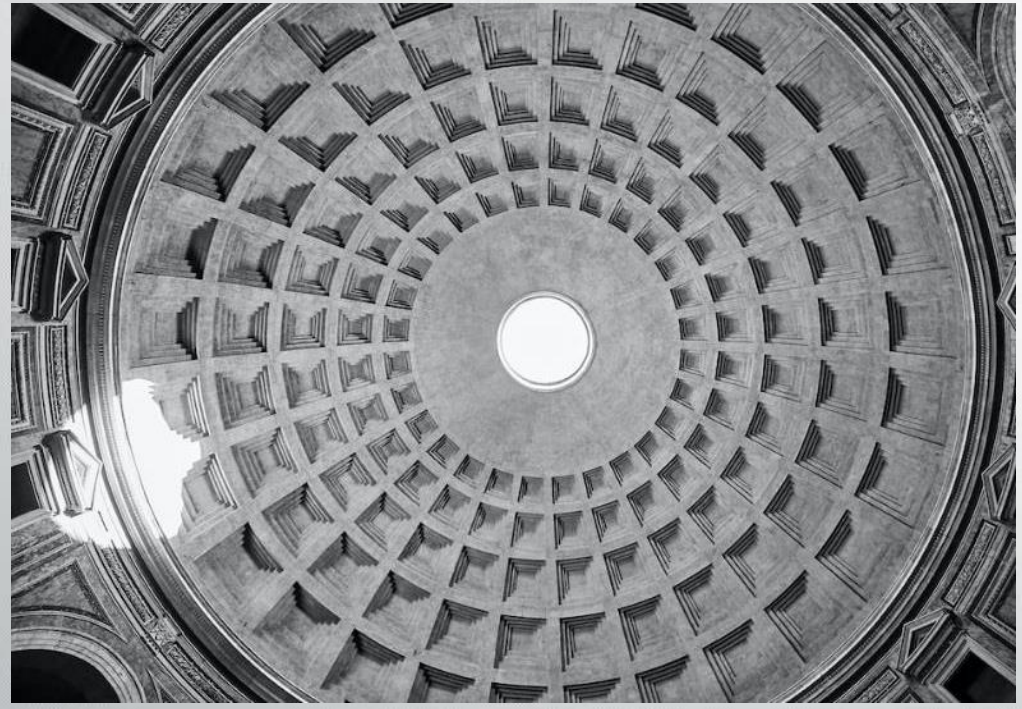
Naturally Resilient & Sustainable

- Mitigates risk
- Highly durable
- Significant safety advantages for…
  - Hurricane
  - Tornado
  - Wildfire / Structural fire
  - Floods
  - Mayhem



Concrete has a Long Service Life

Do it Once…



The Pantheon in Rome. Circa 126

Photo by Mathew Schwartz on Unsplash

Do it Right with Concrete

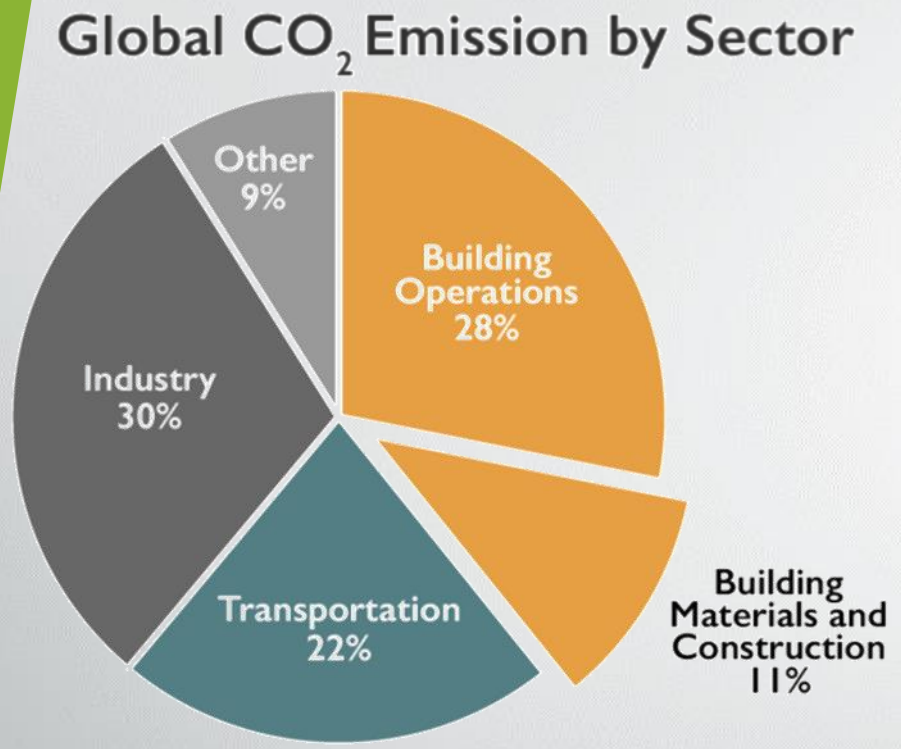
The Baha'i Temple, Wilmette, IL Circa 1930

Photo by Larry Rowland

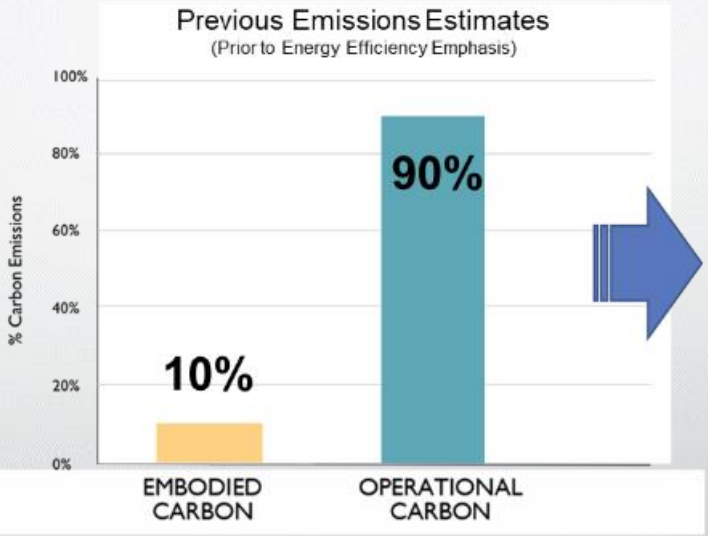
Life Cycle Assessments (LCA)

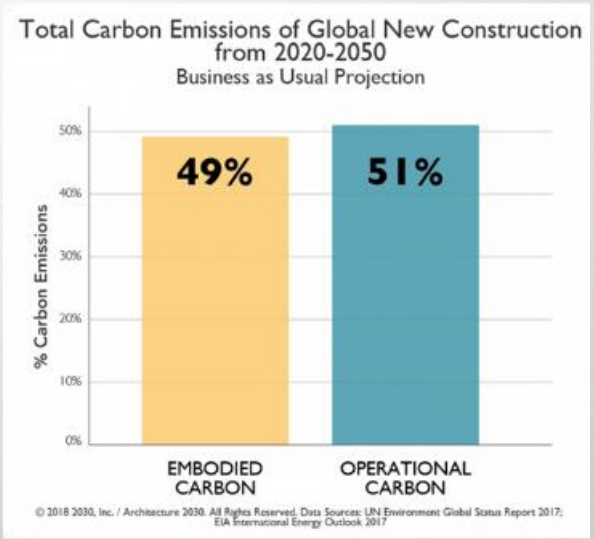
Production Stage			Construction Stage		Use Stage							End Of Life Stage			
Extraction And Upstream Production	Transport To Factory	Manufacturing	Transport To Factory	Installation	Use	Maitenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	Deconstruction / Demolition	Transport	Waste Processing	Disposal Of Waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
x	x	x	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

How it all fits together, then…



Source: © 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

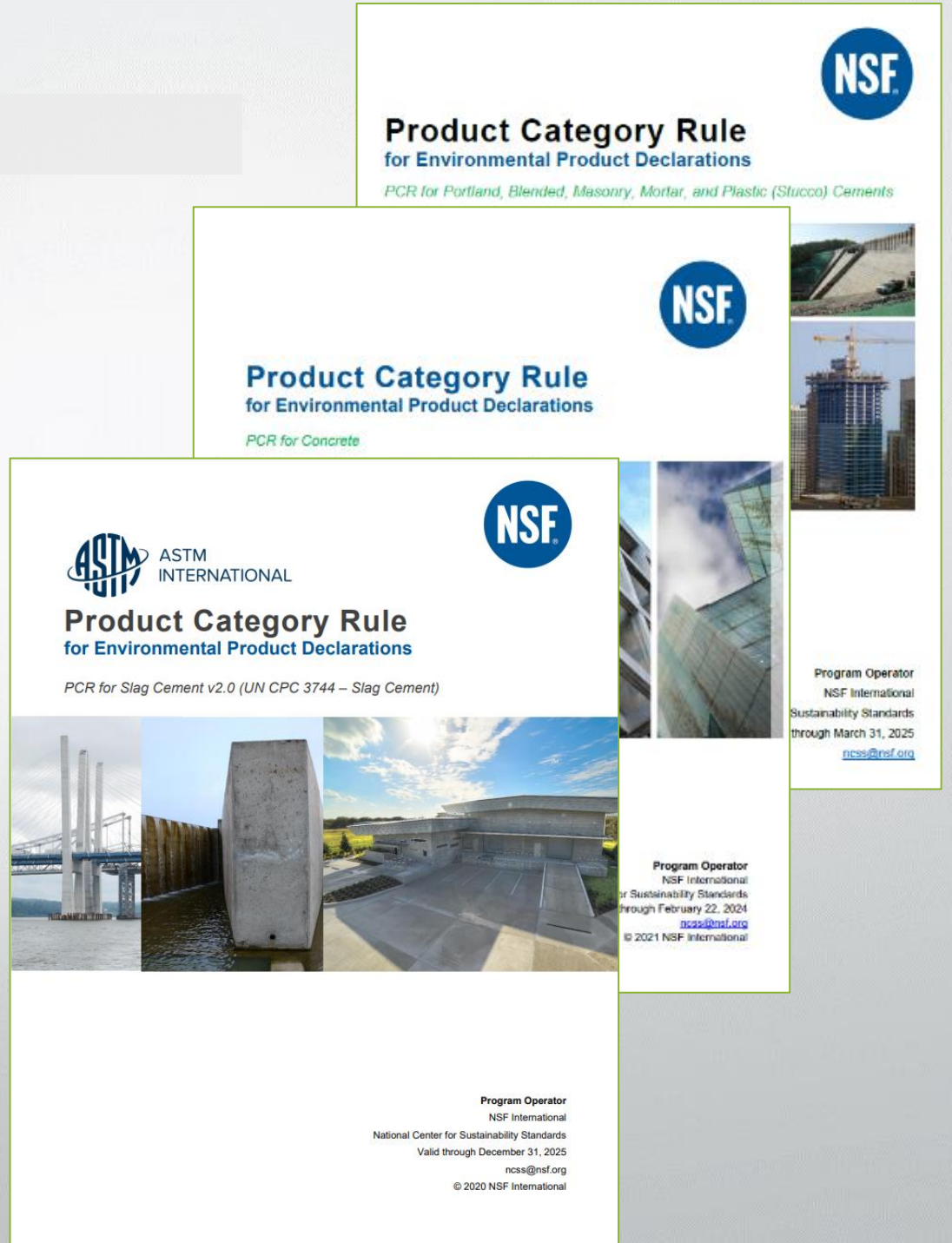




Embodied Emissions

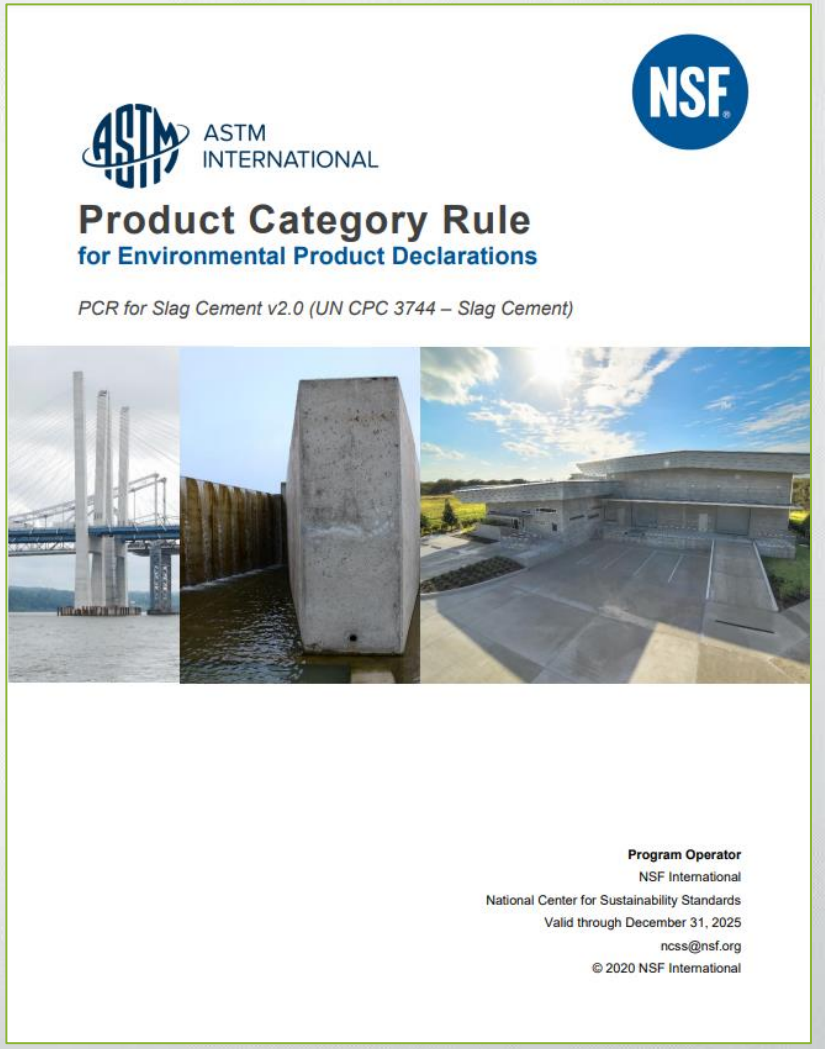
Product Category Rules (PCRs)

- Life Cycle Assessments help level the playing field and report estimated impacts
- Product Category Rules (PCRs) set the baseline requirements for reporting impacts
  - Set scope, and framework of how to do LCAs for EPDs
  - PCRs define what is measured and reported
  - They are product specific
  - Individual PCRs for…
    - Cement valid through March 2025
    - Concrete through Feb. 2024
    - Slag Cement through Dec. 2025



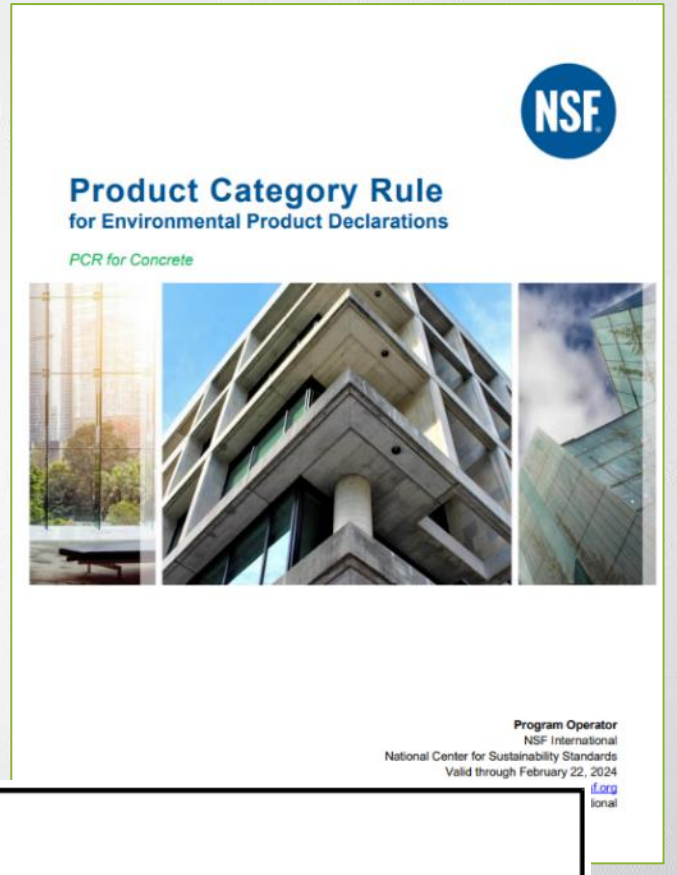
Product Category Rules (PCRs)

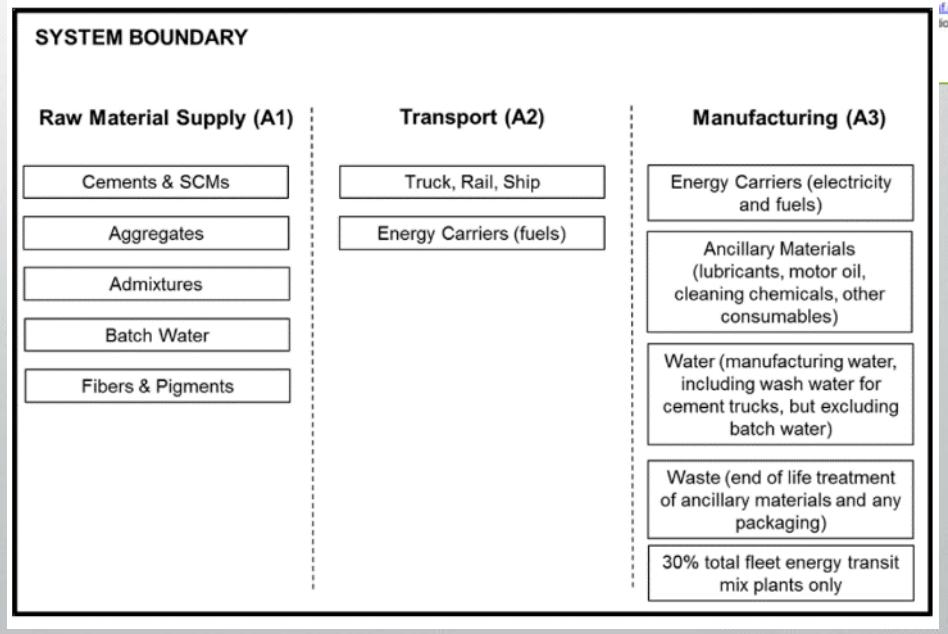
- **The PCR for Slag Cement**
- From cradle-to-gate for life cycle stage Modules A1-A3.
- For Slag produced to ASTM C 988, AASHTO M 302, CSA A3001
- Declared unit shall be one metric tonne (1,000 kg) of slag cement
- Blast-furnace slag shall be considered a recovered material
- Allows for Average EPDs
  - An industry-average EPD shall be comprised of at least three companies operating three different manufacturing locations
  - Only manufacturers who participated in the industry average may benchmark individual Type III EPDs against an industry average



Product Category Rules (PCRs)

- The "Concrete" PCR is for Ready Mixed Concrete
- NRMCA was the sponsor of this PCR
- Limited to Ready Mix so it is a subproduct category rule PCR
  - Metric units to be used m^3, but can include both US yd^3 and metric units
  - Gives optional System Boundary diagram
  - Allows for option to include LCA Construction Stages
    - A4 Transport to site
    - A5 for concrete placement activities



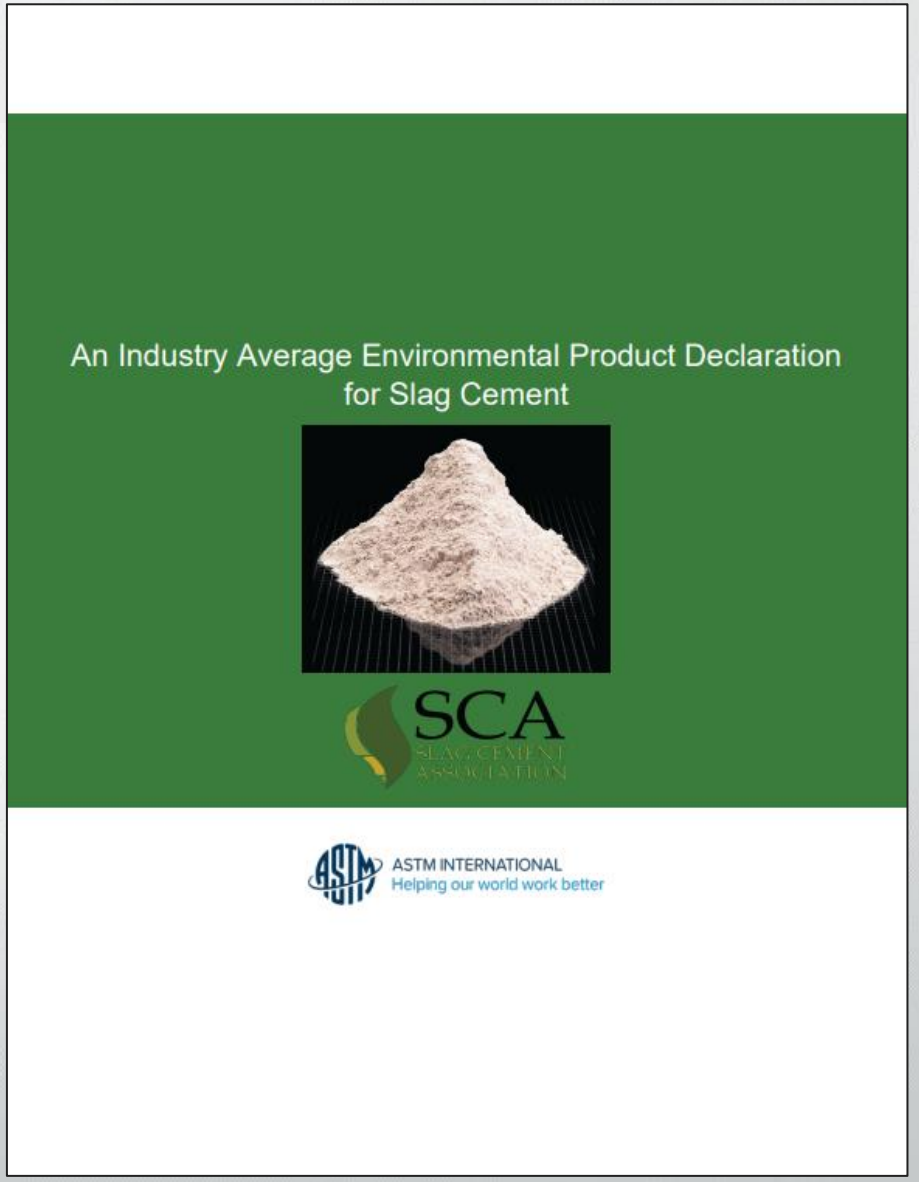


Environmental Product Declarations (EPDs)

What is an EPD?

"Environmental Product Declarations (EPDs) are comparable to a "nutrition label" for products which report a selection of environmental impacts."

- Provide a summary of LCA Results
- Give environmental information on products.
- EPDs are science and evidence-based tool
  - Provides visibility into Impact Categories set by PCR
  - Example: list GWP of Mton of slag cement or M^3 of concrete



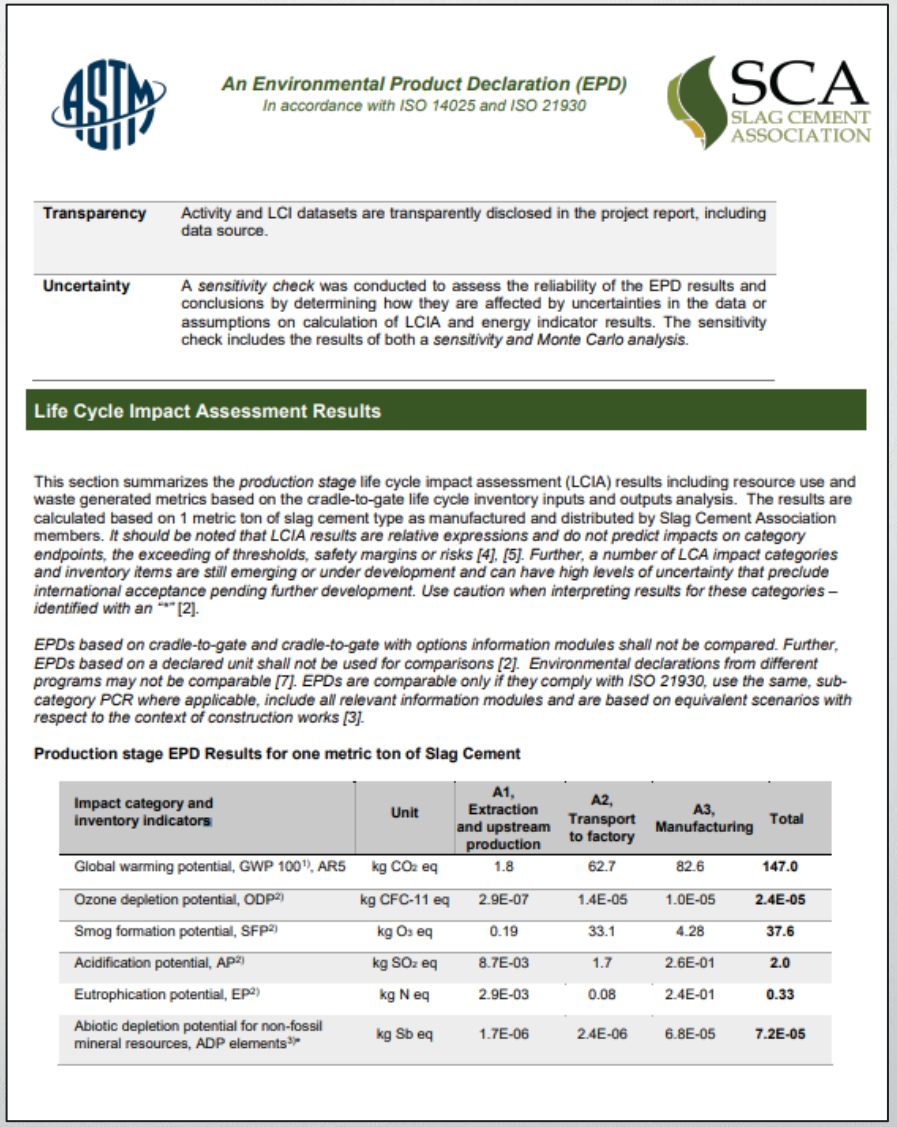
Environmental Product Declarations (EPDs)

Slag Cement Industry Average EPD

- Eight Slag Cement Association Members took part…
- 2-dozen Impact Categories recorded, i.e. Ozone depletion
- GWP Cradle to Gate total is **147 kg CO2** eq. per metric ton

PCA likewise has published an industry average EPD

- GWP Cradle to Gate total is **922 kg CO2** eq. per metric ton



An Environmental Product Declaration (EPD)
In accordance with ISO 14025 and ISO 21930

SCA SLAG CEMENT ASSOCIATION

Transparency	Activity and LCI datasets are transparently disclosed in the project report, including data source.
Uncertainty	A *sensitivity check* was conducted to assess the reliability of the EPD results and conclusions by determining how they are affected by uncertainties in the data or assumptions on calculation of LCIA and energy indicator results. The sensitivity check includes the results of both a *sensitivity and Monte Carlo analysis.*

Life Cycle Impact Assessment Results

This section summarizes the *production stage* life cycle impact assessment (LCIA) results including resource use and waste generated metrics based on the cradle-to-gate life cycle inventory inputs and outputs analysis. The results are calculated based on 1 metric ton of slag cement type as manufactured and distributed by Slag Cement Association members. *It should be noted that LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks [4], [5]. Further, a number of LCA impact categories and inventory items are still emerging or under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting results for these categories – identified with an "*" [2].*

EPDs based on cradle-to-gate and cradle-to-gate with options information modules shall not be compared. Further, EPDs based on a declared unit shall not be used for comparisons [2]. Environmental declarations from different programs may not be comparable [7]. EPDs are comparable only if they comply with ISO 21930, 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 [3].

Production stage EPD Results for one metric ton of Slag Cement

Impact category and inventory indicators	Unit	A1, Extraction and upstream production	A2, Transport to factory	A3, Manufacturing	Total
Global warming potential, GWP 100[1], AR5	kg CO_2 eq	1.8	62.7	82.6	**147.0**
Ozone depletion potential, ODP[2]	kg CFC-11 eq	2.9E-07	1.4E-05	1.0E-05	**2.4E-05**
Smog formation potential, SFP[2]	kg O_3 eq	0.19	33.1	4.28	**37.6**
Acidification potential, AP[2]	kg SO_2 eq	8.7E-03	1.7	2.6E-01	**2.0**
Eutrophication potential, EP[2]	kg N eq	2.9E-03	0.08	2.4E-01	**0.33**
Abiotic depletion potential for non-fossil mineral resources, ADP elements[3]*	kg Sb eq	1.7E-06	2.4E-06	6.8E-05	**7.2E-05**

ARGOS · ASH GROVE A CRH COMPANY · CEMEX · Heidelberg Materials · HOLCIM · OZINGA · SKYWAY SLAG CEMENT · st marys cement · VOTORANTIM cimentos

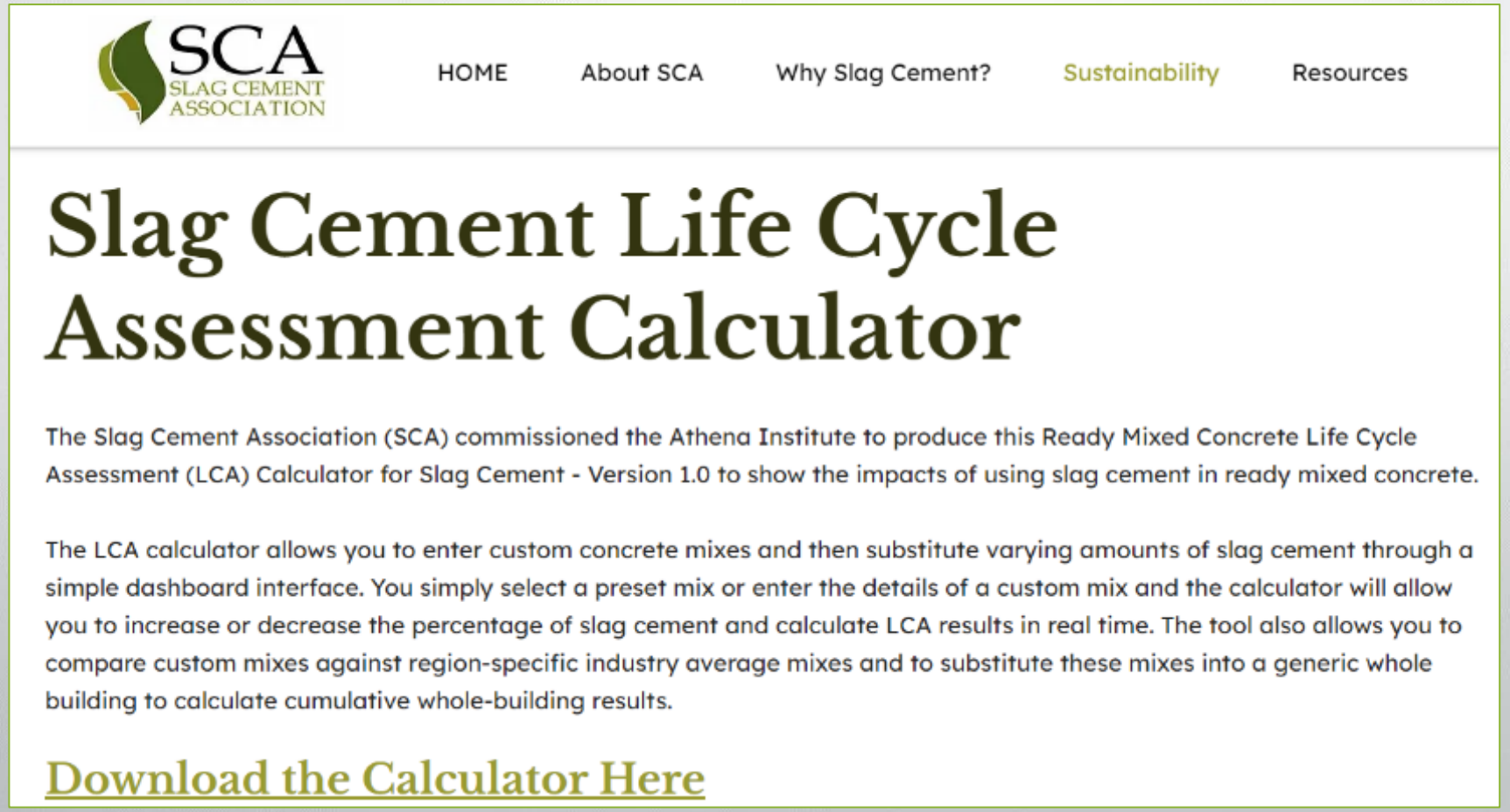
Current Industry EPD's for OPC, GUL and Slag cement

LCA Results - Type OPC/PLC/Slag one metric ton - absolute basis				
Category Indicator TRACI v.2.1 Category Indicators	Unit	Total		
		OPC	PLC	Slag
Global Warming Potential (GWP)	kg CO_2eq	922	846	147.0
Acidification Potential (AP)	kg N eq.	1.75	1.64	2.0
Eutrophication Potential (EP)	kg O_2 eq.	1.02	0.94	0.33
Smog Creation Potential (POCP)	kg O_3 eq.	32.9	30.2	37.6
Ozone Depletion Potential (ODP)	kg CFC -11 eq.	2.10E-05	2.17 E-05	2.4E-05

Carbon Accounting Tools – SCAs LCA Calculator

Counting GWP is a simple way to see the impacts are to compare like mixes

- The Slag Cement Association has an excellent, free LCA Calculator

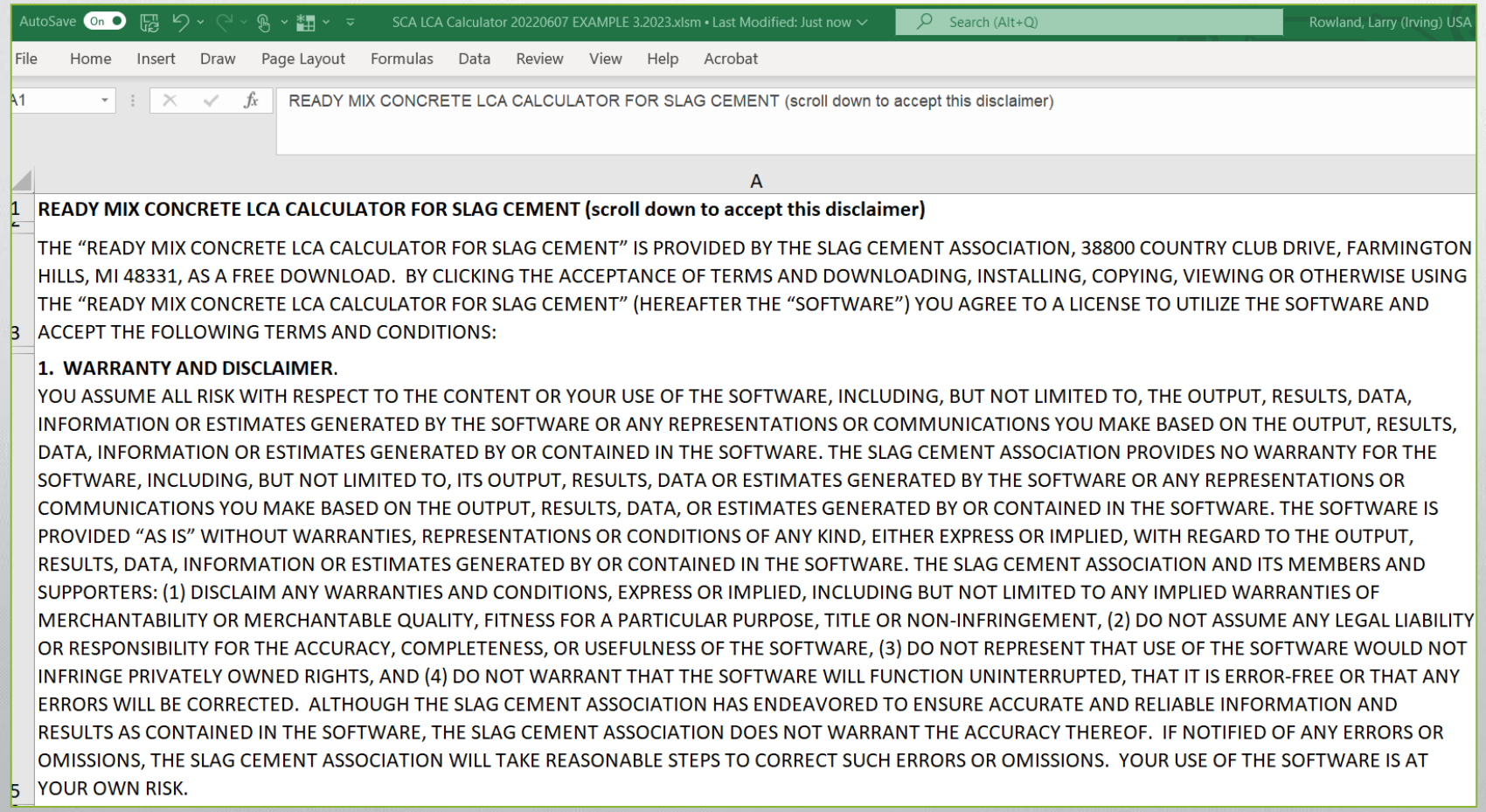


Carbon Accounting Tools – SCAs LCA Calculator

Tool is in the form of a downloadable Excel spreadsheet

- Starts out with a disclaimer and requirement to Accept the Terms of use

Accept and Continue



Carbon Accounting Tools – SCAs LCA Calculator

The calculator is separated into four worksheets:

1. **Slag Substitution:** This main dashboard tab allows you to select from a list of preset concrete mixes and to then alter the percentage of slag cement in that mix.
2. **Custom Mixes:** This tab allows you to enter up to 10 custom mixes that will then be available from the drop-down list on the "Slag Substitution" tab. The environmental impacts of these mixes are calculated.
3. **Comparison to Benchmark:** This tab is used in conjunction with the "Custom Mixes" tab. It shows environmental impacts of the entered "Custom Mixes" in absolute terms and as a percentage of region-specific industry average benchmarks.
4. **Impacts in Whole Building:** This tab allows you to enter amounts for each of the "Custom Mixes" used in a given project to calculate the cumulative whole-building impact. The calculator adds in non-concrete impacts (i.e. steel, glazing, insulation, etc.) in amounts proportional to the amount of concrete. … the results in this tab are not considered a whole-building LCA, but do give you a realistic look at how concrete selection effects whole building impacts.

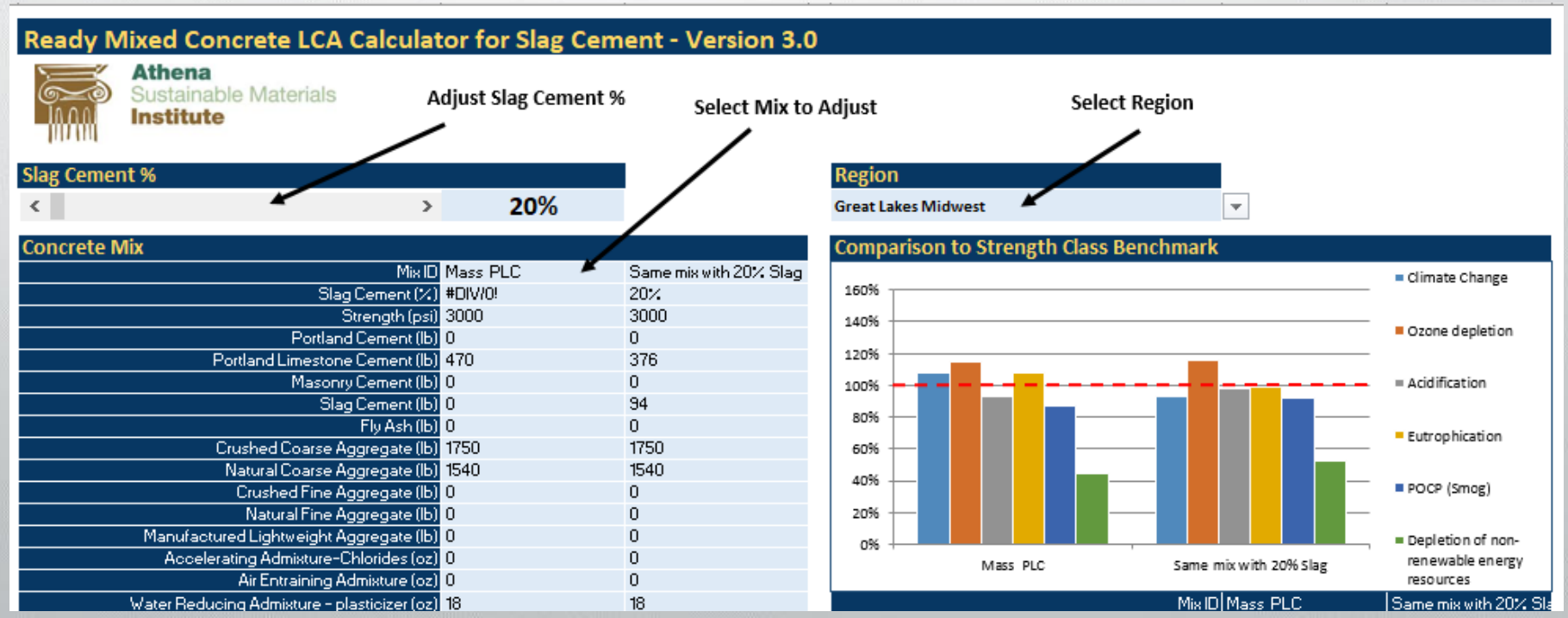
Carbon Accounting Tools – SCAs LCA Calculator

The calculator is separated into 4 worksheets:

Slag Substitution: This dashboard tab allows you to select from a list of preset concrete mixes and to then alter the percentage of slag cement in that mix. The user picks:

- What baseline mix to use (What Mix to Adjust)
- The % replacement
- Region i.e. Great Lakes Midwest

Example of 20% Replacement



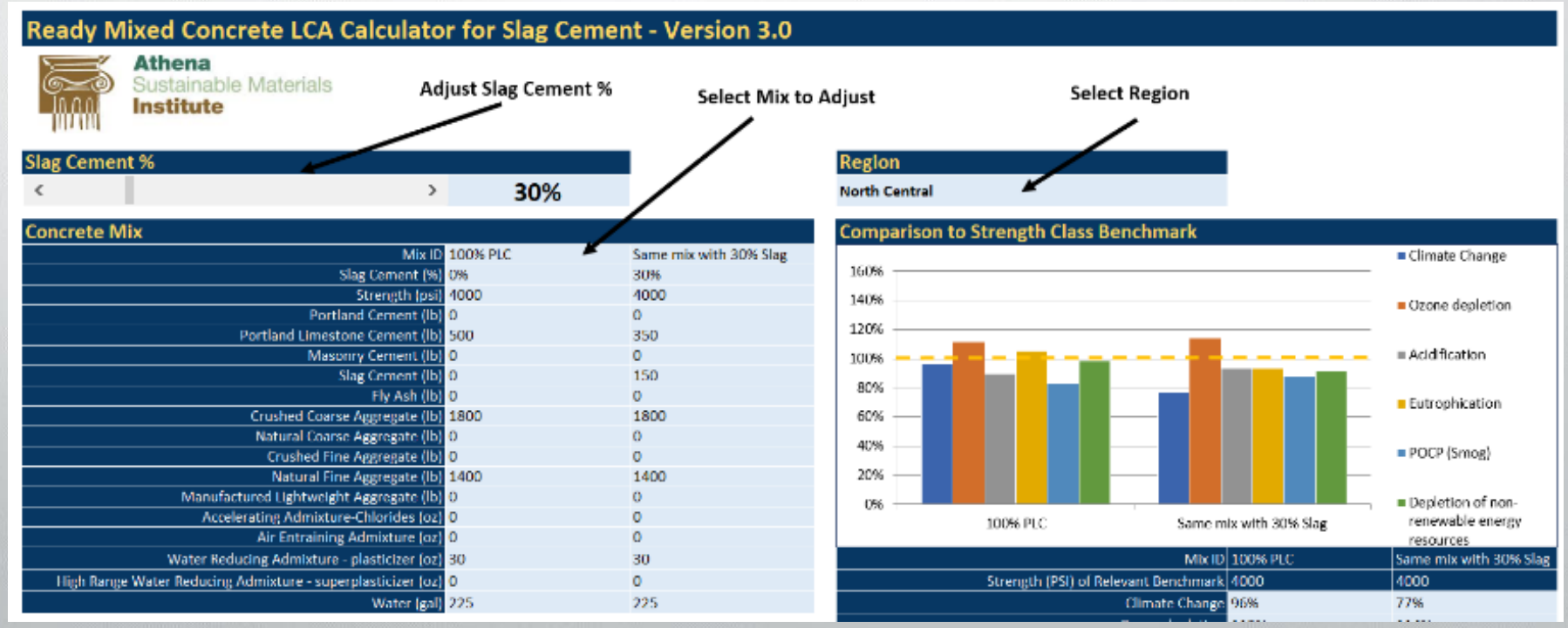
Carbon Accounting Tools – SCAs LCA Calculator

The calculator is separated into 4 worksheets:

Slag Substitution: This dashboard tab allows you to select from a list of preset concrete mixes and to then alter the percentage of slag cement in that mix. The user picks:

- What baseline mix to use (What Mix to Adjust)
- The % replacement
- Region i.e. North Central

Example of 30% Replacement



Carbon Accounting Tools – SCAs LCA Calculator

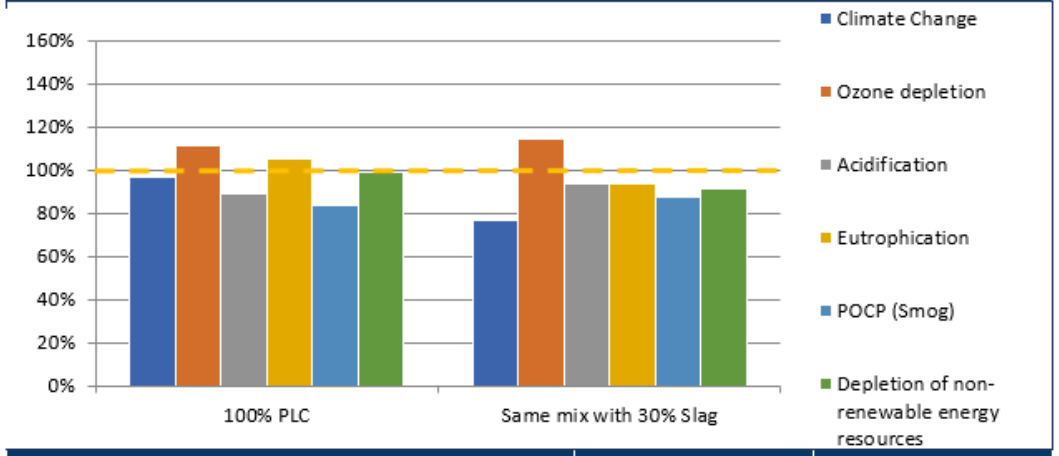
Using the "**Slag Substitution**" tab & 4,000 psi OPC mix at 30% & 40% substitution

Adjust

Select Region

Region
North Central

Comparison to Strength Class Benchmark



Mix ID	100% PLC	Same mix with 30% Slag
Strength (PSI) of Relevant Benchmark	4000	4000
Climate Change	96%	77%
Ozone depletion	112%	114%
Acidification	89%	94%
Eutrophication	106%	93%
POCP (Smog)	83%	88%
Depletion of non-renewable energy resources	99%	91%

Life Cycle Assessment Results

Mix ID	100% PLC	Same mix with 30% Slag
Climate Change (kg CO2-eq)	230.36	183.44

A 30% Slag Substitution in this mix yields:

- ~ 47 kg CO_2 eq. / yd^3 Savings
- ~ 20% reduction in GWP

Life Cycle Assessment Results

Mix ID	
Climate Change (kg CO2-eq)	
100% PLC	Same mix with 30% Slag
230.36	183.44

Carbon Accounting Tools – SCAs LCA Calculator

Using the "**Slag Substitution**" tab & 4,000 psi OPC mix at 30% & 40% substitution

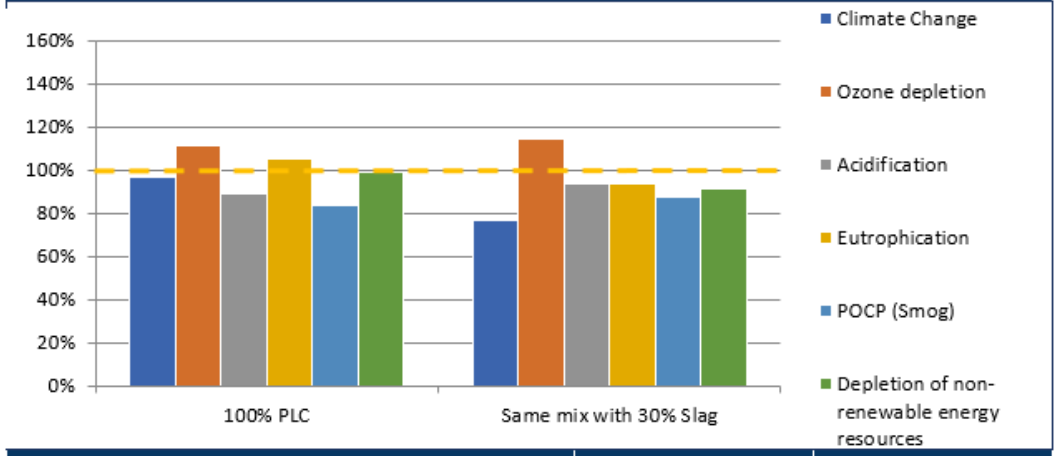
Adjust

Select Region

Region

North Central

Comparison to Strength Class Benchmark



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Life Cycle Assessment Results

Mix ID	100% PLC	Same mix with 30% Slag
Climate Change (kg CO2-eq)	230.36	183.44

A 30% Slag Substitution in this mix yields:

- ~ 47 kg CO_2 eq. / yd^3 Savings
- ~ 20% reduction in GWP

A 40% Slag Substitution in this mix yields:

- ~ 63 kg CO_2 eq. / yd^3 Savings
- ~ 27% reduction in GWP

Carbon Accounting Tools – SCAs LCA Calculator

The "**Custom Mixes**" tab allows comparison of up to 10 mixes at once

The user picks a strength class then manually enters the names and the specific quantities from their mixes. This example is for six 4,000 psi mixes for 50 % 30% slag

Ready Mixed Concrete LCA Calculator for Slag Cement - Version 3.0

Athena Sustainable Materials Institute

Enter Data for Custom Mixes on a per yd3 basis

Concrete Mix (per yd3)						
Mix ID	100% OPC	100% PLC	50% PLC / Slag	470# OPC	50/50 @ 470	30% Sag & PLC
Strength for Benchmarking (psi)	4000	4000	4000	4000	4000	4000
Portland Cement (lb)	500			470		
Portland Limestone Cement (lb)		500	250		235	330
Masonry Cement (lb)						
Slag Cement (lb)			250		235	140
Fly Ash (lb)						
Crushed Coarse Aggregate (lb)	1800	1800	1800	1800	1800	1800
Natural Coarse Aggregate (lb)						
Crushed Fine Aggregate (lb)						
Natural Fine Aggregate (lb)	1400	1400	1400	1450	1450	1450
Manufactured Lightweight Aggregate (lb)						
Accelerating Admixture-Chlorides (oz)						
Air Entraining Admixture (oz)	0					
Water Reducing Admixture - plasticizer (oz)	30	30	30	30	30	30
High Range Water Reducing Admixture - superplasticizer (oz)						
Water (gal)	225.00	225.00	225.00	220.00	220.00	220.00

Carbon Accounting Tools – SCAs LCA Calculator

The "**Custom Mixes**" tab allows comparison of up to 10 mixes at once

Steps to enter custom mixes to compare:

- Type in Mix id
- Pick mix strength class from dropdown
- Type in mix proportions
- Multiple mix classes can be entered in the custom mixes tab and mixes will be populated in the comparison to benchmark tab, impacts in whole building tab and a drop down selection in slag substitution tab.

Ready Mixed Concrete LCA Calculator for Slag Cement - Version 3.0

Athena Sustainable Materials Institute

Enter Data for Custom Mixes on a per yd3 basis

Concrete Mix (per yd3)						
Mix ID	100% OPC	100% PLC	50% PLC / Slag	470# OPC	50/50 @ 470	30% Sag & PLC
Strength for Benchmarking (psi)	4000	4000	4000	4000	4000	4000
Portland Cement (lb)	500			470		
Portland Limestone Cement (lb)		500	250		235	330
Masonry Cement (lb)						
Slag Cement (lb)			250		235	140
Fly Ash (lb)						
Crushed Coarse Aggregate (lb)	1800	1800	1800	1800	1800	1800
Natural Coarse Aggregate (lb)						
Crushed Fine Aggregate (lb)						
Natural Fine Aggregate (lb)	1400	1400	1400	1450	1450	1450
Manufactured Lightweight Aggregate (lb)						
Accelerating Admixture-Chlorides (oz)						
Air Entraining Admixture (oz)	0					
Water Reducing Admixture - plasticizer (oz)	30	30	30	30	30	30
High Range Water Reducing Admixture - superplasticizer (oz)						
Water (gal)	225.00	225.00	225.00	220.00	220.00	220.00

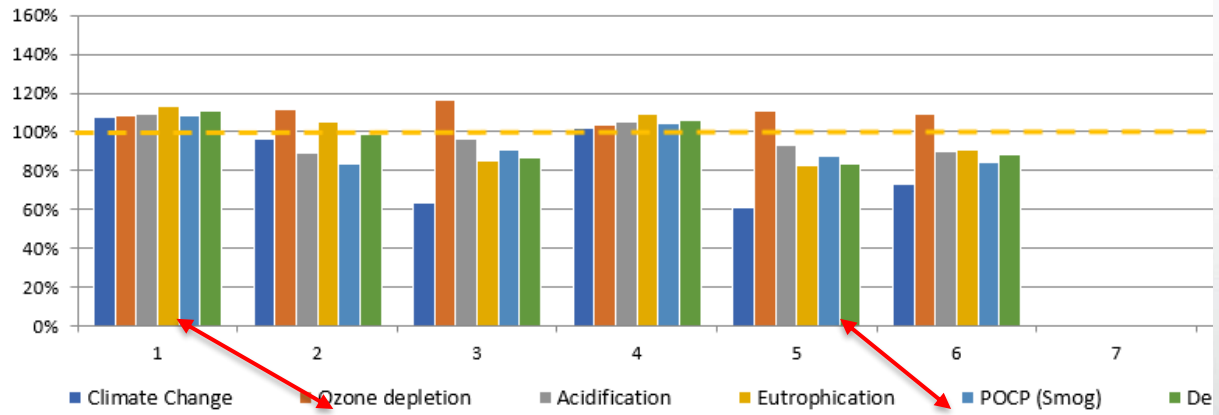
Carbon Accounting Tools – SCAs LCA Calculator

The **Custom Mixes** info populates the info into the "**Comparison Benchmark"** tab

Ready Mixed Concrete LCA Calculator for Slag Cement - Version 3.0

Athena Sustainable Materials Institute

Comparison of Entered Mixes to Strength Class Benchmarks



Mix in Graph	1	2	3	4	5	6
Mix ID	100% OPC	100% PLC	50% PLC / Slag	470# OPC	50/50 @ 470	30% Sag & PLC
Strength (PSI) of Relevant Benchmark	4000	4000	4000	4000	4000	4000
Climate Change	108%	96%	64%	102%	61%	73%
Ozone depletion	109%	112%	116%	104%	111%	109%
Acidification	109%	89%	97%	105%	93%	90%
Eutrophication	113%	106%	85%	109%	83%	91%
POCP (Smog)	108%	83%	91%	104%	87%	85%
Depletion of non-renewable energy resources	111%	99%	87%	106%	84%	88%

Life Cycle Assessment Results

Mix ID	100% OPC	100% PLC	50% PLC / Slag	470# OPC	50/50 @ 470	30% Sag & PLC
Climate Change (kg CO2-eq)	256.96	230.36	152.17	243.75	145.25	174.96

Results shown in the table and plotted graphically

- The GWP or (Climate Change) values are plotted in dark blue
- In this example the GWP values range from:
  - a high of **~257 kg CO2 eq**. / yd3
    for the 500# OPC mix, no slag, Mix 1

  to

  - a low of **~145 kg CO2 eq**. / yd3
    for the 470# PLC mix @ 50% slag, Mix 5

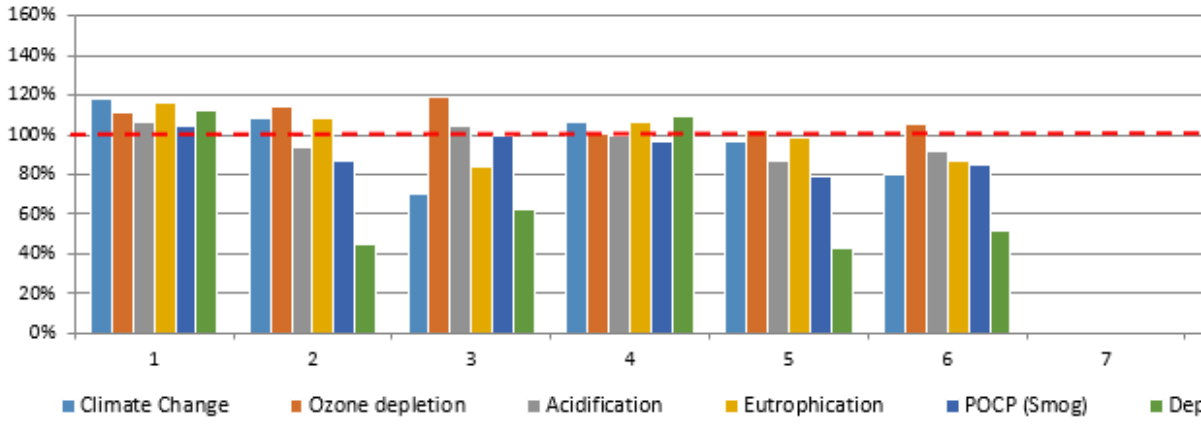
Using the SCA Calculator

The **Comparison to Benchmark** tab will show the environmental impacts compared to the NRMCA Industry EPD.

Ready Mixed Concrete LCA Calculator for Slag Cement - Version 3.0

Athena Sustainable Materials Institute

Comparison of Entered Mixes to Strength Class Benchmarks



Mix in Graph	1	2	3	4	5	6
Mix ID	Mass OPC	Mass PLC	Mass slag	Floor OPC	Floor PLC	Floor slag
Strength (PSI) of Relevant Benchmark	3000	3000	3000	5000	5000	5000
Climate Change	118%	108%	71%	106%	97%	80%
Ozone depletion	112%	114%	119%	100%	103%	105%
Acidification	106%	93%	104%	100%	87%	92%
Eutrophication	116%	108%	84%	106%	99%	87%
POCP (Smog)	105%	87%	100%	96%	79%	85%
Depletion of non-renewable energy resources	112%	45%	63%	110%	43%	51%

Life Cycle Assessment Results

Mix ID	Mass OPC	Mass PLC	Mass slag	Floor OPC	Floor PLC	Floor slag
Climate Change (kg CO2-eq)	230.37	210.33	137.63	295.05	269.00	221.67
Ozone depletion (kg CFC-11-eq)	6.21E-06	6.36E-06	6.60E-06	7.51E-06	7.70E-06	7.86E-06
Acidification (kg SO2-eq)	0.65	0.57	0.64	0.79	0.69	0.73
Eutrophication (kg N-eq)	0.30	0.28	0.22	0.37	0.35	0.31
Photochemical Ozone Creation/Smog (kg O3-eq)	12.71	10.57	12.11	15.18	12.40	13.40
Abiotic Depletion Potential ADPf (MJ)	373.25	319.85	333.96	514.94	445.52	454.71
Abiotic Depletion Potential ADPe (kg Sb eq.)	1.89E-04	1.88E-04	1.75E-04	3.37E-04	3.36E-04	3.28E-04
Use of renewable primary energy (MJ)	11.75	38.77	30.94	25.55	60.67	55.57
Use of non-renewable primary energy (MJ)	1,406.18	563.35	785.23	1,791.34	695.67	840.13
Fresh water consumption (m3)	0.42	0.41	0.33	0.51	0.91	0.83

Introduction | Slag Substitution | Custom Mixes | **Comparison to Benchmark** | Impacts in Wh

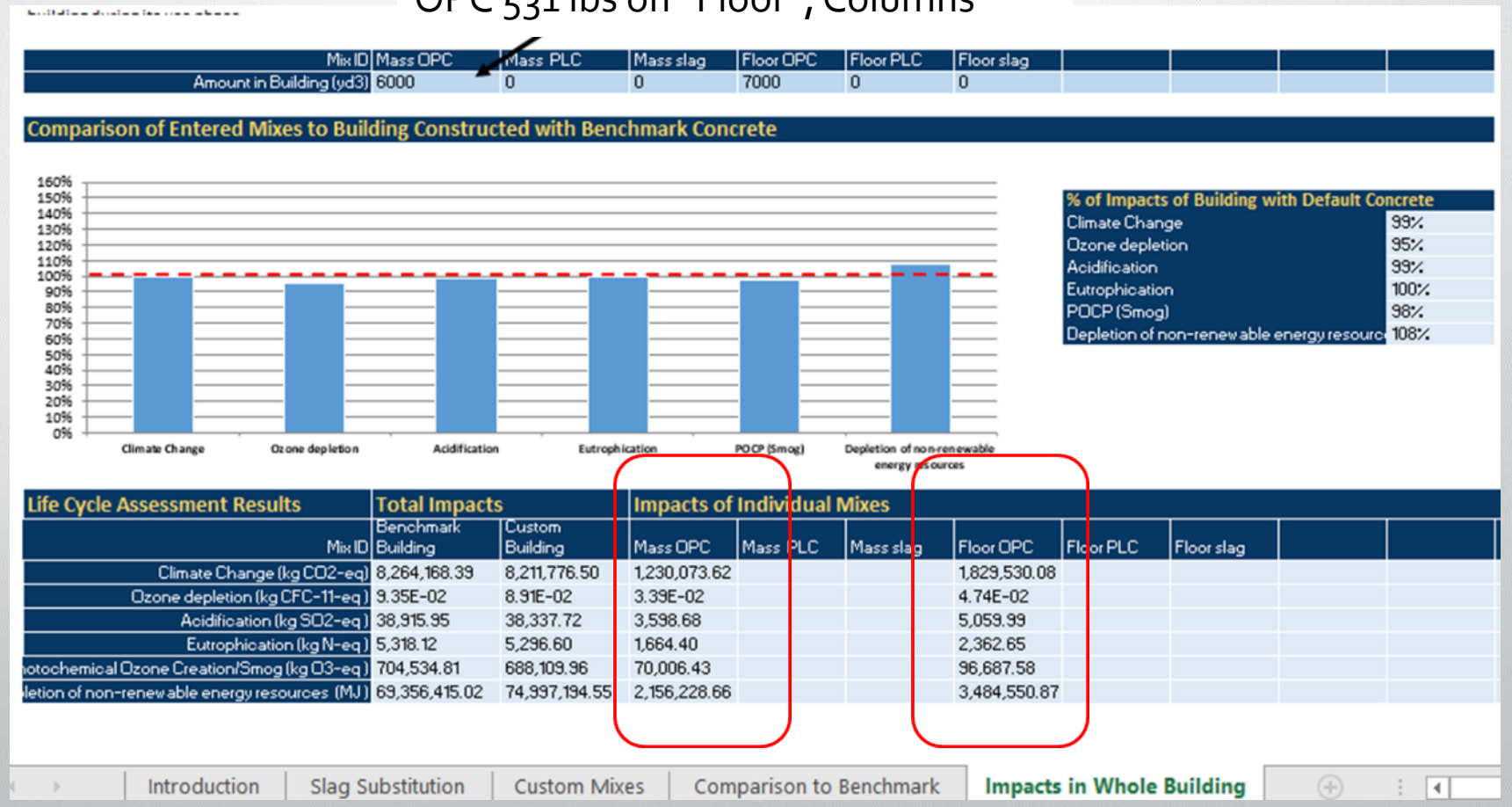
Example of benchmark concrete for whole building aspect

The **Impacts in Whole Building** is an easy tool for designers to apply when evaluating the impact of slag for their project compared to the NRMCA Industry EPD.

Using prescriptive values

OPC 410 lbs on "Mass OPC"

OPC 531 lbs on "Floor", Columns



Mix ID	Mass OPC	Mass PLC	Mass slag	Floor OPC	Floor PLC	Floor slag
Amount in Building (yd3)	6000	0	0	7000	0	0

Comparison of Entered Mixes to Building Constructed with Benchmark Concrete

% of Impacts of Building with Default Concrete	
Climate Change	99%
Ozone depletion	95%
Acidification	99%
Eutrophication	100%
POCP (Smog)	98%
Depletion of non-renewable energy resourc	108%

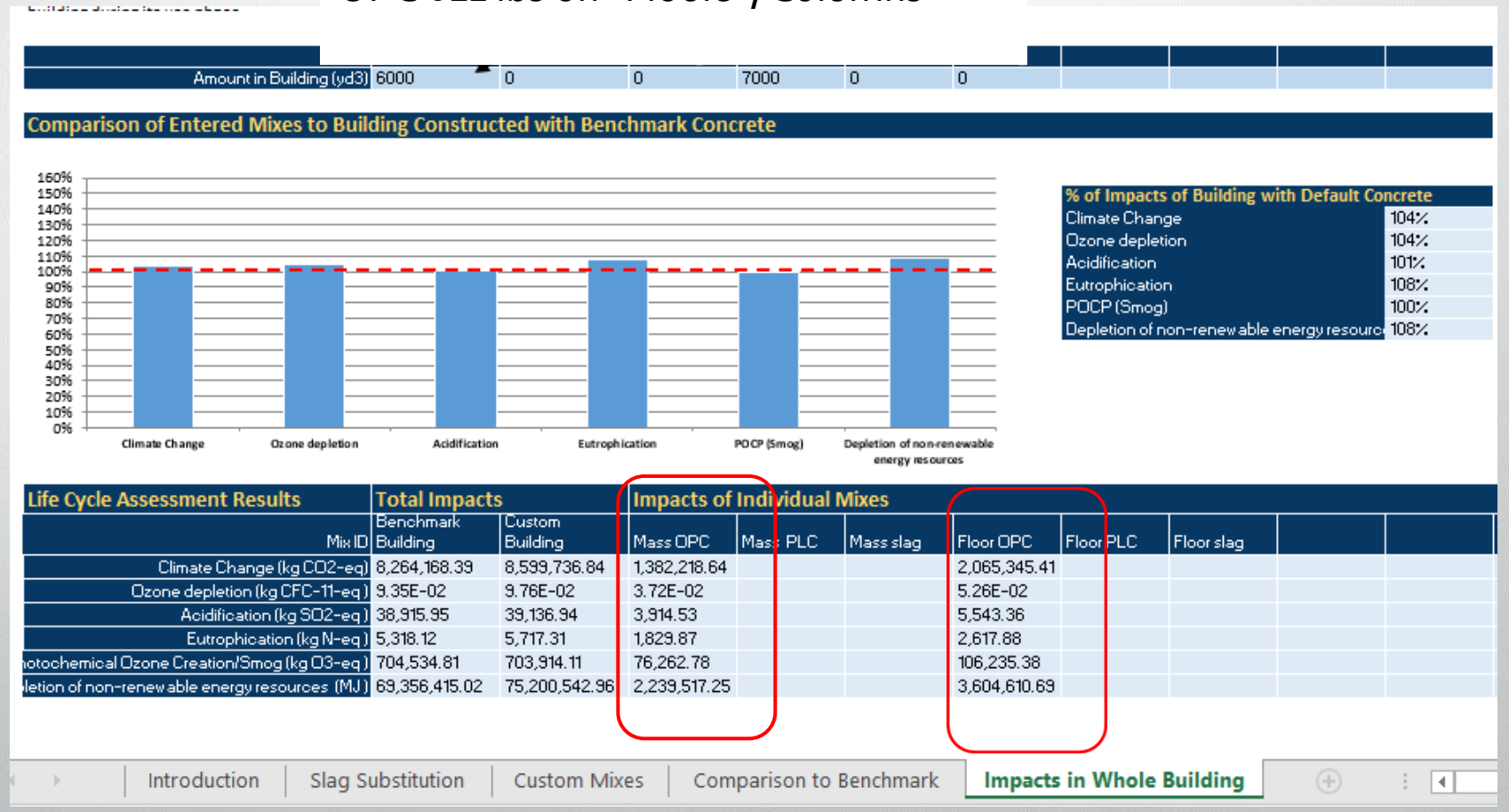
Life Cycle Assessment Results	Total Impacts		Impacts of Individual Mixes							
Mix ID	Benchmark Building	Custom Building	Mass OPC	Mass PLC	Mass slag	Floor OPC	Floor PLC	Floor slag		
Climate Change (kg CO2-eq)	8,264,168.39	8,211,776.50	1,230,073.62			1,829,530.08				
Ozone depletion (kg CFC-11-eq)	9.35E-02	8.91E-02	3.39E-02			4.74E-02				
Acidification (kg SO2-eq)	38,915.95	38,337.72	3,598.68			5,059.99				
Eutrophication (kg N-eq)	5,318.12	5,296.60	1,664.40			2,362.65				
otochemical Ozone Creation/Smog (kg O3-eq)	704,534.81	688,109.96	70,006.43			96,687.58				
letion of non-renewable energy resources (MJ)	69,356,415.02	74,997,194.55	2,156,228.66			3,484,550.87				

Introduction | Slag Substitution | Custom Mixes | Comparison to Benchmark | Impacts in Whole Building

Example of benchmark concrete for whole building aspect

Using original 100% OPC mix values
OPC 470 lbs on on "Mass OPC"
OPC 611 lbs on "Floors", Columns

The **Impacts in Whole Building** is an easy tool for designers to apply when evaluating the impact of slag for their project compared to the NRMCA Industry EPD.



Amount in Building (yd3)	6000	0	0	7000	0	0

Comparison of Entered Mixes to Building Constructed with Benchmark Concrete

% of Impacts of Building with Default Concrete	
Climate Change	104%
Ozone depletion	104%
Acidification	101%
Eutrophication	108%
POCP (Smog)	100%
Depletion of non-renewable energy resourc	108%

Life Cycle Assessment Results	Total Impacts		Impacts of Individual Mixes							
Mix ID	Benchmark Building	Custom Building	Mass OPC	Mass PLC	Mass slag	Floor OPC	Floor PLC	Floor slag		
Climate Change (kg CO2-eq)	8,264,168.39	8,599,736.84	1,382,218.64			2,065,345.41				
Ozone depletion (kg CFC-11-eq)	9.35E-02	9.76E-02	3.72E-02			5.26E-02				
Acidification (kg SO2-eq)	38,915.95	39,136.94	3,914.53			5,543.36				
Eutrophication (kg N-eq)	5,318.12	5,717.31	1,829.87			2,617.88				
otochemical Ozone Creation/Smog (kg O3-eq)	704,534.81	703,914.11	76,262.78			106,235.38				
letion of non-renewable energy resources (MJ)	69,356,415.02	75,200,542.96	2,239,517.25			3,604,610.69				

Introduction | Slag Substitution | Custom Mixes | Comparison to Benchmark | Impacts in Whole Building

Example of benchmark concrete for whole building aspect

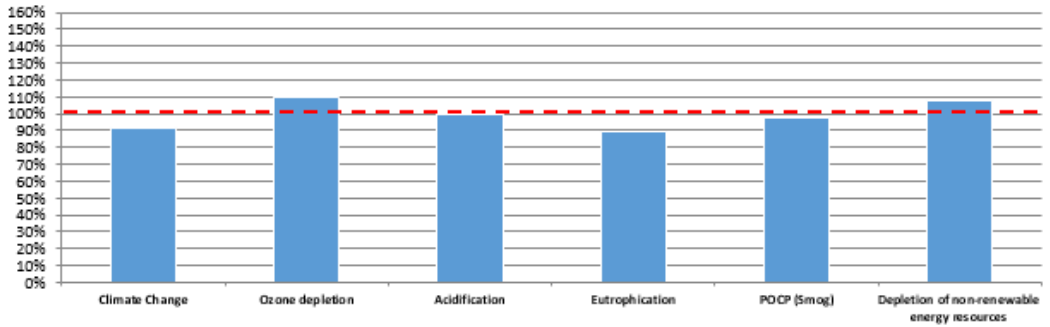
The **Impacts in Whole Building** is an easy tool for designers to apply when evaluating the impact of slag for their project compared to the NRMCA Industry EPD.

Using original PLC& Slag mix values

PLC 235 lbs/ slag 235 lbs on Mass Conc. (50% Slag for 470# mix)

PLC 458 lbs / slag 153 lbs on Floors, Columns (25% Slag for 611# mix)

Comparison of Entered Mixes to Building Constructed with Benchmark Concrete



% of Impacts of Building with Default Concrete	
Climate Change	91%
Ozone depletion	110%
Acidification	99%
Eutrophication	89%
POCP (Smog)	98%
Depletion of non-renewable energy resourc	107%

Life Cycle Assessment Results	Total Impacts		Impacts of Individual Mixes							
Mix ID	Benchmark Building	Custom Building	Mass OPC	Mass PLC	Mass slag	Floor OPC	Floor PLC	Floor slag		
Climate Change (kg CO2-eq)	8,264,168.39	7,529,645.22			825,793.49			1,551,678.94		
Ozone depletion (kg CFC-11-eq)	9.35E-02	1.02E-01			3.96E-02			5.50E-02		
Acidification (kg SO2-eq)	38,915.95	38,619.09			3,827.33			5,112.71		
Eutrophication (kg N-eq)	5,318.12	4,739.95			1,326.89			2,143.51		
otochemical Ozone Creation/Smog (kg O3-eq)	704,534.81	687,858.59			72,654.52			93,788.12		
letion of non-renewable energy resources (MJ)	69,356,415.02	74,543,085.20			2,003,732.70			3,182,937.47		

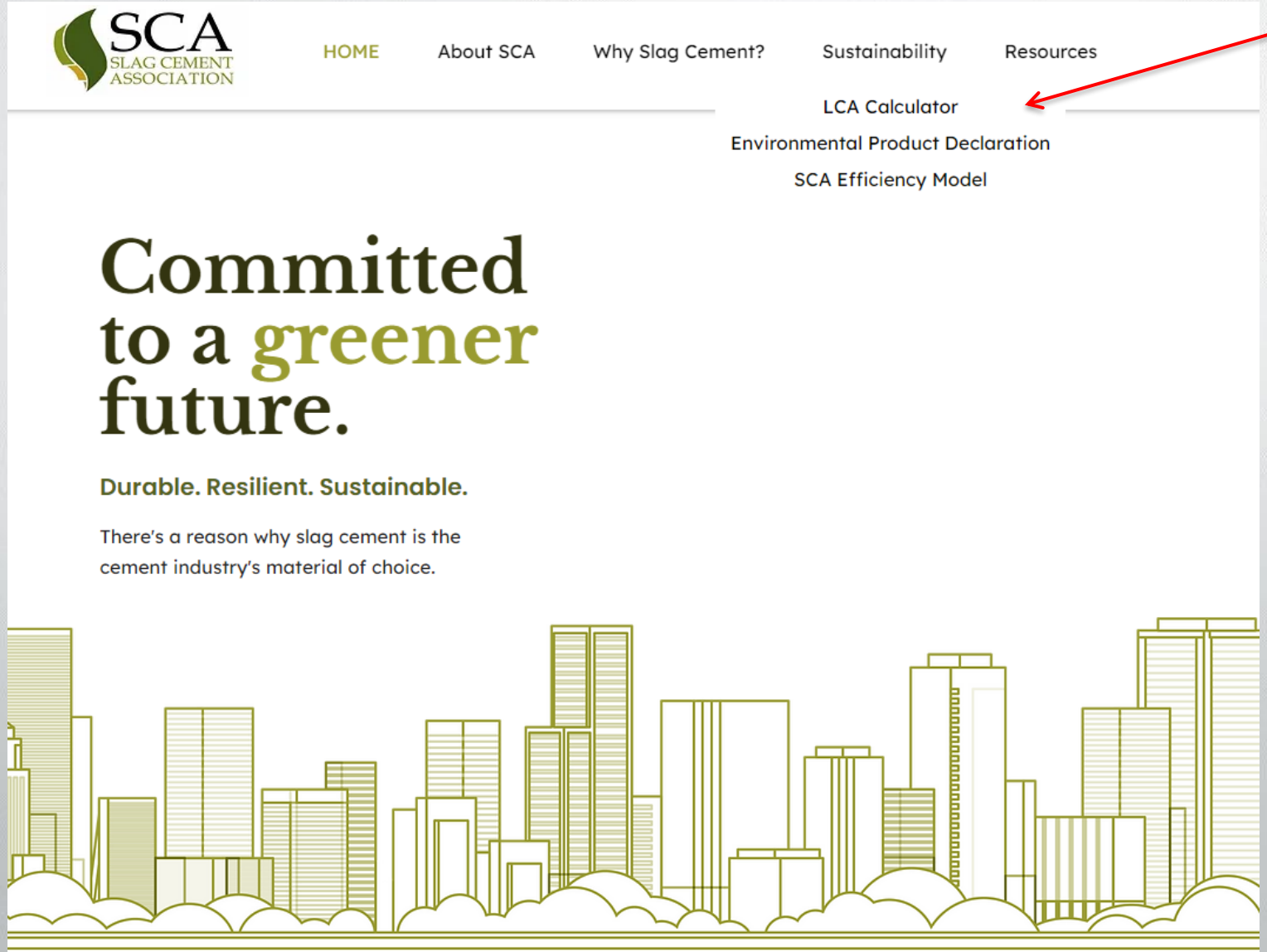
Introduction | Slag Substitution | Custom Mixes | Comparison to Benchmark | Impacts in Whole Building

Mass concrete 33% GWP reduction using PLC and Slag

Floor and Columns 15% GWP reduction

Carbon Accounting Tools – SCAs LCA Calculator

Accessing the Slag Cement Association free LCA Calculator is Easy and its a Quick Useful Tool



Key Messages / Takeaways

1. **Concrete is the Sustainable Building Material!**
   - Meets the criteria: Sustainable constituents, Low CO_2 & Energy, Resilient, Long Lasting
   - No viable alternative; true sustainability needs to account for full project life cycle

2. **We have the tools to improve, key levers include:**
   - Clinker reduction in our cements & SCMS to reduce Portland Cement in our mixes
   - Slag Cement is an exceptionally good SCM due to high replacement levels

3. **The SCA's LCA Calculator is Good Tool for Comparing Environmental Impacts**
   - Relies on EPDs for environmental impact accounting
   - Four tabs work together:
     - **Slag Substitution**: Sets Region for other tabs, quick comparison of standard mixes
     - **Custom Mixes**: Compares up to 10 custom mixes that will then be available from the drop-down list on the "Slag Substitution" tab.
     - **Comparison to Benchmark**: Shows impacts of "Custom Mixes"
     - **Impacts in Whole Building**: Uses Custom Mixes to compare impacts

SCA
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Questions?

…Thank You

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