Demonstrating Resilient Concrete Results with Slag Cement

Shawn Kalyn

October 26th, 2020

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 slag cement professional for 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.

Learning Objectives

- Key terms and definitions commonly used when discussing the carbon impact of concrete;
- How initiatives like the LEED point system, Architecture 2030, and the Carbon Leadership Forum are influencing the use of concrete materials;
- How to reduce the carbon impact of concrete using SCMs like slag cement; and
- How to use product specific information on slag cement including EPDs and LCA Calculator tools to show customers sustainable and durable options for concrete.

Shawn Kalyn

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Technical Services Engineer, St Marys Cement Inc.

Kalyn has been with the company for more than 15 years. He received his degree in civil engineering from Ryerson University in Toronto, ON, Canada. His responsibilities include providing concrete solutions to the cement customers and promotion of concrete and cementitious products. Kalyn is involved with the PCA Sustainability committee, SCA Great Lakes and Marketing Technical Committees , Global Cement and Concrete Association EPD tool and is involved in the MIT sustainability hub.

“

Resilient Concrete

”

Durable yet remindful of long-term global environmental impact changes

According to the Resilient Design Institute, it is “the intentional design of buildings, landscapes, communities, and regions in order to respond to natural and manmade disasters and disturbances—as well as long-term changes resulting from climate change….”

Disclaimer-

Short term Trade offs need to be balanced between time constructability and longer-term durability and sustainability goals

Summer

Winter

Understanding Carbon

- Key Terms
  - **Operational Carbon:** Carbon load created by the use of energy to heat and power a building – 28% of total emissions
  - **Embodied Carbon*:** The greenhouse gasses that are emitted to construct structures and buildings - 11% of total emissions
  - **Carbon**: term used to indicate all greenhouse gas emissions, not just CO2
  - **(EPD) Environmental Product Declaration:** document that quantifies environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function
  - **(PCR) Product Category Rules:** documents that provide rules, requirements, and guidelines for developing an product EPD
  - **(LCA) Life Cycle Assessment:** process to evaluate, assess, and improve the environmental burdens associated with a process, product, or activity by identifying and quantifying energy and materials used and wastes released to the environment.

*Some consider embodied carbon to include the entire life cycle of a building, including the operational carbon. As we are discussing building materials, we will focus on **initial embodied carbon, or the impacts associated with extracting, manufacturing, and transporting materials to a jobsite.**

Transparency in Green Building

ENERGY STAR

GREEN GLOBES

PHIUS
Passive House Institute US

U.S. GREEN BUILDING COUNCIL
LEED
USGBC

ASHRAE

INTERNATIONAL WELL BUILDING INSTITUTE
WELL

architecture 2030

NZEB

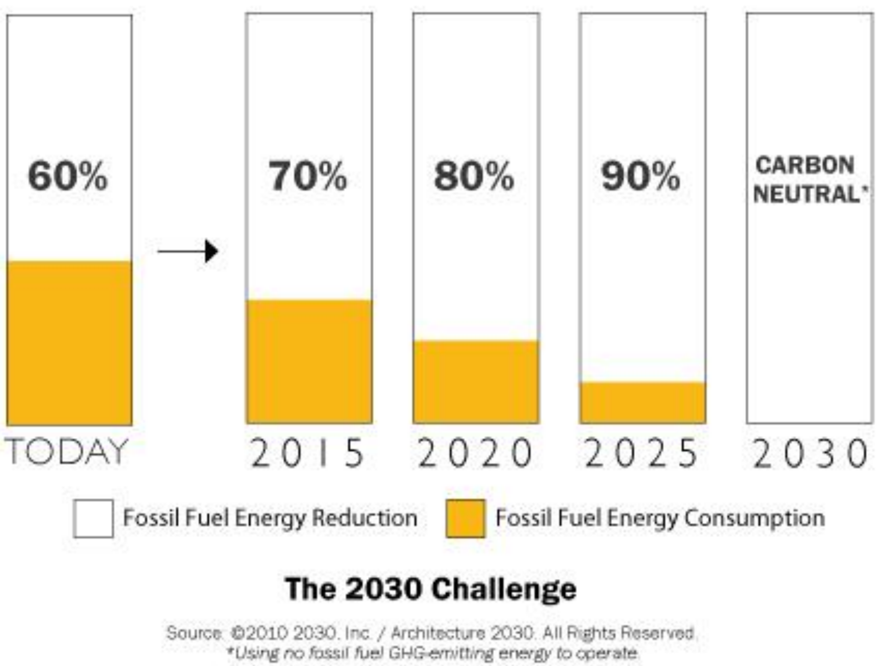
IgCC

LIVING BUILDING CHALLENGE

BREEAM

Environmental Initiatives - Architecture 2030

New bldgs., developments and major renovations designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 60% below average/median for that building type.



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New York City
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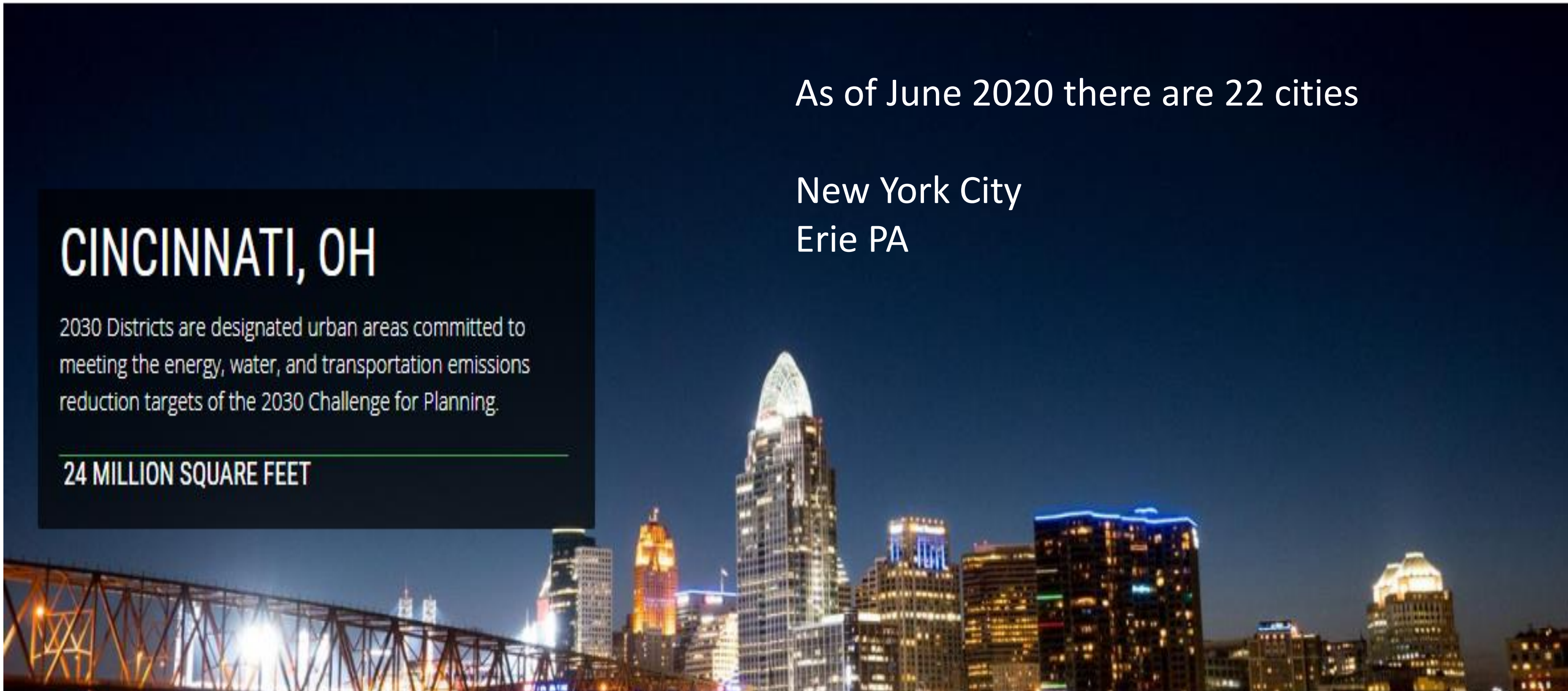


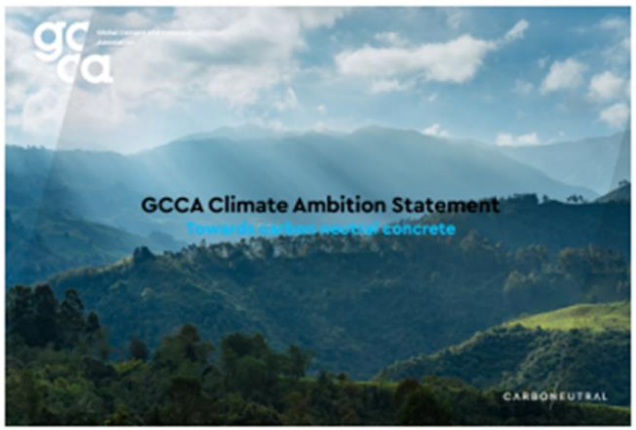
ALBUQUERQUE	ANN ARBOR	BURLINGTON	CINCINNATI	CLEVELAND	DALLAS
DENVER	DETROIT	GRAND RAPIDS	ITHACA	PHILADELPHIA	PITTSBURGH
PORTLAND	SAN ANTONIO	SAN DIEGO	SAN FRANCISCO	SEATTLE	STAMFORD
TORONTO	TUCSON				

City Vision 2030

- “We are making global progress in reducing operating emissions,” said Erin McDade, program manager at Architecture 2030. “According to the best scientific data and consensus, we have to phase out all fossil fuel emissions by 2050. … Without embodied carbon, we will not meet our climate targets.”
- Why are we here?
  - To reduce the environmental impact of the buildings and structures we create.

Sustainable Metrics

Climate Ambition



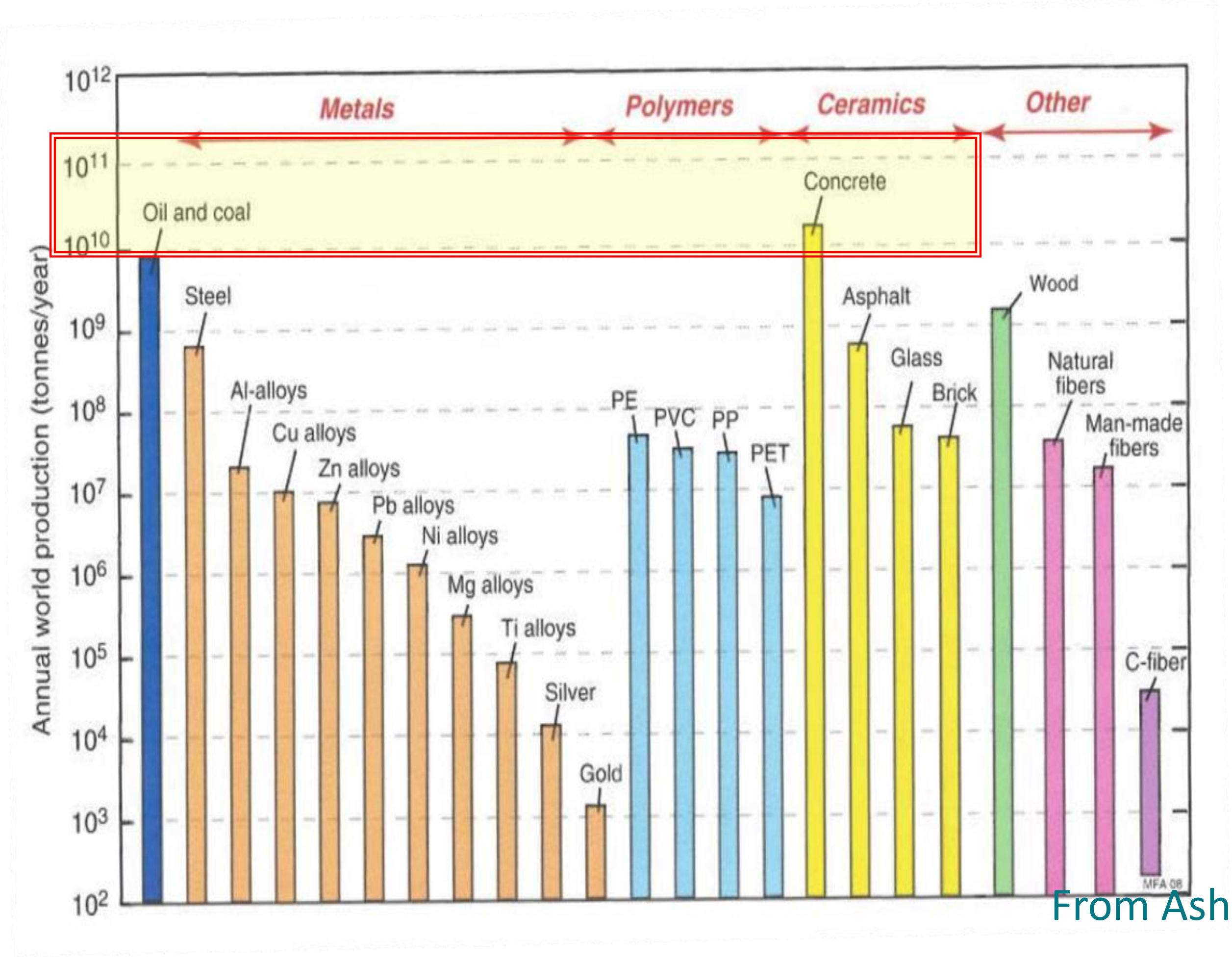
The GCCA launched its Climate Ambition Statement on the 1st September, announcing to the world our industry's plan to provide the world with carbon neutral concrete by 2050.

In consideration of setting requirements for low-carbon cement and concrete

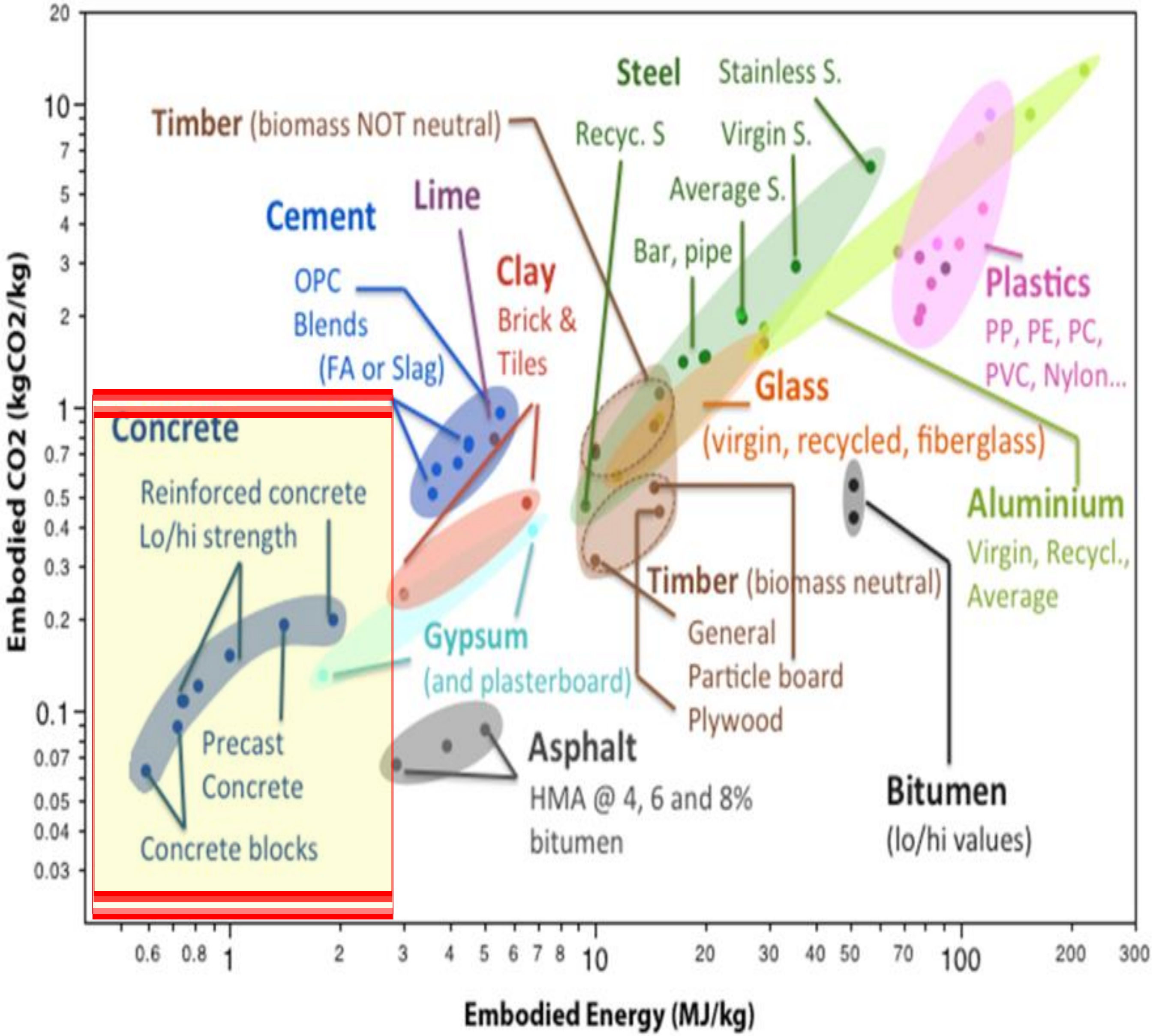
Recently, the Canada Green Building Council (CaGBC) shared with the Treasury Board of Canada Secretariat our industry perspective on the government's proposed requirements for low-carbon cement and concrete as detailed in their Request for Information EN578-200001.

Such a move would reduce environmental impacts by using life-cycle assessment (LCA) techniques to address embodied carbon in construction and renovation materials. Considering the potential impact of these changes, CaGBC felt it important to provide some overarching constructive feedback on behalf of Canada's green building industry.

Concrete is the most used material next to water



From Ashby 2009

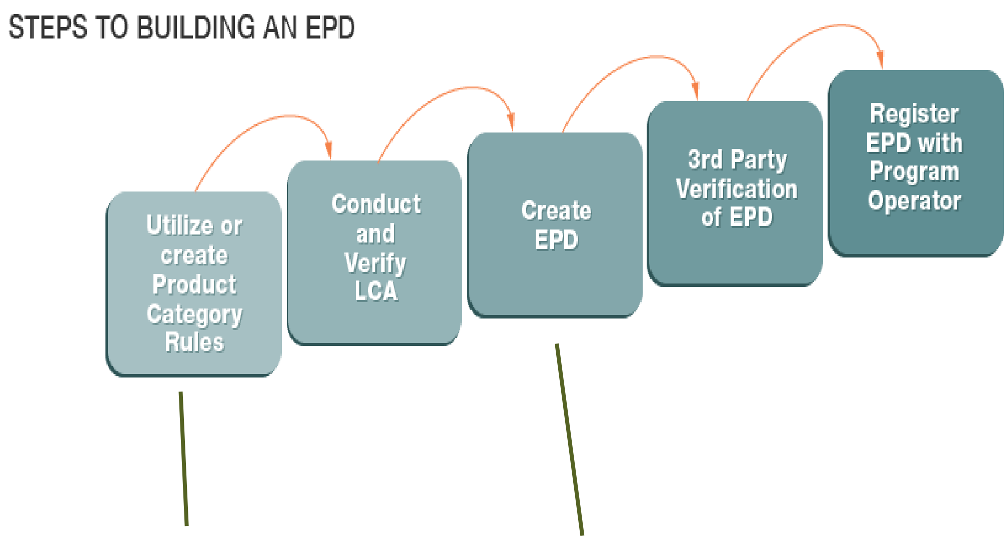


Embodied CO2 (kgCO2/kg)
Embodied Energy (MJ/kg)
Steel
Stainless S.
Recyc. S
Virgin S.
Average S.
Bar, pipe
Timber (biomass NOT neutral)
Cement
OPC
Blends
(FA or Slag)
Lime
Clay
Brick &
Tiles
Plastics
PP, PE, PC,
PVC, Nylon...
Glass
(virgin, recycled, fiberglass)
Aluminium
Virgin, Recycl.,
Average
Concrete
Reinforced concrete
Lo/hi strength
Precast
Concrete
Concrete blocks
Gypsum
(and plasterboard)
Timber (biomass neutral)
General
Particle board
Plywood
Asphalt
HMA @ 4, 6 and 8%
bitumen
Bitumen
(lo/hi values)

How do we accomplish this?

- Use Smart
  - Do the materials you use need to be new? Are there recycled or salvaged materials that can be used instead of creating new materials?
- Build Smart
  - Use materials, tools, and resources available to build the best product (outcome) that will also reduce the carbon impact. Life Cycle Assessment, and other modeling tools are available to compare the use of different materials
- Buy Smart
  - Use Environmental Product Declarations as the “nutrition label” of a products environmental impact.

What is an EPD?



PCR = Guideline

EPD = Communication
"Nutrition label"

EPD "Nutrition" Label

Your Building Product

Amount per Unit

LCA IMACT MEASURES	TOTAL
Primary Energy (MJ)	12.4
Global Warming Potential (kg CO^2 eq)	0.96
Ozone Depletion (kg CFC- 11 eq)	1.80E-08
Acidification Potential (mol H^+ eq)	0.93
Eutrophication Potential (kg N^- eq)	6.43E-04
Photo-Oxidant Creation Potential (kg 03 eq)	0.121

Your Product's Ingredients: Listed Here

Slag Cement LCA Results – 1 metric tonne

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Total
		A1	A2	A3	
Global warming potential	kg CO_2 eq.	4.6	57.0	85	146.6
Acidification potential	kg SO_2 eq.	0.2	1.2	0.7	2.1
Eutrophication potential	kg N eq.	0.01	0.05	0.21	0.27
Smog creation potential	kg O_3 eq.	0.4	20.2	5.8	26.5
Ozone depletion potential	kg CFC-11 eq.	4.21E-07	9.57E-06	6.9E-06	1.69E-05
Total primary energy consumption					
Non-renewable (fossil, nuclear)	MJ	88.9	848.4	1497.2	2,434.5
Renewable (solar, wind, biomass hydroelectric, & geothermal)	MJ	8.6	1.2	66.1	75.9
Material resources consumption					
Non-renewable materials	kg	11.0	0	0.1	11.1
Renewable materials	kg	0.5	0.1	1.9	2.5
Recovered materials	kg	1102.0	0	0	1102.0
Fresh water	l	26.1	0	5.4	31.6
Waste generated					
Non-hazardous	kg	0	0	0.3	0.3
Hazardous	kg	0	0	0.02	0.02

How does slag cement fit into the picture?

- **How does slag cement reduce the carbon footprint of concrete?**
- **What other durable benefits does slag cement contribute to concrete?**
- **How do I use LCA tools to convey these benefits?**
- **How can I use slag cement to get LEED credit?**

2016 PCA Industry EPD

for Portland cement

Metric	Cradle-to-gate total per metric tonne of production	Unit
Environmental impact		
Global warming potential (100 years)	1040	kg CO2-eq.
Acidification potential	2.45	kg SO2-eq.
Eutrophication potential	1.22	kg N-eq.
Formation potential of tropospheric ozone	48.8	kg O3-eq
Ozone depletion potential	2.61E-05	kg CFC 11-eq.

EPD Summary Results - One metric ton of slag cement

Category Indicator	Unit	Raw Material Supply	Transport	Manufacturing	Total
		A1	A2	A3	
Global warming potential	kg CO_2 eq.	4.6	57.0	85	146.6
Acidification potential	kg SO_2 eq.	0.2	1.2	0.7	2.1
Eutrophication potential	kg N eq.	0.01	0.05	0.21	0.27
Smog creation potential	kg O_3 eq.	0.4	20.2	5.8	26.5
Ozone depletion potential	kg CFC-11 eq.	4.21E-07	9.57E-06	6.9E-06	1.69E-05

2016 CAC Industry EPD

for general use and gul (IL) cement

Table 3: LCA Results –Type GU one metric ton – absolute basis

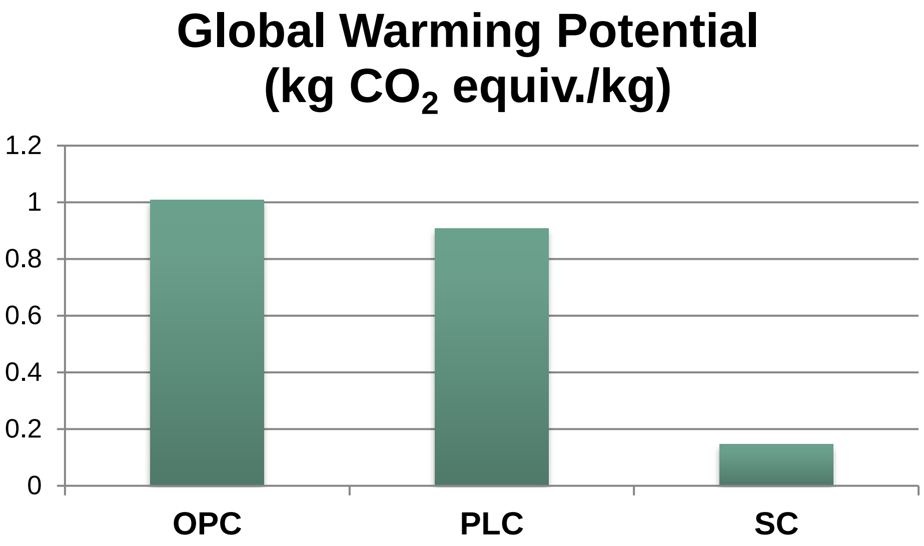
Category Indicator	Unit	Total	A1 Raw Material Supply	A2 Transport	A3 Manufacturing
TRACI v.2.1 Category Indicators					
Global warming potential, GWP	kg CO_2 eq.	940.5	17.9	9.0	913.6
Acidification potential, AP	kg SO_2 eq.	3.7	0.16	0.1	3.5
Eutrophication potential, EP	kg N eq.	0.4	0.06	0.004	0.3
Smog creation potential, POCP	kg O_3 eq.	62.9	2.6	2.2	58.1
Ozone depletion potential, ODP	kg CFC-11 eq.	9.8E-06	1.9E-06	1.8E-08	7.8E-06

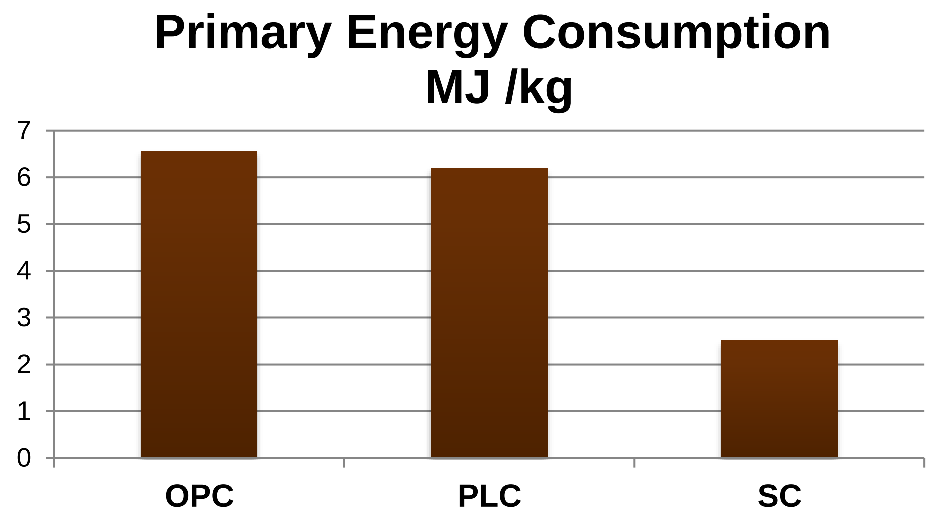
Table 4: LCA Results – Type GUL one metric ton – absolute basis

Category Indicator	Unit	Total	A1 Raw Material Supply	A2 Transport	A3 Manufacturing
TRACI v.2.1 Category Indicators					
Global warming potential, GWP	kg CO_2 eq.	855.6	17.4	8.3	829.9
Acidification potential, AP	kg SO_2 eq.	3.4	0.15	0.1	3.2
Eutrophication potential, EP	kg N eq.	0.38	0.05	0.004	0.3
Smog creation potential, POCP	kg O_3 eq.	57.4	2.5	2.1	52.8
Ozone depletion potential, ODP	kg CFC-11 eq.	9.0E-06	1.9E-06	1.6E-08	7.2E-06

LCA Results

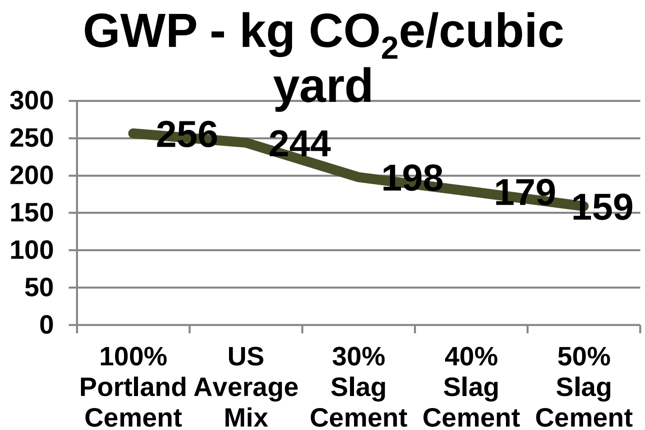
Slag Cement relative to Ordinary Portland Cement & Portland Limestone Cement ….





OPC – 92% clinker, 3% limestone, 5% gypsum
PLC – 82% clinker, 13% limestone, 5% gypsum

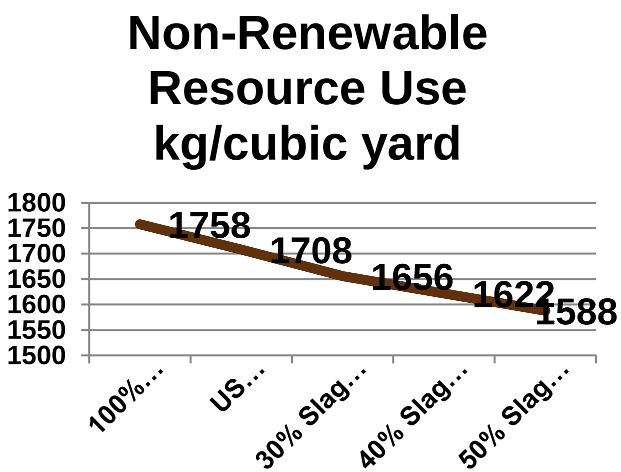
LCA Results for Concrete

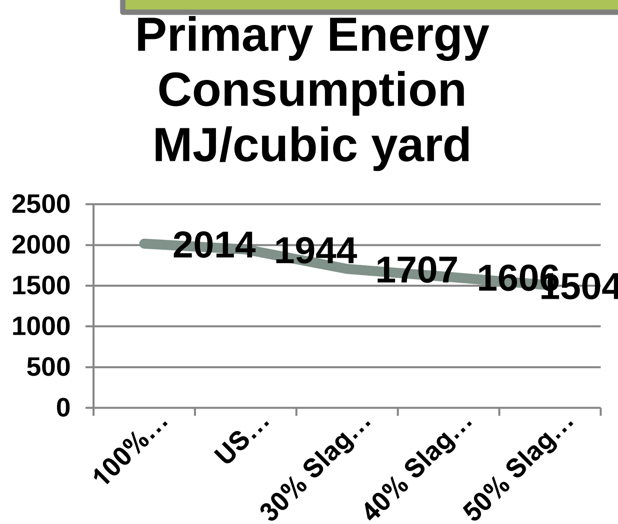


3,000 psi Mix Design

Possible savings...

- 100 kg CO_2
- 200 kg of resources
- 500 MJ of energy



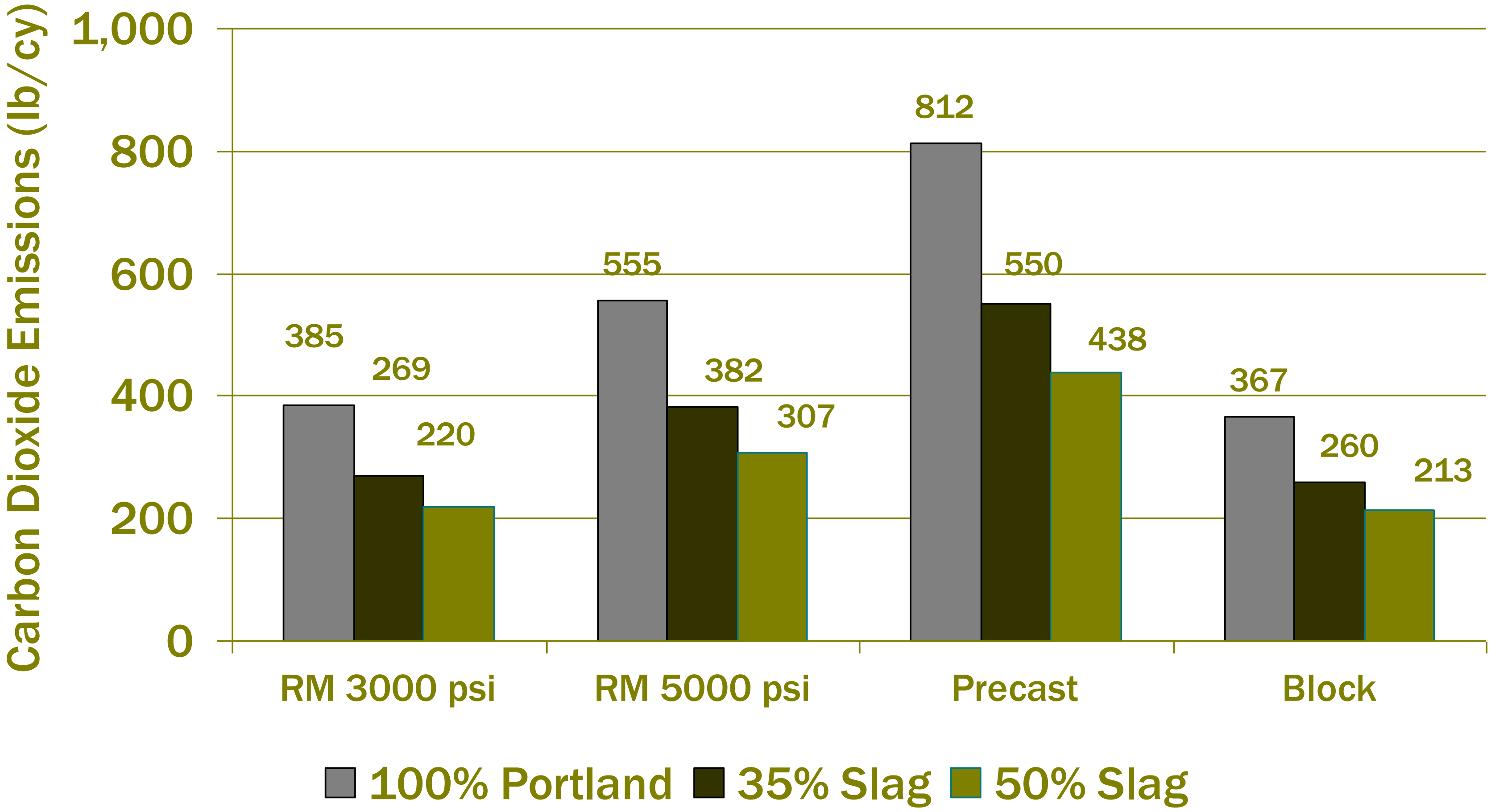


Concrete Environmental Life Cycle Study (CTL)

Ingredient	Ready Mix (3,000 psi)	Ready Mix (5,000 psi)	Precast (7,500 psi)	Block
Cementitious	376 lb/cy	564 lb/cy	850 lb/cy	337 lb/cy
Water	237 lb/cy	237 lb/cy	300 lb/cy	237 lb/cy
Coarse Aggregate	1,900 lb/cy	2,000 lb/cy	1,770 lb/cy	1900 lb/cy
Fine Aggregate	1,400 lb/cy	1,200 lb/cy	935 lb/cy	1400 lb/cy

Source: PCA SR2137: Environmental Life Cycle Inventory of Portland Cement Concrete

Reduced CO_2 to Produce Concrete and Concrete Products



The concrete reality Ohio DOT example

Life Cycle Assessment Results							
Mix ID	QC-1 25%slg	QC-1 30%slg	QC - 25 slg25as	Class C	Class C opt 1	Class C opt 2	Class C opt 3
Climate Change (kg CO2-eq)	260.71	248.28	189.15	321.88	278.88	298.47	229.87
Ozone depletion (kg CFC-11-eq)	7.23E-06	7.10E-06	5.45E-06	7.83E-06	6.76E-06	7.26E-06	6.57E-06
Acidification (kg SO2-eq)	0.97	0.96	0.79	1.00	0.89	0.94	0.90
Eutrophication (kg N-eq)	0.31	0.30	0.23	0.38	0.33	0.35	0.28
Photochemical Ozone Creation/Smog (kg O3-eq)	19.15	18.81	15.73	20.76	18.69	19.64	17.70

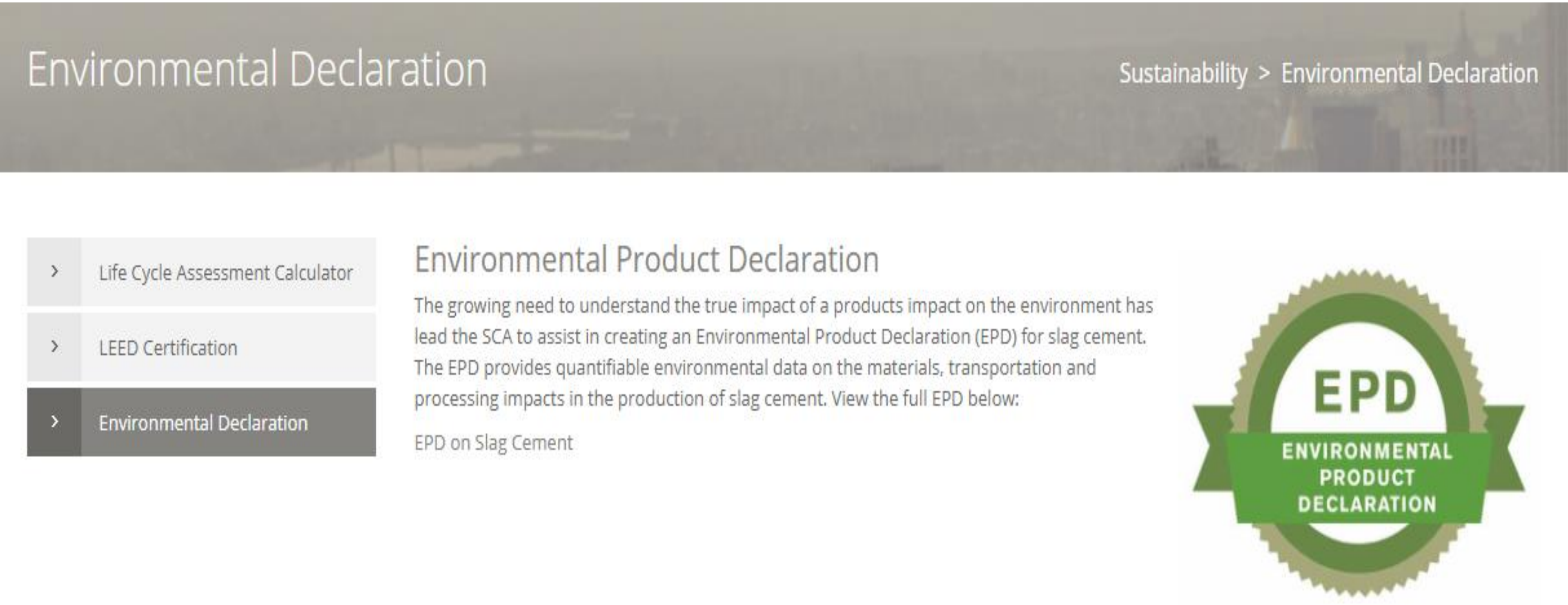
- Class C concrete with 600lb of Portland cement
  - Has 321 CO2kg/yd^3 15% higher than NRMCA U.S. GL benchmark
- Benchmark 4000 psi with 617 lbs cementitious (511/18slg/88ash)
  - Has 281 CO2kg/ yd^3
- ODOT QC1 with 450lbs Portland cement and 150lbs slag cement
  - Has 260 CO2kg/yd^3 7% less than NRMCA U.S. GL benchmark and 19% less then class c

Example of low carbon concrete using slag cement

- Scenario ready mix producer and concrete flatwork construction company need to find ways to lower the global warming potential on a retail shell and core box store in Avon Ohio.
- Project consist of the following concrete items
  - Footings 3000 psi
    - Max Portland allowed 456 lbs or gwp 313 $kgCO_2e/m^3$
  - Interior slab on grade 4000 psi
    - Max Portland allowed 503 lbs or gwp 338 $kgCO_2e/m^3$

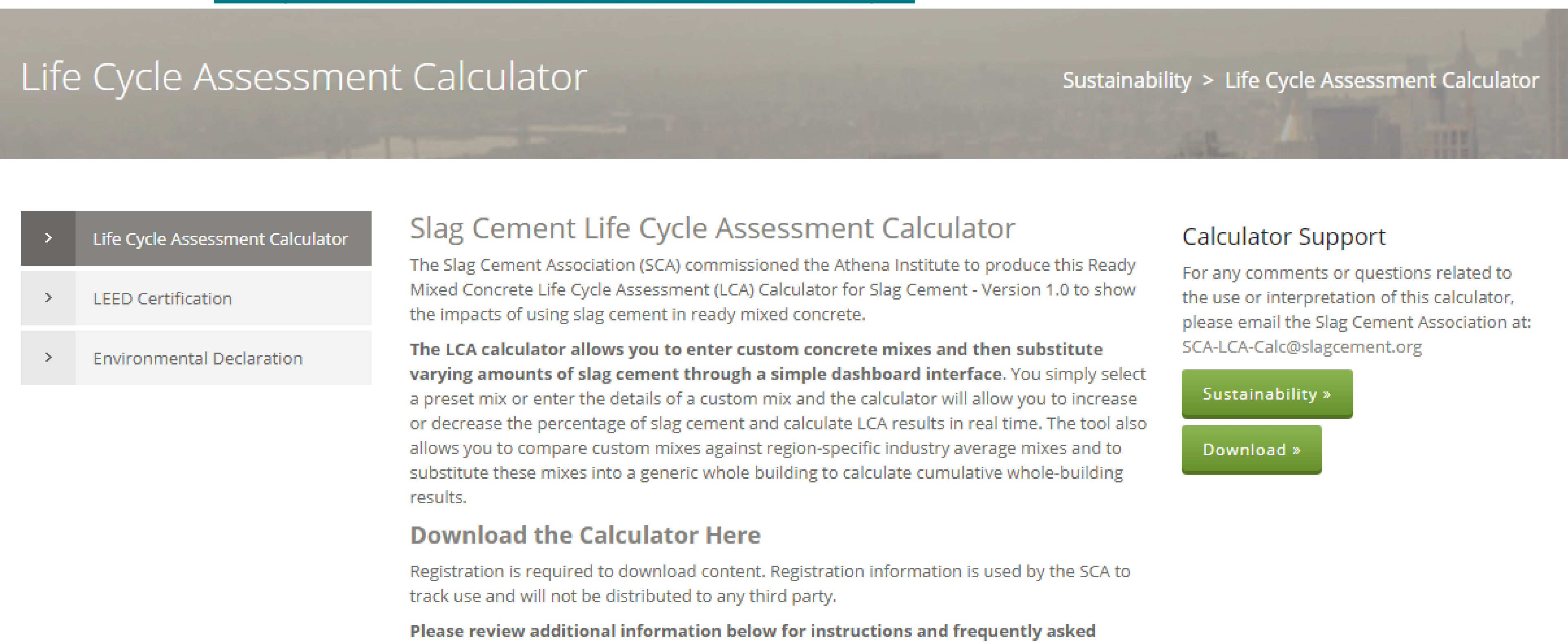
SCA LCA resources

- SCA industry EPD
  - https://www.slagcement.org/portals/11/Files/PDF/Sus-197.EPD.pdf



SCA LCA resources

- SCA Athena Life Cycle Assessment Calculator for Ready mixed concrete
  - https://www.slagcement.org/sustainability/lifecycleassessmentcalculator.aspx



Life Cycle Assessment Calculator

Sustainability > Life Cycle Assessment Calculator

- Life Cycle Assessment Calculator
- LEED Certification
- Environmental Declaration

Slag Cement Life Cycle Assessment Calculator

The Slag Cement Association (SCA) commissioned the Athena Institute to produce this Ready Mixed Concrete Life Cycle Assessment (LCA) Calculator for Slag Cement - Version 1.0 to show the impacts of using slag cement in ready mixed concrete.

The LCA calculator allows you to enter custom concrete mixes and then substitute varying amounts of slag cement through a simple dashboard interface. You simply select a preset mix or enter the details of a custom mix and the calculator will allow you to increase or decrease the percentage of slag cement and calculate LCA results in real time. The tool also allows you to compare custom mixes against region-specific industry average mixes and to substitute these mixes into a generic whole building to calculate cumulative whole-building results.

Download the Calculator Here

Registration is required to download content. Registration information is used by the SCA to track use and will not be distributed to any third party.

Please review additional information below for instructions and frequently asked

Calculator Support

For any comments or questions related to the use or interpretation of this calculator, please email the Slag Cement Association at: SCA-LCA-Calc@slagcement.org

Sustainability »

Download »

Owner’s low carbon requirements

	Cement limits for use with prescriptive compliance methods 19.07.050.1 and 19.07.050.2	**GWP limits** for use with performance compliance methods 19.07.050.3 and 19.07.050.4
Minimum specified compressive strength f'_c, psi (5)	Maximum ordinary Portland cement content , lbs/yd^3 (1, 2, 4)	Maximum Global Warming Potential, GWP, kg CO_2e/m^3
up to 2500 (3,4)	362	260
2501 to 3000	410	289
3001 to 4000	456	313
4001 to 5000	503	338
5001 to 6000	531	356
6001 to 7000	594	394
7001 and higher	657	433
up to 3000 light weight	512	578
3001--4000 light weight	571	626
4001--5000 light weight	629	675

Using the SCA Calculator Inputs

- On the customer mix tab enter custom mixes you would like to use.
- Type in Mix id
- Pick mix strength class
- 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 1.1

Athena
Sustainable Materials
Institute

Enter Data for Custom Mixes on a per yd3 basis

Concrete Mix (per yd3)

Mix ID	Footer max Port	Footer 25%slag	Footer 40% slag	SOG max port	SOG 25%slag	
Strength for Benchmarking (psi)	3000	3000	3000	4000	4000	
Portland Cement (lb)	456	350	282	503	405	
Slag Cement (lb)	0	120	188		135	
Fly Ash (lb)						
Crushed Coarse Aggregate (lb)	1710	1710	1710	1695	1695	
Natural Coarse Aggregate (lb)						
Crushed Fine Aggregate (lb)						
Natural Fine Aggregate (lb)	1589	1560	1547	1527	1433	
Manufactured Lightweight Aggregate (lb)						
Accelerating Admixture-Chlorides (oz)						
Air Entraining Admixture (oz)	9.4	9.4	9.4	0	0	
Water Reducing Admixture - plasticizer (oz)						
High Range Water Reducing Admixture - superplasticizer (oz)						
Water (gal)	27.60	28.50	28.50	29.40	32.00	

Additional Mix Options

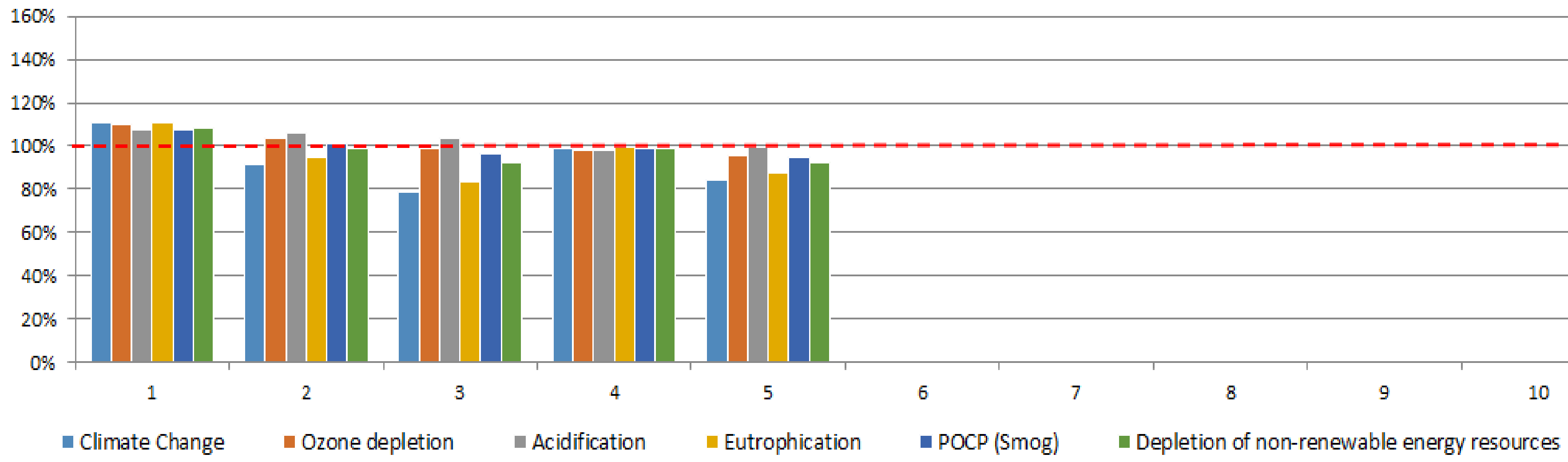
Blended Cement (lb)						

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

Using the SCA Calculator Review

- The comparison to benchmark tab will show the environmental impacts compared to the NRMCA Industry EPD.
- On the Slag substitution tab select NRMCA region (column f, row 5). This will show the regional values for your area in this case the project is in Ohio.
  - Caution please note that NRMCA now is on version 3 so this tool should be used to compare mixes and v3 results may be higher or lower.

Comparison of Entered Mixes to Strength Class Benchmarks



Mix in Graph	1	2	3	4	5	6	7	8	9
Mix ID	Footer max Port	Footer 25%slag	Footer 40% slag	SOG max port	SOG 25%slag				
Strength (PSI) of Relevant Benchmark	3000	3000	3000	4000	4000				
Climate Change	110%	91%	79%	99%	85%				
Ozone depletion	110%	104%	99%	98%	96%				
Acidification	108%	106%	104%	98%	99%				
Eutrophication	111%	94%	83%	99%	88%				
POCP (Smog)	108%	101%	97%	99%	95%				
Depletion of non-renewable energy resources	109%	99%	92%	99%	92%				

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

Life Cycle Assessment Results

Mix ID	Footer max Port	Footer 25%slag	Footer 40% slag	SOG max port	SOG 25%slag
Climate Change (kg CO2-eq)	246.33	203.81	175.93	268.46	230.55

Using the SCA Calculator Review

- If you go to the Slag substitution tab you can scroll on mix id (Column C, row 8) select what mix to use as the benchmark then use the slag adjustment bar (column b row, 5) to see how lowering or raising the slag will impact the results.

Athena Sustainable Materials Institute

Adjust Slag Cement %

Select Mix to Adjust

Select Region

Slag Cement %

28%

Region

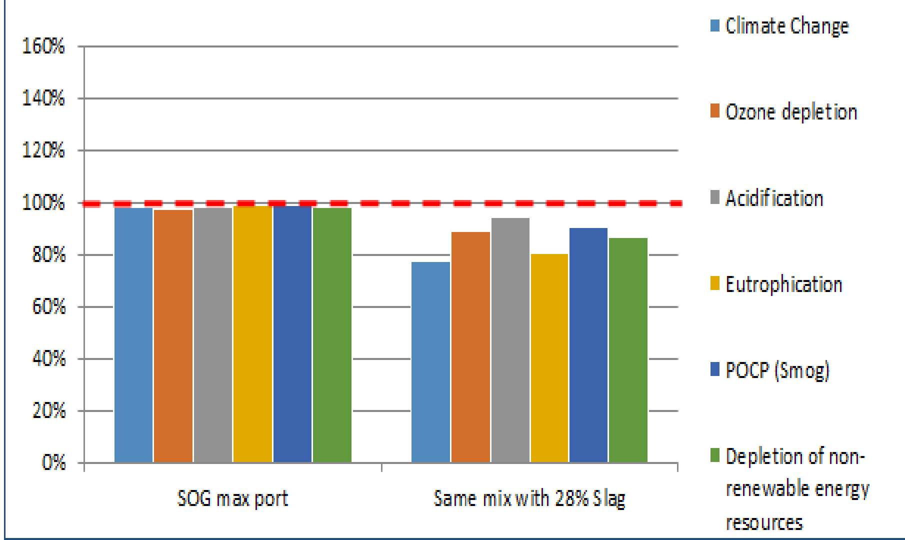
Great Lakes Midwest

Concrete Mix

Mix ID	SOG max port	me mix with 28% Slag
Slag Cement (%)	0%	28%
Strength (psi)	4000	4000
Portland Cement (lb)	503	362
Slag Cement (lb)	0	141
Fly Ash (lb)	0	0
Crushed Coarse Aggregate (lb)	1695	1695
Natural Coarse Aggregate (lb)	0	0
Crushed Fine Aggregate (lb)	0	0
Natural Fine Aggregate (lb)	1527	1527
Manufactured Lightweight Aggregate (lb)	0	0
Accelerating Admixture-Chlorides (oz)	0	0
Air Entraining Admixture (oz)	0	0
Water Reducing Admixture - plasticizer (oz)	0	0
High Range Water Reducing Admixture - superplasticizer (oz)	0	0
Water (gal)	29	29

Additional Mix Options

Comparison to Strength Class Benchmark



Mix ID	SOG max port	Same mix with 28% Slag
Strength (PSI) of Relevant Benchmark	4000	4000
Climate Change	99%	77%

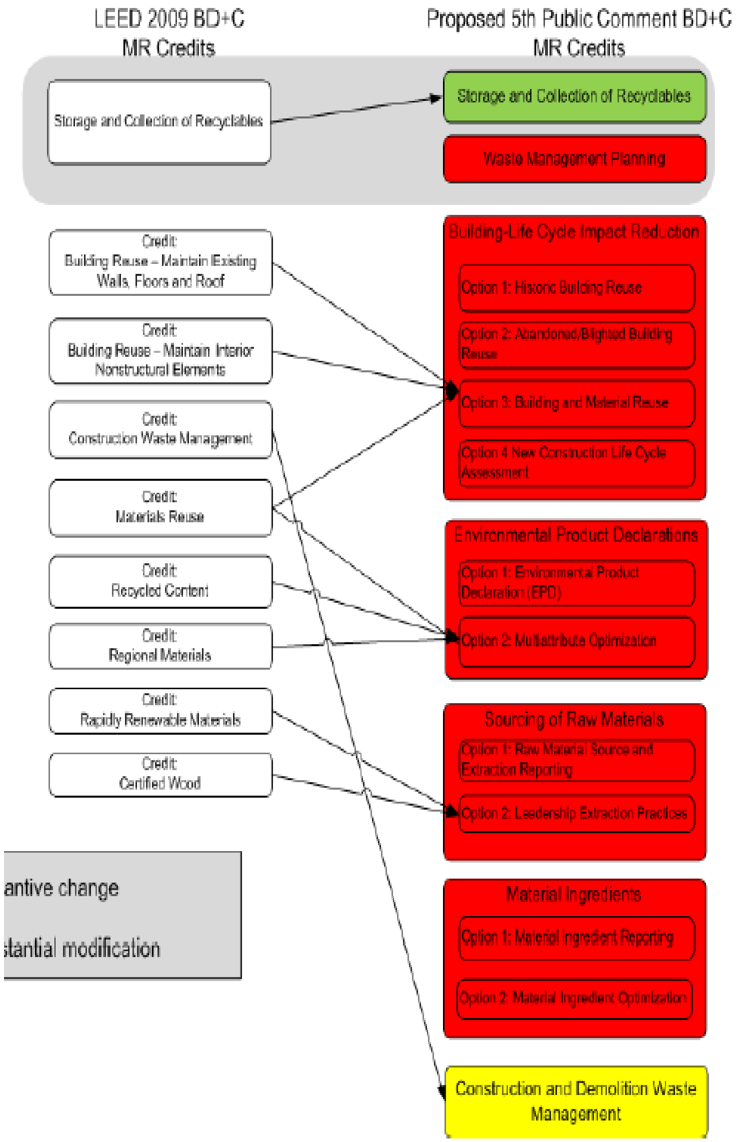
Introduction | Slag Substitution | Custom Mixes | Comparison to Benchmark | Impacts in Whole Building

LEED Versions old and new

V4 and 4.1 are trying have a holistic approach (performance) but with old single attribute ideas

LEED V1 to V3

Single attribute point % of recycled, % fsc wood



Material Cost

Determining Product Cost

Product and materials cost includes all taxes and expenses to deliver the material to the project site incurred by the contractor but excludes any cost for labor and equipment required for installation after the material is delivered to the site.

To calculate the total materials cost of a project, use either the actual materials cost or the default materials cost.

Actual materials cost. This is the cost of all materials being used on the project site, excluding labor but including delivery and taxes.

Default materials cost. The alternative way to determine the total materials cost is to calculate 45% of total construction costs. This default materials cost can replace the actual cost for most materials and products, as specified above. If the project team is including optional products and materials, such as furniture and MEP items, add the actual value of those items to the default value for all other products and materials.

MATERIALS & RESOURCES

PREREQUISITES	CREDITS
Storage and Collection of Recyclables	Building Life-cycle Impact Reduction*
Construction and Demolition Waste Management Planning	*Interiors Life-cycle Impact Reduction***
*Long-term Commitment***	-Building Product Disclosure and Optimization - Environmental Product Declarations
	BPDO - Sourcing of Raw Materials
	BPDO - Material Ingredients
	Construction & Demolition Waste Management

** BD+C Only*

*** ID+C Only*

Slide from USGBC LEED V4.1 Road Show Cleveland 10/7/2019 presented by Stefanie Young

MR Credit: Building Product Disclosure and Optimization –environmental product declarations 1-2 points

Intent

To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.

Option 1. Environmental Product Declaration (EPD) (1 point)

Use at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the disclosure criteria below.

- Product-specific declaration.
    - Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one quarter (1/4) of a product for the purposes of credit achievement calculation.
- Environmental Product Declarations which conform to ISO 14025 and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
    - Industry-wide (generic) EPD -- Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator are valued as one half (1/2) of a product for purposes of credit achievement calculation.
    - Product-specific Type III EPD -- Products with third-party certification (Type III), including external verification in which the manufacturer is explicitly recognized as the participant by the program operator are valued as one whole product for purposes of credit achievement calculation.
- USGBC approved program – Products that comply with other USGBC approved environmental product declaration frameworks.

Environmental Initiatives LEED v4

- **MRc2: Building Product Disclosure and Optimization: Environmental Product Declaration (Possible 2 Points)**
  - **OPTION 1. Environmental Product Declaration (EPD) (1 Point)**
  - Use at least 20 different permanently installed products sourced from at least five different manufacturers (v4.1 is now 10 epd's)
  - Industry Wide EPD = ½ product, Product Specific Type III EPD = whole product (v4.1 industry 1pt)
  - Product Specific Type III EPD = whole product (v4.1 TIII Specific 1.5 pts)

MR Credit: Building Product Disclosure and Optimization – "Benchmarking on V4" 1-2 points

Option 2. Multi-Attribute Optimization (1 point)
Use products that comply with one of the criteria below for 50%, by cost, of the total value of permanently installed products in the project. Products will be valued as below.

- Third party certified products that demonstrate impact reduction below industry average in at least three of the following categories are valued at 100% of their cost for credit achievement calculations.
  - global warming potential (greenhouse gases), in CO_2e;
  - depletion of the stratospheric ozone layer, in kg CFC-11;
  - acidification of land and water sources, in moles H+ or kg SO_2;
  - eutrophication, in kg nitrogen or kg phosphate;
  - formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and depletion of nonrenewable energy resources, in MJ.

- USGBC approved program -- Products that comply with other USGBC approved multi-attribute frameworks.

For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost.

MORE ACCESSIBLE

BPDO – EPDs Credit

Option 2. Multi-Attribute Optimization

Cost requirement lowered from 50% to 10%

OR Option for # of products

(10 for all project types)

Tiers available...

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Building Product Disclosure and Optimization – Environmental Product Declarations

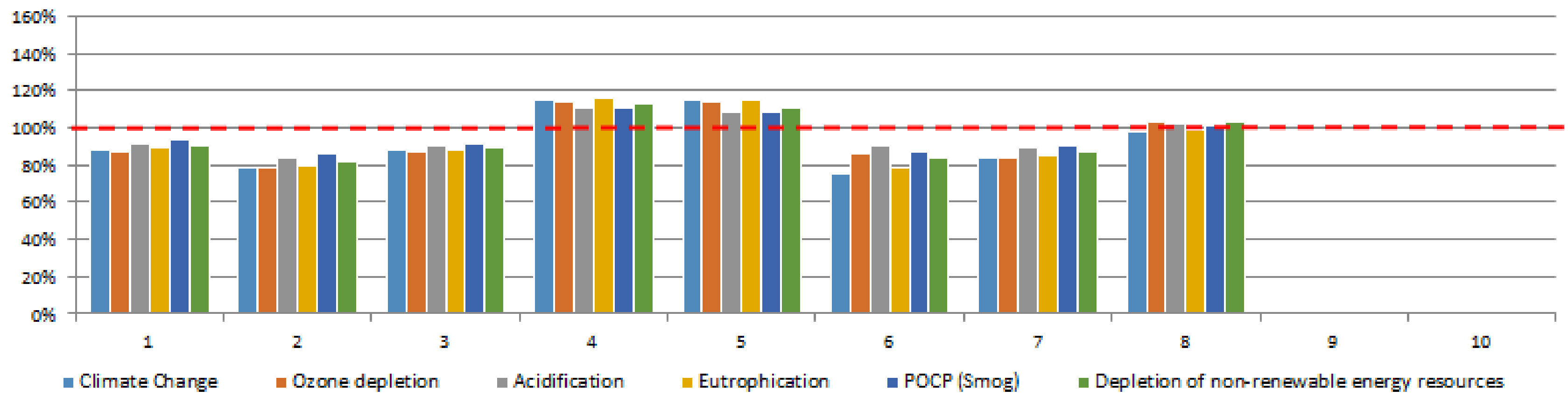
Credit

Option 2. Multi-Attribute Optimization

Action Plan: Reward manufacturer progress towards optimization by analyzing product lifecycle impacts and publicly committing to reductions (50% of cost or ½ product)

i. **Life Cycle Impact Reductions in Embodied Carbon:**
   i. **5% reduction in GWP:** compared to industrywide EPD, product-specific LCA, or Type III EPD (100% of cost, or 1 products)
   ii. **10% reduction in GWP:** compared to industrywide EPD, product-specific LCA, or Type III EPD (150% or 1.5 products)
   iii. **20% reduction in GWP:** considered exemplary; must be compared against type III EPDs only; must also include 5%+ reduction in two additional categories (200% or 2 products)

Comparison of Entered Mixes to Strength Class Benchmarks



Mix in Graph	1	2	3	4	5	6	7	8	9	10
Mix ID	3000 footer	3500 sog	4000 int	4000 air	4000 stair	4500 air	1500 lean	3500 lwt		
Strength (PSI) of Relevant Benchmark	3000	4000	4000	4000	4000	5000	2500	4000 LW		
Climate Change	88%	79%	88%	115%	115%	76%	84%	98%		
Ozone depletion	87%	78%	87%	114%	114%	86%	83%	103%		
Acidification	92%	84%	91%	111%	109%	91%	89%	102%		
Eutrophication	89%	80%	89%	116%	115%	78%	85%	99%		
POCP (Smog)	93%	86%	92%	110%	109%	87%	91%	101%		
Depletion of non-renewable energy resources	90%	82%	90%	112%	111%	84%	87%	103%		

Life Cycle Assessment Results

Mix ID	3000 footer	3500 sog	4000 int	4000 air	4000 stair	4500 air	1500 lean	3500 lwt		
Climate Change (kg CO2-eq)	196.05	215.10	238.95	314.12	312.59	253.04	168.12	412.69		
Ozone depletion (kg CFC-11-eq)	4.90E-06	5.36E-06	5.96E-06	7.83E-06	7.77E-06	7.22E-06	4.21E-06	1.81E-05		
Acidification (kg SO2-eq)	0.72	0.77	0.83	1.01	0.99	0.97	0.64	1.89		
Eutrophication (kg N-eq)	0.24	0.26	0.29	0.38	0.37	0.31	0.21	0.54		
otochemical Ozone Creation/Smog (kg O3-eq)	15.19	16.15	17.30	20.80	20.50	19.16	13.74	27.40		
Total primary energy consumption (MJ)	1,368.20	1,474.47	1,608.19	2,017.99	1,994.58	1,795.75	1,209.41	3,644.35		
etion of non-renewable energy resources (MJ)	1,344.73	1,448.72	1,579.53	1,980.26	1,957.17	1,761.34	1,189.31	3,600.90		
Use of renewable primary energy (MJ)	23.47	25.74	28.67	37.73	37.41	34.41	20.10	43.45		
etion of non-renewable material resources (kg)	1,768.10	1,775.00	1,816.64	1,816.38	1,702.68	1,721.47	1,754.33	1,484.55		
Use of renewable material resources (kg)	1.42	1.56	1.73	2.28	2.26	1.94	1.22	9.44		
Concrete batching water consumption (m3)	0.21	0.23	0.12	0.12	0.26	0.26	0.11	0.13		
Concrete washing water consumption (m3)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07		
Total water consumption (m3)	0.28	0.30	0.19	0.19	0.33	0.33	0.17	0.20		
Concrete hazardous waste (kg)	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01		
Concrete non-hazardous waste (kg)	1.45	1.62	1.82	2.47	2.47	1.88	1.22	2.01		

MR Credit: Building Life-Cycle Impact Reduction

2-6 points

Option 4. Whole-Building Life-Cycle Assessment (3 points)

For new construction (buildings or portions of buildings), conduct a life-cycle assessment of the project's structure and enclosure that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories listed below, one of which must be global warming potential. No impact category assessed as part of the life-cycle assessment may increase by more than 5% compared with the baseline building.

The baseline and proposed buildings must be of comparable size, function, orientation, and operating energy performance as defined in EA Prerequisite Minimum Energy Performance. The service life of the baseline and proposed buildings must be the same and at least 60 years to fully account for maintenance and replacement. Use the same life-cycle assessment software tools and data sets to evaluate both the baseline building and the proposed building, and report all listed impact categories. Data sets must be compliant with ISO 14044.

Select at least three of the following impact categories for reduction:

- global warming potential (greenhouse gases), in kg CO_2e;
- depletion of the stratospheric ozone layer, in kg CFC-11;
- acidification of land and water sources, in moles H+ or kg SO_2;
- eutrophication, in kg nitrogen or kg phosphate;
- formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and
- depletion of nonrenewable energy resources, in MJ.

Building Life-Cycle Impact Reduction Credit

Option 4. Whole-Building Life-Cycle Assessment

Path 1: Conduct a life cycle assessment of the project's structure and enclosure (1 point)

Path 2: 5% reduction (2 points)

Path 3: 10% reduction (3 points)

Path 4: 20% reduction + some amount of reuse (4 points)

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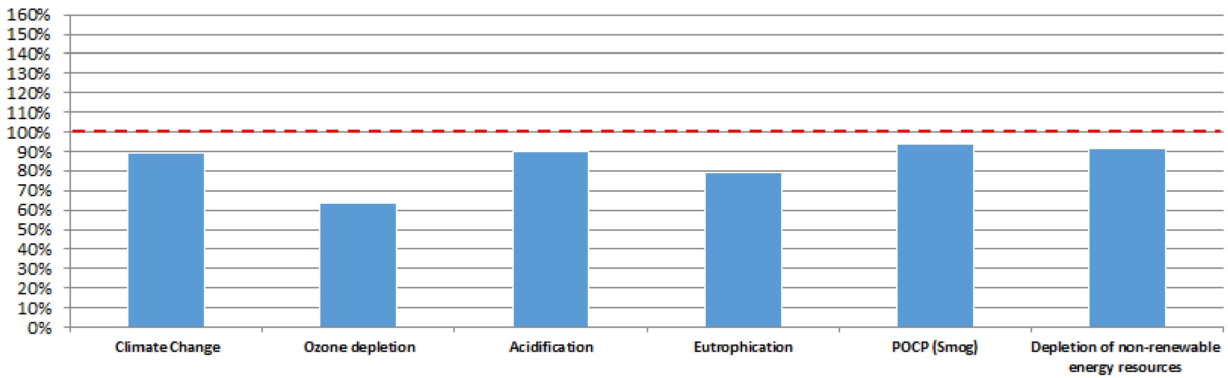
Example of benchmark concrete for whole building aspect

Mix ID	3000 footer	3500 sog	4000 int	4000 air	4000 stair	4500 air	1500 lean	3500 lwt		
Amount in Building (yd3)	120	800	800		40	0	100	800		

Comparison of Entered Mixes to Building Constructed with Benchmark Concrete



% of Impacts of Building with Default Concrete	
Climate Change	89%
Ozone depletion	64%
Acidification	90%
Eutrophication	79%
POCP (Smog)	93%
Depletion of non-renewable energy resources	92%

Life Cycle Assessment Results	Total Impacts		Impacts of Individual Mixes							
Mix ID	Benchmark Building	Custom Building	3000 footer	3500 sog	4000 int	4000 air	4000 stair	4500 air	1500 lean	3500 lwt
Climate Change (kg CO2-eq)	1,883,603.35	1,681,604.08	23,526.51	172,082.30	191,161.73		12,503.63		16,812.21	211,303.88
Ozone depletion (kg CFC-11-eq)	2.80E-02	1.79E-02	5.88E-04	4.29E-03	4.77E-03		3.11E-04		4.21E-04	5.89E-03
Acidification (kg SO2-eq)	9,205.72	8,277.08	86.08	612.79	660.62		39.75		64.37	740.68

Custom mixes used in a given project to calculate the cumulative whole building impact. The results are based on a case study building that is a typical 50,000 square foot 5 story office building that uses 2,800 yd3 of concrete. The calculator adds in nonconcrete impacts (steel, glazing, insulation, etc) in amounts proportional to the amount of concrete selected.

MR Credit: Building Product Disclosure and Optimization –sourcing of raw materials 1-2 points

Intent

To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts. To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner.

MR Credit: Building Product Disclosure and Optimization
–sourcing of raw materials
1-2 points

Option 1. Raw Material Source and Extraction Reporting (1 point)

Use at least 20 different permanently installed products from at least five different manufacturers that have publicly released a report from their raw material suppliers which include raw material supplier extraction locations, a commitment to long-term ecologically responsible land use, a commitment to reducing environmental harms from extraction and/or manufacturing processes, and a commitment to meeting applicable standards or programs voluntarily that address responsible sourcing criteria

- Products sourced from manufacturers with self-declared reports are valued as one half (1/2) of a product for credit achievement.

- Third-party verified corporate sustainability reports (CSR) which include environmental impacts of extraction operations and activities associated with the manufacturer's product and the product's supply chain, are valued as one whole product for credit achievement calculation. Acceptable CSR frameworks include the following:

  - **Global Reporting Initiative (GRI) Sustainability Report**
  - **Organisation for Economic Co-operation and Develoment (OECD) Guidelines for Multinational Enterprises**
  - **U.N. Global Compact**: Communication of Progress
  - **ISO 26000:** 2010 Guidance on Social Responsibility
  - **USGBC approved program***:* Other USGBC approved programs meeting the CSR criteria.

MR Credit: Building Product Disclosure and Optimization –sourcing of raw materials

1-2 points

Option 2. Leadership Extraction Practices (1 point)

Use products that meet at least one of the responsible extraction criteria below for at least 25%, by cost, of the total value of permanently installed building products in the project.

- *Extended producer responsibility.* Products purchased from a manufacturer (producer) that participates in an extended producer responsibility program or is directly responsible for extended

producer responsibility. Products meeting extended producer responsibility criteria are valued at 50% of their cost for the purposes of credit achievement calculation.

- *Materials reuse.* Reuse includes salvaged, refurbished, or reused products. Products meeting materials reuse criteria are valued at 100% of their cost for the purposes of credit achievement calculation.

- *Recycled content.* Recycled content is the sum of postconsumer recycled content plus one-half the preconsumer recycled content, based on cost. Products meeting recycled content criteria are valued at 100% of their cost for the purposes of credit achievement calculation

- *USGBC approved program.* Other USGBC approved programs meeting leadership extraction criteria.

For credit achievement calculation, products sourced (extracted, manufactured and purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the base contributing cost of individual products compliant with multiple responsible extraction criteria is not permitted to exceed 100% its total actual cost (before regional multipliers) and double counting of single product components compliant with multiple responsible extraction criteria is not permitted and in no case is a product permitted to contribute more than 200% of its total actual cost.

Environmental Product Declarations Feeding Whole Building Life Cycle Assessment

- Environmental Product Declarations (EPD’s) can give you more specific carbon footprint information on a given product.
  - However, it is difficult to compare one EPD directly to another.
- Whole building life cycle assessment (WBLCA) looks at the multiple impacts of building materials over the entire life cycle of the structure.
  - Takes the information from the EPD’s and calculates a better, whole picture of the true impacts of construction and use.
- Special software has been developed to do this for design and construction professionals.
  - Athena Impact Estimator
  - Tally

Cement and Concrete Specific LCA

- **Ready Mixed Concrete Life Cycle Assessment Calculator for Slag Cement**
  - Free Download on SCA website
- The calculator lets designers enter custom concrete mixes and then substitute varying amounts of slag cement through a simple dashboard interface allowing them to compare different mix designs.
- The tool also allows users to input mix design information into a hypothetical whole building life cycle assessment scenario.
- Step by step how to use instructions are available on the website.

Thank You

QUESTIONS?