Industry-Average EPD for Concrete Masonry Units

Nick Lang, PE
Vice President, Engineering, Masonry
Concrete Masonry & Hardscapes Association

THE MASONRY SOCIETY

1

Description

- Environmental Product Declarations for building materials are at the forefront of many projects – becoming required submissions in some areas. Driven primary by efforts to reduce embodied carbon, the global warming potential (GWP) impact category is the one that is most of interest recently, from private projects to federal procurement. Recently, CMHA published the first industry-average EPDs for concrete masonry units. These EPDs cover units with a variety of strengths, densities, and constituent materials. This presentation will review these documents along with future plans for more industry environmental data reporting.

2

2

What are EPD & PCR?

3

3

Definitions

- LCA (Life-Cycle Analysis)
  - The calculation for environmental impacts
- PCR = Product Category Rules
  - Basically to rule book for writing an EPD
- EPD = Environmental Product Declaration
  - Basically a 'nutritional label' that lists the GWP and other environmental impacts for a product

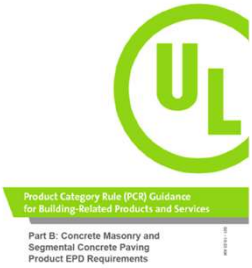
4

4

Product Category Rule

- definitions & descriptions
- system boundary
- units
- service life
- allocation
- estimations and assumptions
- supporting documentation…..

- BASICALLY, THE RULES
- FOR DEVELOPING EPDs



NOTE: Must be renewed every five years – efforts starting now to publish new version fall 2025

5

5

Environmental Product Declarations

- They report environmental impacts using pre-defined impact indicators

- **They aren't required to report:**
  - mix designs
  - raw materials
  - extraction locations
  - ANY PROPRIETARY INFORMATION

ENVIRONMENTAL IMPACTS

Declared Product:
CMU: NW

Declared Unit: 1 m^3 of concrete formed into manufactured concrete masonry product (CMU)

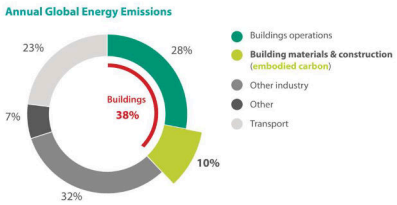
Global Warming Potential (kg CO_2-eq)	211
Acidification Potential (kg SO_2-eq)	0.71
Eutrophication Potential (kg N-eq)	0.25
Smog Creation Potential (kg O_3-eq)	17.0
Ozone Depletion Potential (kg CFC-11-eq)	5.41E-6

Material Composition: Aggregate (natural), Aggregate (crushed), Portland cement, Batch water, Admixture (plasticizing)

6

6

Why is this important….embodied carbon



Source: "Net-zero Buildings: Where Do We Stand?" *World Business Council for Sustainable Development*. https://www.wbcsd.org/contentwbc/download/12446/185553/1. Accessed 13 Sept. 2021.

7

7

Industry-Average EPDs

8

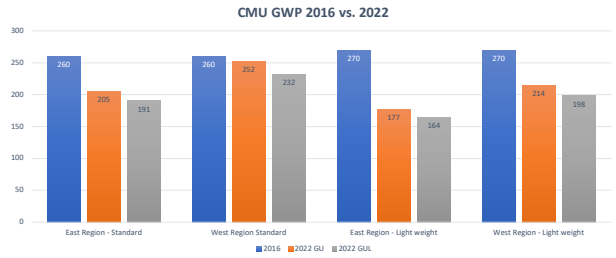
8

Canadian Industry Average EPD

- Originally published 2016
- 2nd version published 2022
- 13 producers throughout Canada
- NW and LW CMU
- GU and GUL cements
- Done by Athena
- Verified by ASTM

9

Canadian Industry Average EPD

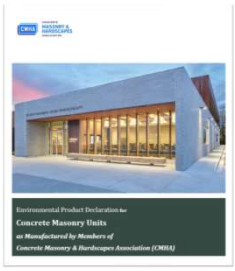


10

10

US Industry Average

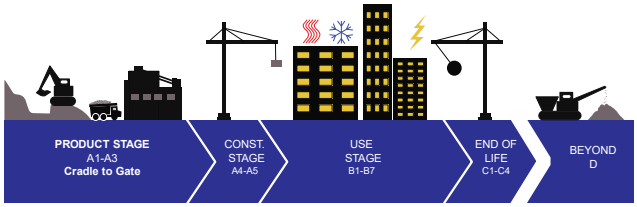
- Published August 2024
- 35 manufacturing facilities
- 71 individual CMU
- 7 categories of CMU
- NW, MW, and LW
- Manufactured & Natural Aggregates
- Done by Climate Earth
- Verified by ASTM



11

11

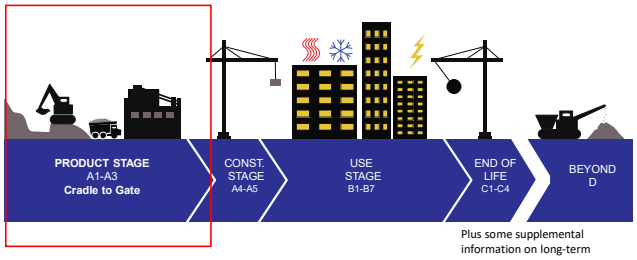
Life Cycle Analysis Stages



12

12

Covered in IA-EPD



Plus some supplemental information on long-term sequestration

13

13

Participants

14

14

Industry-Average CMU EPD

Category	Strength Range	Aggregates
NW1	2000 – 3240 psi	---
NW2	3250 – 4490 psi	---
NW3	> 4500 psi	---
MW-M	2000 – 3240 psi	Manufactured LW agg
MW-N	2000 – 4490 psi	Pumice, scoria, limestone, byproducts (slag, bottom ash)
LW-M	2000 – 4490 psi	Manufactured LW agg
LW-N	2000 – 3240 psi	Pumice, scoria, limestone, byproducts (slag, bottom ash)

15

Industry-Average CMU EPD

ENVIRONMENTAL IMPACTS (A1-A3 Cradle-to-Gate)

Declared Product: Concrete Masonry Units
Declared Unit: 1 m^3 of concrete formed into manufactured concrete masonry units (CMU)

	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Global Warming Potential (GWP)*	208	232	241	360	244	395	286
Acidification Potential (kg SO2-eq)	0.83	0.74	0.78	1.73	1.04	1.93	1.70
Eutrophication Potential (kg N-eq)	0.36	0.40	0.41	0.55	0.42	0.53	0.46
Smog Formation Potential (kg O3-eq)	16.3	14.7	14.8	23.8	22.5	26.6	40.3
Ozone Depletion Potential (kg CFC-11-eq)	6.94E-06	7.19E-06	7.18E-06	2.76E-05	7.03E-06	3.04E-05	6.77E-06

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.

16

Carbon Sequestration

Remember Heidi talked about this some?

17

17

DRY-CAST CONCRETE SEQUESTRATION
RESEARCH UNDERWAY

- CMU were collected from across the US and Canada and allowed to naturally carbonate
- TGA was performed periodically to measure carbon uptake

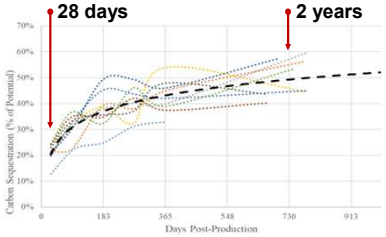
Set 6 4 Week | Set 6 13 Week | Set 6 26 Week

18

SUMMARY OF TEST RESULTS
% of potential

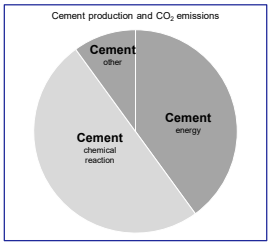
- **28 days ~ 21%**
- 6 mo. ~ 37%
- 1 year ~ 43%
- **2 years ~ 49%**

Projected results
- 7 years ~ 60%
- 20-25 years ~ 70%



19

CO_2 EMISSIONS OF CEMENT PRODUCTION

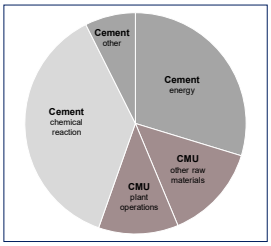


Rough Estimation

≈ 50% due to chemical reaction
≈ 40% due to energy required
≈ 10% other cement plant processes

20

CO_2 EMISSIONS OF CMU PRODUCTION



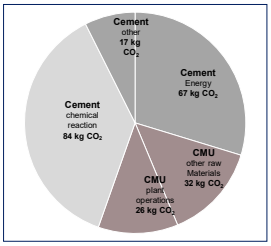
Rough Estimation

≈ 74% due to cement
≈ 14% due to other CMU raw materials
≈ 12% due CMU plant operations

In this scenario:
- dry-cast normal weight concrete block
- industry average GWP of **226 kg CO_2e** per M^3 (≈140 8" block)
  - **before inclusion of carbon sequestration**

21

CO_2 EMISSIONS OF CMU PRODUCTION PER M^3

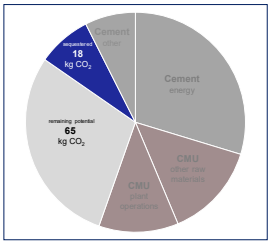


- ≈ 84 kg CO2 due to chemical reaction
- ≈ 17 kg CO2 due cement plant operations
- ≈ 67 kg CO2 due to energy use
- ≈ 32 kg CO2 due to other CMU raw materials
- ≈ 26 kg CO2 due CMU plant operations

- **In this scenario:**
  - dry-cast normal weight concrete block
  - industry average GWP of 226 kg CO2e per M3 (≈140 8" block)
    - before inclusion of carbon sequestration

22

CO_2 EMISSIONS OF CMU PRODUCTION PER M^3



28 days

- Total sequestration ≈ 18 kg CO2
- 21% of potential
  - emissions associated with chemical reaction only
- 8% of total associated emissions
  - emissions associated with the whole process of CMU manufacturing
- GWP
  - 208 CO2e per M3 at the gate (A3)

23

Industry-Average CMU EPD

Supplemental Information – Natural Carbon Sequestration

The carbon sequestration levels of coupons aged 28 days to 6 months were determined with Thermogravimetric Analysis (TGA) and reported in the reference paper. Preparation and testing protocols as well as raw material background compensation procedures are also detailed in the ASTM reference paper. The reported Global Warming Potential (GWP) values reported in the A1-A3 impact results for the various product types (Tables 3 – 9) in this EPD include the natural carbon sequestration achieved in the first 28 days post-production, which captures a representative A1-A3 boundary condition. Based on the average of the nine sets in the ASTM study, the carbon naturally sequestered over the first 28 days post-production is equivalent to 21% of the calcination carbon emissions. Applying this factor, Table S1 below summarizes the cradle-to-gate A1-A3 Global Warming Potential (GWP) including the calcination carbon emissions and the natural carbon sequestration over 28 days for the product types in this EPD as reported in Tables 3 – 9.

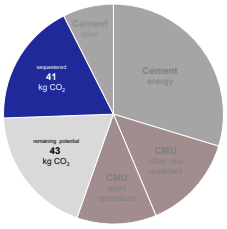
Table S1: A1-A3 Global Warming Potential (GWP)

		Product Type						
Impact Assessment	Unit	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Global Warming Potential (GWP)*	kg CO_2 e	208	232	241	360	244	395	286
Calcination Carbon Emissions	kg CO_2 e	84	103	105	96	96	92	100
Carbonation Carbon Removals Natural Carbon Sequestration at 28 days	kg CO_2 e	-18	-22	-22	-20	-20	-19	-21

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation.

24

DRY CAST CO_2 SEQUESTRATION OF CMU
PER M^3



2 years
- Total sequestration ≈ **41 kg CO_2**

- **49% of potential**
  - emissions associated with chemical reaction only
- **18% of total associated emissions**
  - emissions associated with the whole process of CMU manufacturing
- **GWP**
  - **185** CO2e per M^3

25

Industry-Average CMU EPD

Supplemental Information – Natural Carbon Sequestration

Sampling and testing of each set of units in the original study has continued after the ASTM paper publication in 2022. The sets have been tested through 2 years after initial production. The average natural carbonation sequestration of the sets following 2 years of exposure is equivalent to 49% of the calcination carbon emissions. Applying this factor, Table S2, below, summarizes Global Warming Potential (GWP) after 2 years of service including the calcination carbon emissions and the natural carbon sequestration for the product types in this EPD after 2 years of service. This data can be incorporated into Whole Building Life Cycle Analysis for the use module, B1, depending on the exposure of the CMU to atmospheric carbon dioxide.

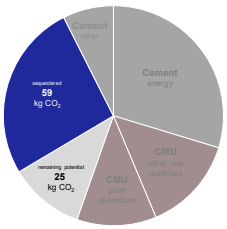
Table S2: Global Warming Potential (GWP) after 2 Years of Service

		Product Type						
Impact Assessment	Unit	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Global Warming Potential (GWP)*	kg CO_2 e	185	204	212	333	217	369	258
Calcination Carbon Emissions	kg CO_2 e	84	103	105	96	96	92	100
Carbonation Carbon Removals	kg CO_2 e	-41	-50	-51	-47	-47	-45	-49
Natural Carbon Sequestration at 2 years								

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation.

26

DRY CAST CO_2 SEQUESTRATION OF CMU
PER M^3



20-25 year projection

- Total sequestration ≈ 59 kg CO2

- 70% of potential
  - emissions associated with chemical reaction only
- 26% of total associated emissions
  - emissions associated with the whole process of CMU manufacturing

- GWP
  - 167 CO2e per M3

27

Wrap Up

28

28

How does this compare?

GSA IRA Limits for Low Embodied Carbon Concrete Masonry Units (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per cubic meter - $kgCO_2e/m^3$)		
Top 20% Limit	Top 40% Limit	Better Than Average Limit
217	256	290

	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Global Warming Potential (GWP)*	208	232	241	360	244	395	286

29

29

Conclusions

- US FINALLY has Industry-Average EPD
- Current numbers compare well to GSA (for normal weight)
- One number doesn't fit all for different types of CMU
- Producers still encouraged to get product-specific EPDs
- Accounting for carbon sequestration important to understand total CMU footprint

Want low-carbon concrete? Use CMU

30

30

THE MASONRY SOCIETY

Nick Lang
571-224-0935
nlang@masonryandhardscapes.org

31