GreenPlum Street LLC

USCA Project (C-20435)

Buy Clean Maryland
Report on Industry Averages of GWP emissions for Several Categories of Concrete Mixtures
March 30, 2025

This is a summary of the study of both embodied carbon in concrete and cement used in Maryland to establish a baseline understanding of the eligible materials of the Buy Clean Maryland Act. The results of this summary is intended to be included in the methodology to support the proposed rulemaking language in establishing an acceptable global warming potential (GWP) for concrete and cement.

The process of setting limits in the Buy Clean Maryland project will evaluate the embodied carbon impacts for different categories of concrete mix designs and cement manufactured in Maryland. The data from the Portland Cement Association as well as the National Ready-Mix Concrete Association's (NRMCA) Life Cycle Assessment (LCA) report for the US and Eastern Region which includes Maryland and data collected by Building Transparency's EC3 Tool is summarized below.

1. Understanding the Standards

Categorization in PSI:
Compressive strength is the most common and accepted measurement for determining a concrete mix's ability to withstand structural forces and carry loads. Concrete strengths are categorized using PSI (pounds per square inch) to measure the compressive strength of concrete, which dictates how much force a concrete mix can withstand before it cracks or breaks. PSI is a standardized unit of measurement that indicates the amount of force (in pounds) that a concrete sample can withstand when compressed over an area of one square inch. Higher PSI numbers indicate stronger and more durable concrete, generally leading to longer lifespan and requiring more expensive mixes. The specific PSI needed for a project depends on factors like the type of structure, its intended use, and the environmental conditions.

Testing and Standardization:
Concrete compressive strength is typically tested at 7 and 28 days after casting to determine the PSI rating, with the 28-day test being the standard used in the American Concrete Institute (ACI) standards.

2. Benchmarks

Cement Benchmark

For cement, the Portland Cement Association (PCA) published an industry-wide EPDs based on the survey of cement produced in the United States (US) by members posted at ASTM International, a program operator. Four main categories of cement have been covered; ASTM C150 portland cement, ASTM C595 portland-limestone cement, ASTM C595 blended cements, and ASTM C91 masonry cement produced in North America. Table 1 shows the Production Stage Cradle-to-gate EPD Results for Cements (2023).

Table 1. Production Stage Cradle-to-gate Global Warming Potential results from PCA industry-wide EPDs for Cements (2023)

Global Warming Potential, GWP 100, IPCC 2013	***Per 1 metric ton***	***Unit***
ASTM C-150 portland cement[i]	919	$KgCO_2$ eq
ASTM C595 portland-limestone cement[ii]	844	$KgCO_2$ eq
ASTM C595 blended cement[iii]	739	$KgCO_2$ eq
ASTM C91 masonry cement[iv]	587	$KgCO_2$ eq

Concrete Benchmark

As a concrete EPD program operator, the National Ready Mixed Concrete Association (NRMCA) used data collected in developing the LCA and Industry-Wide EPDs (IW-EPD) for concrete to develop a set of regional benchmarks for key environmental impacts. The NRMCA Member National and Regional LCA Benchmarks Report (Benchmark Report) represents the environmental impacts of products with varying strengths for different applications and exposure conditions at the national level and eight NRMCA regions. The methodology used statistical assessment of GWP developed based on primary data gathered as part of the NRMCA industry regional benchmark LCA for each life cycle modules. Table 1 is adopted from the NRMCA Benchmark Report - v3.2 (2022)[v]. The Eastern Region values are **bolded** as a Maryland reference point for comparison.

Table 2. Global Warming Potential results from NRMCA national and regional benchmarks for ready-mixed concrete (2022) in $kgCO_2e/m^3$

		Normal weight (2,000-2,600 kg/m^3)						Lightweight (<2,000 kg/m^3)		
Compressive Strength in PSI (MPa)		*2500 psi (17.2)*	*3000 psi (20.7)*	*4000 psi (27.6)*	*5000 psi (34.5)*	*6000 psi (41.2)*	*8000 psi (55.2)*	*3000 psi (20.7)*	*4000 psi (27.6)*	*5000 psi (34.5)*
REGION	Pacific Southwest	257	279	323	378	401	456	500	546	594
	Pacific Northwest	235	261	316	386	408	487	518	575	632
	Rocky Mountains	232	255	301	358	379	440	484	532	580
	South Central	226	245	286	336	356	409	468	510	555
	North Central	241	264	312	372	394	460	487	537	591
	Southeastern	247	268	309	360	382	435	478	521	562
	Great Lakes	232	255	303	363	383	452	499	551	603
	Eastern	**240**	**264**	**314**	**378**	**399**	**472**	**517**	**573**	**628**
	National	240	262	308	365	385	446	492	540	588

3. Local Context

To establish global warming potential (GWP) limits for cement and concrete as required by the Buy Clean Maryland Act, it is essential to adopt context-relevant methods that consider local mitigation potential and data availability.

In Maryland, cement production is currently the largest contributor to emissions in the Maryland manufacturing sector, dominated by process emissions with limited mitigation options. The majority of emissions occur due to process emissions in clinker production - the active ingredient required to create cement. Process emissions are a chemical byproduct of the materials used in clinker production and cannot be avoided based on the established recipe for cement. A significant challenge in decarbonizing Maryland's cement sector is that the primary emissions blend into other major sectors, including transportation, energy, and buildings. These overlapping emissions materialize as the transportation of raw materials, electricity usage in facility buildings, and energy use required to power manufacturing processes.

> The two cement plants in Maryland, Lehigh's Union Bridge and Holcim's Hagerstown, emit significantly more than non-cement facilities. Historical emissions from these plants have grown over time. Moreover, Union Bridge emitted 2,277,259 tCO_2 in 2020, more than five times the 431,936 tCO_2 emitted by the Hagerstown facility in the same year[vi]. The industry average emissions intensity for cement production in the U.S. is 776 kg CO_2 /mt of cement. Union Bridge's emissions intensity is slightly more efficient than average at 720 kg CO /mt of cement, while Hagerstown's emissions intensity is significantly less efficient than average at ~1000 kg CO_2 /mt cement. These facilities have already taken actions or made plans to reduce emissions. Both plants switched the bulk of their production in 2023 to Portland Limestone Cement (PLC), which has a lower clinker factor and correspondingly lower emissions[vii]. Both facilities also have plans to phase-down coal use.[viii]

The existing available concrete EPDs in Maryland are collected using the Building Transparency's Embodied Carbon in Construction Calculator (EC3) tool, which aims to collect all third party reviewed EPDs for published categories.

While the number of available EPDs has grown over the last few years, there is still a small number of manufacturers producing them in the state. At the time of access (January 28, 2025), there were six manufacturers listed in the EC3 tool with 1454 valid EPDs so the data may not necessarily statistically representative of the whole population of producers in the state. The values are listed in Table 3. Other values beyond 28-day strengths (3-day, 7-day, 56-day , etc) were not included.

Table 3. Average GWP values (28 day) from EC3 tool - Maryland

	Normal weight						Lightweight		
Compressive Strength in PSI (MPa)	*2500 psi (17.2)*	*3000 psi (20.7)*	*4000 psi (27.6)*	*5000 psi (34.5)*	*6000 psi (41.2)*	*8000 psi (55.2)*	*3000 psi (20.7)*	*4000 psi (27.6)*	*5000 psi (34.5)*
Maryland EC3 Average ($kgCO_2e/m^3$)	254	287	321	351	364	354	393	450	452
Number of EPDs (28d)	55	265	386	371	64	26	3	6	2
% Compared to NRMCA Eastern Region Benchmark	106%	109%	102%	93%	91%	75%	76%	79%	72%

According to the EC3 database, the Maryland overall average and range in Figure 1 (per m^3):

- Conservative: 372 $kgCO_2e$
- Average: 315 $kgCO_2e$ ± 0.249%
- Achievable: 252 $kgCO_2e$

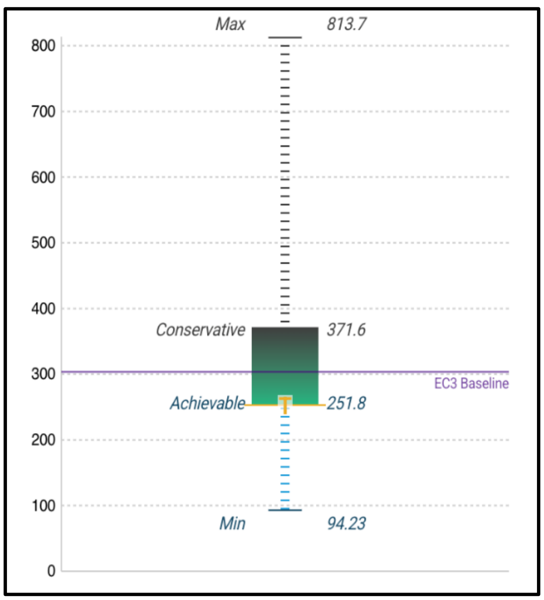

Figure 1 Maryland GWP Range from EC3

ENDNOTES

i Portland Cement Association [PCA], EPD 195 Portland Cement, ASTM International, October (2023)

ii Portland Cement Association [PCA], EPD 196 Portland-Limestone Cement, ASTM International, October (2023)

iii Portland Cement Association [PCA], EPD 193 Blended Hydraulic Cement, ASTM International, October (2023)

iv Portland Cement Association [PCA], EPD 194 Masonry Cement, ASTM International, October (2023)

v NRMCA, NRMCA Member National and Regional LCA Benchmark (Industry Average) Report – V 3.2, Athena Sustainable Materials Institute (December 2021)

vi Kennedy, K., et. al., Manufacturing Sector Decarbonization Strategies and Impacts in the State of Maryland, University of Maryland, School of Public Policy (October 2022)

vii Lehigh Cement Plant in Union Bridge, Maryland, Transitions to EcoCemPLC, Press Release (07/14/22) https://www.heidelbergmaterials.us/home/news/news/2022/07/14/lehigh-cement-plant-in-union-bridge-maryland-transitions-to-ecocemplc#:~:text=Lehigh%20Hanson%2C%20Inc.%2C%20is,cement%20plan%20in%20North%20America, accessed December 21, 2024

viii Kennedy, K., et. al., Manufacturing Sector Decarbonization Strategies and Impacts in the State of Maryland, University of Maryland, School of Public Policy (October 2022)