NWPMA 2023

C.O.P.

Low Carbon Concrete Initiative

Josh Huber PBOT, MQCS

(503)-823-8407

Joshua.huber@portlandoregon.gov

PLEASE ASK QUESTIONS

- At anytime

About Me

- 30 years experience testing construction materials in both field & laboratory environment for commercial buildings, City Streets, highways & bridges.
  - Asphalt, Concrete, Aggregates and Soils, etc.
  - QC / QA / QCCS roles
  - USACE (4), Private QC companies (11), ODOT R1 (15)
  - PBOT (currently) – MQCS (similar to QCCS)
    - Reviewing Material submittals, ensuring proper testing procedures/frequencies are being followed.
    - Reviewing field/laboratory test reports
    - Reviewing Q&Q for payment, Etc.

About You

- Contractors (Sub /Prime)
- Suppliers
- Different Municipalities (State, City, Counties)
- Other

Definitions / Terms

- CGC-Commercial Grade Concrete(Non-Structural)
- LCC-Low Carbon Concrete
- GWP-Global Warming Potential- prod/plant specific
- EPD-Environmental Product Declaration- prod/plant specific
- SCM-Supplemental Cementitious Material
  - Fly Ash
  - Slag
  - ?

What's an Environmental Product Declaration (EPD)?

An EPD is a third-party verified label that discloses the quantified environmental impacts of producing a product. EPDs can enable comparisons between products serving the same function. EPD labels are governed by the ISO 14025 standard. All EPDs must follow the same "accounting standards" published in the product category rule (PCR) for each product. In the case of ready mix concrete, the product category rule was developed by the Carbon Leadership Forum and can be found on their website here: http://www.carbonleadershipforum.org/2017/01/03/concrete-pcr/

An EPD is valid for 5 years

Some Structural Mixes in the Metro Area

CITY OF PORTLAND
MATERIALS TESTING LAB
1405 N. River St., Portland, OR 97227

2020 City of Portland Standard Construction Specifications

andrew.weiher@portlandoregon.gov
503-823-2340

Approved Concrete Mix Designs

Oct 2, 2023

Concrete Supplier	Mix Class-Agg	Supplier ID	Air	Slump	Design W/C	Binder	*GWP (kgCO2eq/yd³)	Approved Use	Date
CalPortland	3000 psi - #4	0234FSLC	5.5%	4"	0.50	530# 30% Slag	198 - 199	Commercial Grade Concrete (00440)	Dec-22
(Includes Front Ave, Troutdale, and	3300 psi - 1"	0739LC2	5.5%	4"	0.48	573# 37% Slag	210-211	Structural (00540) & Commercial Grade Concrete (00440)	Dec-22
West Vancouver)	4000 psi - 1 1/2"	0522CRLC	4.5%	4"	0.44	611# 38% Slag	242	Structural Concrete (00540)	Dec-22
	100 psi - CLSM	0974FS	8%	6"	0.84	475# 95% Slag	82	Controlled Low Strength Materials (00442)	Jan-23
Heidelberg (Cadman) Materials	3300 psi - 1"	2317406	5.5%	4"	0.59	480# 30% Slag	145	Commercial Grade Concrete (00440)	Jun-23
(Includes Port of Portland)	4000 psi - 3/8"	1308376	5.0%	4"	0.49	658# 15% Slag	214	Commercial Grade Concrete (00440)	Jun-23
	4000 psi - 3/4"	1308207	5.5%	4"	0.38	711# 14% Slag	231	Commercial Grade Concrete (00440)	Apr-23
	4000 psi - 3/4"	2318207	5.5%	4"	0.51	564# 30% Slag	165	Commercial Grade Concrete (00440)	Jun-23
	4000 psi - 1"	2319001	5.5%	4"	0.51	564# 30% Slag	166	Commercial Grade Concrete (00440)	Jun-23
	4500 psi - 1 1/2"	1599880	5.0%	6"	0.40	625# 14% Slag	207	Structural Concrete (00540)	Jun-23
	4000 psi - 3/8"	1599976	2.5%	8.5"	0.45	750# 50% Slag	178	Drilled Shaft Concrete (00512)	May-22
	100 psi - CLSM	1547602	10%	10"	2.22	200# Cmt	93	Controlled Low Strength Materials (00442)	Feb-23
Knife River Sand & Gravel	3300 psi - 3/4"	246NPGBF00	5.0%	4"	0.47	570# 43% Slag	193	Commercial Grade Concrete (00440)	Jun-23
(Includes Coffee Lake & Linnton)	100 psi - CLSM	245HZAWL00	18%	8"	0.75	500# 82% Slag	84 - 97	Controlled Low Strength Materials (00442)	Feb-23
	100 psi - CLSM	24CILAWDH9	12%	8"	1.46	200# Cmt	128 - 129	Controlled Low Strength Materials (00442)	Mar-23
Wilsonville Concrete Products	3000 psi - 3/4"	3000A2050	5.0%	4"	0.55	470# 20% Slag	168	Commercial Grade Concrete (00440)	Sep-23
(Includes Wilsonville)	3500 psi - 3/4"	3538A3055	5.0%	4"	0.49	517# 30% Slag	167	Commercial Grade Concrete (00440)	Mar-21
	3500 psi - 3/4"	3538A2060	5.0%	4"	0.45	564# 20% Slag	204	Structural (00540) & Commercial Grade Concrete (00440)	Aug-22
	4000 psi - 3/4"	4036A2070	5.0%	4"	0.40	647# 20% Slag	234	Commercial Grade Concrete (00440)	Apr-23
	4000 psi - 3/4"	40CIA2070	5.0%	4"	0.39	658# 20% Slag	231	Commercial Grade Concrete (00440)	Sep-23
	4000 psi - 1 1/2"	4032A3070	4.5%	4"	0.39	658# 30% Slag	206	Pavement (00756) & Structural (00540)	Apr-21

Note: This list does not waive the responsibility of the contractor to provide quality control testing as outlined in the appropriate sections of the City Standard Specifications.

Low-Carbon Concrete Initiative

- The City of Portland's 2016 Sustainable Supply Chain Analysis identified construction services as the top spend category contributing to the City's supply chain greenhouse gas (GHG) emissions. Within construction services, concrete is one of the most GHG-intensive materials typically used on City construction projects. As a result, in 2019, after gathering both internal and external stakeholder input, the City established its Low-Carbon Concrete Initiative to reduce the overall carbon intensity of the concrete mixes used on City projects. From 2019 to early 2022, the Initiative involved: 1) establishing a product-specific Environmental Product Declaration (EPD) requirement for concrete mixes used on City projects; 2) conducting pilot tests of lower-embodied carbon concrete mixes; and 3) defining Global Warming Potential (GWP) Thresholds for concrete mixes.

Lower-Embodied Carbon Concrete Pilot Projects

- In order to understand how lower-carbon concrete mixes perform compared to traditional 100% cement mixes, the City has been conducting pilot tests of different lower-carbon concrete mixes.

Pilot Projects

- Types of Low-Carbon Mixes Tested
  - Type I/II Cement + Slag (slag % ranged from 30-50%)
    - One pilot also included Carbon Cure
  - Portland Limestone Cement (PLC)/Type 1L + Slag (30% slag)
- Pilot Project Applications – Different Times of Year, Weather
  - Sidewalk & Curb Ramps
  - Driveway
  - Concrete Pavement
  - Pole Footings
  - Retaining Walls, Bike/Pedestrian Path, other Park Infrastructure

Type 1L Cement
As per ASTM C595, the term portland-limestone cement (PLC or Type 1L) refers to a hydraulic cement in which the limestone content is more than 5% but less than or equal to 15% by mass of the blended cement.
In other words, with Type 1L cement, up to 15% raw (uncalcined) limestone is ground with calcined clinker. Type 1L has a lower global warming potential (GWP) due to the reduction in clinker use.

Pilot Projects & Research Key Findings

- Lower-Carbon Mixes - Properties
  - Type 1L (PLC) – can be direct sub for Type I/II
  - Slag
    - In general, lower early strength gain; but overall meets or exceeds required strength
    - Up to 30%, likely little impact on finishing tasks for flatwork
    - Over 30%, impact will be more directly noticeable for flatwork in cool weather (longer set time)
    - Set times can be improved with use of accelerators
    - No impact on ability to get underground utility readings
  - **Overall, lower-carbon mixes meet specifications**. Some nuances to understand.
  - **Both Type 1L and SCMs (like slag or Fly Ash) reduce GWP of mixes**
    - **23-50% less** than the 100% cement “status quo” mixes.

Pilot Projects & Research Key Findings

- Additional Findings
  - Pricing of low-carbon mixes: no firm conclusions due to fluctuating markets and contractor-supplier account relationships
  - SCM supply – availability was fine, but will need to work on supporting additional options
  - Overdesign is Common – likely due to:
    - Inconsistent testing practices
    - Desire by crews to have high early strength to move through subsequent tasks quicker
    - Low-bid approach may also contribute to the above…

Pilot Project Data - Sidewalks

Date	*Mix Design	from EPD GWP Total kg CO2 eq	**CMT / SCM	Amb. Temp	Plastic Properties				Time of Test	Initial Cure		Average Strength @ Day				Location
					Slump	Temp	Unit Wt.	% Air		Min.	Max.	7D	14D	28D	56D	
4/10/20	KR 246KN17000	308.45	100% Cmt	49	3 1/2"	66	143.2	3.6%	8:05	69	73	3740	4670	5290	5880	Michigan & Fremont NW Corner
4/10/20	KR 246KPG8F00	238.62	30% Slag	68	3 3/4"	68	142.4	3.8%	13:30	66	69	2210	3370	4670	5420	Michigan & Fremont NE Corner
4/14/20	KR 246KPG8G00	204.51	40% Slag	51	3 3/4"	62	140.7	5.1%	9:00	68	70	2030	3480	4550	5190	Michigan & Failing SE Corner
4/14/20	KR 246KN17000	308.45	100% Cmt	73	5 3/4"	67	141.9	5.0%	13:15	66	71	3070	3810	4780	5330	Michigan & Failing SW Corner
4/28/20	KR 246KN17000	308.45	100% Cmt	55	5"	68	145	4.5%	7:30	70	77	3440	4250	5110	5650	Michigan & Fremont SW Corner
4/28/20	KR 246KPG8F00	238.62	30% Slag w/ 96 oz CC	72	4"	70	143.4	4.8%	12;15	72	77	2520	3690	5000	5830	Michigan & Fremont SE Corner
4/30/20	KR 246KN17000	308.45	100% Cmt	62	5 1/4"	68	143.3	5.1%	7:40	68	73	3240	4220	4860	5560	Michigan & Failing NE Corner
4/30/20	KR 246KPG8F00	238.62	30% Slag w/ 96 oz CC	68	3 1/4"	73	143.8	5.0%	12:15	68	71	2430	3750	4580	5550	Michigan & Failing NW Corner
5/20/20	CP 0739LC2	228.91	50% Slag	56	4.75	69	144.9	4.0%	10:45	63	69	3010	4610	5510	6500	Michigan & Webster NE Corner
5/20/20	CP 739	344.26	100% Cmt	58	4	72	145.6	4.0%	13:15	66	72	4620	5400	5930	6300	Michigan & Webster SE Corner
5/22/20	CP 739LC	263.18	35% Slag	58	4.25	71	146.8	3.7%	11:35	72	74	3550	4810	5810	6490	Michigan & Webster NW Corner
5/22/20	CP739	344.26	100% Cmt	58	3.75	73	145.9	4.2%	13:15	62	70	4890	5700	5940	6420	Michigan & Webster SW Corner

* Info from delivery ticket

** Info from batch weights

CC = Carbon Cure additive

Specifications

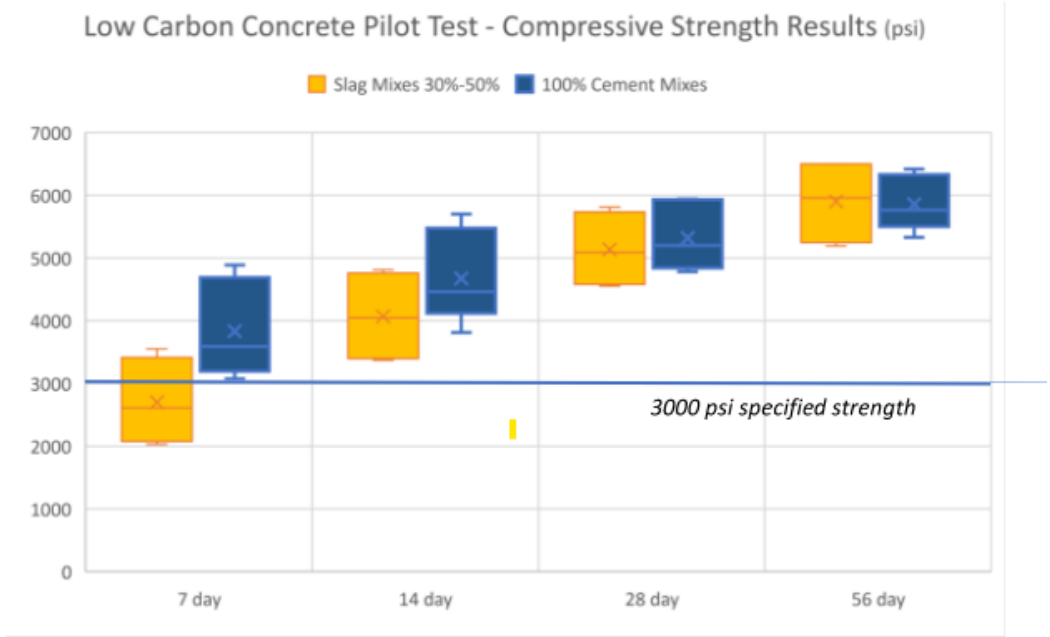
Slump: 5" Max.

% Air: 4%-7%

Con Temp: 50f-90f

Compressive Strength: 3000psi

Results



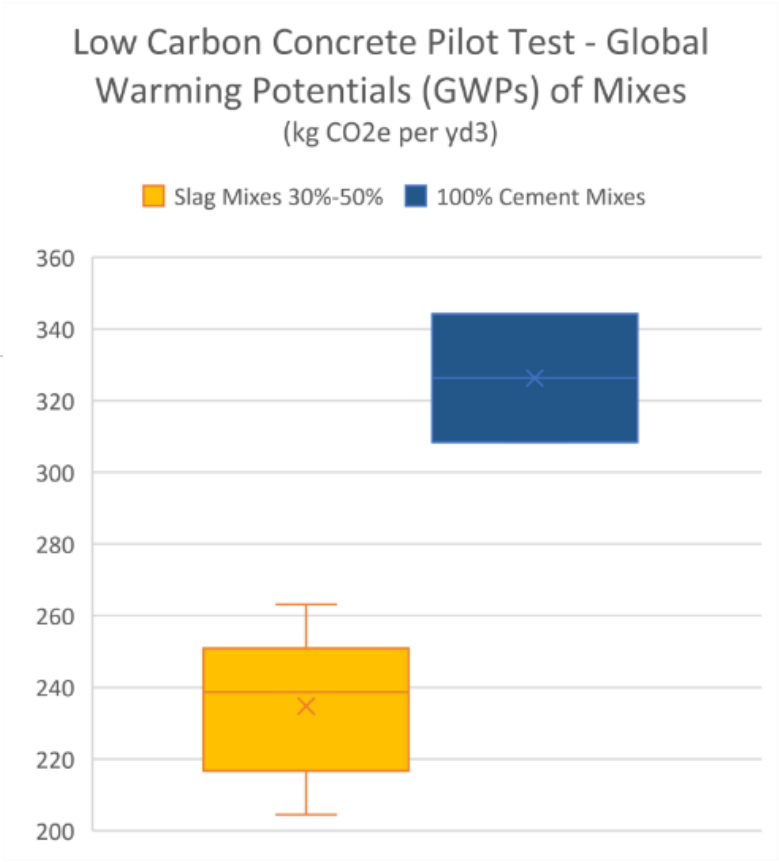


Figure 2 shows that the slag mixes had a considerably lower GWPs than the straight cement mixes. By using less cement and adding slag, GHG reductions ranged from 23-34% compared to the more typical 100% cement mixes. It's important to note that carbon reductions were achieved by reducing cement contents and not by simply increasing slag contents to meet a percent slag target.

In terms of workability, the concrete finisher interviews did not raise any red flags regarding how the lower-carbon concrete mixes performed. Comments ranged from a preference for working the lower-carbon mixes to observing they were not discernable from any other mix. The only issue raised was that for a couple of the lower-carbon mixes, some finishers observed that the set time was longer, but it did not affect overall workflow.

The three and six-month post-project visual inspections did not reveal performance concerns attributed to a specific mix. The corners were essentially indistinguishable in terms of the presence of cracking, scaling, pop-outs, or other defects.

During this time, PBOT also confirmed with local utility locate firms that they are not aware of any concerns with slag interfering with locate readings, but it may be prudent to test this in future pilot tests.

QUESTIONS?

- THANK YOU!

More Information

- Current Sustainable Procurement Initiatives | Portland.gov
- Carbon Leadership Forum:
  - http://www.carbonleadershipforum.org/2017/01/03/concrete-pcr/
- **For questions related to the Low-Carbon Concrete Initiative,** contact Josh Huber, Materials Quality Compliance Specialist, Portland Bureau of Transportation, joshua.huber@portlandoregon.gov (503)-823-8407