



U.S. General Services Administration

Low embodied carbon concrete and environmentally preferable asphalt

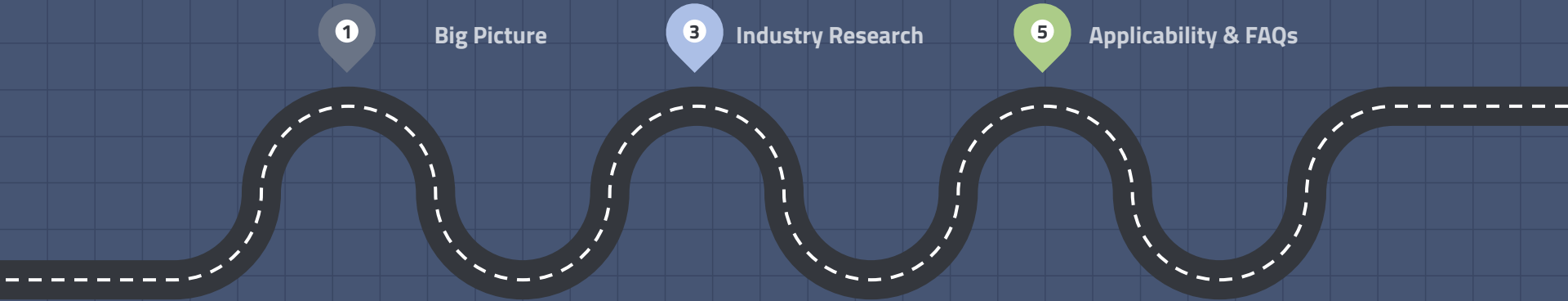
Training on new standards

May 18, 2022

Walter Tersch, PBS Design & Construction



ROADMAP



Triple Bottom Line

“Prioritizing government procurement with **lower carbon and cleaner construction materials** means helping American manufacturers and workers make products that are **more globally competitive** – and **better for [people and] the planet**.

It makes sense to work strategically with our partners early on because **the emissions from constructing a new building can contribute more to climate change than three decades of operating it.**”

- GSA Senior Advisor on Climate Sonal Larsen



What is Embodied Carbon?

Carbon Emissions in Building: 'Upfront' Embodied Carbon and Operational Carbon



'Upfront' Embodied Carbon
Manufacture, transport and
installation of construction materials

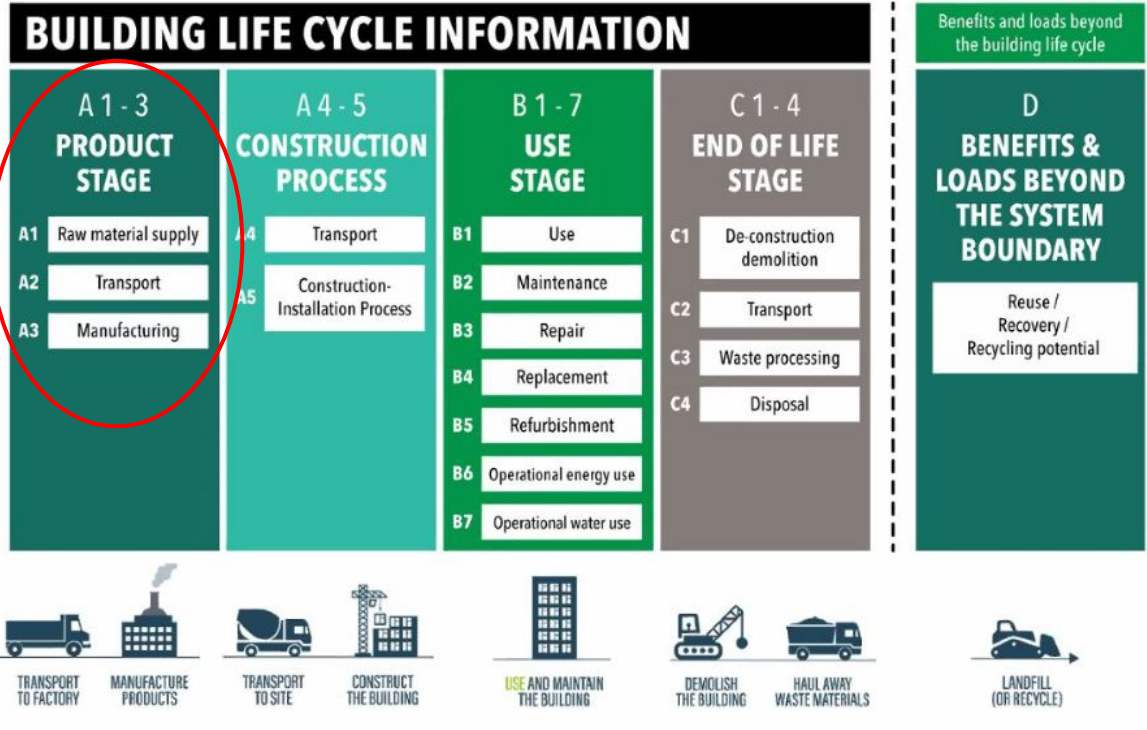
Operational Carbon
Building energy consumption

Embodied carbon refers to the greenhouse gas (GHG) emissions associated with the materials' manufacturing, transportation, installation, maintenance, and disposal.

Calculated as **global warming potential** (GWP). Expressed in metric tons of carbon dioxide equivalent (**CO₂e**)

What is an Environmental Product Declaration (EPD)?

An EPD is a standard, third-party-verified summary that lists the primary environmental impacts associated with a product's extraction, transportation, and manufacture.



ENVIRONMENTAL IMPACTS

Declared Product:
 Mix PN4888 • Quivas Plant
 Description: 4,000 Non-Air Entrained
 Compressive strength: 4000 PSI at 28 days

Declared Unit: 1 m³ of concrete

Global Warming Potential (kg CO ₂ -eq)	457
Ozone Depletion Potential (kg CFC-11-eq)	1.19E-5
Acidification Potential (kg SO ₂ -eq)	1.36
Eutrophication Potential (kg N-eq)	0.55
Photochemical Ozone Creation Potential (kg O ₃ -eq)	28.0
Abiotic Depletion, non-fossil (kg Sb-eq)	8.00E-6
Abiotic Depletion, fossil (MJ)	503
Total Waste Disposed (kg)	3.76
Consumption of Freshwater (m ³)	0.63

Product Components: natural aggregate (ASTM C33), Portland cement (ASTM C150), admixture (ASTM C494), batch water (ASTM C1602)



Cradle to Gate

Cradle to Grave

Cradle to Cradle

Why is Embodied Carbon Important?

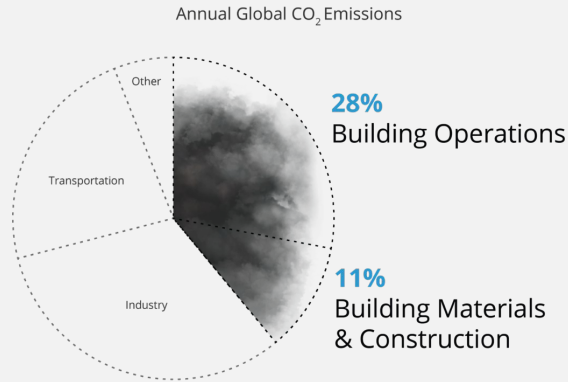


- Embodied carbon
- Scenario 1: Standard performance building
- Scenario 2: High-performance building

	2030	2050
EC	67%	56%
OC	33%	44%

Embodied carbon contributes **more climate-changing emissions than 30 years of operating a high-performance (e.g. typical new GSA) building!**

Why these materials?

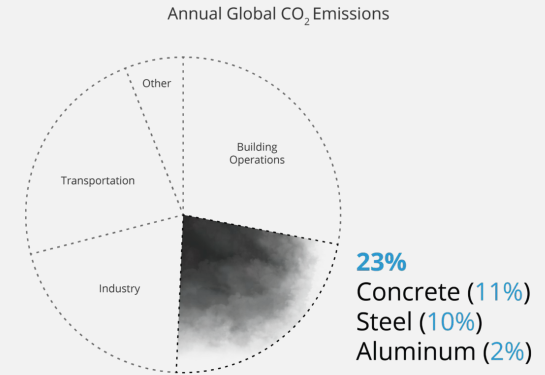


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Data Sources: Global ABC Global Status Report 2018, EIA

“Buildings generate nearly 40% of annual global CO₂ emissions.

*Of that total, building operations are responsible for 28% annually, while building materials and construction (typically referred to as **embodied carbon**) are responsible for an **additional 11% annually.**”*

-AIA Architecture 2030



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Data Sources: Global ABC Global Status Report 2018, EIA

- Concrete is the most widely used building material, with over half a billion tons produced in the U.S. each year.
 - Carbon intensive: limestone needs to be heated to ~2700 degrees F to make clinker for Portland cement.
- And over 90% of U.S. paved roads are asphalt-surfaced, with about 420 million tons of asphalt produced in the U.S. each year.
- These widespread materials present an opportunity to lighten the environmental footprint of GSA's building and paving projects, including along America's northern and southern borders.

How We Got Here

GSA Green Building Advisory Committee (GBAC) policy recommendations:

- 1) All projects (small & large) should apply a **material approach**, and require environmental product declarations (EPDs) for 75% of products; and
- 2) Large projects should use a **whole building life cycle assessment approach** to target a 20% carbon reduction, compared to a project-specific baseline building.

New **P100** Decarbonization section: "careful consideration must be given to the use of high embodied carbon items like concrete and steel. See the Carbon Smart Materials Palette." (§ 1.9.2.9)

Bipartisan Infrastructure Law provides major funding for GSA Land Port of Entry projects on the northern and southern borders.

Issued standards for **low embodied carbon concrete** and **environmentally preferable asphalt**



Embodied Carbon **Roundtable** gathered ideas and insights from more than 50 experts.

GSA's new Embodied Carbon Task Force selected **three priority actions**:
1) Smaller projects will use EPDs for a material approach;
2) Larger projects will implement whole building life cycle assessment early; and
3) Asset planning must factor in embodied carbon.

Sustainable Acquisition Initiative promotes sustainability (including embodied carbon reduction) in high-dollar, high-risk, or high-opportunity contracts.

Executive Order 14057: "promote use of construction materials with lower embodied emissions". (§§ 102(v), 303)

Issued **requests for information** from the concrete and asphalt manufacturing industries

CEQ kicked off interagency **Buy Clean Technical Advisory Group** meetings

First projects are applying new standards.

Whole building embodied carbon reduction measure is also live

Request for Information (RFI) Take-Aways

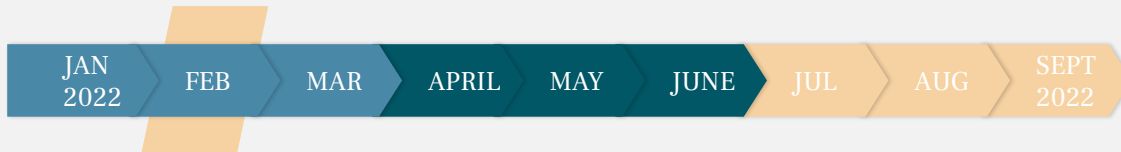
In February 2022, GSA released two RFIs to gather current marketplace insights from industry, including small businesses, on the national availability of concrete and asphalt materials with environmental product declarations, low embodied carbon, or superior environmental attributes.

Over 130 responses received

34% of concrete manufacturers were small businesses

61% of asphalt manufacturers were small businesses

- Concrete
 - Over 80% already produce or supply low embodied carbon concrete
 - Over 60% have developed a product-specific environmental product declaration (EPD)
 - Over 55% say low-embodied-carbon concrete costs about the same
 - Over 55% use carbon-reducing supplementary cementitious materials, and 34% have suppliers with EPDs
- Asphalt
 - Over 90% use reclaimed asphalt pavement
 - Over 70% use warm mix technology to reduce asphalt's environmental impact
 - Over 65% say environmentally preferable asphalt costs the same or less than conventional equivalents



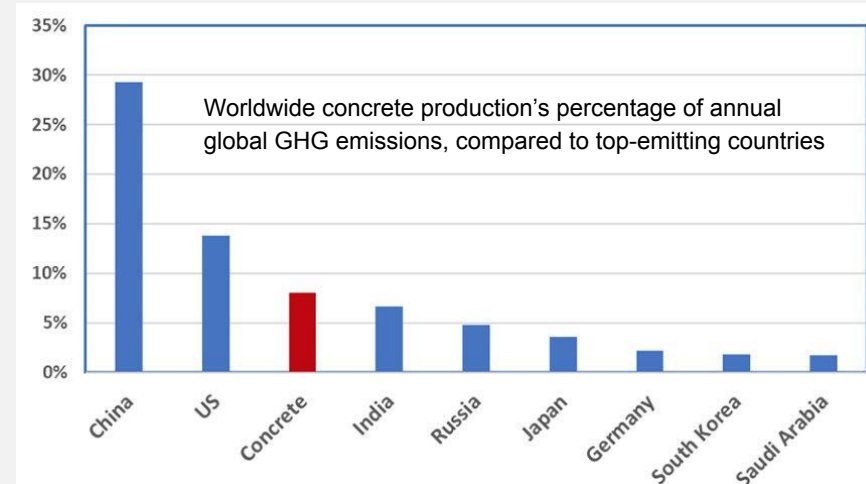
Material Standards for All GSA Projects

GSA.gov/p100 has March 17, 2022 issuance memo and concrete and asphalt standards. Must be included in solicitations for all GSA projects where at least one mix will involve 10 or more cubic yards of material. Summary:

- Require environmental product declarations (**EPDs**) and **lower-carbon concrete (20% lower global warming potential, vs. limits in proposed code language)**
- **Asphalt** mixes shall provide an EPD, if available, and **use two or more of the following:**
 - Reclaimed asphalt pavement (RAP) content (over 20%)
 - Warm mix technology
 - Non-paving recycled content
 - Bio-based or alternative binders
 - Improved plant/ equipment efficiency OR
 - Other environmentally preferable features or techniques

P100 waiver process is available.

GSA will collect data and learn from this groundbreaking nationwide effort.



Low Embodied Carbon Concrete (1/2)

- 1) The [prime contractor] shall provide a **product-specific cradle-to-gate Type III environmental product declaration (EPD) for each concrete mix design** specified in the contract and used at the project, using NSF International's product category rule for concrete. Please send EPD(s) with each concrete mix batch design (including type [e.g. standard or lightweight mix] and volume) to embodiedcarbon@gsa.gov, and upload the submittals into GSA's project management information system.
- 2) The [prime contractor] shall provide low embodied carbon **concrete that meets the global warming potential (GWP) limits** of the table below, for concrete of the mix type and strength class.

Specified compressive strength (f'c in PSI)	Maximum Global Warming Potential Limits for GSA Low Embodied Carbon Concrete (kilograms of carbon dioxide equivalent per cubic meter - CO ₂ e kg/m ³)		
	Standard Mix	High Early Strength	Lightweight
up to 2499	242	326	462
2500-3499	306	413	462
3500-4499	346	466	501
4500-5499	385	519	540
5500-6499	404	546	N/A
6500 and up	414	544	N/A

These numbers reflect a 20% reduction from GWP (CO₂e) limits in proposed code language: "[Lifecycle GHG Impacts in Building Codes](#)" by the New Buildings Institute, January 2022.



Low Embodied Carbon Concrete (2/2)

- 3) These requirements apply to **all GSA projects that use at least ten (10) cubic yards of concrete**.
- 4) If it is not feasible to meet GSA's EPD requirement or GWP limits, the [prime contractor] shall ask the GSA project manager to request a [P100 waiver](#).
 - a) The [prime contractor] shall outline and provide evidence of the specific circumstances that make compliance infeasible. For example, the only concrete suppliers within the maximum transport range for the mix design:
 - i. are small businesses that have not yet invested in EPDs; or
 - ii. do not yet offer mixes that meet GSA's GWP limits, e.g. because lower-carbon materials are unavailable, or do not meet specific client-driven performance requirements.
 - b) Any requests for waivers from the GWP limits must include the strategies, if any, that will be used to reduce GWP to the extent feasible. Such strategies include, but are not limited to, the use of alternative cements, supplementary cementitious materials, or alternative aggregates.
 - c) **For each concrete mix for which GSA has granted a waiver from the EPD requirement, the [prime contractor] shall send a GWP estimate** generated with a tool such as [ZGF's LCA Tool](#), [Athena IE](#) or the U.S. DOT Federal Highway Administration's [LCA Pave Tool](#) to embodiedcarbon@gsa.gov.
 - d) GSA will respond to each complete P100 waiver request with a decision or a request for more detail within ten (10) business days. A complete waiver request is deemed granted if no response is provided within that time.

Environmentally Preferable Asphalt (1/2)

- 1) The [prime contractor] shall provide a **product-specific cradle-to-gate Type III environmental product declaration (EPD) for each asphalt mix specified in the contract** and used at the project, using version 2 of the National Asphalt Paving Association's [product category rule](#) for asphalt mixtures. Please send EPD(s) to embodiedcarbon@gsa.gov, and upload EPD(s) into GSA's project management information system.

- 2) The [prime contractor] shall provide **environmentally preferable asphalt**, which is defined in this context as material manufactured or installed using at least two (2) of the following techniques. Please send each asphalt mix batch design (including type, volume, and a description of the proposed techniques) to embodiedcarbon@gsa.gov, and upload the submittals into GSA's project management information system.
 - a) Greater than 20% reclaimed asphalt pavement (RAP) content (specify percentage, and whether in-place or central plant recycling is used);
 - b) Warm mix technology (reduced onsite mix temperature);
 - c) Non-pavement recycled content (e.g. roof shingles, rubber, or plastic);
 - d) Bio-based or other alternative binders;
 - e) Improved energy/ carbon efficiency of manufacturing plants or equipment (e.g. using natural gas or electric to heat materials); or
 - f) Other environmentally preferable features or techniques (please specify).



Environmentally Preferable Asphalt (2/2)

- 3) These requirements apply to all GSA projects that use at least ten (10) cubic yards of asphalt.
- 4) If it is not feasible to meet GSA's EPD requirement or to implement at least two of the listed environmentally preferable features or techniques, the [prime contractor] shall ask the GSA project manager to request a [P100 waiver](#).
 - a) The [prime contractor] shall outline and provide evidence of the specific circumstances that make compliance infeasible. For example, the only asphalt suppliers within the maximum transport range for the mix design:
 - i. are small businesses that have not yet invested in EPDs; or
 - ii. do not yet offer mixes that use at least two environmentally preferable features or techniques while meeting specific client-driven performance requirements.
 - b) For each asphalt mix for which GSA has granted a waiver from the EPD requirement, the [prime contractor] shall send a GWP estimate generated with a tool such as [Athena Pavement LCA](#) or the Federal Highway Administration's [LCA Pave Tool](#) to embodiedcarbon@gsa.gov.
 - c) GSA will respond to each complete P100 waiver request with a decision or a request for more detail within ten (10) business days. A complete waiver request is deemed granted if no response is provided within that time.

Applicability

- [GSA.gov/p100](https://www.gsa.gov/p100) contains Chuck Hardy's issuance memo and the new concrete and asphalt standards. They apply to:
 - All projects (incl. repairs) that use at least 10 cubic yards of material, including onsite mobile batch plants
 - Design and construction contract awards for all GSA projects, both capital and small, regardless of funding source: paving upgrades, modernizations, new construction, customer-funded projects through BA80 Reimbursable Work Authorizations, privately-financed projects such as Energy Savings Performance Contracts, and all Bipartisan Infrastructure Law projects
- These do NOT apply to:
 - Leased space except lease-construct
 - Precast concrete panels or bricks that were fabricated off-site

Compliance

- To tentatively determine compliance:
 - Concrete: review concrete mix EPDs if available. Ensure GWP value on the environmental product declaration is within the table's limits.
 - Asphalt: Identify which two or more of the practices on the standard's qualitative menu of options are being used, and whether an EPD is available.
- What to submit, and when?
 - What: **Project name, building ID, EPD**, concrete or asphalt **type** (e.g. standard mix, lightweight, or high early strength), and planned **amount** (e.g. 50 tons, 20 cubic yards, etc.). Contract number not currently required.
 - From: either (a) prime contractor or GC, copying the COR; or (b) PM or COR.
 - When: suggest sending concrete mix info BEFORE seeking COR acceptance.
 - To whom: embodiedcarbon@gsa.gov or walter.tersch@gsa.gov
 - Then: I will log the info to build GSA's baseline, and will advise whether central office accepts it.
 - This informs the COR's official decision whether to accept the submittal in Kahua.

Frequently asked questions (1/2)

- Achievability?

	Reference	Maximum Global Warming Potential Limits* for GSA Low Embodied Carbon Concrete (kilograms of carbon dioxide equivalent per cubic meter - CO ₂ e kg/m ³)		
Specified compressive strength (f _c in PSI)	National Average (50th percentile per National Ready Mixed Concrete Association (NRMCA))	Standard Mix	High-early Strength	Lightweight concrete
f _c , psi	Maximum CO ₂ e kg/m ³ (kilograms of carbon dioxide equivalent per cubic meter)			
up to 2499	266	242	326	462
2500-3499	291	306	413	462
3500-4499	342	346	466	501
4500-5499	405	385	519	540
5500-6499	429	404	546	N/A
6500 and up	498	414	544	N/A

Compared to NRMCA national averages, GSA's Standard Mix GWP limits are:

- 9% lower
- 5% higher
- 1% higher
- 5% lower
- 6% lower
- 17% lower

- GSA's limits are 20% lower than NBI's proposed [75th percentile of GWPs] code language.

- **GSA's Standard Mix GWP limits are on average only 5% lower than industry-standard NRMCA baselines.**

- Workability?

- RFI respondents reported that potential low carbon concrete challenges -- workability, especially finishability and pumpability, slower early strength development, and availability of raw materials -- can be overcome with mixture optimization and admixtures.
- Quality, workability, or durability challenges with low embodied carbon concrete were "Not [experienced] when the mixture is properly optimized. Many times the results are equal to or better than straight cement mixtures."

Frequently asked questions (2/2)

- Isn't this a big change?
 - No. Since 2015, P100 has stated that “Concrete ready mix and site mix must have a minimum amount of fly ash equal to or greater than 15%, or ground granulated blast-furnace (GGBF) slag equal to or greater than 25%.” (§ 3.3.5 “Masonry and Concrete Materials”).
 - This carbon-lowering standard has also been in GSA’s [Key Sustainable Products](#) since 2014.
 - The fly ash requirement stems from EPA’s [Comprehensive Procurement Guidelines](#) (CPG) program, authorized by Congress under Section 6002 of the Resource Conservation and Recovery Act of 1976, as amended, (RCRA) (42 U.S. Code 6962).
 - CPG promotes the use of recovered waste materials.
 - EPA published [guidelines](#) designed to encourage the use of cement and concrete containing coal fly ash in the Federal Register in January 1983.
 - Slag (an iron smelting byproduct) has been used in concrete for over 100 years
- What if one of my mixes complies, but another doesn't?
 - Depending on what we learn from initial implementation, GSA may evaluate a weighted average compliance approach. Current standard requires a P100 waiver on a per-mix basis.

Initial Compliance Progress

- Six R2 Paving Projects: meeting asphalt standard, thanks to over 20% reclaimed asphalt pavement content, improved plant efficiency (natural gas), and milling and removing existing asphalt for use at other sites.
- Moss CH historic seismic upgrade/ renovation - TBD. Will either (a) upgrade cement; (b) change concrete suppliers to a local one with EPDs; or (c) use “ZGF” tool to estimate the GWP of “type IL” portland limestone cement (PLC) originally scoped. Structural shotcrete
- DFC Bldg. 48 - compliance expected. Mainly sidewalks
- Lukeville, AZ LPOE paving project - compliant, with asphalt EPD
 - This 8a (small disadvantaged business) vendor will also be used at BA54 Andrade LPOE and and IJJA Otay Mesa LPOE

First project to implement: Lukeville AZ LPOE

Bipartisan Infrastructure Law in Action, First Construction Contract Awarded

April 22, 2022

The U.S. General Services Administration (GSA) recently awarded a \$460,908 asphalt replacement contract for the **Lukeville Land Port of Entry** (LPOE) to OCS Construction, a small disadvantaged business and certified 8(a) contractor. This award supports several key GSA initiatives. It not only marks the start of **Bipartisan Infrastructure Law (BIL)** funding use but also aligns with GSA's FY22 **agency-wide goal** of increasing the allocation of awarded contracts to small disadvantaged businesses, and will implement the **newly established standards** for low embodied carbon concrete/asphalt.

President Biden has charged the historic Bipartisan Infrastructure Law funding to be used in building a better America. GSA is intending to do just that.

“The Bipartisan Infrastructure Law provided us with a once-in-a-generation opportunity to make a positive impact on safe and secure border crossing as well continue our efforts in creating sustainable facilities,” said R9 Public Building Services Regional Commissioner Dan Brown. “The law has provided \$3.4 billion for GSA work at over 26 Land Ports of Entry projects of varying size and scope on the northern and southern borders. In addition to the Lukeville LPOE paving project, we also have four other major construction or modernization projects and a paving project at the Otay Mesa LPOE funded in GSA's Pacific Rim Region.”

GSA's contracting team “found their way to yes” in securing BIL funding by **incorporating the newly established low embodied carbon concrete and asphalt standards**. Those standards require environmental product declarations of at least two environmentally preferable techniques or practices to be used during the materials manufacture or installation of their products. The new embodied carbon standard design will in turn lighten the environmental footprint, meeting the increase in sustainability goals, and provide cleaner construction initiatives.



Concrete Plants with EPDs, and GSA's upcoming [border station](#) and LPOE paving projects



This GSA-maintained [map](#) shows the location of concrete plants with published EPDs as of 4/18/22, from EC3.

Ways to reduce concrete's carbon footprint

1. Consider the design strength and curing time of concrete mixes to optimize the amount of portland cement needed to meet the design's specifications. Longer curing times help reduce GWP.
2. Use a whole-building approach to "right-size" the design of buildings to use less concrete, and maximize structural efficiency.
3. Use blended cements, such as "portland-limestone cement" (PLC, or "Type 1L" cement) instead of conventional portland cement to reduce concrete's carbon footprint by about 10%.
4. Reduce the amount of portland cement in the concrete by using supplementary cementitious materials (SCMs) such as fly ash, slag, and pozzolans from natural sources or recycled glass.
5. Use admixtures, e.g. carbon nanotube-infused concrete mixtures.
6. Reduce the clinker content of cement, e.g. through "carbon mineralized concrete" that uses impounded CO₂ to enhance strength and durability.
7. Use locally sourced components such as aggregates to reduce transportation emissions.
8. Select concrete from a plant with an Energy Performance Indicator (EPI) and that meets the ENERGY STAR benchmark for industrial plant energy performance.

Lendlease Chicago high-rise employs low-carbon concrete

The new mix uses 60% less Portland cement and could last 30 years longer than conventional concrete, according to its creators.

Published March 15, 2022

By Katie Pyzyk



Permission granted by Lendlease

In Chicago, new high-rise buildings going up near the Loop is nothing unusual. But one such tower currently under construction is getting attention for its innovative construction material: low-carbon concrete.

Private sector case study [article](#)

“McHugh [Concrete] developed the proprietary concrete mix with collaboration from concrete company Oremus Material. The team discovered that they could replace up to 60% of the Portland cement used in most conventional concrete mixes with other materials. . .

They primarily substituted waste materials that otherwise would end up in landfills or the environment: fly ash, a byproduct of coal-fired power plants; slag, a byproduct of steel production; and silica fume, a byproduct from the production of silicon alloys. . .

Currently, [low carbon concrete] adds about 1% to 2% to the overall cost of a project. But that is projected to change with more widespread use.

‘The price will probably be very comparable to traditional mixes’ once more widespread adoption of lower-carbon concrete occurs[.]”

Asphalt presents innovation opportunities too, [e.g.](#):

→ [Learn More](#)

FASTCOMPANY

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05-18-22 | 5:00 AM | WORLD CHANGING IDEAS

This company crushes old roads— and rebuilds them to store carbon

For stabilizing roads, Carbon Crusher ditches bitumen, a byproduct of crude oil, for lignin, sourced from trees.



[Photo: Carbon Crusher]

“Constructing a lane-mile of road releases between 1,400 and 2,300 tons of CO₂, even before any maintenance or reconstruction. That’s in part because road materials are bound together using bitumen, a sticky, blackish substance that’s a byproduct of crude oil.

Carbon Crusher builds new roads as well as fixes old and damaged ones, and it does so using lignin, an organic polymer found in trees that becomes a waste byproduct of paper production (and which is often then burned, generating more emissions).

This “green carbon binder,” as the company calls it, contains carbon from its natural life, and continues to sequester carbon in the roads.

Next Steps/ Discussion

- Track and learn from projects applying these standards. Follow technical developments. Fine-tune policies as needed.
- Coordinate with interagency Buy Clean Task Force, DOT, and other agencies to promote consistent federal policy.
- Include in P100 addendum this summer, and in the full 2024 edition.

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