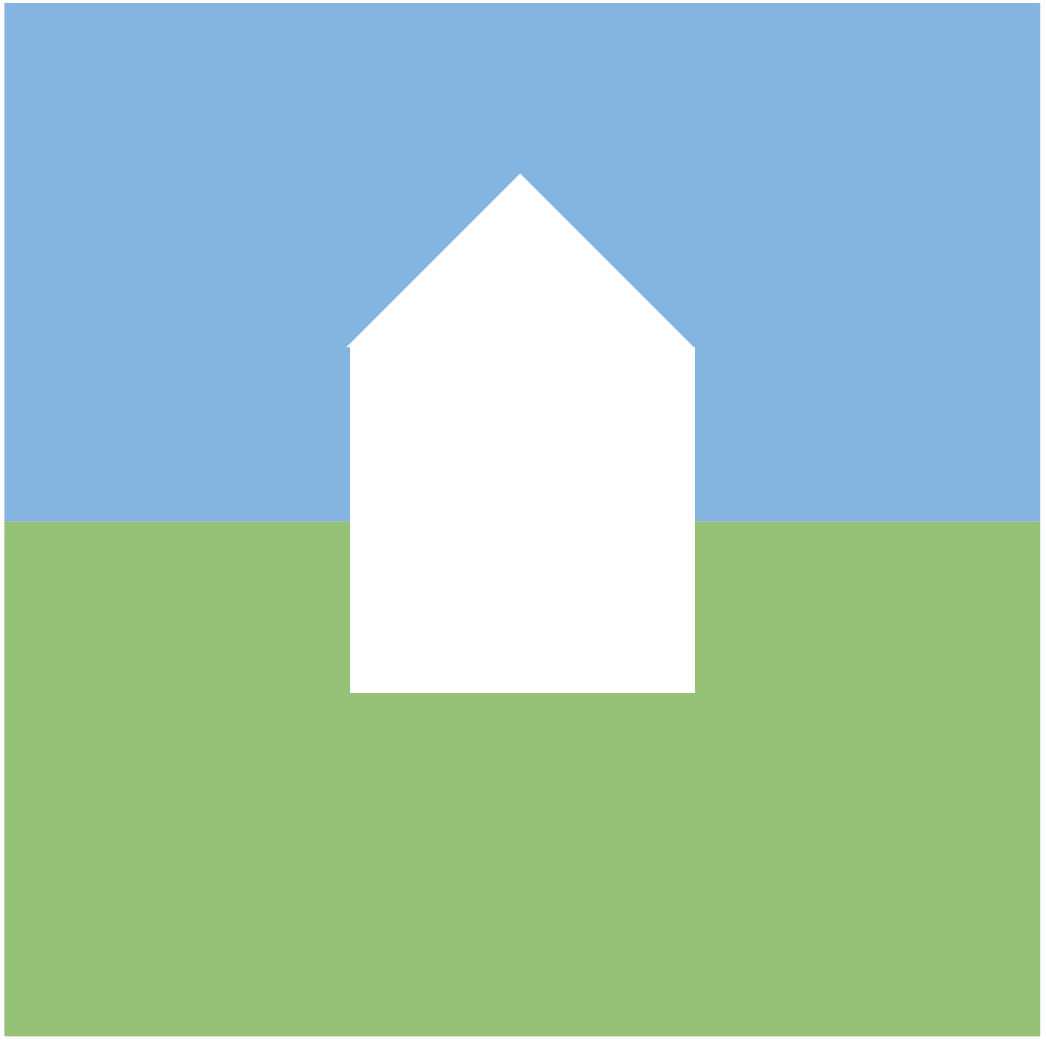

MARYLAND GREEN BUILDING COUNCIL

ANNUAL REPORT *2022*

December 2022

with

FINDINGS AND RECOMMENDATIONS ON SECTION 13 OF THE *MARYLAND CLIMATE SOLUTIONS NOW ACT 2022*

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The Maryland Green Building Council provides current and thoroughly researched information and advice on state green building issues to the Governor and General Assembly.

University of Maryland
School of Public Policy
77,000 square-feet
LEO A DALY, in association with VJAA
LEED Gold

Message from the Secretary

The Maryland Green Building Council and Department of General Services are pleased to submit this 2022 Annual Report to the Governor, General Assembly and citizens of Maryland. The report represents collective efforts and hard work of multiple Maryland agency participants and representatives of environmental, business and citizen interests who serve on the Maryland Green Building Council.

The council promotes creation of State of Maryland buildings and technologies that increase efficiency in use of energy, the sites on which they are placed, conservation of natural resources and in construction and operation.

The Maryland Green Building Council evaluates and promotes high performance building technologies and provides recommendations on those that are most cost-effective for use in design and construction of state facilities. The council provides recommendations on evaluation criteria for state facilities and means of expanding green building in the state.

These efforts align with efforts of other State of Maryland agencies to conserve the state's financial, natural and human resources.

In 2022, the Maryland Green Building Council made progress in *Changing Maryland for the Better* by positively influencing the creation of hundreds of thousands of square feet of new, energy-efficient facilities used for research, kindergarten through high school and higher education, and state offices.

Through the council's efforts, buildings constructed by the state, directly contribute to the health of the state's citizens, and create positive impacts on the state's economy and the environment.

Sincerely,

Ellington E. Churchill, Jr., Secretary
Maryland Department of General Services

Message from the Chair

We are at a time such that there is a confluence of energy efficiency, climate action, and infrastructure improvements. The Maryland Green Building Council is at the nexus for being able to move each of these issues forward in Maryland. I am happy for our accomplishments this year as we finetuned the *High-Performance Green Building Program.*

The Council has responded to requirements of the 2022 Climate Solutions Now Act. We look forward to following through to address additional requirements of the law and in cooperation with other agencies, boards and commissions in 2023.

Sincerely,

Cherise Seals, Chair,
Maryland Green Building Council

Summary

HOW GREEN BUILDING FITS WITH MARYLAND

The State of Maryland has long sought to protect and conserve our state's resources. This mission is a focus of nearly every agency in the state. With the Maryland Department of General Services' Maryland Green Building Council's efforts to promote the delivery of efficiently built and operated facilities, the department performs its role in advancing the state-wide conservation mission. The efforts dovetail with other state agency programs such as the Maryland Department of Agriculture's conservation practices and programs to balance crop and livestock production with protection of natural resources, the Department of Planning's Water and Sewerage Plan Facilities to assure adequate water and sewerage facilities will be provided to support planned redevelopment and growth as outlined in the Comprehensive Land Use Plan, the numerous programs of the Maryland Department of Natural Resources to conserve and enhance open space and Maryland Department of the Environment's efforts to clean and protect the state's surface waters, air and indoor environments.

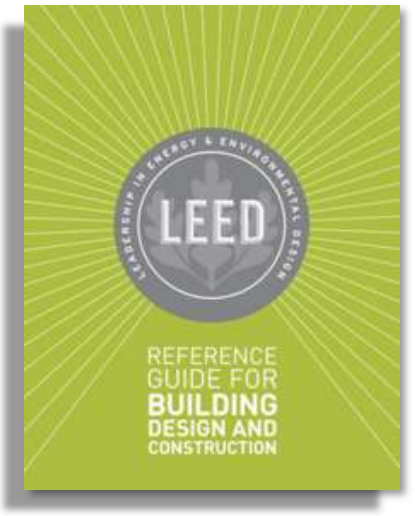
The Maryland Green Building Council (Council) was established in 2007 with *House Bill 942 – Section 4-809* of the State Finance and Procurement Article. The Council is within the Maryland Department of General Services (DGS). Its membership consists of private-sector representatives appointed by the Governor, representatives from key state agencies and staff support from DGS. The Council meets monthly and reports to the Governor and General Assembly annually.

Maryland *State Finance and Procurement Article Code Ann. § 3-602.1* (2014) requires that the State employ green building technologies when constructing or renovating State-owned buildings that meet specific criteria. To promote the technologies, the council established the *High-Performance Green Building Program*.

The *High Performance Green Building Program* applies to all State of Maryland agencies and local educational agencies (LEAs) that program, design and build facilities.

The *High Performance Green Building Program* also pertains to capital projects funded solely with State of Maryland funds, state-funded new and replacement school construction and community college capital projects receiving state funds.

The *High Performance Green Building Program* requires the use of one of three green building certification or rating programs in the design, construction and operation of facilities: LEAs must follow the Program but are exempt from certification requirements.



1. Leadership in Energy and Environmental Design (LEED), a program of the U.S. Green Building Council
2. *International Green Construction Code* (IgCC), one of the many codes of the International Code Council
3. The Green Globes protocol of the Green Building Initiative.

GREEN BUILDING IN MARYLAND IS BECOMING THE NORM

What was viewed as an anomaly for design and construction of State-owned facilities when the *Maryland High-Performance Green Building Program* was introduced in 2007 has become the norm in 2022. There is an increased awareness of the program among DGS staff, design and construction managers, consultants and customer agencies.

FUTURE CHALLENGES FOR GREEN BUILDING IN MARYLAND

One challenge for sustainable design and construction is that building codes and standards over the past decade have become more stringent. Initially, the tally of emissions produced by building and construction tended to include only operational emissions and excluded significant emissions from construction and demolition at the beginning and end of a project, which minimized the environmental impact of the sector. Now the focus is on adding operational and construction emissions, providing a more accurate picture. Achieving targets that exceed basic building code requirements may become more difficult in the future.

Future sustainability evaluation programs may question the very idea of construction of new facilities: no matter how energy-efficient a new building is, and how sustainable its materials are, it will never be as good for the environment as building nothing at all.

HOW GREEN BUILDING IN MARYLAND FITS WITH GLOBAL AND NATIONAL TRENDS

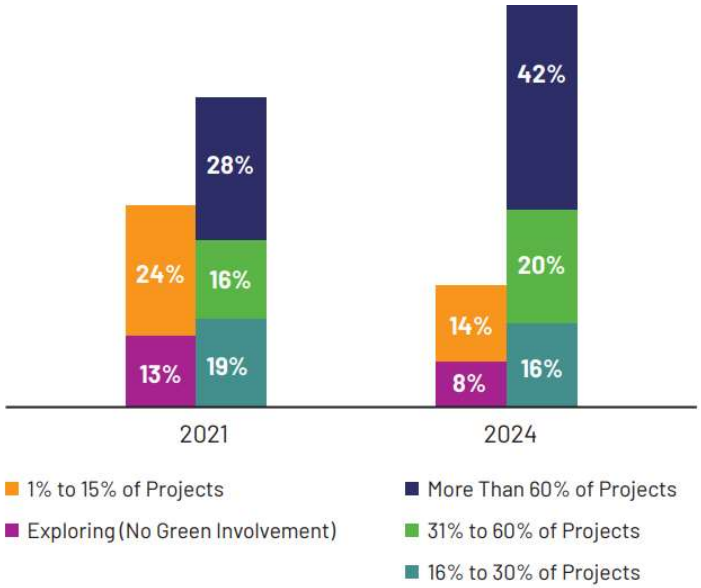
INCREASE IN GREEN CONSTRUCTION

The Dodge Data & Analytics and Carrier *2021 World Green Building Trends Study*[1] reveals global trends in a commitment to increasing green building. An increased level of growth is expected in the next three years. Findings indicate that green building continues to remain a global priority, driven in part by:

- Increase in regulations and financial incentives. rules and policy of government and other regulatory authorities.
- Increasing energy costs and a desire to reduce energy consumption,
- Social responsibility
- Improve indoor air quality
- Reduce waste
- Reduce water consumption
- Conserve and protect natural resources
- Desire to lower global greenhouse gas emissions and mitigate the effects of extreme weather

Findings demonstrate a compelling business case for building green:

- The average reduction in operating costs in the first 12 months for new green buildings is 10.5% and five-year operating costs savings is 16.9%.
- Green renovations and retrofits of existing buildings have even stronger performance globally at 11.5% and 17%, respectively.
- Owners report that new green buildings and renovation/retrofit projects increase the asset value of buildings by more than 9%.



MARYLAND'S POSITION NATIONALLY

The U.S. Green Building Council (USGBC) announced the ranking of its annual top ten states for construction of LEED-certified building square footage. Maryland ranks seventh in the nation. The rankings are for LEED certified programs only. Although likely a good indicator, rankings do not include use of other certification programs such as Green Globes or IgCC which may be used for design and construction of State of Maryland-owned facilities.

[1] Dodge Data & Analytics and Carrier *World Green Building Trends 2021 https://proddrupalcontent.construction.com/s3fs-public/WorldGreen-2021-SMR-29Oct.pdf*

MARYLAND GREEN BUILDING COUNCIL GOALS

The promotion of technologies and creation of energy efficient buildings throughout the State of Maryland remain priorities for the council. For state facilities, this includes achieving compliance with the *High-Performance Green Building Program*, promoting new green building technologies and developing criteria for high-performance buildings.

1. Existing Building Education
    a. Upgrade existing buildings for energy conservation
    b. Focus on how to improve performance of existing buildings
    c. Develop recommendations to improve efficiency of state leased facilities
2. Conduct Outreach
    a. Correlate Maryland Green Building Council initiatives with the governor's agenda.
    b. Engage with other, related state agencies
    c. Perform outreach at conferences and conduct seminars
    d. Assess effectiveness of the council through surveys and year-over-year *High Performance Green Building Program* use
3. Energy Efficiency Education
    a. Develop recommendations to measure energy and water use in existing buildings in order to guide upgrades and future facilities
    b. Highlight demonstration projects
    c. Assist in the establishment of state energy reduction goals
4. Financial Incentives
    a. Promote use of green building standards for private sector
    b. Recommend financial incentives for renovation of existing facilities

Green building construction employs environmentally sustainable materials, assembly techniques and control technologies to create facilities that conserve water, energy and other resources and provide healthy living, education, and workspaces.

Council Activities

HIGHLIGHTS

Through the past year, the Council worked to amplify our efforts and strengthen the relationships between the Green Building Council and other state agency committees engaged in complimentary efforts.

We participated in discussions with the Maryland Green Purchasing Committee, to establish procurement requirements and standards for more energy efficient building systems.

Council members participated in the Maryland Department of the Environment's Commission on Climate Change's report '*Decarbonizing Buildings in Maryland*'. The report recommended policy goals of achieving carbon neutral facilities in Maryland and outlines a path for achieving them. The report had a key, supporting role in the Climate Solutions Now Act 2022.

OUTREACH

Outreach and education are integral to the Maryland Green Building Council's mission. The council's Outreach Committee promotes green building principles among facility designers, builders, owners, investors, and managers. The stakeholders' awareness and acceptance of green building features begins with an understanding of how the features may benefit the projects. The Outreach Committee works to communicate these features' impacts on facility comfort, productivity, return on investment, and containment of operating expense and risk.

Ongoing efforts include delivery of presentations on the role of the Council and application of green building programs and technologies in state-funded facilities projects. Once again in 2022, the presentation was delivered at the Maryland Community College Facilities Planners Council. Other presentations describing how government policy initiatives promoting energy efficiency directly affect new facility design and promote resource conservation, have been delivered to college students.

John Shaw House, Annapolis
National Register of Historic Places and one of the State of Maryland's oldest facility assets – view from the State House dome.

ENERGY EFFICIENCY, EDUCATION AND EXISTING BUILDINGS

The Energy Efficiency and Existing Buildings Committee works with the Department of General Services to encourage State agencies to provide information on building use, square footage and energy consumption so that an inventory could be compiled of State buildings. While green building in new construction is important, the majority of the state's buildings are existing. Understanding the full complement of existing buildings can help state agencies prioritize green building upgrades in order to direct scarce and competing resources.

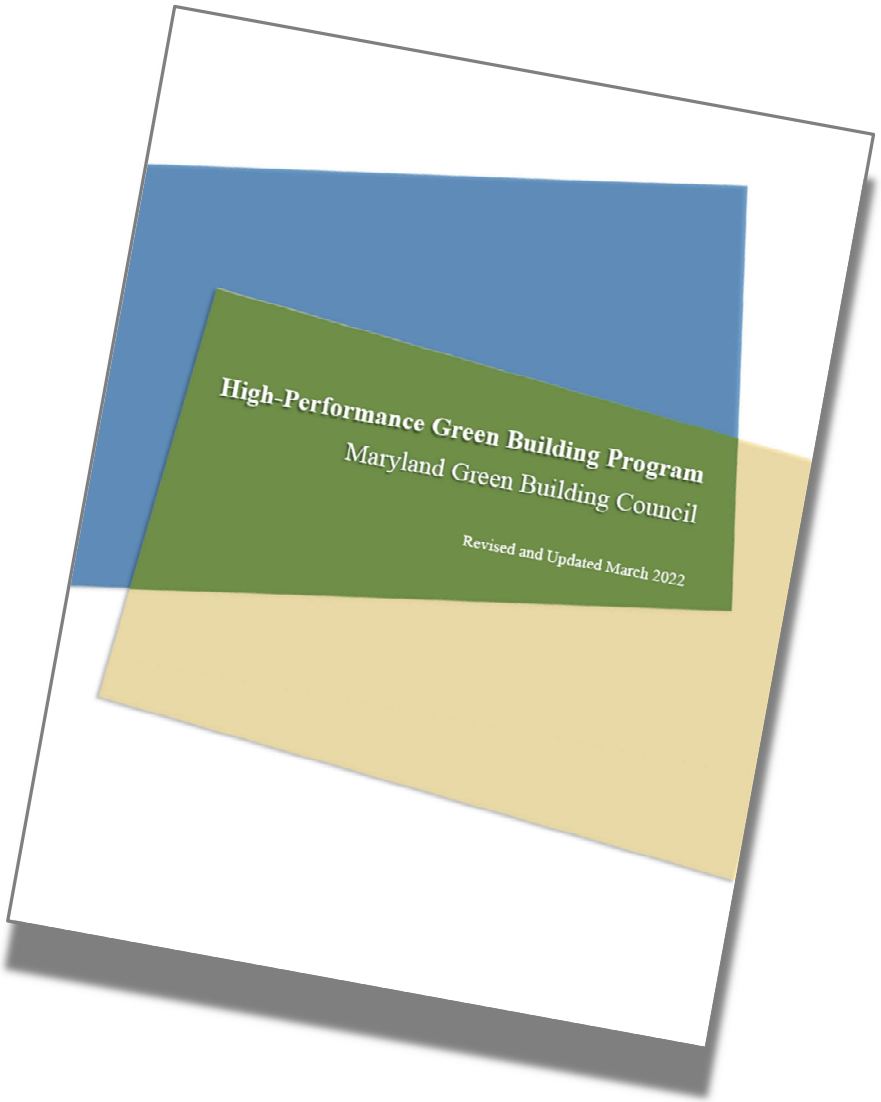
UPDATE OF THE HIGH-PERFORMANCE GREEN BUILDING PROGRAM 2022

The *High-Performance Green Building Program* applies requirements for high-performing buildings to projects funded solely with State of Maryland funds, state-funded new and replacement school-construction and community-college projects receiving state funds. The High-Performance Green Building Program requires the use of one of the three approved green building rating programs or codes in the design, construction, and operation of facilities:

4. Leadership in Energy and Environmental Design (LEED), a program of the U.S. Green Building Council;
5. *International Green Construction Code* (IgCC), one of the codes of the International Code Council; or
6. The Green Globes protocol of the Green Building Initiative.

The program was revised and updated for ease of use and to reference current codes and a clarified waiver process.

The updated version was made public, posted on 14 March 2022 and incorporated by reference to Maryland DGS contracts for facility design and construction.



Legislative Review

Each year, proposed legislation with potential impacts to building energy efficiency or sustainability are brought forth in Maryland General Assembly. The DGS Legislative Liaison assists the Maryland Green Building Council in tracking proposed legislation and provides input on them in the form of resolutions to the Secretary of the Department of General Services and Governor, testimony at hearings or through informal correspondence. During the 2022 session, the council reviewed several bills and provided recommendations.

2022 was a busy year for legislation related to green building. Most notable is the Climate Solutions Now Act and its far-reaching implications for the Maryland Green Building Council:

The Climate Solutions Now Act sets some of the most aggressive greenhouse gas (GHG) reduction goals in the country was passed by the Maryland General Assembly and was signed into law by Governor Hogan. The Council has taken up specific tasks and detailed work required to implement it.

The Climate Solutions Now Act (SB 528) requires the state to reduce total GHG emissions by sixty (60) percent from 2006 levels by 2031 and reach economy-wide, net-zero emissions by 2045.

The legislation lays out specific requirements for the commercial building sector. All existing commercial and multi-family buildings of 35,000 square feet or larger must begin reporting their direct GHG emissions in 2025, lower those emissions twenty (20) percent by 2030 and reach net zero by 2040. Some buildings and use types – such as manufacturing facilities and commercial kitchens – are

exempt from this requirement.[2] Specific requirements for state-owned facilities are being studied and recommendations will be made by Maryland Department of the Environment with DGS and Maryland Green Building Council input, to the governor and legislature by 1 December 2023.

Overcoming the technical and cost barriers to implementing the bill's provisions and achieving its goals will be an enormous task. SB 528 mandates the completion of more than two dozen studies on various aspects of implementation.

[2] NAIOP Maryland: https://www.naiopmd.org/news/climate-solutions-bill-presents-bold-goals-big-challenges/

2022 MARYLAND LEGISLATIVE ACTIVITIES RELATED TO THE MARYLAND GREEN BUILDING COUNCIL

Bill	*Name*	*Sponsor*	*Status*	*Maryland Green Building Council Response*
		Approved		
HB 133 SB 372	Environment – Coal Tar Sealant Products – Prohibitions (Safer Sealant Act of 2022)	Stewart Kagan	Enacted under Article II, Section 17(c) of the Maryland Constitution - Chapters 709, 710	
SB179	EPCs-Duration	DGS Departmental	B&T, APP Approved by the Governor, Chapter 247	
SB528	Climate Solutions Now Act of 2022	Pinsky	Enacted under Article II, Section 17(b) of the Maryland Constitution - Chapter 38	
		Failed		
HB 43	Department of General Services – Energy–Conserving Standards (Maryland Sustainable Buildings Act of 2022)			
HB171 SB135	Climate Crisis & Environmental Justice Act			
HB 61 SB 81	Charter Counties - Enforcement of Local Building Performance Laws (Building Energy Performance Standards Acto of 2022)			
HB365	Public School Construction-Fossil Fuel Energy-Based System Costs-Prohibition			
SB490	MD Recycling Act-Recyclable Materials & Solid Waste Stream			
HB 729 SB471	Facilitating University Transformations by Unifying Reductions in Emissions (FUTURE) Act			
SB494	MEA-Energy & Water Efficiency Standards			

Bill	*Name*	*Sponsor*	*Status*	*Maryland Green Building Council Response*
SB 588	Capital Projects - High Performance and Green Buildings			
HB 708	Comprehensive Climate Solutions			
HB 806	Building Standards and Emissions Reductions – High Performance, State, and Local Government Buildings, State Operations, and Eligible Projects			
SB 961	Public Projects – Global Warming Potential of Materials			
HB 1126 SB 854	Graywater Systems-Public & Private Buildings			
HB 1331	Coal Ash - Use, Recycling, and Management (Coal Ash Recycling Act of 2022)			
SB 627	State Building Code-Electric Vehicles			

Building Green in Maryland

PROJECTS REQUIRED TO COMPLY WITH THE HIGH-PERFORMANCE BUILDING ACT

These are projects that receive all their funding from the State of Maryland and therefore must meet the minimum requirements defined in the Maryland High Performance Green Building Program; of either USGBCs LEED Silver, 2 Green Globes or compliance with the *International Green Construction Code*.

Notable projects for which design or construction have been initiated or completed during the past year are included here. These facilities join a long, cumulative list back to the inception of the program in 2007.

Annapolis Post Office	LEED Silver (Minimum)	130,000 GSF $13,500,00	completed 2021
St. Mary's College Academic Building and Auditorium	LEED Silver (Minimum)	52,300 GSF $66,000,000	Construction underway anticipated completion 2022

Facility for the College's Music department, Educational Studies department, a learning commons study space, and a 700-seat auditorium.

Old Annapolis Post Office (above)

St. Mary's College Academic Building and Auditorium LEED Silver GWWO Architects with Graham Gund and Holder Construction Company (left)

GREEN BUILDINGS INDEPENDENT OF THE HIGH-PERFORMANCE BUILDING ACT

Although not required to do so, these facilities meet the minimum requirements defined in the Maryland High Performance Green Building Program of achieving either USGBCs LEED Silver, 2 Green Globes or compliance with the *International Green Construction Code*. Although most, but not all funding for these facilities may be from State of Maryland sources, they are exempt from the program requirements.

Notable projects that have either been initiated or completed during the past year are included here.

University of Maryland Baltimore Community Engagement Center	IgCC	20,000 GSF $ 9,000,000	Construction Complete

The renovated 1917 building located within the university's bio science research park in Baltimore, contains a large event space, a dance and movement studio, private clinical rooms, and computer lab. The project preserves elements of the original architecture, in an open atmosphere. It is among the first state-0funded facilities to be constructed using the International Green Construction Code (IgCC) to achieve its sustainability goals.

OTHER FACILITIES COMPLETED

Following HPGBP - University at Shady Grove Biomedical Science and Engineering Educational Facility - LEED Platinum Certified June 2020

Independent of HPGBP - University of Maryland Brendan Iribe Center for Computer Science and Engineering - constructed to MDGBC amended version of 2012 IgCC

New projects under HPGBP:

University of Maryland Center for Environmental Science Chesapeake Collaborative Building

University of Maryland MFRI Western Maryland Training Center

University System of Maryland at Shady Grove Biomedical Science and Engineering Educational Facility - LEED Platinum Certified June 2021

Baltimore City's First Net Zero Schools
Graceland Park/O'Donnell Heights & Holabird Elementary/Middle School
Grimm and Parker Architecture, Inc.
Achieved LEED Platinum in 2021

"Utilizing the sites as teaching tools, the schools will be equipped with student gardens, outdoor classrooms, rooftop solar labs, and vegetative roofs that further push innovation while intertwining sustainable concepts in education – staying true to their mission to nurture, engage, and empower the whole child for life-long excellence." *G+P*

FACILITIES IN PROGRESS UNDER THE HPGBP:

University of Maryland Southern Maryland Building #3 (LEED Silver expected)

Frostburg State University Education & Health Sciences Center (LEED Silver expected)

University of Maryland Eastern Shore School of Pharmacy and Health Professions (LEED Silver expected)

University of Maryland CMREC Headquarters (IgCC path)

University of Maryland Chemistry Wing 1 Replacement (LEED Silver expected)

Bowie State University New Communication Arts & Humanities Building (LEED Silver expected)

FACILITIES SEEKING CERTIFICATION INDEPENDENT OF HPGBP:

University of Maryland New Cole Fieldhouse (LEED Silver expected)

University of Maryland School of Public Policy (LEED Silver expected)

University of Maryland New Dining Hall (LEED Silver expected)

University of Maryland New Residence Hall (LEED Silver expected)

MARYLAND GREEN SCHOOL BUILDINGS

Collectively, the Maryland public schools program implements the greatest number of high-performance facilities in the state. In 2021, notable projects initiated or completed in the state will seek or have achieved LEED Silver and Gold certifications. A few will achieve net zero status. A net zero-energy building is a building with zero net energy consumption. This means the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created within the facility and on the site. Efficiencies are being achieved through implementation of efficient plumbing systems, smart monitoring and controls, photovoltaic solar and bioretention on site. In some circumstances, the systems used to conserve resources are made visible for incorporation into educational programs at the schools.

GREEN SCHOOLS STARTED OR COMPLETED IN 2022

PROJECT	RATING	LOCATION
Arnold Elementary School	Silver	Anne Arundel County
Baltimore City has started or completed 24 new facilities and major additions for high schools, elementary and middle schools.	Silver, Gold and Platinum	Baltimore City
Baltimore County has started or completed 16 new facilities and major additions for high schools, elementary and middle schools.	Silver and Gold	Baltimore County
Northern High School	Silver	Calvert County
Beach Elementary School	Silver	Calvert County
Career and Technology Center	Silver	Carroll County
Greensboro Elementary School	Silver	Caroline County
Gilpin Manor	Silver	Cecil County
New Chesapeake City Elementary School	Silver	Cecil County
Charles County has started or completed 4 new facilities and major additions for high schools, elementary and middle schools.	Silver	Charles County
North Dorchester High School	Silver	Dorchester County
Frederick County has started or completed 6 new facilities and major additions for high schools, elementary and middle schools.	Silver	Frederick County
Youth Benefit ES	Silver	Harford County
Havre de Grace MS/HS	Silver	Harford County
Joppatown Elementary School	Silver	Harford County
Howard County has started or completed 5 new facilities and major additions for high	Silver (4) Platinum (1)	Howard County

schools, elementary and middle schools.		
Montgomery County has started or completed 13 new facilities and major additions for high schools, elementary and middle schools.	Silver	Montgomery County
Prince George's County has started or completed 6 new facilities and major additions for high schools, elementary and middle schools.	Silver	Prince George's County
J. M. Tawes Center	Silver	Somerset County
Easton ES	Silver	Talbot County
Urban Educational Campus - BOE component	*	Washington County
Sharpsburg ES	Silver	Washington County
West Salisbury Elementary	Silver	Wicomico County
Beaver Run ES	Silver	Wicomico County

Graceland Park Elementary/Middle School
Baltimore City's First Net Zero, LEED Platinum School
PV Solar, Geothermal, Green Roof
Grimm and Parker Architects
CAM Construction
(Construction Completed September 2020)
Achieved LEED Platinum in 2021

Maryland Green Building Council Membership

The council includes members with an exceptional array of talents and technical knowledge necessary to advance the state's mission of promoting efficient and responsible facility development and operation. The members are passionate about conservation of our state's and global resources and translate that passion to actions that advantage the state. Composition of the council membership is mandated by statute. It consists of the secretary of select State of Maryland agencies or their designee.

General Services,
Budget and Management,
Department of the Environment,
Housing and Community Development,
Natural Resources,
Planning,
Transportation,
Maryland Energy Administration,
Interagency Committee on Public School Construction,
Chancellor of the University System of Maryland,

Six additional members of the council are appointed by the Governor to represent environmental, business, and citizen interests, one of whom has expertise in energy conservation or green building design standards. Terms of the governor-appointed members are two years each and are staggered, with half of the terms up for renewal every other year.

In addition to council members, several interested parties and individuals regularly attend meetings and provide essential, meaningful contributions. Meetings comply with the Maryland Open Meetings Act and are open to all. Despite public health assembly restrictions, the Council met on-line and once in person, monthly throughout 2022.

The council welcomes all its new members and thanks those who have moved on for their contributions.

Gubernatorial Appointees

Cherise Y. Seals, Chair
Maryland Green Building Council
Senior Business Development Manager
NORESCO, LLC.

Cherise Seals is a Senior Account Executive for NORESCO, an energy solutions provider, where she develops distributed generation, energy efficiency, and infrastructure improvements for institutional and governmental clients. She serves as an Advisory Committee member for the MD Clean Energy Center. Having a 25-year career in the energy industry, her experience spans engineering, sales, and business.

Cherise holds a BS in Electrical Engineering with Mathematics Minor from Virginia Tech, an MBA from Loyola University and has a Certified Energy Manager designation. A wife and mother of two, Cherise is a youth advisor and avid singer, plays tennis, writes plays, and serves as a mentor.

Michael Daly, Managing Principal
Architectural Support Group

As an architecture, engineering, and construction consultant Michael helps build better buildings. Buildings that are built using healthful materials that can be reused and remanufactured, that are designed to produce more energy than consumed, that have green roofs that create habitat, produce food and restore landscapes, that reclaim and filter storm water, integrate natural light and ventilation, and provide for a safe and comfortable environment. We've been doing this for over thirty years and are committed to a program and process that fosters creativity that is integrative and collaborative in nature, and that effectively engages all stakeholders in a process that is designed to produce the best possible outcome.

Marisa Britton, AIA Assoc. LEED AP BD+C,
Project Manager
Sustainable Design Consulting, LLC

Marisa Britton has over fifteen years of expertise in several facets of the building and design industry. Over the past ten years, she has focused on sustainable project management, resiliency, and net zero facilities. Her goal is to continue to emerge as a leader and educator in the industry.

Marisa holds a Bachelor of Architecture from the University of Miami.

Gubernatorial Appointees

Ryan Schwabenbauer, MBA, LEED AP, Director of Sustainability
Saint John Properties

Ryan leads St. John Properties mission to implement sustainable business initiatives that positively impact 40+ ongoing new construction projects and 20 million square feet of existing commercial real estate under management. He oversees strategies resulting in operational cost reductions and assures all future projects are LEED Certified. Advocating for the health and wellness of our 2,200 clients, St. John Properties is the regional leader with over 65 LEED certified buildings. Ryan holds a BS in Finance from Penn State University, an MBA from University of Baltimore and is a LEED Accredited Professional.

Stuart Kaplow, Esquire
Stuart D. Kaplow, P.A.
Sustainability & Green Real Estate Attorneys

Stuart represents a breadth of business interests in a varied law practice, concentrating in real estate and environmental law with focused experience in green building and sustainability.

Mr. Kaplow is a frequent speaker and lecturer on innovative solutions to the environmental issues of the day, including speaking to a wide variety of audiences on green building and sustainability. He has authored more than 700 articles centered on his philosophy of creating value.

Mr. Kaplow is a graduate of the University of Baltimore School of Law. He graduated with honors from the University of Maryland, Division of Behavioral & Social Sciences, with a Bachelor of Arts degree in land use planning.

Agency Representatives

Alex Donahue, Deputy Director for Field Operations
Interagency Committee on Public School Construction

Alex leads the Maryland IAC's field operations, coordinating the efforts of the IAC's regional facilities managers and school-facility assessment staff. Alex comes most recently from the National Council on School Facilities where he analyzed trends and best practices in school construction across the nation. He previously served as a principal and district administrator for a large public-school district.

Mark Beck, Director of Capital Planning and Sustainability
University System of Maryland

Mark coordinates capital budget, facilities and sustainability efforts of the System's twelve institutions.

Previously, Mark planned campus venues for the 2002 Winter Olympics at the University of Utah, and developed a capital facilities rebuilding program at Yale University. He has a master's degree in urban planning and was an adjunct professor of geography and urban economics.

Steven Allen, AICP
Maryland Historical Trust (MHT), part of the
Maryland Department of Planning

Steve Allan is a planner with the Maryland Historical Trust's Office of Planning Education and Outreach, where he works in hazard mitigation, technical assistance, comprehensive plan review and as staff to the Governor's Commission on Maryland Military Monuments. He previously served as point person for the LEED education program at the Maryland Department of Planning, having particular interest in green building practices in existing buildings.

Agency Representatives

Allan Fisher, Ph.D.
Deputy Secretary, Mission Support, Office of the Secretary
Maryland Department of Natural Resources

Fisher's experience includes guiding senior management teams throughout all business areas, including finance, human resources, management information systems, facilities, and project management.

In past roles, Fisher served as director of administration for the U.S. Nuclear Regulatory Commission, associate administrator for administration and chief financial officer of the U.S. Department of Transportation Federal Motor Carrier Safety Administration and chief financial officer and director of administrative services for the U.S. Equal Employment Opportunity Commission.

Eddie Lukemire, Program Manager, The Secretary's Office
Maryland Department of Transportation

Eddie leads the environmental stewardship, sustainability, performance and energy policies and programs across all MDOT transportation business units and the Maryland Transportation Authority. He oversees and coordinates environmental management activities in transportation planning, design, construction, operations, and maintenance. Eddie received his bachelor's degree in Environmental Science and Policy from the University of Maryland, and his master's degree in Environmental Science and Policy from the John's Hopkins University.

Christopher Russell, Program Manager, State Buildings & Energy Codes
Maryland Energy Administration

Chris brings over 25 years of energy industry experience to the Maryland Energy Administration, where he is the program manager for State Buildings and Energy Codes. He holds an M.B.A. and a Master of Arts degree from the University of Maryland and a B.A. from McGill University.

Publications that Chris has authored include "Managing Energy from the Top Down" and "North American Energy Audit Program Best Practices."

Agency Representatives

Laura Armstrong, LEED AP O+M
Director, Sustainability Program
Maryland Department of the Environment

Laura promotes sustainable business practices through technical assistance programs, demonstration projects and recognition programs. Technical services include on-site energy, water and waste reduction assessments and Environmental Management System implementation. She also manages the Maryland Green Registry, a voluntary program of more than 500 organizations across the state, which encourages members to share their environmental best practices through online profiles that highlight their successes and inspire others.

Ted Walsh, Office of Capital Budgeting
Department of Budget and Management

Ted is a budget analyst in the Office of Capital Budgeting. Responsible for capital projects with the Maryland Department of General Services, Project types analyzed include Judiciary, Military, Department of IT and Maryland Public Television.

Past professional experience includes roles as Research Associate at Lockheed Martin and Finance and Operations Manager for National Immigration Forum. He holds a Master of Public Policy from the University of Maryland, College Park and a Bachelor of Arts in Political Science from the University of South Carolina, Columbia.

Agency Representatives

Norman Wang, RA, Director of Maryland Codes Administration
Department of Labor, Licensing and Regulation

Norman leads the Maryland Building Codes Administration to fulfill several Maryland statutes mandated responsibilities, including (i) adoption of State building codes, (ii) administration of Maryland Industrialized Building Program, Maryland Accessibility Code, Minimum Livability Code, and (iii) providing training on building codes for local government employees.

Norman also represents the Department in several state-wide councils/committees, including Green Building Council, Maryland Building Rehabilitation Council, Maryland Resiliency Partnership, and Maryland Building Officials Association.

Norman is a registered architect in several states in US, including Maryland. He holds a Masters of Architecture Degree from the Ohio State University.

Stephen Lauria, Architect & Landscape Architect, LEEDap, Chief of Design,
Department of General Services
Maryland Green Building Council Staff
Maryland Hearing Accessability Board

Steve integrates facilities and infrastructure with their sites and communities through environmentally sensitive and sustainable solutions. For over thirty-five years, he has led strategic, facility and land-use planning, design and construction projects for government, mixed-use, higher education, water and wastewater, power generation, biomedical and pharmaceutical research, military and healthcare facilities.

Relevant board service includes a role on the Alexandria, Virginia Environmental Policy Commission in 1986, continued as president of a National Trust Historic District in Baltimore and chair of the advisory committee of the Baltimore Regional Transportation Board.

Key Participants

Martha Shrader, LEED AP-BD&C, Sustainability Manager
University System of Maryland
Facilities Management, P&C-Support

Ms. Shrader is a graduate of the University of Maryland College Park (UMD) with a BS in Natural Resource Management. She is currently the Sustainability Manager for the Facilities Management Planning and Construction Department at UMD where she provides technical support in the area of green design and construction. She has worked on multiple LEED certified projects in the University System of Maryland.

When not involved in green design and construction activities, Martha enjoys reading, walking, biking, yoga, and practicing and performing with Tagé on Steel, a steel drum band based in Hyattsville, MD.

Ellen Robertson, Legislative Liaison
Maryland Department of General Services,
Office of the Secretary

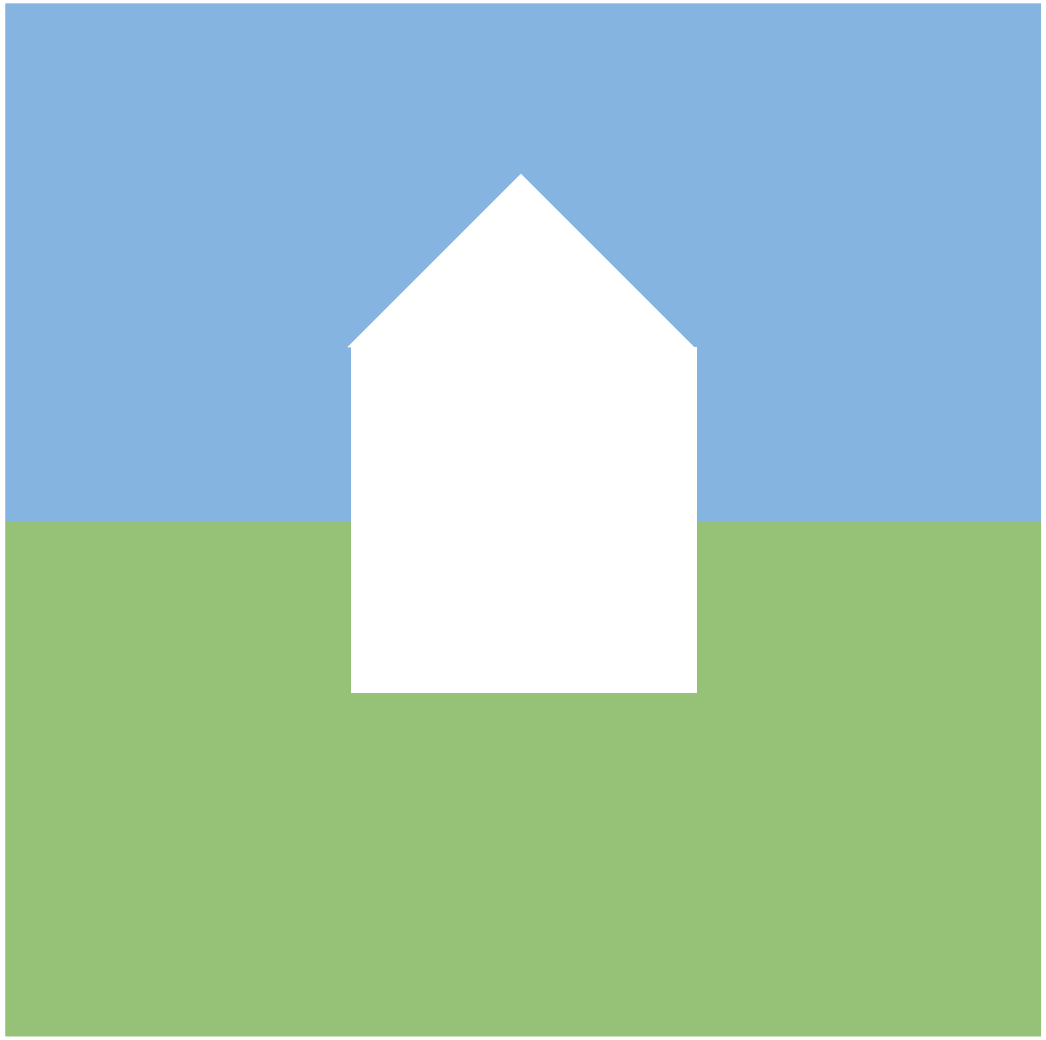
Ms. Robertson assists in identifying and reviewing legislation that may impact the work of the Green Building Council, as well as considering and implementing relevant policy. She provides invaluable guidance for content of the council comments on legislation or action the council should consider.

Cindy Guo
Mount Hebron High School
Ellicott City, Maryland

Ms. Gou's experience with the Applications and Research Laboratory, Architectural Design Academy and Independent Research for a Green Architecture Research Project provided key expertise for her support of the Maryland Green Building Council.

In a summer internship with the Council, in 2022, she conducted research, direct outreach and organization of public participation for the Council on use of low-carbon concrete in the state. Her work is an important element of the *Maryland Green Building Council Finding and Recommendations on Section 13 of the Maryland Climate Solutions Now Act 2022* now under review by the governor and legislature.


CHANGING
Maryland
for the Better



MARYLAND GREEN BUILDING COUNCIL

FINDINGS AND RECOMMENDATIONS ON SECTION 13 OF THE *MARYLAND CLIMATE SOLUTIONS NOW ACT 2022*

December 2022

Larry Hogan
Governor

Boyd K. Rutherford
Lt Governor

Maryland
DEPARTMENT OF GENERAL SERVICES

Ellington E. Churchill, Jr.
Secretary

Nelson E. Reichart
Deputy Secretary

OFFICE OF THE SECRETARY

December 1, 2022

The Honorable Larry Hogan
Governor

Re: DGS Report on Climate Impact of Concrete Procured
Senate Bill 528, Chapter 38 Laws of 2022, Section 13

Dear Governor Hogan:

In accordance with Senate Bill 528, Chapter 38 Laws of 2022, Section 13, the Maryland Green Building Council of the Department of General Services was tasked to examine:

(1) the use of environmental product declarations to measure the climate impact of concrete procured by the State;
(2) the use of performance incentives to encourage adoption of low–carbon materials and methods by concrete manufacturers that provide concrete for State–funded projects;
(3) the establishment of an expedited product evaluation, testing, and approval protocol for low–carbon concrete products;
(4) the implementation of performance–based specification standards for concrete, including requirements that a structural material achieve specified performance–based outcomes from the use of structural material, including outcomes related to strength, durability, permeability or other attributes related to the function of building material for applied uses; and
(5) the use of methods of compliance, including maximum cement content specifications and specifications based on maximum potential for global warming.

In examining the items above, the Maryland Green Building Council shall consult with:
(1) any relevant associations that set industry standards for the procurement of low–carbon concrete;
(2) affected contractors and subcontractors to consider both environmental and health and safety impacts.

On or before December 1, 2022, the Maryland Green Building Council shall report its findings and recommendations to the Governor and, in accordance with § 2–1257 of the State Government Article, the General Assembly.

301 West Preston Street
Baltimore, Maryland 21201
(410) 767-4960
FAX (410) 333-5480

Toll Free 1-800-449-4347
email: Ellington.Churchill@maryland.gov
email: Nelson.Reichart@maryland.gov
TTY users 1-800-735-2258

Please feel free to contact Steve Lauria, DGS Office of Design, Construction and Energy at Steve.Lauria@maryland.gov or 410-767-4163 if you have further questions.

Sincerely,

Ellington E. Churchill, Jr.
Secretary

Attachment

c: The Honorable Bill Ferguson, President of the Senate
The Honorable Adrienne A. Jones, Speaker of the House
The Maryland General Assembly
Sarah Albert, DLS Library
Steve Lauria, DGS DCE
The Maryland Green Building Council
Ellen Robertson, DGS Legislative

Summary of Maryland Green Building Council

HOW GREEN BUILDING FITS WITH MARYLAND

The State of Maryland has long sought to protect and conserve our state's resources, a focus for nearly every agency in the state. Through the Maryland Department of General Services (DGS) Green Building Council's efforts to promote the delivery of efficiently built and operated facilities, DGS performs its role in advancing the state-wide conservation mission.

The Maryland Green Building Council (Council) was established per Chapter 116, 2007 Maryland Laws, (House Bill 942), effective June 1, 2007. The Council is housed within DGS and consists of private-sector representatives appointed by the Governor, representatives from key state agencies, and DGS staff support. As required by Chapter 589, 2014 Maryland Laws, (House Bill 207) effective October 1, 2014, the Council established the *High-Performance Green Building Program* to promote green building technologies when constructing or renovating State-owned buildings.

Requirements Addressed

REQUIREMENTS OF THE MARYLAND CLIMATE SOLUTIONS NOW ACT- 2022 FOR THE MARYLAND GREEN BUILDING COUNCIL

Per Chapter 38, 2022 Maryland Laws (Senate Bill 528), effective June 1, 2022 this report addresses the Council's recommendations "on specified items relating to the procurement of concrete by the State; and generally relating to climate change impacts and measures to combat climate change impacts.".

The Council was charged with the following:

(a) examining:

(1) the use of environmental product declarations to measure the climate impact of concrete procured by the State;

(2) the use of performance incentives to encourage adoption of low–carbon materials and methods by concrete manufacturers that provide concrete for State–funded projects;

(3) the establishment of an expedited product evaluation, testing, and approval protocol for low–carbon concrete products;

(4) the implementation of performance–based specification standards for concrete, including requirements that a structural material achieve specified performance–based outcomes from the use of structural material, including outcomes related to strength, durability, permeability or other attributes related to the function of building material for applied uses; and

(5) the use of methods of compliance, including maximum cement content specifications and specifications based on maximum potential for global warming.

(b) In examining the items under subsection (a) of this section, the Maryland Green Building Council shall consult with:

(1) any relevant associations that set industry standards for the procurement of low–carbon concrete; and

(2) affected contractors and subcontractors to consider both environmental and health and safety impacts.

Examination and Recommendations

The following sections address the requirement to examine various aspects of concrete, its procurement by the State of Maryland, tools to measure their environmental impact and execution procedures.

(a) 1] USE OF ENVIRONMENTAL PRODUCT DECLARATIONS TO MEASURE CLIMATE IMPACT OF CONCRETE PROCURED BY THE STATE

As the world's most widely used construction material, concrete is also a key contributor to carbon dioxide emissions globally as a direct result of its production. The widespread use of concrete provides an opportunity for the State of Maryland to reduce its environmental impact through building and infrastructure development through the use of low carbon options. The State of Maryland could use environmental product declarations (EPDs) to measure the climate impact of concrete procured by the State.

A variety of existing and proposed legislation that regulates public procurement at the federal, state, and city levels requires the collection of EPDs in order to report the greenhouse gas (GHG) emissions associated with building material production, including resource extraction, transportation, and manufacturing.

Initiated in 2019, the Buy Clean California Act requires contractors who bid on state infrastructure projects to disclose greenhouse gas emissions data for certain materials with an environmental product declaration (EDP). These materials include steel, glass, and concrete. Several other states and jurisdictions have now adopted this practice including Colorado; Oregon; Hawaii; New York State; Marin County, California; Austin, Texas; and Portland, Oregon. In 2021 the General Services Administration (GSA) began the Federal Buy Clean Initiative, which promotes the development of low-carbon construction materials and supports job growth in clean US manufacturing. In 2022, the GSA released amended requirements that tie concrete compressive strength to a maximum global warming potential (GWP) limit.[1] GSA has collaborated with the EPD Program Operators including the National Ready Mixed Concrete and ASTM International to develop these requirements.

A significant challenge for the State of Maryland is that currently no in-state concrete manufacturers have developed EPDs for their mixes. Most concrete producers already have the knowledge and experience manufacturing low carbon concrete mixes that have less Portland cement and high supplementary cementitious materials (SCM) content. EPDs do, however, allow for a quantitative comparison of mixes and their global warming potential measuring seven climate impact indicators, one significant category being GWP. GWP is significant as it is a direct measurement of embodied carbon, in a kilogram CO2 equivalent.

Typically, EPDs are valid for five years and are often referred to as a “nutrition label” for reporting the life cycle assessment of a

[1] https://www.gsa.gov/cdnstatic/Low%20embodied%20carbon%20concrete%20SOW%20language-Sept%202022.pdf

building material translating in a comparable data set, the product's environmental impact. If EPDs are used to compare concrete mixes, the functional units must be the same specified characteristic that affects concrete performance (e.g., air entrainment, unit weight, high early strength requirements, etc.).

There are many different types of EPDs, those that are internally verified, product specific, industry-specific, etc. An EPD can be used for multiple similar products from the same manufacturer and still count as a "product-specific" EPD. The GSA's requirements have adopted the most stringent type of EPD: Type III, which are product-specific and third-party reviewed. These EPDs use the NSF International's product category rule (PCR) for concrete, conforming with recognized standards.

Adding EPDs to the procurement process could increase the cost of concrete for the State but is likely to significantly increase costs for concrete suppliers, particularly small businesses. A recent survey found the first cost of a new single EPD was approximately $15,000. The actual cost may be significantly higher because the real cost is not producing the EPD, but rather supplying low carbon concrete. **Low carbon concrete with an EPD will cost the State more than concrete currently being used.**

EPDs can be tracked through Lifecycle Assessment (LCA) databases like OneClick and the Embodied Carbon in Construction Calculator (EC3 Tool), which includes over 24,000 concrete EPDs available for products manufactured in the USA and Canada. The EPDs are searchable and sortable by strength, location, manufacturer, plant, mix ID and most are concrete mix and batching plant specific.[2]

[2] https://www.carboncure.com/concrete-corner/concrete-epds-the-4-things-you-should-know/

(a) 2] USE OF PERFORMANCE INCENTIVES TO ENCOURAGE ADOPTION OF LOW–CARBON MATERIALS AND METHODS BY CONCRETE MANUFACTURERS THAT PROVIDE CONCRETE FOR STATE–FUNDED PROJECTS

The use of performance incentives could encourage adoption of low carbon materials and methods by concrete manufacturers that provide concrete for State funded projects.
Currently, there are discussions of utilizing EPDs for a comparison of products in terms of their greenhouse gas emissions, but there has been very little interest and little, if any, market experience in this realm. While the uptake of published EPDs from Maryland's building material manufacturers is starting – only a few unique products are currently in the EC3 Database – it's important to realize that this is concentrated in only a few industries at a handful manufacturing locations or batch plants.

Unlike steel, wood, or other materials that are shipped from a point source in a final finished form, concrete is a dynamic material. **Concrete can be modified to adapt to construction scheduling, and production, and overcome design challenges to facilitate efficient and timely construction**. Mix design changes and materials used can change while the project is underway to accommodate unanticipated, necessary, or desirable changes. Any procurement regulation would fundamentally preclude necessary flexibility during construction to offset delays by unforeseen events.

Providing financial assistance to manufacturers to facilitate the production of EPDs, and the reporting mechanism based on life-cycle analysis, will improve the state's ability to make purchasing decisions that align with state carbon reduction goals. It also ensures that small manufacturers and rural areas are not put at a competitive disadvantage and allow those areas to successfully participate and support rural carbon reduction goals.

The following recommendations are provided by the Council to incentivize the use of low-carbon materials and methods by concrete manufacturers:

1. Provide matching grant funds for smaller building material manufacturers in Maryland to produce product-specific Environmental Product Declarations. Since producing EPDs requires 12 months of data, funding should not be delayed so smaller manufacturers can begin collection immediately for disclosure requirements. The external costs for a single facility to produce EPD's is comprised of data collection and analysis costs (which is site and facility specific), EPD generation by a provider costs approximately $10,000 plus subscription fees, third-party verification costs ~$3,000 with ongoing annual maintenance fees of $2,000 per facility.

2. Fund a publicly accessible database of completed projects with embodied carbon, material type, and quantity data. The project's name, the project team members, and supplier/ manufacturer's names should be redacted. Product Category Rules and EPDs are regularly updated and need to be maintained to ensure fair comparisons between projects. The database should also include information such as the type(s) of the structural systems, the types of concrete applications, and the project location.

3. Set carbon reduction targets to incentivize project carbon performance. Setting a project-specific carbon budget can provide both the measurement against published industry averages and the ability for contractors to offset higher emitting materials with lower emitting materials in equal measure. Require quantifiable embodied carbon budgets and identify the baseline for measuring the budgets. In addition,

consider requiring quantifiable carbon reduction targets for operational carbon, such as obtaining energy use intensity targets below code-required levels as material decisions can affect operation carbon emissions.

Upon completion of the project, the project analysis shall calculate and summarize the resulting embodied carbon levels as achieved by the project.

a. If the project meets the published project carbon reductions or exceeds them, a bonus shall be paid to the project contractor material suppliers upon verification of the embodied carbon reduction as contributed to the project.

b. A standard bonus formula for exceeding embodied carbon reductions shall be determined and published by DGS and incorporated by the awarding agency into their state funded construction project specifications.

4. Reward Manufacturing and Transportation Reductions. Provide a financial and/or point bonus during bid award analysis for manufacturing facilities that have reduced manufacturing energy usage and process emission. This can be done through participation in programs such as Energy Star Plant Certification, the Concrete Sustainability Council, or conversion of diesel equipment and delivery trucks to either renewable diesel, natural gas options, or electric. Another way to consider performance incentives is to alter the target directing the incentive both at reducing the overall cost of the project and carbon:

    a. Eliminate off-street parking space minimums for projects that meet quantifiable carbon reduction targets. This addresses the issues of carbon in the construction of the project and carbon in the building operation. Eliminating parking will also create savings in project costs.

(a) 3] ESTABLISHMENT OF AN EXPEDITED PRODUCT EVALUATION, TESTING, AND APPROVAL PROTOCOL FOR LOW–CARBON CONCRETE PRODUCTS

The challenge for the State of Maryland is developing a policy that concrete suppliers can feasibly achieve in a reasonable timeline. Prior in this report, no in-state suppliers have EDPs on their concrete products. Until suppliers can feasibly pursue this data, embodied carbon cannot be quantified. The council provides the following recommendations to work with stakeholders to implement low-embodied-carbon requirements and adjust targets over time to help drive the market toward low-embodied carbon building:

1. Engage key stakeholders early, particularly structural designers and material producers.
2. Incrementally introduce embodied carbon into the codes.
3. Make compliance forms compatible with local supplier's mix documentation.
4. Require documentation at permit submission and again in construction phase/inspection.
5. Allow for a path of recourse if a noncompliant mix is poured (redoing concrete defeats the purpose of the low carbon code).
6. Support and educate architects, developers, and structural engineers during the code development, adoption, and implementation phases.
7. Develop public/private network for support needed to effectively implement.

The Carbon Leadership Forum (CLF) has created a Carbon Policy Toolkit — an array of resources to support the crafting of policies to radically reduce embodied carbon. The CLF recommends policymakers consider one of the following strategies to encourage harmonization and allow for the addition of eligible materials over time and HERE:

1. Request supply chain–specific EPDs with additional life cycle stages beyond A1-A3.
2. Require product specific EPDs and participate in PCR development to encourage the inclusion of upstream data and additional life cycle stages in PCRs.

For additional information on EPDs in Policy see HERE.
A material-scale approach is often limited to the impacts in the early stages of a product's lifecycle and to a handful of carbon-intensive materials, but this will change over time as the market adjusts and code continue to increase measures on climate impacts.

Components of concrete include:

- air (1.5%),
- cement (10 %),
- water (18.5%),
- fine aggregate (sand/crushed rock: 25%) and
- coarse aggregate (stone/gravel: 45%).

With the goal of reducing carbon during the production of concrete, the most practical method is to find ways to reduce the carbon generated in production of cement and when mixing concrete. Currently Carbon Capture Utilization and Storage is the most promising option to substantially reduce emission of CO2 in the production of concrete.

Through research and development by academics and the industry, new types of cement and new methods of concrete production have become available. For cement, Portland Limestone Cement is available which includes 10% more

limestone than common cement. Some manufacturers plan to switch to 100% PLS starting 2023, while other manufacturers use Ground Granulated Blast-furnace Slag in place of limestone to reduce the carbon quantity during production of cement. Alternative fuels are being used during cement production which can reduce carbon. Carbon generated from production can be removed from the atmosphere by using carbon capture technology.

New methods for manufacturing concrete have also been developed, including:

- A process of removing CO2 from creation of cement and injecting it into concrete during mixing.
- Using the CO2 from the exhaust stack of power plants to produce a synthetic aggregate that can be used to produce concrete. Through this process, CO2 from flue gas is converted to carbonated CO3, which permanently locks up the carbon.
- Production of concrete without cement, replacing cement with ground slag, a waste by-product of steel making. Concrete mix is cured with CO2captured from other sources. During curing, the gas becomes a solid, binding together with the slag granules, giving the resulted concrete its strength.
- Using a lower temperature, lower energy process, resulting in 30% to 40% less CO2 emissions during cement manufacture. The concrete cures with the wasted CO2 instead of water which permanently traps the CO2. The concrete cures in less than 24 hours compared to 28 days for traditional concrete.

Evaluation of the products made from the new methods or new components for their environmental impacts can be certified using the available EPD system, though it may presently be costly. New testing requirements may not be necessary since all concrete, regardless of traditional or low carbon, are required by building or other applicable codes to go through certain prescribed tests including the compression strength of the concrete. An approval system for use of low carbon concrete can be derived based on the evaluation system described above. A minimum score should be established during the evaluation. Once a new batch of low carbon concrete has been evaluated to obtain a score higher than the threshold, it can be approved for use in its planned application areas.

(a) 4] IMPLEMENTATION OF PERFORMANCE–BASED SPECIFICATION STANDARDS FOR CONCRETE, INCLUDING REQUIREMENTS THAT A STRUCTURAL MATERIAL ACHIEVE SPECIFIED PERFORMANCE–BASED OUTCOMES FROM THE USE OF STRUCTURAL MATERIAL, INCLUDING OUTCOMES RELATED TO STRENGTH, DURABILITY, PERMEABILITY OR OTHER ATTRIBUTES RELATED TO THE FUNCTION OF BUILDING MATERIAL FOR APPLIED USES

Since the 2014 update to ACI 318, Building Code Requirements for Structural Concrete and Commentary, moved toward performance-based concrete specifications, it has become easier for jurisdictions to facilitate the ability to use some of the advances in low-carbon concrete. This has allowed multiple jurisdictions as well as the Federal Government to proceed with legislation to provide language, requirements, and specification samples for the implementation of low-carbon concrete.

In 2019, the Marin County, California Board of Supervisors adopted requirements for performance specifications and provide samples of specification sections. Marin County developed their performance thresholds through an involved stakeholder process, resulting in four pathways of compliance. Two of the pathways are 'cement limiting' mainly directed for use by small scale projects (i.e., residential) while the other two pathways are a performance metric, tying the embodied carbon limits to the compressive strength of the mix. Refer to Table 19.07.050 of the Marin County Low Carbon Concrete Code below.

	Cement limits for use with any compliance method 19.07.050.2 through 19.07.050.5	**Embodied Carbon limits** for use with any compliance method 19.07.050.2 through 19.07.050.5
Minimum specified compressive strength f'_c, psi (1)	Maximum ordinary Portland cement content, lbs/yd³ (2)	Maximum embodied carbon kg CO_2e/m^3, per EPD
up to 2500	362	260
3000	410	289
4000	456	313
5000	503	338
6000	531	356
7000	594	394
7001 and higher	657	433
up to 3000 light weight	512	578
4000 light weight	571	626
5000 light weight	629	675

Notes
(1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits.
(2) Portland cement of any type per ASTM C150.

For jurisdictions interested in adopting a similar ordinance, the Marin County site includes a link to a 'Code Amendment Toolkit'[3]. Additionally, their sample non-residential specification section includes compliance forms and multiple paths for compliance.[4] Marin's Development and Adoption Process highlights the considerations, challenges, and studies they conducted to develop their policy.[5]

In 2022, the Federal government adopted low embodied carbon concrete for all GSA projects. The GSA required all projects to select mixes that complied but did offer a waiver which addresses concrete suppliers within the maximum transport range for the mix design. This may include small businesses that have not yet invested in EPDs, or the mix needed does not meet

[3] https://www.marincounty.org/depts/cd/divisions/sustainability/low-carbon-concrete

[4] https://www.marincounty.org/-/media/files/departments/cd/planning/sustainability/low-carbon-concrete/12172019-update/sample-nonresidential-specification.pdf?la=en

[5] https://www.stopwaste.org/sites/default/files/MarinLCCCProcessSummary2021.pdf

the GSA's embodied carbon limits due to client-driven performance requirements, or lower-carbon materials are unavailable.

Consideration should be given to:

1. Making compliance forms compatible with local supplier's mix documentation.
2. Require documentation prior to issuance of permit and prior to approval of inspections following concrete placement.
3. Forms of recourse available if noncompliant mix is poured (redoing concrete defeats the purpose of the low carbon code).
4. Support & education available to architects, developers, structural engineers during the code development, adoption, and implementation phases.
5. development, adoption, and implementation process.
6. Develop public/ private network for support needed to effectively implement.
7. Early engagement of local suppliers for feedback.

New York State has also adopted similar performance specifications for low-carbon concrete. The language adopted in April 2022 follows.

Covered Materials and Products

Concrete for use in buildings as well as horizontal (roadways and infrastructure) (1) including modular units such as Concrete Masonry Units (CMU) and Concrete Brick.

Goal

To inform through this guidance document how Design Professionals (Architects or Engineers of Record) specify concrete, in a way that builds upon current market capabilities, practices, and available materials, so that we dramatically reduce the embodied carbon burden of the entire building industry.

Background

To achieve the GHG reduction goals of the Climate Leadership and Community Protection Act the State needs to reduce the embodied carbon in our built environment. Concrete includes use of cement, which yields approximately 0.9 pounds of carbon emission equivalents CO2e) for each pound of cement produced.

Standard Setting and Certifying Programs

EPDs [3]: Type III declaration that quantifies environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function. The EPD methodology is based on the LCA tool that follows ISO series 14040 (from ISO 14025).
CMU and Concrete Bricks:
1. Provide Industry EPDs when available.
2. Consider reduced-profile web design per ASTM C-90.
3. Reduce cement content using guidance above. This may require additional additives to affect a cure-time that allows release from any molds with the planned pre-cast timeframe.
Entities are encouraged to consider the following (no order of priority):

- Maximize SCM percentage while still meeting performance requirements
- Extend cure-time to 56 days for designed strength

- Consider sourcing from an Energy Star Certified Industrial Plant (note there are currently none listed in NY
- state)
- Expose structural concrete as finish material to reduce additional material layers
- Ensure "right-sized" structural elements
- Use alternate structural components (e.g., mass timber)
- Apply Carbon Capture, Utilization, and/or Storage (CCUS) in tandem with additional cement reduction
- Include anticipated life of project in defining embodied carbon goals

Take-Back/ Recycling
Affected entities are encouraged to:

- Limit "attic stock" when purchasing modular units.
- Develop a plan for a design and responsible on-site use of any overage from concrete mixer trucks or on-site mixing processes

Disposal
If materials are being transferred for disposition, a record of each disposition shall be retained by the affected entity. Documentation shall be provided to the affected entity demonstrating that these products have been disposed of or beneficially reused in an environmentally sound manner in compliance with applicable local, state, and federal laws. Related to pre-cast units, such as CMU, the contractor or disposing party shall provide assurance to the affected entity that all exports of used materials collected for reuse, recycling, or disposal will comply with the laws of the importing country.

Packaging

Packaging shall comply with Environmental Conservation Law section 37-0205. Packaging shall not contain inks, dyes, pigments, adhesives, stabilizers, or any other additives to which any lead, cadmium, mercury, or hexavalent chromium is intentionally added or contain incidental concentrations of lead, cadmium, mercury or hexavalent chromium which together are greater than 100 parts per million by weight (0.01%).

New York State encourages affected entities to adopt the following:

- The use of bulk packaging.
- The use of reusable packaging.
- The use of innovative packaging that reduces the weight of packaging, reduces packaging waste, or utilizes
- packaging that is a component of the product.
- That all packaging remains the property of the supplier and not become the property of the affected state entity under any circumstance or condition. The vendor shall certify that the packaging material will be reused, recycled, or composted, and managed in compliance with applicable local, state, and federal laws.
- Packaging that maximizes recycled content and/or meets or exceeds the minimum post-consumer content level for packaging in the U.S. Environmental Protection Agency Comprehensive Procurement Guidelines.
- Packaging that is recyclable or compostable.

In addition to these jurisdictions, multiple manufacturers have provided low-carbon concrete specifications or inserts.[6]

(a) 5] USE OF METHODS OF COMPLIANCE, INCLUDING MAXIMUM CEMENT CONTENT SPECIFICATIONS AND SPECIFICATIONS BASED ON MAXIMUM POTENTIAL FOR GLOBAL WARMING

Consideration should be given to what is both feasible and impactful in the State of Maryland, including but not limited to resources to support industry transitions, trainings, and maintain sensitivity to the industry and their ability to accommodate change.

[6]EPDs were developed to know the content of concrete without having to directly test all concrete being used . It seems that the key components of a state system to regulate carbon content in concrete would be:

1. Standards for GWP such as the examples shown.
2. A requirement for EPDs for concrete produced by producers.
3. Requirements for certification of the carbon content of any concrete used by builders and/or owners of projects; etc.

The State of Maryland could also consider other components for a regulatory system, such as an offset.

	Maximum Global Warming Potential Limits for GSA Low Embodied Carbon Concrete (kilograms of carbon dioxide equivalent per cubic meter - CO_2e kg/m^3)		
Specified compressive strength (f'c in PSI)	**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 (CO_2e) limits in proposed code language: "Lifecycle GHG Impacts in Building Codes" by the New Buildings Institute, January 2022.			

[6] Link to more information on the GSA low-embodied carbon policy for concrete: https://www.gsa.gov/cdnstatic/Horn_GBAC_Embodied%20Carbon.pdf

Recommendations[7]:

PATH 1: Specify the MAXIMUM CEMENT CONTENT
Develop a standard three-part specification with clauses to limit cement content. The standard specification would incorporate requirements indicated:

PART I – GENERAL.

DEFINITIONS
Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, slag cement, and silica fume; subject to compliance with requirements.
[Carbon dioxide mineralization: Active carbonation treatment of concrete during mixing such that the carbon dioxide (CO2) that is injected during mixing is mineralized (i.e., chemically converted into a mineral) within the concrete.]
[Carbonation treatment: Active introduction of CO2 into the concrete pore fluid which reacts with calcium from calcium hydroxide and calcium silicate hydrate to form calcite (CaCO3).].

SUBMITTALS
Design Mixtures: Each concrete mixture design to be used on the project shall be reviewed and approved by the Testing Agency and Structural Engineer prior to concrete being delivered to site.
Submit proposed mixture designs for each class of concrete. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
Contractor shall supply a Reduced Carbon Concrete Compliance Form (Cement) to the project architect within 6 weeks after completion of concrete work on the project. The mixture design number listed on the Reduced Carbon Concrete Compliance Form must match the mixture design number shown on the proposed mixture design.

Product Test Reports and Certificates
Cementitious materials, per ASTM C150, ASTM C595, ASTM C618, ASTM C989, and/or ASTM C1240, as applicable.
Carbon dioxide mineralization: Provide concrete producers certificate verifying mineralization of carbon dioxide. Include quantity, location, and supplier of injected CO2.

PROJECT GOALS AND BIDDING REQUIREMENTS
Alternate Concrete Mixtures Plan: The contractor's plan for meeting the project goals with alternate concrete mixtures shall include (for each type of concrete), proposed mixture designs, an analysis and narrative on the expected set time, temperature, strength gain, maturity testing, [stressing time,] [stripping time,] shoring and re-shoring, cost and schedule impacts, for both the specified mixture proportions and materials, and for the proposed alternate. ▪

Contractor shall supply a revised Reduced Carbon Concrete Compliance Form for each proposed alternate that shows cement use in each alternate concrete mixture is less than the cement limit for the mixture. Multiple alternate mixtures may be provided on one form.

If contractor chooses to use an absolute project total instead of limits for each mixture, contractor shall supply a revised Reduced Carbon Concrete Compliance Form for each proposed

[7] https://www.marincounty.org/-/media/files/departments/cd/planning/sustainability/low-carbon-concrete/3-balccdraft-sample-specs-clauses-and-forms.pdf?la=en

alternate that shows the total project cement use in concrete is less than the maximum allowable cement use in concrete.

PART 2 – PRODUCTS

CONCRETE MATERIALS
Supplement Portland Cement with the following Supplementary Cementitious Materials (SCM):
Fly Ash: ASTM C618, Class F.
Slag Cement (Ground granulated blast furnace slag – GGBSF): ASTM C989, Grade 120.
Silica Fume: ASTM C1240, Standard Specification for Silica Fume Used in Cementitious Mixtures.
High-Reactivity Metakaolin: ASTM C618, aluminosilicate pozzolan.
Cementitious material used shall have at least [2][X] years of use with proposed aggregates without detrimental reaction based on testing to ASTM [C1260 or C1567].
Carbon dioxide mineralization: [ASTM XX] Carbon dioxide in the mixture must be postindustrial CO2 sourced from an emitter within [X] miles from the injection site.

CONCRETE MIXTURES
Definition of Mixture Properties:
[Drying shrinkage limit is percentage change in length after 28 days of drying when tested as per ASTM C157 with 4 inches x 4 inches x 11 inches specimen moist cured 7 days prior to drying.]
Supplementary Cementitious Materials (SCM): Use fly ash, pozzolan, ground granulated blast furnace slag, and silica fume as needed to reduce the total amount of Portland cement, which would otherwise be used, as noted within this specification. If the cement content of a mixture exceeds the allowable cement content per Reduced Carbon Concrete requirements, demonstrate through the Reduced Carbon Concrete Compliance Form that the total cement used on the project is less than the total allowable for the project.

For each specified mix, indicate the require structural performance and percentage of cement allowed.

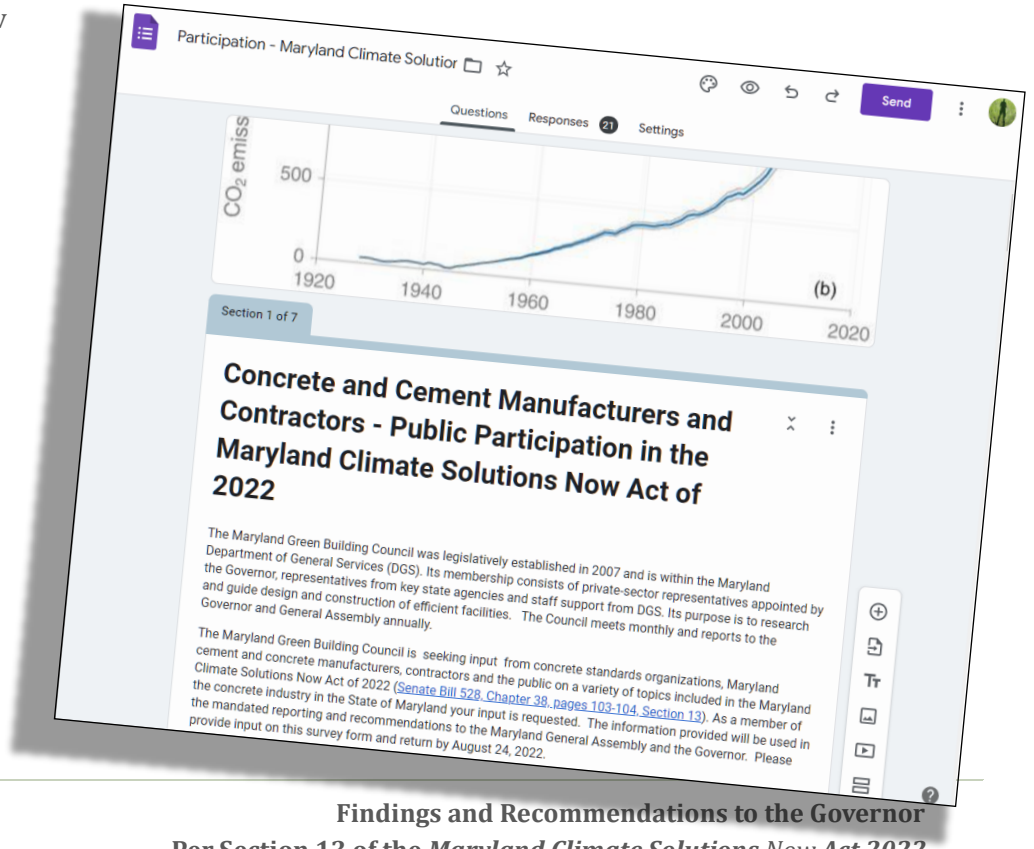
(b) 1], 2] ENGAGEMENT OF RELEVANT ASSOCIATIONS THAT SET INDUSTRY STANDARDS (E.G. AMERICAN CONCRETE INSTITUTE, ASTM INTERNATIONAL, FORMERLY KNOWN AS AMERICAN SOCIETY FOR TESTING AND MATERIAL, ETC.) AND AFFECTED CONTRACTORS AND SUBCONTRACTORS AND MANUFACTURERS

Per Chapter 38, 2022 Maryland Laws (Senate Bill 528), effective June 1, 2022 the Maryland Green Building Council solicited input from concrete standards organizations, Maryland cement and concrete manufacturers, contractors, and the public on the variety of topics included in the Maryland Climate Solutions Now Act of 2022.

Input was solicited through Maryland Green Building Council monthly public meetings and directly through outreach using direct calling, email, and Google Forms sent to relevant entities. Forms included a variety of questions on topics required by legislation. The survey schedule was as follows:

1. 11 August 2022: Survey distribution
2. 24 August 2022: Receipt of comments
3. Autumn 2022: Compilation of responses and report to governor and legislature

Although input was requested on the survey form by August 24th 2022, Input was accepted as late as October 17th 2022. Twenty-one responses were received.



SURVEY AND RESPONSES

Section 1, a.]
Does your company use or create EPDs for each product created and/or sold? (e.g. mix, precast)

1. No - we are a general contractor
2. We are attorneys who draft the specs for the industry, and No in Maryland. There is some limited use of national industry standard EPDs in Maryland, but it is very limited.
3. ASTM International has EPDs but is not currently actively involved in producing them
4. No-ish. Only when required by and for the specific project.
5. N/A
6. No. PCA is an industry association of cement manufacturers, but we do not produce any cement ourselves. We help our members create industry-wide EPDs for some products (cements), but do not have enough data for all products. Some of our members do have product-specific EPDs.
7. yes
8. No, but we are in the process of doing and expect to be done by end of year.
9. yes

10. No
11. Yes, for bulk and packaged cement products (Type III EPD) and slag cement (industry-average EPD).
12. No, only selected items
13. No
14. We use and create EPDs for select mixes produced at select ready mix concrete plants. We have plans to expand their use to all plants.
15. Participated in Industry Wide Generic Concrete EPD.
16. Yes
17. We do not have mix-specific EPDs. We did participate in NRMCA's industry-wide EPD
18. yes
19. No.
20. Yes
21. No

Section 1, b.]
How does or would creation of an EPD affect total costs of a product manufactured or sold by your company?

1. N/A
2. It would increase costs. There would be a plant base cost and then a cost for each product, including each mix with any one of a number of additives, that would arguably change seasonally.
3. ASTM International does not produce or sell concrete or cement
4. The cost for the EPD's are included in the project cost and passed along to the customer that is requesting them.
5. No cost
6. N/a
7. 5%
8. It would increase the costs slightly.
9. yes

10. It would definitely be an added cost

11. During the creation of an EPD, there were three external costs incurred: an LCA consultation fee, a program operator fee, and a project manager tasked with handling environmental data, marketing communications, and sustainability aspects of the process. Internal resources must also be considered, and Lehigh estimates 100-120 professional man-hours for cement EPD development and 40 man-hours for development of concrete EPDs. The consultant and program operator cost can total $5,000 for members of the Global Cement and Concrete Association, where calculation tools were developed early on for the North America cement and concrete Product Category Rules (PCRs).

12. Increase about 2 to 3 percent

13. Increase costs

14. There are administrative costs to generate EPDs as well as to audit and track the varying components in each mix. We estimate the cost of an EPD could potentially add 1-3% to the cost of concrete.

15. Increased regulatory burden with negligible value or impact on product quality always adversely impacts costs. Increased costs would be directly passed on to individual projects. Costs are indirectly passed on to all taxpayers. Ultimately inflated costs for individual projects limit the number of necessary infrastructure projects that can be completed within constraints of capital budgets,

16. varies

17. Mix specific EPDs require a significant one-time expense, as well as significant ongoing expenses that would be passed on to the consumer

18. NA

19. N/A

20. It wouldn't

21. I understand it is very expensive and needs to be created individually for each facility.

Section 1, c.]
Is a product EPD useful in comparing one product to another? (e.g., comparing concrete of different strengths and for varying uses).

1. Yes- primarily for comparing environmental impact of different mix designs from different suppliers. We present this data to clients along with cost to allow our clients to make the most informed decisions for their program or building priorities

2. No because there is no standardized EPD.

3. I think that's the point

4. No. The comparison is irrelevant because the project specifications dictate the actual mix design.

5. It can be if the same product category rule is used but in many cases PCRs have not been developed so different products adopt different PCRs

6. No. EPDs can compare concrete mixes for a single strength/application. Comparing a mix designed for 3000 psi to one designed for 4000 psi, or for the same strength but different applications (e.g. interior floor slab vs. a bridge deck) are not valid uses of EPDs.

7. yes

8. No. In the same way that buying a cheap pair of shoes, means they be less comfortable and need to be replaced sooner. EPD's do not capture the TOTAL environmental impact

9. yes

10. Not particularly for most of our customers

11. Possibly, but with conditions. Such a comparison makes sense amongst, for example, three 3,500 PSI @ 28 day28 day concrete mixes from different producers. However, a comparison is not valid when comparing products of different strengths (e.g., a 3,500 PSI mix and a 4,500 PSI mix) and certainly is not valid for comparing concrete with a different construction material (i.e., concrete vs. asphalt, wood or steel). It is also important to recognize that there is still substantial variability in EPDs across producers of the same construction materials, which can give misleading results when using it as a comparison tool. Finally, and perhaps most importantly, the full life cycle of products beyond that which is simply captured by the EPD should be considered in assessing the carbon footprint of a construction project. Factors such as recyclability and circularity should all be considered when assessing the carbon intensity of a construction project. EPDs only assess the “cradle to gate” aspects of a product, while full life cycle evaluates durability, resilience, maintenance, recyclability, and circularity, all of which needs to be considered when assessing the carbon intensity of a construction project. EPDs only assess the “cradle to gate” aspects of a product, while full life cycle evaluation considers the “cradle to cradle” aspects.

12. Yes

13. No. It is just an equation. It does not tell how well a mix is designed for it's intended use.

14. Yes - it's very likely that similar mixes produced by several different concrete companies would have significantly different embodied carbon levels, as such those EPDs would be useful to distinguish between them.

15. EPDs for individual mix designs with slight adjustments due to water/cement ratio or other requirements are not likely to show significant variance. The use of EPDs could be useful in comparing concrete to asphalt in lifecycle analysis when designing projects.

16. yes

17. No. It could be used to compare mixes designed for the same specifications and purpose, but not to compare mixes of different strength classes or intended for different uses. May be useful to compare one product to another when performing life cycle analysis (e.g. concrete vs asphalt in pavement)

18. absolutely

19. Unknown

20. Somewhat

21. Not that I am aware

Section 1, d.]
Describe the impact of a requirement to submit EPDs with each product sold to the State of Maryland impact your company, if any?

1. Yes

2. It will increase cost to the state, possibly with limited efficacy.

3.

4.

5. One the EPD is completed, it is a simple submission

6. Our members produce cement, which is generally used as an ingredient in concrete, and sold to the concrete producer, rather than sold directly to the end user of the concrete.

7. It's a duplication of effort with no benefit because the products we sold to the state, due to durability specifications, have to be low carbon.

8. See question 1a. We will have EPD's by 2023 already for the concrete products that we manufacture/prepare.

9. No impact

10. Yes there is a financial obligation attached to the requirement

11. As a producer of cement, this requirement is not insignificant to our company during the development of the EPD. Once completed, however, it does not create substantial burden on our ability to sell product to the State of Maryland. However, companies who are downstream of the cement manufacturing process (in many cases our customers) who produce and sell concrete for projects of the State of Maryland may be more significantly impacted due to the wide range of mix designs they produce and sell, which all would require separate EPDs.
During a recent Lehigh Hanson customers survey, the majority of concrete product producers have very limited knowledge on EPDs and the EPD creation process. Less than 15% of producers had ever been asked for an EPD. In addition, for single plant concrete producers, having an EPD and life cycle assessment completed is a substantial cost to their business. Education involving the EPD (i.e., development, meanings, interpretation, usage) is a key component to implementing any strategy that involves EPDs and the costs and efforts associated with EPD development must be reduced.

12. Created more overhead
13. Additional cost , passed on to the end user (the state).
14. We would need a bit of time to ensure we could comply with the regulation, but it shouldn't be a problem.
15. Regulatory burden with negligible variances between mix designs.
16. There will be an administrative burden and a cost to hire third party verifier.
17. Additional administrative burden, raising costs
18. na
19. None
20. There is a cost to having these developed - not significant to major manufacturers
21. It would be a huge burden on smaller companies such as ours. Larger companies have additional resources to carry this out.

Section 2, a.]

Select examples of your company's preferred performance incentives to be applied in use of low–carbon materials (LCMs) in State of Maryland projects:

1. Bid Credits for use of LCM materials, Expedited Permitting and Review of projects using LCMs, Subsidies for demonstrated pollution control by manufacturers and builders, Tax-subsidy incentives for manufacturers and builders
2. Cash. The state should pay more for these products
3.
4.
5. Bid Credits for use of LCM materials, Expedited Permitting and Review of projects using LCMs
6.
7. be a shortlisted preferred supplier
8. Bid Credits for use of LCM materials, Bid Penalties for use of non-LCM materials, Expedited Permitting and Review of projects using LCMs, Emission Reduction Credits (ERCs), Capped Allowance Systems, Subsidies for demonstrated pollution control by manufacturers and builders, Tax-subsidy incentives for manufacturers and builders
9. Emission Reduction Credits (ERCs)

10. Bid Credits for use of LCM materials, Expedited Permitting and Review of projects using LCMs, Tax-subsidy incentives for manufacturers and builders
11. Bid Credits for use of LCM materials, Expedited Permitting and Review of projects using LCMs, Emission Reduction Credits (ERCs), Capped Allowance Systems
12. Bid Credits for use of LCM materials, Bid Penalties for use of non-LCM materials, Emission Reduction Credits (ERCs)
13.
14. Bid Credits for use of LCM materials, Subsidies for demonstrated pollution control by manufacturers and builders
15.
16. Bid Credits for use of LCM materials, Expedited Permitting and Review of projects using LCMs, Emission Reduction Credits (ERCs), Subsidies for demonstrated pollution control by manufacturers and builders, Tax-subsidy incentives for manufacturers and builders
17. low-carbon content cannot be the deciding factor in selection because may not provide sufficient strength, durability, etc for DOT concrete
18. Bid Credits for use of LCM materials, Tax-subsidy incentives for manufacturers and builders
19. N/A

20. The technologies current exist to use LCMs. There can be significant cost for cement manufacturers to build equipment to reduce carbon emissions in their cementitious material (blenders, calciners, etc.). Helping defray that cost would be useful. Also, an expedited review process to allow new materials or blends of materials would be useful.

21.

If you chose "Bid Credits" above:
What percentage advantage would be reasonably applied to use of LCMs? How would the credit be evaluated, applied and verified? What percentage advantage would be reasonable applied to use of LCMs?

1.

2. This is likely a bad idea for something that should be universally mandated or not.

3.

4.

5. All good yet very difficult questions. Likely there is not one answer. I would think a scoring system needs to be implemented to accompany other measures of a bid, such as cost and schedule

6.

7.

8. It probably needs to be a sliding scale; instead of a yes/no question. Minor improvements, take little capital/time to implement. Major improvements usually are more difficult and riskier to implement. Crediting for LCMs should be done accordingly.

9.

10. 5%

11. Lehigh Hanson is supportive of the bid credit. There should be an incentive to provide the impetus to use LCMs. Conceptually, the bid credit approach is a solid approach, but specific percentages will vary to do variability that needs to be incorporated, including local/regional factors. LCMs will come at a premium cost, therefore incentives to offset, either wholly or partially, are warranted. Lehigh Hanson would welcome the opportunity to further discuss this concept with the Council.

12. 10 to 20 percent

13.

14. You should evaluate the total as built cost of the structure, estimate the amount of value that the concrete itself contributes to the overall cost of the structure, and apply a 5% advantage to concrete that meets the LCM definition on the project.

15.

16. 50%

17. ?

18. 4% third party verifiers such as Verra

19.

20. na

21.

Section 2, b.]
Provide input on your company's position on examples of preferred performance incentives you mentioned above:

1. Fee incentives for achieving a GWP (embodied carbon) reduction compared to a baseline

2. The state should pay more for these more expensive products

3.

4.

5. Keep it simple, reward success but do not penalize the status quo

6.

7.

8. We have a preference for incentives that are directly credited back to the manufacturer. Oftentimes we, as manufacturers, do not receive the benefits of a green premium.

   Our secondary preference is for incentives that advantage LCMs for state-funded projects.

9. Carbon Credits

10. I think this should be a carrot incentive not a stick. Not all producers have the capacity to use LCM materials and would require massive reworking of facilities and may simply opt out of bidding.

11. Bid Credits –
    Bid Credits provide advantages to materials that are lower in embodied carbon, such as blended cements. They could be in the form of a selection or preference or possibly a financial incentive to offset the increased cost that would be associated with the use of lower carbon materials. Importantly, they can also incorporate resilience and recyclability factors as well.

    Expedited Permitting –
    Reducing time for project approval to ensure that construction begins within a reduced time frame. This improves efficiency of the project (reduced administrative resources, lowered construction time, delivering more efficient infrastructure/construction to the marketplace), and also, in some cases, helps with lowering the environmental impact of constructing the project.

    Emission Reduction Credits and Capped Allowance Systems -
    These programs are key to the manufacturers of concrete ingredients, such as cement. The ability to generate credits or the establishment of an allowance system can certainly be influential in reducing carbon emissions from the cement manufacturing process. Any carbon pricing must ensure a level playing field and position carbon-neutral production as the most preferred business case, and it can be achieved through a market-based carbon price (preferably cap and trade mechanism) consistent with fairness, transparency, and innovation principles. Carbon leakage protection is also critical to ensure the same carbon cost burden exists for all relevant market participants, including manufacturers from other

states. Also, any pricing program should support investment in carbon abatement technologies, including any infrastructure necessary to support such technologies.

12. Use of EPD to measure actual carbon usage, not reduction compared to competitors

13.

14. Any program introduced should ensure that A) concrete is not disadvantaged in any way in the bid process vs. competing materials, and B) that any incentive/disincentive makes it past the GC and Concrete Contractor to the Concrete Producer. If the GC gets any benefit or negative impact then they may or may not pass that along to the concrete supplier, and the goal of the program would not be met.

15.

16. Sustainability is a culture not an initiative. Credits should be given for not only EPD's but water reclaiming and travel time (emissions).

17. providing lower carbon content while still meeting other performance requirements and standards has to be the method

18.

19. N/A

20. I'm not sure what the answer is - just understand that there is a significant cost to cement companies who are already moving down this road but see the real and significant cost as a problem and also struggle with the fact that some of our proposed methods of reducing carbon are not currently allowed by state and national specifications. Allow for expedited spec changes and provide subsidies for those who are proposing to make significant changes in their manufacturing processes.

21.

Section 2, c.]
Describe your company's experience in use of LCM performance incentives - if any. How were the evaluations performed?

1. LCM use helps to achieve LEED points. On a few projects, we presented carbon impact alongside product cost. We've had a client or two apply weighting factors to carbon and price to determine a 'best value' awarded.
2. I know of no such effort in Maryland. The concrete industry has used fly ash and slag for many years, but I have never seen it as a performance incentive.
3.
4.
5. All need territory for everybody
6.
7.
8. We've seen requests in specs. However, we see a lot of bait and switch, where the LCM is not directly used in the project in question.

The plant servicing the project needs to track the credits from manufacturing to use.

We have also seen, where the contractor is not fully relaying this information to us as producers/manufacturers. They only realize what they want after it's installed. Education and communication through the material supply chain needs to be improved.

9. EPDs

10. We have gotten fast tracks to bid through other state DOT's

11. In the United States, the largest knowledge gap concerning embodied carbon in buildings exists at the whole-building level. The lack of publicly accessible building-level data and guidelines to establish reference cases are obstacles to reaching consensus on forming baselines or benchmarks used to define an LCM product.

12. none

13. none

14. We have no real experience in bid credits affecting the production, supply and sale of RMX concrete.

15.

16. Typically, it has been a requirement of the job, or in the specifications. It is usually a specified percentage below the industry average for an overall project.

17. no

18. we provide a LCM technology to concrete producers

19. N/A

20. na

21. None

Section 2, d.]
Should performance incentives be used for all LCMs used in a construction project: such as lumber, concrete, glass, steel, etc.?

1. Structural materials such as concrete and steel should be prioritized, as these materials have the highest environmental footprint (biggest bang for your carbon buck to achieve GWP reduction). It also seems that EPDs are more readily available for these materials. For concrete, there are calculators that help calculate the GWP without a fully certified third party EPD. These types of tools help level the playing field more quickly for suppliers and can facilitate the adoption of LCM regulations.

2. LCMs are a bad idea. but why only on the construction industry and not all State of Maryland procurement.

3.

4.

5. Yes but the various materials should not be compared. In other words, wood should not get credit as an alternative to concrete or steel. Each material should be baselined and then credit given for progress to lower the GWP with respect to that baseline for that specific material. Comparing different materials to each other cannot be done.

6.

7.

8. Yes with the caveat that all materials are compared on equal footing---that is TOTAL environmental impact over its full lifecycle. Concrete has thermal mass which makes building easier to climate control and ultimately saves significant energy. This is the true goal of these efforts.

9. No

10. If it doesn't compromise quality and durability

11. It is appropriate for any incentives to be applicable to multiple products as long as those products are not compared across product categories. In other words, concrete should be compared to concrete, not lumber or steel.

12. Yes

13. I am not an expert in lumber, glass, steel, etc. LCM concrete has its place and depending on how you define "LCM Concrete", is also not suitable for certain applications.

14. If you want to be consistent then yes - it would be good if the system(s) chosen were all similar in nature.

15.

16. Yes

17. no, not in concrete

18. yes

19. No

20. I think the environmental concerns with every construction product should be part of the design of every construction projectet and that include life cycle modeling needs to be included in any assessment.

21. Please don't single concrete out, if you do this, do it across the board. do not put concrete at a disadvantage to other materials. This should apply to asphalt also.

Section 3, a.]
What resources are needed to perform expedited product evaluation, testing, and approval protocol for low–carbon concrete products?

1. 1) a standardized form issued by the State for GWP tracking, 2) multiple pathways for suppliers to quantify their GWP (EPDs is one), 3) a subsidy for manufacturers to want to pursue EDP for their products

2.	Money for plant approvals, money for product approvals, .. this can all be done, even if it is not efficacious, if the State wants to pay for it.
3.	
4.	
5.	Most important is a common database of input data that can be used by all sides to generate uniform LCAs
6.	It depends on the product and its intended use. This is far too complex a topic for a google form.
7.	
8.	Standards. Testing equipment. Deadlines for responding to producers
9.	Maryland Embodied Carbon Calculator
10.	If the state had a program similar to NRMCA's build with strength where producers could submit source materials and mix designs and have EPD's generated that would be ideal.
11.	This is a significant undertaking, especially if the Maryland Green Building Council appropriately determines to incorporate full life cycle impacts in low carbon products and projects. Third party tools for life cycle evaluation are available to be utilized, but the gathering of all data can be challenging, especially for smaller to mid-sized companies who sell to the State of Maryland. Foremost, Maryland Green Building Council needs to establish a baseline for concrete products and define what percent reduction from baseline would be low-carbon concrete products. A very straightforward, well-crafted definition of "low carbon" must be established and supported by data. For example, most cement in the U.S. and Maryland has been ASTM C150 (M85) cement. The current low carbon cement product would be

	PLC (Portland Limestone Cement), and there will be other products in the future as the industry determines ways to elevate additions of limestone and supplemental cementitious materials (SCM) into cement products while continuing to meet stringent ASTM product quality standards. In addition, the time necessary to approve future low-carbon products must change. Significant testing on cement quality and use characteristics by third parties like ASTM takes many years (sometimes a decade). Ensuring new products coming into the market remain safe is key. However, many times states decide to undertake their own testing and evaluation program, oftentimes duplicating the ASTM process over many years and resulting in the same conclusions. States, especially DOTs, should accept the work for trusted third parties like ASTM and begin accepting and specifying the use of new low carbon products once ASTM certification has been issued.
12.	not sure
13.	Verify mix proportions are consistent with/appropriate for mix application. "LCM" concrete may not be appropriate for all applications.
14.	In my opinion, the goal would be achieved by a standardized approach to EPD generation, and some sort of certification process to ensure that the EPDs are compliant with the state's required methodology. It's important that no one has an unfair advantage if their reporting method was different than another supplier.
15.	
16.	Third party technology to create EPD.
17.	concrete testing laboratories have to test/verify proposed mixes; the possible mix variations to be tested could be endless because of the large number of raw material suppliers and different mix designs
18.	Concrete companies would need to certify all new mix designs which can be costly $20,000

19. Unknown

20. Morgan State University is developing a new concrete program (breaking ground in January). A board is set to be put in place comprised of MD SHA, MD American Concrete Institute, and Morgan professors to oversee the program and the physical facility. This could be a good conduit for identifying and expediting low-carbon technologies.

21. Don't know

Section 3, b.]
Are the standards for testing and evaluation consistent among different companies?

1.

2. Yes, in some areas, but testing for what? There are industry standards and then MDOT has certain standards, but this is a professional matter specified by an architect with a structural engineer and then the responsibility of a general contractor and its materialmen.

3.

4.

5. Not sure what this means but probably the answer is no

6. Standards are not developed by individual companies. They are developed by organizations like ACI, ASTM, etc. through ANSI approved consensus processes. But there are sometimes more than one test for a performance characteristic of concrete. For example, alkali-silica reactivity can be assessed using tests on mortar (ASTM C1260, C1567) or using tests on concrete (ASTM C1293). Different engineers may have a

	preference for specifying tests using mortar or for concrete. They may also take a prescriptive risk-reduction approach to the mixture design instead.
7.	
8.	Unsure
9.	No
10.	No
11.	Standards can be consistent if governed by an appropriate body. However, this can be a challenge even with a consistent governing body in the context of EPDs. MIT has evaluated EPDs previously and has found significant variability across different companies, between 5% and 15% (MIT presentation entitled "Challenges and Opportunities of Using EPDs in Environmental Performance Comparisons of Concrete" may be found on YouTube). In the presentation, Dr. Gregory specifically calls out the difficulties of ranking/comparison (9:40-10:00 minute mark) and discusses the comparison of 3,000 EPDs w/NRMCA (18:35-21:08 minute mark). Benchmarks showed substantial variability across different product types (strengths) as well as how the same datasets can be input into different systems with different results compared to a single benchmark. These are challenges that create difficulty in model legislation being based off EPDs only. A great number of tools are available to facilitate embodied carbon analysis; however, their underlying databases could lead to great discrepancies in results. Guidelines for data standardization and transparency are needed.
12.	No, how we measure savings is VERY flawed, we need to ensure actual used versus actual used
13.	They ought to be.

14. Likely not currently, so the standards would need to be established and implemented, then participants would need to be monitored.
15.
16. No, not presently. If using the same set of standards and third party resource, then we can be consistent.
17. probably not
18. No
19. Unknown
20. For concrete performance, yes. Following ASTM and ACI.
21. Don't know

Section 3, c.]
What organizations (e.g., ASTM, ACI, etc) already have these protocols in place? What are the protocols?

1.
2. None

3.

4.

5. ASTM and ACI do not have protocols in place. Some trade orgs have driven it like NRMCA, SCA, ACAA

6.

7. The NRMCA

8. Product category rules for EPD's. ASTM, ACI

9. Structural Engineers Institute : SE2050 - Methodology Guide for Quantifying Embodied Carbon

10. There is really no industry standard. A consultant or staff engineer writes the EPD's and mixes are proprietary designs based on each companies' interpretation of LC materials

11. ASTM has published C1697 blended SCM which covers products containing two or three ASTM compliant SCMs in concrete. Maryland specification needs to accelerate the adoption of new ASTM standards such as C595 (M240), C1157 and C1697. In addition, providing a reasonable and expedient verification process for concrete producers that are trying to use these newer and lower carbon raw materials is important.

12. The data is in ACI / ASTM the protocols are not

13. ACI has recommendations for mixture proportions which ought to be maintained even if the resulting mixture doesn't meet whatever the definition of "LCM concrete" turns out to be.

14. This would need to be confirmed.

15.

16. Its building code and owner driven. If its not required by local government or code, its typically not a requirement. Some groups, Facebook & Amazon have LCM requirements. Its typically a request, not a requirement.

17. ASTM & ACI have testing methods established

18. ASTM oversees the EPD program, but don't provide them. There is intense mix evaluations to determine the LCA of mix designs using lower carbon products and technologies

19. Unknown

20. ASTM, AASHTO, and ACI. There are many different ways to measure concrete performance and when looking at new technologies a protocol outlining which test are applicable should be developed.

21. Don't know

Section 3, d.]

Are testing and evaluation outcomes independently verified so that the state may rely on their consistency?

1.

2. No

3.

4.

5. Not always, but they should be.

6. They can be. Two key programs are AASHTO re:source and the Cement and Concrete Reference Laboratory (CCRL). Re:source has an accreditation program for lab quality programs and specific test methods. CCRL conducts lab inspections for quality and specific test methods. Both also have proficiency testing programs.

   In addition, ASTM standard test methods are supposed to have precision statements that address the repeatability of the test method and acceptable variability between labs. The extent of these statements depends on available data from ASTM-conducted interlaboratory studies, which have been conducted for some, but not all ASTM cement and concrete test methods.

7.

8. Some

9. Yes using EPD

10. No

11. See answer to Section 3,b. Approval for raw materials usage and approval for ready mix concrete producers' mix designs that are trying to use newer and lower carbon ingredients seem to be two separate processes. For example, Maryland DOT approved PLC (Portland Limestone Cement) early on. However, the process of allowing each individual concrete producer to use PLC in their mix design had been a much longer journey. Changes to the cement manufacturing equipment/design is sometimes needed to accommodate the production of PLC. Cement producers will not incur the cost of these changes if there is no market for the PLC cement. Therefore, cement producers wait until a significant number of concrete producers (i.e., customers) are able to produce concrete using PLC before making the necessary investment. The time needed to gain investment approvals and make process/equipment changes can be lengthy, and that time is added following the allowance of PLC in concrete, further delaying the transition to low carbon material.

12. Have the raw materials, when it comes to concrete go through the independent testing, the data through EPD's can then be evaluated

13. As far as I know the state performs their own evaluations for mix designs. Field testing is performed by the state or third party depending, and the field testing of "LCM concrete" and "regular concrete" is the same.

14. This would need to be confirmed

15.

16. Yes

17. depends; typically, MD DOT SHA witnesses mix design testing. They would need to accept an independent lab accreditation. Could accept testing performed under the oversight of a licensed professional engineer

18. yes

19. Unknown

20. Depends on the test. Some can be certified by the manufacturer. Some are verified and test by the state. Some are done by independent labs.

21. Don't know

Section 3, e.]
What are the steps in evaluation, testing, and approval of products?

1.

2. Far too complicated for a survey like this. But what are you asking" Approval for what?

3.

4.

5. This is an extensive conversation. There is no three step program or simple answer.

6.

7.

8. Unclear, if this is for state approval or internal approval.

9. EPD

10. This is determined by individual companies

11. As stated in the response to Section 3.a., the time necessary to approve future low-carbon products must change. Significant testing on cement quality and use characteristics by third parties like ASTM takes many years (sometimes a decade). Ensuring new products coming into the market remain safe is key. However, many times states decide to undertake their own testing and evaluation program, oftentimes duplicating the ASTM process over many years and resulting in the same conclusions. States, especially DOTs, should accept the work for trusted third parties like ASTM and begin accepting and specifying the use of new low carbon products once ASTM certification has been issued.

12. n/a

13. Proportion, trial batch, evaluation, approval.

14. This would need to be confirmed

15.

16. Third party

17. meet industry standards; receive approval for use on MD DOT SHA projects; proposed mixes have to be tested for conformance with the required specifications for each mix design

18. having third party labs verifying mix designs

19. Unknown

20. That's a big question and depends on what type of product and whether the product has a history that can be verified. The problem that we have is that for about 100 years, we have made concrete basically the same way and their is reluctance to change. For materials like slag cement and fly ash, the state already has a lot of experience. For newer materials like calcined clays, ponded ash, ground glass, etc., there is not as much history. Basic properties such as strength, set time, slump retention etc. can be measured relatively quickly. Durability properties can take longer (ASR resistance, sulfate resistance, freeze thaw durability, etc.). The larger problem is potential product shortage / stock outs. If a concrete plant is purchasing a product with 30% slag cement and that product is unavailable and they need to start purchasing a blended product with calcined clay, trial batches would need to be run which could take as long as 3-4 months. As mentioned before, if Morgan was in the loop on this, protocols and testing could be accomplished here and methodologies could be developed to switch between products without the need to perform trial batches.

21. Don’t know

Section 3, f.]
How could the protocols be expedited?

1.

2. See above

3.
4.
5. A common database and subsidy to support development
6.
7.
8. Spot testing instead of comprehensive testing. Non-destructive evaluations Real-time sensors.
9. Coordination with all MD agencies i.e. MD SHA
10. If the state had objective consistent criteria
11. Maryland should be more trustworthy of third-party, creditable approval and testing processes. An example of a more efficient process is that of VaDOT. VaDOT process involves a request letter and approval is given since the cement supplier is ultimately responsible for the cement, whether or not it is tested separately by VaDOT. Lehigh Hanson would encourage Maryland to review the program of their neighboring state and consider duplication of it.
12. Deadlines

13. Allow ready-mix producers to test and certify their own mixes without needing an on-site observer from the state present during trial-batching.
14. This would need to be confirmed
15.
16. Clear consistent goals or requirements
17. if witnessing concrete plant mix design testing, MD DOT SHA would have to have more personnel available
18. incorporate performance based concrete mix designs vs prescriptive. The states requirements are way over designed and have a heavy carbon footprint because of this
19. Unknown
20. As stated above, bring Morgan in the loop with oversight from MD ACI and MD SHA.
21. Don't know

Section 4, a.]
Does your company have and use non-proprietary performance-based specifications of products for use in public work?

1.	no
2.	Sort of. But nearly all of it is proprietary
3.	ASTM International publishes non-proprietary standards for cement and concrete including performance specifications such as C1157/C1157M-20a Standard Performance Specification for Hydraulic Cement C1810/C1810M-21a Standard Guide for Comparing Performance of Concrete-Making Materials Using Mortar Mixtures
4.	
5.	Some are used. Not as common as prescription but growing
6.	n/a
7.	no
8.	We do not determine the specs as a manufacturer.
9.	Yes
10.	Yes
11.	Not applicable. Lehigh provides bulk cement and cementitious materials to those companies using it in public work.

12. Not allowed in Public work it is a very bad prescription specification.
13. Yes
14. To some extent yes; The majority of the best performing products for the applications used by the state have proprietary mix designs to provide the greatest value to our customer, and the state should look at means to allow the use of proprietary mixes in this regard as well.
15.
16. No
17. typically, public work has required plans & specifications
18. na
19. No
20. Very few performance specs in public work
21. Yes

Section 4, b.]

What are sources of information that the State of Maryland might rely on to prepare non-proprietary performance-based specifications?

1. Carbon Leadership Forum, consulting leading Structural Engineers in LCM such as MKA (Seattle based), Thornton Tomesetti, etc.
2. ?
3. see www.astm.org
4.
5. Again, another tough question with a long answer required. Performance-based specifications are simple to conceive but difficult to develop because performance is defined differently by different stakeholders and aspects such as durability cannot be easily measured in advance. Believe me, if we could, we would. So, setting a performance spec for durability is practically impossible. Generally, a deemed to comply spec can be written but the user needs to be ready to accept that the spec will not be perfect, failures will occur. These factors need to be considered.
6. Look to the NRMCA P2P program (prescription to performance) and CP Tech Center's PEM (performance engineered mixtures) program.
7. Model performance specifications from the NRMCA
8. NRMCA
   Academic Journals
   ACI
9. Structural Engineers Institute

10. ASTM C94 and MDOT SHA 902
11. NRMCA has guide to discuss performance based specification, and Lehigh Hanson considers it to be a great resource on this topic. NRMCA has the P2P initiative; FHWA and some state DOTs have started the implementation of PEM (performance engineered mixture) where they only specify strength and permeability at certain age, freeze/thaw durability using SAM number, etc.
12. Other states, ACI - which are not used in the concrete materials currently to any effect.
13. ACI, NRMCA
14. NRMCA lab test results, or individual supplier test results performed by certified or 3rd party labs would meet this requirement.
15.
16. Athena
17. contact the National Ready Mixed Concrete Association (NRMCA)
18. ask the concrete producers they are up to speed on all new technologies and materials. There are a lot that work in unison together to achieve the lowest LCA possible
19. NRMCA publications
20. ACI, NRMCA

21. contact the National Precast Concrete Association

Section 5, a.]
What are some examples of methods of compliance in the low-carbon concrete context?

1.
2. Use of fly ash, slag and now Type IL cement
3.
4.
5. Maximum cement content is an excellent answer. An EPD of the final concrete mixture is also a good measure.
6. A maximum cement content is a prescriptive method that is flawed, because it ignores the GWP of the cement, as not all cements are the same. Additionally, some cements are blended products and already contain more non-clinker material than a Portland cement. A maximum GWP value could be considered a performance characteristic of the mixture. This gives the concrete producer substantial leeway to engineer the mixture to meet this and the other required performance characteristics of the concrete for the intended application. The US GSAs recently released low-embodied carbon concrete standard is an example of this. A big challenge is how to benchmark the target values for a material that has so many possible formulations. Recommend watching the GSA to see how their new policy is panning out.

7.	Benchmark with the industry wide average compiled and published by the NRMCA
8.	Use of EPD's Reviewing of documentation Submittals
9.	In the Schematic Design Phase of a State-funded project, the A/E shall review and evaluate the owner's program and budget requirements and discuss alternate approaches to the design and construction to reduce embodied carbon. As mutually agreed, the A/E then prepares conceptual design documents for the owner's approval. These may include preliminary sketches, small-scale schematic plans, elevations, sections, diagrams, renderings, and other graphic and written documents that illustrate the general scope, scale, and relationship of the project components, and describe in general the type of construction and equipment proposed. Written documents shall consist of preliminary project descriptions and preliminary cost projections.
10.	Using recycled supplemental cementitious materials, recycled aggregates, CO2 capture
11.	This topic is complex. As a starting point, Lehigh would reference the Council to the recently-published GSA model (https://www.gsa.gov/cdnstatic/Low%20embodied%20carbon%20concrete%20SOW%20language-Mar2022_0.pdf). However, this model is not perfect and improvements could be made. Lehigh Hanson would welcome the opportunity to further discuss this concept with the Council.
12.	Use of CarbonCure - CO2 minimization, use of slag cement and reduction of total cement contents
13.	Please stay away from specifying cement contents. SCM proportions should be specified based on the the intended application of the mix and methods of construction.

14. Minimum GWP thresholds are the best, as they allow the concrete producer maximum flexibility in achieving the mark. Make sure you include Scope 2 and Scope 3 emissions in the calculation for the greatest impact.
15.
16. 1L cement, optimizing mixes, reduced water, reduced emissions (local business), supplementary cementitious material
17. use of supplemental cementitious materials which are recycled materials; use of Type IL cement
18. testing
19. Unknown
20. Other states have tried to do this but it is hard to do.
21. ?

Section 5, b.]
How are we able to balance a proper amount of cement content in concrete while also reducing its production of carbon dioxide?

1. How do you define "proper amount". SCMs can replace cement up to 50% in some cases depending on application. Structural engineers should be required to review and approve any mix designs containing SCMs, and proper test reports should be supplied for each mix.

2. There is no good answer. Bur carbon is only one of many considerations

3.

4. One issue is outside of the mix designs. You can optimize a mix design but lose all of its value (carbon reduction) because of construction curfews, slump limitations that require more energy for placement, and outdated specifications regarding methods.

5. It can be done. Most mixtures are over-cemented. The best way to get to a lowest possible cement content is by examining the testing and acceptance of concrete. Most mixtures are over cemented because the contractor is paid on strength and to ensure they do not fail the strength test, they put in extra cement. Plus, the testing is often not done correctly so to compensate, they put in more cement. This is all no secret. Examining acceptance of concrete is a major part of lowering the cement content.

6. 1. Do not have minimum cement content requirements.
   2. Specify performance of the concrete, not the design of the mixture. Treat GWP / CO2 footprint as a desired performance characteristic. Don't specify things that are not needed.
   3. Ensure the specifications permit a broad range of cementitious materials, as most supplementary cementing materials (SCMs) have very low GWP and also improve the overall long-term strength and durability characteristics of concrete. But specifications are sometimes too restrictive
   4. Flexibility in construction schedules. Pushing speed in construction will cause contractors to use mixtures that attain higher strength faster, and high-early strength mixtures tend to have more cement. They do so not because more cement yields more strength in the long run, but because more cement generates more heat, which accelerates the overall hydration reactions of the cements that cause concrete to gain strength. Alternatively, targeting 56-day or 90-day strengths will make it easier to design concrete mixtures with lower Portland cement contents and thus lower GWP.
   5. Encourage optimized aggregate gradations that increase the amount of aggregate in the mixture, thereby reducing the amount of cement paste required.

7. Extend the strength acceptance age of concrete and permit higher amount of supplementary cementitious materials.

8. Cement is the most expensive component of concrete. A properly managed performance spec should not encounter this issue unless there is poor QC at a plant.

   EPD's will also separately account for this challenge.

9. Use GWP rather than cement content

10. Carbon offsets, using recycled materials, holding contractors responsible for timely placement

11. The biggest obstacle for Maryland concrete producers and ready-mix producers elsewhere in US is prescriptive specifications where limitations such as minimum cement content, maximum w/c ratio, and minimal SCM replacement are capped by specification. Essentially, standards are recipe-based rather than application based. This results in the cement and concrete used in sidewalks being identical to the cement and concrete used in NYC skyscrapers.

    Performance-based standards should be employed over prescriptive specifications (i.e., recipe-based), which would result in the significant reduction of carbon attributed to concrete. These standards, including such specifications as ASTM C-1157, and others, can significantly incentivize the innovative use of blended cements with substantially reduced carbon footprints.

    In addition, construction standards themselves can be changed to better adapt to the needs and ability of cement blends and concrete mix designs. But this approach must not only focus on the embodied carbon of cement and/or concrete, but of the overall project. For example, structural columns may be able to be reduced in size with a higher compressive strength mix, which may be higher per yard in carbon intensity, but because the volume of concrete needed is reduced for the overall project, the overall carbon intensity is lowered.

12. Look at the actual use and realistic life of the item being made. A sidewalk does not need Mix 6 or 13 with 610 lbs. of cement, if finished correctly that number should be reduced by 20 percent.

13. Specify a performance metric and allow the producer to control the total cementitious content and proportions. Remember, the cementitious portion of the mix is the most expensive portion of the mix, and it is already in the producer's interest to minimize this portion of the mix.

14. By setting a GWP threshold along with all the minimum performance-based criteria on the concrete as specified, the state will be getting a product that is designed to perform to meet all the stated criteria. Minimum cement contents are counterproductive and tie the producer's hands unnecessarily; alternative cementitious materials should always be allowed as 1-1 substitutes for Portland cement. Evaluate the mix based on performance criteria not on the specific constituents or recipe.

15.

16. See above

17. use a cement with a lower carbon; Type IL

18. performance based specifications

19. Unknown

20. Alternate cementitious materials is the best answer - there is a trade off with acceptable early strength and set times in concrete. You also need to look at life cycle of concrete. We often have higher cementitious content to increase, in some cases double, the life cycle of the concrete. High performance concrete needs to be a part of the discussion.

21. ?

Section 5, c.]
How might costs for monitoring compliance by industry and enforcement by the government be included in the products? If it is by independent third party inspections, should those costs be considered in the product evaluation?

1.
2. As little government involvement as is possible is better
3.
4.
5. Yes, the contractor should be paid to test. If not, they will not do it. But then, the testing requirement needs to be enforced but first we need to figure out what to test.
6. I don't know.
7.
8. It should be a separate line item in the budget independent from the construction budget/what is paid for the product. If it needs to be included there will be too much incentive to cut costs/corners on the inspections.
9. Compliance/Evaluation forms submitted by Structural Engineer. Form itemizes GWP by structural component.

10. That would have to be included in the bid. The producers are not going to be willing to incur additional costs on top of the costs to implement low carbon solutions and internal monitoring and roll out of compliance to new regulations.
11. These costs should be included in consideration of the product evaluation. The amount of data gathering and auditing will require substantial resources, both by producers and government agencies, to ensure that appropriate and accurate accounting it is being kept.
12. If independent inspections, the cost factor will rise too high. audits probably are more effective and cost less.
13. They will be included in the unit cost of the final cost, ultimately bore by the state.
14. The state should use a recognized standard approach for GWP calculation and use a 3rd party company to spot check / audit the calculation. If a project is awarded to a supplier, then the state should require that the GWP calculation is verified.
15.
16. Yes
17. yes
18. yes
19. Yes.
20. Costs for concrete will increase.

21. ?

Do you have any questions, comments, or concerns?

1. We are a large national GC and actively promoting the use of low carbon materials across all projects. We would strongly encourage the State of MD to follow in the footsteps of CA, NY and others in advancing LCMs in their procurement process.

2. Why is this survey so "carbon" heavy? The statute says the Council is supposed to be looking at the "climate impact of concrete". Carbon is only one impact and possibly not the major one in Maryland (i.e., we don't produce any limestone in Maryland, so ..). This is Maryland so we care a lot about water, .. what about the impact on water?

3. Continued growth in sustainable building design and construction is helping fuel many dynamic initiatives within Committee C09. One area is the use of fly ash as an admixture in concrete production. Fly ash is a byproduct from burning pulverized coal in electric power generating plants. When used in concrete production, it improves workability, cohesiveness, finish and durability while also consuming less energy, improving efficiency and enhancing building performance - all important goals in green construction. Currently, fly ash is used in more than 50 percent of all ready-mixed concrete placed in the United States, according to data from the National Ready Mixed Concrete Association.

   Subcommittee C09.24 on Supplementary Cementitious Materials, part of ASTM Committee C09 on Concrete and Concrete Aggregates, offers standards such as C618 on coal fly ash to enable the reuse of industrial materials in concrete. Similar goals are being achieved by Subcommittee C09.27 on Ground Slag through C989 on slag cement, which specifies reusing ground granulated blast-furnace slag in concrete and mortars.

   Committee C09 has developed several standards to assist industry stakeholders in the selection, testing and blending of fly ash in concrete production, ultimately supporting greater concrete usage and furthering sustainable practices. C1697, Specification for Blended Supplementary Cementitious Materials, provides core guidance for blending of two or three ASTM compliant supplementary cementitious materials, including coal fly ash, for use in concrete or mortar. This standard is used in conjunction with two fly ash standards: C311/C311M, Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete, and C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

Proposed New Specification for Supplementary Cementitious Material for Use in Concrete WK70466 aims to support use of new supplementary cementitious materials (SCMs) that are needed to continue supporting concrete sustainability. The proposed standard will provide a means of specifying a supplementary cementitious material (SCM) for materials that do not meet an existing ASTM standard (for example, C618, C989, C1240). This will be a performance-based specification for SCMs to address this need.

Nonhydraulic Cements are supposed to reduce carbon footprint by using carbon dioxide for curing rather than water. C01.14 on Non-hydraulic Cements can serve as an alternative to the more common Portland cement in some applications. Architects, engineers, and others involved in building design and construction have a growing interest in such alternative cements. C01.14 Non-hydraulic Cements working on these new standards:

- WK42602 New Standard Compressive Strength of Alkali Activated Cementitious Material Mortars (Using 2-in. or [50-mm] Cube Specimens)
- WK62026 New Standard Cement that Hardens by Carbonation
- WK73827 New Standard Compressive Strength of Mortar Cubes Prepared with Cement that Hardens by Carbonation

Blended cements are a solution that can reduce CO2 emissions while resulting in equal or better concrete performance. Blended cements are covered by ASTM C595/C595M. Conventional Portland cements are covered by ASTM C150/C150M.

In 2012, ASTM committee C01 approved a change to ASTM C595/C595M to allow the use of up to 15% limestone in blended cements. Cement with up to 15% limestone is known as Portland-Limestone Cement (PLC) and is standardized as Type IL. In 2017, the committee made further changes to allow the use of these PLCs in sulfate-rich environments, which was a critical change to allow these cements to be used in all part of the US. ASTM C595 has performance requirements so that cement manufacturers can demonstrate equal or better performance to conventional ASTM C150/C150M cements, while achieving a CO2 reduction.
The 15% limestone content in PLCs compares to the 5% allowed in ASTM C150/C150M, and results in approximately 10% CO2 reduction for the same performance. Further reductions are possible by blending pozzolans and slag with up to 15% limestone. These cements are standardized in ASTM C595/C595M as Type IT cement.
In the 10 years since PLCs were originally published in ASTM C595, PLC's have been adopted widely in specifications and building codes. In many parts of the US, PLCs have completely replaced conventional ASTM C150/C150M cements, with further momentum across the US to reach this milestone in the next few years. Given the conservative nature of the concrete and construction industry, which is attributable in part to the life-safety considerations and expected long-life of concrete, the short length of this conversion to lower-carbon cements is remarkable and unprecedented.

ASTM's Relationship with the International Code Council (ICC) and the American Concrete Institute (ACI)

The International Code Council (ICC) maintains the International Building Code and International Residential code for building design and performance in new and existing construction. More than 500 ASTM International are cited in the model codes. These standards are authoritative

technical documents which provide fundamental information for specifying, testing, installing and maintaining various materials and systems.

The American Concrete Institute (ACI) is a non-profit technical society and standards developing organization. Model Building Codes developed by the International Code Council (ICC) reference ACI 318 Building Code Requirements for Structural Concrete which includes the requirements for design and construction of structural concrete that are necessary to ensure public health and safety. Although ASTM has long had a relationship with ACI, ASTM formalized the relationship with ACI through a June 2022 MoU. Part of the new MoU is to "…collaborate on advancing solutions that reduce carbon emissions within the concrete constructions sector."

ACI 318 references several ASTM specifications as follows in section 26.4.1.1.1:

26.4.1.1.1 Compliance requirements:
(a) Cementitious materials shall conform to the specifications in Table 26.4.1.1.1(a), except as permitted in 26.4.1.1.1(b).

Table 26.4.1.1.1(a)—Specifications for cementitious materials
Cementitious material Specification
Portland cement ASTM C150
Blended hydraulic cements ASTM C595, excluding Type IS (≥70) and Type IT (S ≥ 70)
Expansive hydraulic cement ASTM C845
Hydraulic cement ASTM C1157
Fly ash and natural pozzolan ASTM C618
Slag cement ASTM C989
Silica fume ASTM C1240

(b) Alternative cements shall be permitted if approved by the licensed design professional and the building official. Approval shall be based upon test data documenting that the proposed concrete mixture made with the alternative cement meets the performance requirements for the application including structural, fire, and durability.

Earlier this year, one of ASTM's members was a key driver in developing a New Acceptance Criteria Approved for Low-Carbon Alternative Cements using the ICC's Evaluation Service. An ICC-ES Report is a document that presents the findings, conclusions, and recommendations from a particular evaluation. ICC-ES Reports verify that new and innovative building products comply with code requirements. The new ICC-ES acceptance criteria (AC529) is based on several ASTM tests, but the core "criteria" are based largely on ASTM C1157. Because that approach was so readily accepted, the ASTM Subcommittee C01.14 on Non-hydraulic Cements intends to draft a standard that looks a lot like C1157 but for

	alkali-activated cements, rather than hydraulic cements. When done, the expectation is that this new standard will be referenced directly by ACI 318 and replace the AC 529.
4.	
5.	This is not a simple problem. Do move on it but move carefully. You are commended for taking this step of a survey.
6.	
7.	
8.	Stress tackling the totality of the challenge. Addressing only parts of the built environment will not lead to the intended outcome of reducing climate impact. Buildings need to be evaluated on total emissions. Also recognize the limitations of EPD's as currently constructed.
9.	To reduce to upfront embodied carbon, it is essential to engage the Architect and Engineer to evaluate alternate building structures that reduce embodied carbon In the Schematic Design Phase of a State-funded project, the A/E shall review and evaluate the owner's program and budget requirements and discuss alternate approaches to the design and construction to reduce embodied carbon. As mutually agreed, the A/E then prepares conceptual design documents for the owner's approval. These may include preliminary sketches, small-scale schematic plans, elevations, sections, diagrams, renderings, and other graphic and written documents that illustrate the general scope, scale, and relationship of the project components, and describe in general the type of construction and equipment proposed.

Written documents shall consist of preliminary project descriptions and preliminary cost projections.

10. This is a great idea on paper but currently the technology to implement genuinely low carbon concrete does not exist at an economical or feasible state outside of using recycled materials.

11. Cement is the second most consumed commodity in the world, behind only water. Significant quantities of cement and concrete are used throughout the State of Maryland for numerous purposes. It is paramount that any development of standards and/or guidance involves collaboration with the cement and concrete industry. The industry can serve as a key resource for the State, and Lehigh Hanson, with its own decarbonization goals and strategy, welcomes continued engagement with the State of Maryland on this topic.

12. The only concern is that we will sit on the specifications for far too long and that new projects being built next year will only contribute more rather than save carbon.

13. From NRMCA Publication 2PE004-21c "Concrete is unique among building materials. The composition of each mixture is highly influenced by its application. Design professionals and contractors have a greater influence on concrete mixture composition than they do with other building products. Concrete's mixture proportions has the greatest impact on carbon footprint of concrete." There are many considerations when proportioning mixtures, and carbon reduction may be one consideration. However, the main drivers behind concrete mix design must remain suitability for its intended application, durability, constructability and safety. Proper proportioning is best left to the design professional, and poorly thought out and/or arbitrary requirements delegated from above by layman will have unintended consequences.

14. We appreciate the opportunity to participate in this process and look forward to next steps.

15.

16. We would like to join the council. Please provide contact information.

17. mandates for maximum allowable carbon content of concrete could result in a deterioration of other desired properties such as strength, rate of strength gain, set time, finish ability, durability and other plastic and hardened properties

18. NA

19. No

20. This is a big, multifaceted problem. Typically, in the construction world, a committee would be formed to work this out. Part of my suggestion to bring the Morgan, MD ACI, MD SHA group together to work this problem out. Need a way to evaluate products for plastic and hardened properties and for durability. Need to find a way to evaluate products for their environmental impact. Need a way to get changes into specifications in a timely fashion. Need a way to make changes in a timely fashion at concrete plants when switching products.

21. At a time when we are short staffed with material shortages, now is not the time to implement this. This would give larger companies the advantage over smaller companies like ours.

DEFINITIONS

- Aggregates: the gravel, sand, or recycled and sometimes decorative materials, at specified sizes, that are held by the cured paste in concrete.
- Cement: a powder of alumina, silica, lime, iron oxide, and magnesium oxide burned together in a kiln and finely pulverized.
- CMU: Concrete Masonry Units are standard-sized rectangular blocks made from concrete in off-site production, typically using molds or cutting machines. Mix includes cement and aggregates such as sand or gravel and may include add-mixtures or decorative pigments or aggregates.
- Embodied Carbon[2]: The amount of CO2 equivalence (CO2e) in mining, manufacturing/processes, and assembly of a product in what is referred to as "Stage A1-A3" of a Life Cycle Assessment, also known as the up-front embodied carbon emissions.
- GGP (Ground-Glass Pozzolans): A supplementary cementitious material (SCM) that results from the processing of suitable recycled glass products. Finely ground glass powder mitigates alkali-silica reaction (ASR).
- Local Aggregates: Locally sourced stone at requisite size and characteristics for use in the concrete mix, reducing embodied carbon through reduction in transit weigh and volume.
- Matrix: the paste and aggregate combination that is the concrete mix.
- Paste (also Binder): the slurry of cement, SCM, and water that cures to hold the aggregates in concrete.
- PLC (Portland-Limestone Cement): a slightly modified version of Portland cement that improves the environmental footprint; now described in ASTM and AASHTO specifications.
- Recycled Concrete Aggregates and Coarse Crushed Concrete Aggregates (RCA and CCCA): deconstructed concrete crushed on-site or off, intended for re-use in projects, typically as fill. RCA is not called for in the listed approaches.
- Strength test: A test of poured units, performed most often at 28-days of curing, to confirm the concrete has achieved the required strength.
- Supplementary Cementitious Materials (SCM): materials resulting from another manufacturing process or waste stream that may be processed and used to replace portions or all cement in concrete. SCMs chemically react to provide cementitious properties and enhance concrete strength and durability, and include fly ash, slag cement, silica fume, natural pozzolans, or GGP. These materials should comply with relevant specifications.

Maryland Green Building Council Membership

The council includes members with an exceptional array of talents and technical knowledge necessary to advance the state's mission of promoting efficient and responsible facility development and operation. The members are passionate about conservation of our states and global resources and translate that passion to actions that advantage the state. Composition of the council membership is mandated by statute. It consists of the secretary of select State of Maryland agencies or their designee.

General Services,
Budget and Management,
Department of the Environment,
Housing and Community Development,
Natural Resources,
Planning,
Transportation,
Maryland Energy Administration,
Interagency Committee on Public School Construction,
Chancellor of the University System of Maryland,

Six additional members of the council are appointed by the Governor to represent environmental, business, and citizen interests, one of whom has expertise in energy conservation or green building design standards. Terms of the governor-appointed members are two years each and are staggered, with half of the terms up for renewal every other year.