Credits Related to Embodied Carbon in North American Green Rating Systems

Contents

Introduction

Around the 1990s, major green rating systems for buildings were developed and released in North America and Europe. These green rating systems were created to help provide designers a framework for minimizing the impacts their building designs have on the natural environment. Today, many green rating systems approach the built environment's effects on the natural environment through varying levels of requirements, strategies, and measurements. The purpose of this document is to provide structural engineers a brief background on each rating system and summarize the credits related to embodied carbon that structural engineers can influence to help their clients achieve the project's targeted green rating. For resources on explaining, measuring, and reducing embodied carbon, see the SE 2050's Resource page. It is essential to note what version of the green rating system the project uses since green rating systems evolve and change as the science and knowledge of sustainability, embodied carbon, and their effects on the natural environment mature.

Even if a project is not pursuing certification through a green rating system, structural engineers can still employ strategies contained within each rating system. In addition to green rating strategies, structural engineers can utilize other tactics to reduce the embodied carbon on a project. To be included in the sustainability conversation and positively impact the design profession, engineers should educate themselves on embodied carbon and reduction strategies.

Please select a green rating system's logo below to learn about the embodied carbon credits available for structural engineers. When comparing different green rating systems, note that some language is redundant. This is due to the similarities of the embodied carbon reduction credit's goals and strategies to achieve the credit.

Green Rating Systems in North America

Green Building Initiative's (GBI) *Green Globes for New Construction (NC) 2019*

Background

In 2004, GBI began adopting a Canadian web-based tool developed from the Building Research Establishment Environmental Assessment Method (BREEAM) for US commercial buildings. By the end of 2004, GBI released the *Green Globes* environmental assessment and rating tool into the US market. *Green Globes NC 2019* is based on *ANSI/GBI 01-2019 Green Globes Assessment Protocol for Commercial Buildings* which is under continuous maintenance and contains six environmental assessment areas under its certification program. These areas include Project Management, Site, Energy, Water Efficiency, Materials, and Indoor Environment. One thousand points are available, of which 150 are in the Materials category. The lowest rating threshold is 35% of all applicable points, which must include at least 20% of the points in each category.

There are multiple sections within the Material environmental assessment area that structural engineers can contribute towards to help achieve program points and address embodied carbon. Table 1 summarizes the sections in *Green Globes NC 2019* structural engineers can engage in to help their client reach the target project certification level while reducing the structural system's embodied carbon.

Table 1: Summary of Credits Related to Embodied Carbon for Structural Engineers in GBI *Green Globes for NC*

Summary of Credits Related to Embodied Carbon for Structural Engineers in GBI *Green Globes for NC - Version 2019*				
Section(s)	*Credit Title*	*Credit Required or Optional*	*Achievable Points*	*Probability of Embodied Carbon Reduction*
5.1.1.1	Whole Building Life Cycle Assessment	Optional	Up to 30 Points	Almost Certainly
5.2.1.1	Product Life Cycle Cradle-to-Gate	Optional	Up to 19 Points	Sometimes
5.2.1.2	Product Life Cycle Cradle-to-Grave	Optional	Up to 10 Points	Sometimes
5.4.1.1	Product Sustainable Materials Attributes	Optional	Up to 10 Points	Sometimes
5.5.1.1	Reuse of Structural Systems and Non-Structural/Interior Elements	Optional	Up to 12 Points	Almost Certainly
5.5.2.1	Material Reuse from Off-Site	Optional	Up to 4 Points	Almost Certainly
5.6.2.1	Supply Chain Waste Minimization	Optional	Up to 4 Points	Sometimes
5.7.1.1	Off-Site Fabrication for Construction Optimization	Optional	Up to 4 Points	Usually
5.7.2.1	Design for Deconstruction	Optional	6 Points	Usually

Credits Related to Embodied Carbon

Section 5.1.1.1 Whole Building Life Cycle Assessment: To achieve points in *Green Globes* Section 5.1.1.1, the team conducts a Whole Building Life Cycle Assessment (WBLCA). As part of the WBLCA, structural engineers can run a Life Cycle Analysis (LCA) on their structural framing to measure and reduce the global warming potential (GWP)[1]. A registered design professional must verify the structural material quantities for the design options, with the exception of existing buildings. The final building design shall achieve a minimum 5% reduction for GWP and at least two other impact indicators, with no impact indicator exceeding the baseline building by more than 5%. Early in the design phase, the project team should agree on which consultant should include the WBLCA for the baseline building in their scope. For additional information on developing a baseline building for a WBLCA, see "Whole Building Life Cycle Assessment: Reference Building Structure and Strategies" published by the ASCE SEI Sustainability Committee. Up to 30 points can be awarded to the design team depending on the percentage reduction of adding at least three impact indicators. Table 2 lists the points that would be awarded to the team based on the percentage reduction.

Table 2: GBI *Green Globes for New Construction 2019*, Section 5.1.1.1 Points

Percentage Reduction (Adding at least three impact indicators)	**Points Awarded**
≥ 25%	30
24%	28
23%	26
22%	24
21%	22
20%	20
19%	18
18%	16
17%	14
16%	12
15%	10
< 15%	0

[1] Carbon dioxide equivalent (CO_2-e) is a unit of measurement based on the relative impact of a given greenhouse gas on global warming or its Global Warming Potential (GWP). Therefore, embodied carbon and GWP are often used interchangeably. CO_2-e emissions are associated with the extraction and manufacturing of materials and products; in-use maintenance and replacement; and end of life demolition, disassembly and disposal; including transportation relating to all three.

Section 5.2.1.1 Product Life Cycle: This section of *Green Globes* requires the design team to provide at least 20 Environmental Product Declarations (EPDs) for the project. Depending on the amount and type of EPDs submitted for the project, up to 29 points can be achieved. A majority of structural materials have either a product-specific Type III EPD or industry-wide Type III EPD obtained from the material supplier. By asking structural material manufacturers for product-specific EPDs, structural engineers can drive the market towards transparency regarding the environmental impacts of the materials engineers specify on their projects.

Section 5.2.1.2 Product Life Cycle: This section of *Green Globes* requires the design team to provide at least 5 cradle-to-grave product-specific Environmental Product Declarations (EPDs) for the project. Depending on the number submitted for the project, up to 10 points can be achieved. It is a benefit not only for the project, but also for the industry since cradle-to-grave product-specific, third-party verified Type III EPDs produce an accurate picture of the environmental effects of a manufacturer's product. By asking structural material manufacturers for cradle-to-grave product-specific EPDs, structural engineers can drive the market towards transparency regarding the environmental impacts of the materials engineers specify on their projects.

Section 5.4.1.1 Product Sustainability Attributes: In this section, structural engineers can help the project team achieve ten points and reduce the structural system's embodied carbon by using materials with pre- and post-consumer recycled content, biobased content, or third-party sustainable forestry certification. Some structural materials have optimized the amount of recycled content due to resource availability, manufacturing process, embodied carbon reduction, and consumer demands. For projects utilizing structural timber, engineers can specify a third-party sustainable forestry certification. *Green Globes* recognizes and accepts the Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), and American Tree Farm System (ATFS) sustainable forestry certifications. Research[2] has shown timber harvested from responsibly managed forests can contribute to a lower embodied carbon footprint when compared to non-certified wood. Using building products with sustainable attributes can achieve up to ten points for the project.

Sections 5.5.1.1 and 5.5.2.1 Reuse of Existing Structures and Materials: Reuse of existing structural materials on a project both on and off site can help reduce the demand for new materials and the structure's carbon emissions from extraction and manufacturing. Structural engineers will need to assess and determine the condition and strength of existing structural elements to ensure they will be adequate for the demands of the proposed design. It is paramount that structural engineers are engaged during schematic design when building and material reuse is a design option. Depending on the percentage of the existing structural system that is reused (relative to total square footage of the entire structural system on the project), up to 12 points can be obtained in Section 5.5.1.1. Potentially four points can be achieved for

[2] See Carbon Leadership Forum. (2020). "Learning about Forests, Carbon, and Wood." Seattle, WA. Accessed July 10, 2021. https://carbonleadershipforum.org/learning-about-forest-carbon/

materials on the project that are reused, refurbished, or off-site salvaged. The points for off-site reused materials are based on their value per Section 5.5.2.1.

Section 5.7.1.1 Off-Site Fabrication for Construction Optimization: This section provides the option for project teams to utilize off-site fabricated building elements through modular or prefabricated construction. Structures applying modular or prefabricated construction benefit from shorter site phase programmes, increased worker safety, and reduced material waste and transportational embodied carbon. The quantity of points (up to four) awarded for utilizing modular or prefabricated construction is dependent on the percentage of square footage employing off-site fabrication.

Section 5.7.2.1 Design for Deconstruction (DfD): For a project utilizing design for deconstruction, this section will award the project six points. With select structural systems the upfront costs for designing for deconstruction may be more expensive than traditional construction methods. However, savings can be achieved through reduced assembly construction. A few strategies structural engineers can investigate and employ when designing for deconstruction include using mechanical fasteners over welding, simplifying connections, utilizing standard details to the maximum extent possible, and avoiding cast-in-place concrete composite systems. A structural system designed for deconstruction can provide a renewable construction material resource that can reduce the demand for new materials and promote a circular economy. However, the embodied carbon benefit related to this strategy will not be realized until the materials are reused. For additional guidance and strategies on designing for deconstruction see "Whole Building Life Cycle Assessment: Reference Building Structure and Strategies" published by the ASCE SEI Sustainability Committee.

Institute for Sustainable Infrastructure (ISI) *Envision, Version 3*

Background

Envision was first developed and published by the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure (ISI) in 2012. *Envision*'s purpose was to provide owners, engineers, and other infrastructure stakeholders the framework to deliver sustainable and resilient infrastructure through non-prescriptive requirements. The type of infrastructure projects that can pursue a rating from *Envision* are listed in Figure 1. *Envision* consists of 64 credits with a total of 1,000 points organized under five categories: quality of life, leadership, resource allocation, natural world, and climate & resilience.

Figure 1: Type of Projects that can Pursue a Rating from ISI *Envision, Version 3* (Source: ISI. 2018. "*Envision*." Version 3, Washington, DC)

Table 3 summarizes the ISI *Envision*, version 3 credits that structural engineers can engage in to help their client achieve the target project certification level while reducing the structural system's embodied carbon.

Table 3: Summary of Credits Related to Embodied Carbon for Structural Engineers in ISI *Envision*

Summary of Credits Related to Embodied Carbon for Structural Engineers in ISI *Envision* - Version 3				
Credit(s)	*Credit Title*	*Credit Required or Optional*	*Achievable Points*	*Probability of Embodied Carbon Reduction*
RA1.2	Use Recycled Materials	Optional	Up to 16 Points	Almost certainly for reused materials, usually for recycled-content materials
CR1.1	Reduce Net Embodied Carbon	Optional	Up to 20 Points	Definitely

Credits Related to Embodied Carbon

<u>*Credit RA1.2: Use Recycled Materials:*</u> Pursuit of this credit can award a team up to 16 points depending on the percentage of project materials that are reused or recycled. Structural engineers can help the project team receive points and reduce the structural system's embodied carbon by using materials with high recycled content or reusing structural systems. Some structural materials have optimized the amount of recycled content due to resource availability,

manufacturing process, embodied carbon reduction and consumer demands. Engineers should confirm that any specified recycled content materials have reduced embodied carbon, since using high recycled content materials may not necessarily reduce embodied carbon relative to standard practice. Reusing existing structural materials on a project can help reduce the demand for new materials and will typically reduce the structure's embodied carbon since extraction and manufacturing is not needed. Structural engineers will need to assess and determine the condition and strength of existing structural elements to ensure they will be adequate for the proposed design requirements. It is paramount that structural engineers are engaged during schematic design when building and material reuse is a design option.

Credit CR1.1: Reduce Net Embodied Carbon: This credit requires the project team to reduce the upfront carbon of the primary materials used on the project during construction and operation. Structural engineers play a crucial role in helping the project team reduce the embodied carbon of the infrastructure's structural components. The certification will award the team five points for a five percent reduction of embodied carbon compared to a baseline. The points step up as a larger amount of embodied carbon is reduced. Up to 20 points will be awarded if the team achieves a 50% embodied carbon reduction compared to the baseline. In *Envision*, a baseline is defined as conventional performance or "business as usual." Due to the broad applicability of types, sizes, and locations of infrastructure projects, appropriate and applicable baselines must be determined by the project team. *Envision* provides four acceptable ways of defining a baseline, in order of preference:

1. Existing conditions or the existing system(s) the project will replace
2. A seriously considered project alternative
3. Industry "standard practice" or existing codes, standards, or regulatory requirements
4. A project of similar scope and size operating within the same geographic area or a geographic area with similar operating conditions.

Early in the design phase, the design team should agree on which consultant should include the life cycle assessment (LCA) for the baseline in their scope. Engineers will need to utilize embodied carbon reduction strategies and technologies in addition to measuring the structural embodied carbon through an LCA tool. By measuring and utilizing reduction strategies, the embodied carbon footprint can be reduced to the greatest extent possible.

International Living Future Institute's (ILFI) *Core Green Building Certification* (*CORE*)

Background

The ILFI *CORE* is a simple certification system that outlines ten achievements a building must obtain to be certified: place, transit, water, energy, health, materials, equity, inclusion, biophilia, and inspiration. *CORE* was established to minimize the gap between the highest levels of established green building certification programs and ILFI's *Living Building Challenge* targets.

Credits Related to Embodied Carbon

Structural engineers can help the project team achieve *CORE* Imperative 6 (*Living Building Challenge* Imperative 12): Responsible Materials. This imperative requires:

1) One Declare label per 2150 square feet (200 square meters), for up to 20 distinct products. All other product manufacturers must, at a minimum, receive a letter requesting the manufacturer disclose their ingredients and identify any Red List content.

3) 50% of timber used on the project to be Forest Stewardship Council (FSC) certified, salvaged, or harvested on-site either for the purpose of clearing the area for construction or to restore or maintain the continued ecological function of the site.

4) 20% or more of material's construction budget originates within 310 miles (500 kilometers) of the project site. See the ILFI *CORE* Standard for the definition of the materials construction budget.

5) The project must divert 80% of construction waste from landfills.

Therefore, structural engineers will need to update their specifications to convey these requirements to the contractor. Research[3] has shown that timber harvested from responsibly managed forests, like FSC Certified wood, can contribute to a lower embodied carbon footprint than non-certified timber.

International Living Future Institute's (ILFI) *Living Building Challenge 4.0*

Background

ILFI's *Living Building Challenge* provides a framework for design, construction, and the cooperative relationship between people, the community, and nature. The *Living Building Challenge* utilizes seven "petals" (place, water, energy, health+happiness, materials, equity, and beauty) with subsequent "imperatives" for its challenge. For a building to obtain "Petal Certification" or "Living Certification," a required set of petals and imperatives must be achieved. Table 4 summarizes the ILFI's *Living Building Challenge* petals structural engineers can engage in to help their client achieve the target project certification level while reducing the structural system's embodied carbon.

[3] See Carbon Leadership Forum. (2020). "Learning about Forests, Carbon, and Wood." Seattle, WA. Accessed July 10, 2021. https://carbonleadershipforum.org/learning-about-forest-carbon/

Table 4: Summary of Embodied Carbon Imperatives for Structural Engineers in ILFI *Living Building Challenge*

Summary of Embodied Carbon Imperatives for Structural Engineers in ILFI *Living Building Challenge 4.0*				
Pedal - Imperative	*Credit Title*	*Credit Required or Optional*	*Achievable Imperatives*	*Probability of Embodied Carbon Reduction*
Energy - Core Imperative 07	Energy + Carbon Reduction	Required	1 (Core)	Definitely
Energy - Imperative 08	Net Positive Carbon	Required	1	Definitely
Materials - Core Imperative 12	Responsible Materials	Required	1 (Core)	Usually
Materials - Imperative 14	Responsible Sourcing	Required	1	Sometimes
Materials - Imperative 16	Net Positive Waste	Required	1	Sometimes

Embodied Carbon Imperatives

Energy Petal - Core Imperative 07: Energy + Carbon Reduction: This core imperative requires that new or existing buildings demonstrate a 20% reduction in the embodied carbon of primary materials when compared to an equivalent baseline. Embodied carbon measurements for the baseline and project should be based on stages A1 (Raw material extraction) - A5 (construction installation) as defined by standard EN 15978. Measurements for embodied carbon should be completed using an approved Whole Building Life-Cycle Assessment (WBLCA) tool. Some WBLCA tools approved by ILFI include Tally, Athena Impact Estimator, and One-Click LCA. The project's baseline should be identical to the initial design except for the claimed material reductions, similar in project scope, and use material and design parameters based on standard industry practices. Additional information on establishing a baseline can be found in the *Energy Petal Handbook, version 4.0* from ILFI. Existing buildings may count as in-situ materials against the required 20%. As part of the WBLCA, structural engineers can run a Life Cycle Analysis (LCA) on their structural framing. An LCA and understanding of materials' embodied carbon can highlight high carbon impact areas and allow the structural engineer to actively provide solutions to meet the 20% reduction from the baseline. Early in the design phase, the design team should agree on which consultant should include the WBLCA for the baseline in their scope. By measuring and utilizing reduction strategies, structural engineers can reduce the building's embodied carbon footprint to the greatest extent possible.

Energy Petal - Imperative 08: Net Positive Carbon: For buildings to meet this imperative, projects must account for the embodied carbon emissions by utilizing carbon-sequestering materials and/or a one-time carbon offset purchase through an ILFI approved carbon offset provider. Embodied carbon measurements that are offset should be based on stages A1 - A5. Measurements for embodied carbon should be completed using an approved WBLCA tool. Approved ILFI WBLCA tools include Tally, Athena Impact Estimator, and One-Click LCA. Through the WBLCA, engineers can reduce the structural system's embodied carbon to the greatest extent possible and account for the carbon-sequestering materials, such as wood. The larger the reduction and more carbon-sequestering materials used architecturally and structurally, the fewer carbon offsets the owner has to purchase.

Materials Petal - Core Imperative 12: Responsible Materials and Imperative 14: Responsible Sourcing: This imperative requires:

1) One Declare label per 2150 square feet (200 square meters), for up to 20 distinct products. All other product manufacturers must, at a minimum, receive a letter requesting the manufacturer disclose their ingredients and identify any Red List content.

3) 50% of timber used on the project to be Forest Stewardship Council (FSC) certified, salvaged, or harvested on-site either for the purpose of clearing the area for construction or to restore or maintain the continued ecological function of the site.

4) 20% or more of material's construction budget originates within 310 miles (500 kilometers) of the project site. See the ILFI *CORE* Standard for the definition of the materials construction budget.

5) The project must divert 80% of construction waste from landfills.

Therefore, structural engineers will need to update their specifications to convey these requirements to the contractor. Research[4] has shown that timber harvested from responsibly managed forests, like FSC Certified wood, can contribute to a lower embodied carbon footprint than non-certified timber.

Materials Petal - Imperative 16: Net Positive Waste: Net Positive Waste strives to have projects reduce or eliminate the production waste during design, construction, operation, and end of life. To achieve this petal, structural engineers will need to coordinate the potential to reuse or salvage materials on the project and design for deconstruction at the end of the building's lifecycle to mitigate the amounts of materials that end up in the landfill. Reusing existing structural materials on a project can help reduce the demand for new materials and the structure's embodied carbon from the process of extraction and manufacturing. Structural engineers will need to assess and determine the condition and strength of existing structural elements to ensure they will be adequate for the proposed design's demands. It is paramount that structural engineers are engaged during schematic design when building and material reuse is a design option.

With select structural systems, the initial costs of designing for deconstruction and/or construction of the systems may result in a final design more expensive than traditional construction methods. However, savings may be achieved through reduced assembly. Overall, a whole life costing approach is a fairer comparison between differing approaches. A few

[4] See Carbon Leadership Forum. (2020). "Learning about Forests, Carbon, and Wood." Seattle, WA. Accessed July 10, 2021. https://carbonleadershipforum.org/learning-about-forest-carbon/

strategies structural engineers can investigate and employ when designing for deconstruction include using mechanical fasteners over welding, simplifying connections, utilizing standard details to the maximum extent possible, and avoiding cast-in-place concrete composite systems. A structural system designed for deconstruction can provide a renewable construction material resource that can reduce the demand for new materials and promote a circular economy. For additional guidance and strategies on designing for deconstruction see "Whole Building Life Cycle Assessment: Reference Building Structure and Strategies" published by the ASCE SEI Sustainability Committee.

International Living Future Institute's (ILFI) *Zero Carbon Standard 1.0*

Background

In 2018, ILFI's Zero Carbon Certification was developed to directly address the building sector's role in the global climate crisis. Zero Carbon Certification is a third-party verified standard to authenticate a project's operational and embodied carbon emissions are neutralized. Performance requirements are specified for new and existing buildings and consider the following principles: Projects must first reduce, to the greatest extent possible, operational energy use and embodied carbon emissions associated with building materials and construction. A hundred percent of the operational energy use associated with a project must be offset by new on- or off-site renewable energy. A hundred percent of the project's embodied carbon emissions associated with the construction and materials must be disclosed and offset.

Credits Related to Embodied Carbon

Structural engineers play a crucial role in aiding the project team to achieve the net-zero embodied carbon portion of the ILFI's Zero Carbon Certification. The certification requires an embodied carbon reduction of 10% for the project's foundation, structure, and enclosure compared to a baseline building. The baseline building shall be of equivalent size, function, and energy performance. Early in the design phase, the design team should agree on which consultant should include the WBLCA for the baseline building in their scope. For additional information on developing the baseline building for a WBLCA, see "Whole Building Life Cycle Assessment: Reference Building Structure and Strategies" published by the ASCE SEI Sustainability Committee and the ILFI's *Zero Carbon Certification Handbook*. In addition to the 10% reduction, the building's total embodied carbon cannot exceed 500 kg CO_2e/m^2. Care should be taken to determine if embodied carbon calculations for wood products include or exclude biogenic carbon. Engineers will need to utilize embodied carbon reduction strategies and technologies in addition to measuring the structural embodied carbon through a LCA tool. By measuring and utilizing reduction strategies, the embodied carbon footprint can be reduced to the greatest extent possible and thereby minimize the cost of offsets from on-site carbon-sequestering materials or by a one-time purchase of carbon offsets from an ILFI approved source, to obtain net-zero.

International Living Future Institute's (ILFI) Zero Energy (ZE) Certification

Background

ILFI's *ZE* certification requires that one hundred percent of the building's energy consumption on a net annual basis be supplied by on-site renewable energy. No combustion is allowed. The certification is third-party audited and based on the building's in-service energy consumption, not a modeled performance.

Credits Related to Embodied Carbon

Due to ILFI's *Zero Energy* certification's focus on net-zero operational energy, there are no credits on embodied carbon that structural engineers can help the project team achieve.

International WELL Building Institute's (IWBI) *WELL Building Standard, Version 2.0*

Background

Launched in 2014, the *WELL Building Standard* was developed using scientific and medical research to support and advance human health and wellness within buildings, interior spaces, and communities. There are ten concepts within *WELL version 2.0*: air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, and community. Each concept consists of features with specific health intents.

Credits Related to Embodied Carbon

Due to *WELL*'s focus on healthy interior spaces, there are currently no credits on embodied carbon that structural engineers can aid the project team in achieving.

Passive House Institute US+ (*PHIUS+*) 2018

Background

Founded and headquartered in Germany, Passive House is a building standard that focuses on energy efficiency and occupant comfort. Passive buildings are designed and built under five principles: continuous insulation without thermal bridging, an airtight envelope, high-performance windows, balanced heat and moisture recovery ventilation, and minimal space conditioning. Buildings pursuing Passive House can do so under the United States *PHIUS+* or Germany's *PHI* green rating system.

Credits Related to Embodied Carbon

Due to PHIUS's focus on energy efficiency and occupant comfort, there are currently no credits on embodied carbon that structural engineers can help the project team achieve.

United States Green Building Council's *Leadership in Energy and Environmental Design (USGBC LEED) Building Design + Construction (BD+C), Version 4.1*

Background

USGBC and LEED's development started in 1993 under three individuals' guidance and their desire to design and construct environmentally responsible buildings. LEED version 1.0 launched in 1998 and, in 2003, saw a significant number of projects seeking LEED certification. Since then, LEED has been the central green rating system within the United States and has expanded its reach across the world. There are multiple LEED rating systems tailored to different construction types, including new construction, interiors, existing buildings, and residential, to name a few. There are seven credit categories within *LEED BD+C*, including Integrative Process, Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. Starting with *LEED BD+C version 4.0*, product transparency and materials' environmental impacts throughout their life-cycle came into focus under the Materials and Resources credit category. Under this credit category, Environmental Product Declarations (EPDs) and Whole Building Life-Cycle Assessments (WBLCA) became vital, while reuse strategies continue to be rewarded in the rating system.

The latest version of LEED, version 4.1, was released as a beta in 2018 and has been updated quarterly based on stakeholder feedback. In that time, the LEED v4.1 system has undergone several changes to various credits relating to embodied carbon in order to emphasize outcomes and simplify credits. Further updates may happen before the rating system is formally balloted, which is expected in late 2021. Check the LEED credit library at USGBC's website for the latest versions of credits.

There are multiple *LEED BD+C version 4.1* credits under the Materials and Resources category available for structural engineers to help their project team achieve embodied carbon reductions. In general, there are credits that reward design decisions that reward dematerialization and structural choices that reduce intrinsic carbon (such as building reuse and WBLCA), as well as points that reward the selection of products that have conducted life-cycle analysis and optimized their products (EPDs). Finally, projects can procure low carbon materials during the construction phase to further reduce embodied carbon. Table 5 summarizes the *LEED BD+C version 4.1* credits structural engineers can engage in to help their client achieve the target project certification level while reducing the structural system's embodied carbon.

Table 5: Summary of Credits Related to Embodied Carbon for Structural Engineers in USGBC *LEED BD+C*

Summary of Credits Related to Embodied Carbon for Structural Engineers in USGBC *LEED BD+C - Version 4.1*				
Section(s)	*Credit Title*	*Credit Required or Optional*	*Achievable Point(s)*	*Probability of Embodied Carbon Reduction*
MR Credit	Building-Life Cycle Impact Reduction, Option 1: Building and Material Reuse	Optional. Note: either option 1 or 2 below - not both	Up to 4 Points	Almost Certainly
MR Credit	Building-Life Cycle Impact Reduction, Option 2: Whole Building Life-Cycle Assessment	Optional. Note: either option 1 above or 2 - not both	Up to 4 Points	Almost Certainly
MR Credit	Environmental Product Declarations	Optional	Up to 2 Points	Sometimes
MR Credit	Sourcing of Raw Materials	Optional	Up to 2 Points	Usually
MRpc102 Credit	Legal Wood	Optional	Up to 2 Points	Usually
MRpc132 Credit	Procurement of Low Carbon Construction Materials	Optional	Up to 2 Points	Usually

Credits Related to Embodied Carbon

Material and Resource Credit - Building-Life Cycle Impact Reduction, Option 1: Building and Material Reuse: For this credit, structural engineers can help the project team identify potential reusable or salvageable structural elements. By reusing structural elements in existing buildings, the structural system's overall embodied carbon footprint is reduced due to mitigation of carbon released during manufacturing and transporting new structural materials to the construction site. Up to four credits can be achieved depending on the percentage of existing walls, floors, and roof reused relative to the total floor area. In addition, salvaged or reused materials from offsite are allowed to be counted as reuse within this credit. For example, using salvaged timber or steel beams from another building and incorporating it into a the project would count as offsite reuse that is eligible for this credit. Reuse need not be the same material used as the same original function (a salvaged structural beam can be reused as a decorative finish or for other nonstructural purposes, for example). Teams should consider this strategy when offsite salvage materials are available, or if the project needs some additional reused materials to hit a higher credit achievement threshold.

Material and Resource Credit - Building Life-Cycle Impact Reduction , Option 2: Whole Building Life-Cycle Assessment: As part of the WBLCA, structural engineers can run a Life Cycle Analysis (LCA) on the structural design to help identify areas of high environmental impacts and provide embodied carbon measurements. Just conducting a WBLCA for the project's structure and enclosure can help the project team achieve one LEED point. If the WBLCA demonstrates a reduction in global warming potential (GWP) of 5% or 10% compared to the baseline building, the project can obtain two or three LEED points, respectively. For a WBLCA on the project's structure and enclosure demonstrating at least a 20% reduction for GWP and a 10% reduction in two additional impact categories, the team can obtain four LEED points (however, projects must incorporate some reuse materials to be eligible for the fourth point). Early in the design phase, the design team should agree on which consultant should include the WBLCA for the baseline building in their scope. For additional information on developing the baseline building for a WBLCA, see "Whole Building Life Cycle Assessment: Reference Building Structure and Strategies" published by the ASCE SEI Sustainability Committee and the *LEED V4.1 Building Design and Construction Guide*.

Material and Resource Credit - Building Product Disclosure & Optimization: Environmental Product Declarations: Under this credit, structural engineers have the opportunity to help the project team achieve two LEED points. One credit is earned if 20 EPDs from five different manufacturers are submitted. Almost all structural materials have either a product-specific Type III EPD or industry-wide Type III EPD obtained from the material supplier. Product-specific Type III EPDs are weighted with a factor of one or 1.5 depending on if they were internally or externally reviewed by a third-party, respectively. An industry-wide Type III EPD is weighted with a factor of one. Therefore, it is beneficial for the industry and LEED project to obtain product-specific Type III EPDs that provide a more accurate picture of the environmental effects of a manufacturer's product in order to quantify the total embodied carbon impact of a building. By asking structural material manufacturers for product-specific EPDs, structural engineers can drive the market towards transparency regarding the environmental impacts of the materials engineers specify on their projects.

An additional credit can be earned by selecting Embodied Carbon/LCA Optimization reports for five products from three different manufacturers. One such report type is an action plan that is published by manufacturers, as well as optimized EPD reports based on product improvement in embodied carbon impacts over time. As a significant number of conditions impact the weighting of individual reports, the *LEED V4.1 Building Design and Construction Guide* documentation should be consulted for further details.

Material and Resource Credit: Sourcing of Raw Materials: Structural engineers can specify: 1) Structural timber certified by the Forest Stewardship Council (FSC) or USGBC approved equivalent, 2) Employ reused or salvaged materials, and 3) Utilize structural materials with recycled content to achieve two LEED points. Research[5] has shown that timber harvested from responsibly managed forests, like FSC Certified wood, can contribute to a lower embodied carbon footprint than non-certified timber. Reusing existing structural materials on a project can help reduce the demand for new materials and the structure's embodied carbon from extraction and manufacturing (note: if salvaged or reused materials from offsite are incorporated into the project, they cannot be double counted in this credit and the Building Life-Cycle Impact Reduction credit). Structural engineers will need to assess and determine the condition and strength of existing structural elements to ensure they will be adequate for the demands of the proposed design. It is paramount that structural engineers are engaged during schematic design when building and material reuse is a design option.

Materials and Resources Pilot Credit 102: Legal Wood: This pilot credit is an alternative compliance path to the Material & Resource Credit: Sourcing of Raw Materials. This pilot credit requires 100% of structural framing lumber is from legal sources as defined by ASTM D7612-10 and 70% (based on cost) of all wood is from responsible sources as defined by ASTM D7612-10. Sourcing timber from legal and responsible sources helps protect forests from unsustainable harvesting and managing practices and ensures forests continue to promote biodiversity and carbon sequestering.

Materials and Resources Pilot Credit 132: Procurement of Low Carbon Construction Materials: For the project team to be awarded points for this pilot credit, the structural engineer can provide the team with the following information:

- Material embodied carbon intensity baselines ($mECI_b$)
- Actual material embodied carbon intensities ($mECI_a$)
- Building embodied carbon intensity baseline ($bECI_b$)
- Actual building embodied carbon intensity ($bECI_a$)

Structural materials included in the pilot credit are concrete, steel, timber, and metal framing. The engineer shall obtain the structural material quantities used for calculations from 100% CD Construction estimate, 100% CD BIM bill of materials, or the contractor's material quantity take-offs.

The $mEBI_b$ is determined by multiplying the structural material quantities by the material embodied carbon baseline values published by the University of Washington - Carbon Leadership Forum (or other approved data provider). The sum of all materials required to be accounted for in the baseline is then taken as the $bECI_b$. To calculate the $mECI_a$, the structural material quantities are multiplied by GWP numbers from third-party verified Environmental Product Declaration with the applied University of Washington - Carbon Leadership Forum methodology. The sum of $mECI_a$ is taken as the bEC_a and compared to the building embodied carbon intensity baseline ($bECI_b$). If the percent difference between the $bECI_b$ and the $bECI_a$ is between zero to 30%, one point is awarded. If the percent difference is greater than 30%, two points are rewarded.

[5] See Carbon Leadership Forum. (2020). "Learning about Forests, Carbon, and Wood." Seattle, WA. Accessed July 10, 2021. https://carbonleadershipforum.org/learning-about-forest-carbon/

It is beneficial for the industry to ask and obtain EPD's for structural materials to drive the market towards transparency and prioritization of low embodied carbon materials.

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