CONCRETE CONTRIBUTIONS TO LEED® v4

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In its continued goal to transform the marketplace, the U.S. Green Building Council (USGBC) developed its newest product, LEED® v4, after an unprecedented six public comment periods and a vote of the full committee membership in June 2013. LEED v4 includes six products, namely LEED for:

- Building Design and Construction
- Interior Design and Construction
- Existing Buildings:
  - Operations and Maintenance
  - Homes
  - Neighborhood Development

The primary focus of this article is how concrete can contribute to credits in LEED v4 for Building Design and Construction (BD+C), which includes New Construction, Core & Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality, and Healthcare. Requirements for complying with prerequisites and credits in LEED v4 are detailed in a comprehensive User's Manual.[1]

By focusing on the inherent properties of concrete, this article highlights credits in LEED v4 to which concrete may contribute. Concrete's characteristics of low albedo, thermal mass, recyclability, local availability, lack of volatile organic compounds (VOCs), and the industry's transparency can all contribute to more-sustainable projects.

[1] U.S. Green Building Council (USGBC). 2013. Reference Guide for Building Design and Construction v4. *www.usgbc.org/resources/leed-reference-guide-building-design-and-construction*

Low Albedo

Concrete is an obvious material choice for reducing the urban heat island effect.

Albedo, which in this context is synonymous with solar reflectance, is the ratio of the amount of solar radiation reflected from a material to the amount that shines on the material. Solar radiation includes the ultraviolet as well as the visible spectrum. Generally, light-colored surfaces have a high albedo, but this is not always the case. Surfaces with lower albedos absorb more solar radiation. The absorbed radiation is converted into heat and the surface gets hotter. Where paved surfaces are required, using materials with higher albedos will reduce the heat island effect—consequently saving energy by reducing the demand for air conditioning—and improve air quality. As the temperature of urban areas increases, so does the probability of smog and pollution. Smog episodes rarely occur when the temperature is below 21°C (70°F).

Concrete constructed using ordinary portland cement generally has a reflectance of approximately 0.35, although it can vary. Measured values are reported in the range of 0.35 to 0.5. For concrete made with white portland cement, values are reported in the range of 0.7 to 0.8.

SSc5: Heat Island Reduction

In LEED v4, this credit combines the LEED 2009 non-roof and roof credits for heat-island reduction. One strategy for achieving credit in this category is to use materials with an initial solar reflectance of 0.33. In LEED v4, this credit is only applicable to paving in the non-roof category, concrete without added pigments or coatings

Paved areas with light-colored surfaces reflect heat rather than absorb it, reducing the heat island effect and improving air quality.

should be able to meet the requirement. Concretes tested and reported by PCA[2] all meet the initial (installation) requirement, including darker concretes.

LTc5: Access to Quality Transit

This credit requires dedicated walking or bicycling lanes from school buildings to the end of the school property, in the direction of the transit lines. Although sidewalks no longer count toward SSc5 requirements for heat-island reduction, by using concrete for walking or bike lanes, an added benefit of reduction in the heat-island effect could be realized (though not eligible for credit through LEED).

LTc6: Bicycle Facilities

This credit requires bicycle networks that connect the project to various types of buildings. Although a bicycle network can include streets with limited speed limits, it also includes bicycle paths and bicycle lanes. Like with credit LTc5, if concrete is used for the bike paths, additional heat-island reduction on the site is possible (though not eligible for credit through LEED).

Thermal Mass

Concrete has significant thermal mass. This means concrete components have enough heat-storage capacity to moderate daily temperature swings. Buildings constructed of cast-in-place, tilt-up, or precast concrete; insulating concrete forms (ICF); or masonry possess thermal mass that helps moderate indoor temperature extremes and reduces peak heating and cooling loads.

The thermal-mass advantages of concrete should be utilized when designing for passive thermal strategies or minimizing energy use in a building. In many climates, these buildings have lower energy consumption than non-massive buildings with walls of similar thermal resistance. When buildings are properly designed and optimized, incorporating thermal mass can lead to a reduction in heating, ventilating, and air-conditioning equipment capacity. Reduced equipment capacity can represent energy and construction cost savings. It is important when modeling energy performance of a building to take into account the thermal mass benefits.

Concrete's high capacity to store heat, called thermal mass, moderates temperature swings and reduces the heating and cooling needs of buildings.

EAp2: Minimum Energy Performance

In this prerequisite, the general requirement is that new construction save 5% compared to ANSI/ASHRAE/IESNA Standard 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential Buildings.[3] This can be demonstrated through whole building energy simulations (computer modeling) for Option 1, through compliance with ASHRAE Advanced Energy Design Guides (AEDG)[4] for Option 2, or through compliance with Advanced Buildings Core Performance Guide[5] for Option 3.

The requirements of the ASHRAE standard are cost-effective and not particularly stringent for concrete. Insulating to meet or exceed the standard requirements is generally a wise business choice. Determining compliance for the envelope components is relatively straightforward using the tables in Appendix B of the ASHRAE standard.

EAc2: Optimize Energy Performance

This credit builds on EAp2 and specifies how many more points can be achieved by saving more energy. This savings can be demonstrated through whole building energy simulations (computer modeling) for

[2] Marceau M.L., and VanGeem, M.G, Solar Reflectance for LEED Sustainable Sites Credit: Heat Island Effect, PCA Publication No. SN2982, Portland Cement Association, 2007.

[3] American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). 2010. Energy Standard for Buildings Except Low-Rise Residential Buildings. www.ashrae.org/resources--publications/bookstore/standard-90-1-document-history#2010

[4] American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). Advanced Energy Design Guides. www.ashrae.org/standards-research--technology/advanced-energy-design-guides

[5] advancedbuildings.net/core-performance

Concrete is frequently crushed and recycled into aggregate for road bases or construction fill.

Option 1, for up to 18 points; or through compliance with ASHRAE Advanced Energy Design Guides (AEDG) for Option 2, for up to 6 points. As mentioned in EAp2, meeting or exceeding the requirements of the ASHRAE standard are cost-effective and not particularly stringent for concrete.

Recyclable

Concrete is a relatively heavy construction material, yet is frequently crushed and recycled into aggregate for road bases or construction fill. This assists in the LEED v4 credits related to construction waste.

MRp2: Construction and demolition waste management planning

This is a new prerequisite in LEED v4 for planning construction, renovation, and demolition waste. No thresholds are set, yet a waste management plan must be created. Concrete waste is minimal in new construction and can be recycled in most urban areas.

MRc5: Construction and Demolition Waste Management

This credit encourages diversion of construction waste from landfills and incineration. Calculations are still done by weight or volume. Two options are available for earning points in this credit.

In Option 1, the possible points depend on whether 50% of the total construction and demolition waste is diverted from three material streams (1 point), or 75% of the total construction and demolition waste is diverted from four material streams (2 points). For Option 2, a project can earn 2 points if less than 2.5 lb of construction waste is generated per square foot of building floor area. No matter the option chosen by the project team, concrete can contribute because waste is minimal, and whatever waste is generated is recyclable in most areas.

Local Availability

Concrete, and its constituent materials, are typically sourced locally. For example, ready-mix and precast concrete plants generally use aggregates that are extracted within 80 km (50 miles) of the plant. Cement and supplementary cementitious materials used for buildings are also often manufactured within 800 km (500 miles) of a job site. Reinforcing steel is usually manufactured within 800 km (500 miles) of a job site, and is typically made from recycled materials from the same region. This aids in value calculations for Material and Resource credits in LEED v4.

MRc3: Building Product Disclosure and Optimization—Sourcing of Raw Materials

This credit has changed significantly since the last version of LEED. The intent of this credit is: "To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts. To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner." Two options are available: Raw Material Source and Extraction Reporting, and Leadership Extraction Practices.

The first method of compliance (Raw Material Source and Extraction Reporting) is to use 20 permanently installed products—sourced from at least 5 different manufacturers—that have a publicly released report from suppliers including:

- Raw material supplier extraction locations,
- A commitment to long-term ecologically responsible land use,
- A commitment to reducing environmental harms from extraction and/or manufacturing processes, and
- A commitment to meeting applicable standards or programs voluntarily that address responsible sourcing criteria.

If manufacturers provide self-declared reports for Option 1, products are valued at ½ of a product. Manufacturers that have third-party verified corporate sustainability reports (CSR), conforming to one of the following frameworks, are valued at 1 whole product.

- Global Reporting Initiative (GRI) Sustainability Report[6]
- Organisation for Economic Co-operation and

[6] globalreporting.org/

Concrete and its components are typically sourced locally, often within 50 miles, and constructed with local labor.

Development (OECD) Guidelines for Multinational Enterprises[7]

- U.N. Global Compact: Communication of Progress[8]
- ISO 26000: 2010 Guidance on Social Responsibility[9]
- USGBC approved program

For Option 2, Leadership Extraction Practices, 25% of the total value of permanently installed building products must meet at least one of the following criteria:

- Bio-based according to the Sustainable Agriculture Network's Sustainable Agriculture Standard
- New wood certified by FSC or USGBC-approved equivalent
- Reused materials
- Recycled content, which is still calculated as postconsumer content plus ½ preconsumer content
- USGBC-approved program

Concrete typically uses supplementary cementitious materials, such as fly ash, silica fume, and slag cement, which are considered post-industrial recycled content.

For the purpose of calculations, products are valued based on source location as such:

- Products sourced within 100 miles of project site are valued at 200% of their cost.
- Products sourced domestically within 500 miles of project site are valued at 150% of their cost.

As mentioned previously, concrete and its constituents are typically sourced very close to the project site and can add to the material valuation of this credit.

Low or No VOCs

Concrete contains low to negligible volatile organic compounds (VOCs). These compounds degrade indoor air quality when they off-gas from new products. In addition, VOCs combine with other chemicals in the air to form ground-level ozone. Complaints due to poor indoor air quality routinely include eye, nose, and throat irritation; dryness of the mucous membranes and skin; nose bleeds; skin rash; mental fatigue and headache; cough; hoarseness; wheezing; nausea; dizziness; and increased incidence of asthma.

EQc2: Low-Emitting Materials

This credit contains a statement that plain concrete is inherently non-emitting and VOC emission testing is not required. The text states: "Products that are inherently non-emitting sources of VOCs – specifically stone, ceramics, powder-coated metals, plated metals or anodized metals, glass, concrete, clay brick, and unfinished/untreated solid wood flooring – are considered fully compliant without any VOC emissions testing if they do not include integral organic-based surface coatings, binders, or sealants."

For Healthcare and Schools projects, LEED has this new requirement for exterior[10] applied products: "Adhesives, sealants, coatings, roofing and waterproofing materials applied on-site shall meet the VOC limits of California Air Resources Board (CARB) 2007 Suggested Control Measure (SCM) for Architectural Coatings and South Coast Air Quality Management District (SCAQMD) Rule 1168 effective July 1, 2005. The provisions of this section shall not apply to small containers of adhesives and sealants subject to state or federal consumer product VOC regulations."[11] There are sealants and coatings that are applied to the exterior surface of concrete and masonry that meet this requirement.

[7] oecd.org/daf/internationalinvestment/guidelinesformultinationalenterprises/

[8] unglobalcompact.org/cop/9 www.iso.org/iso/home.html

[9] www.iso.org/iso/home.html

[10] The building exterior is defined as everything outside and inclusive of the primary and secondary weatherproofing system, including waterproofing membranes and air and water resistive barrier materials.

[11] http://aqmd.gov/rules/download.html

Because of its mass, concrete provides an effective buffer to reduce noise from the outside or from neighboring rooms.

Resistance to Noise

Because of its mass, concrete provides a buffer between outdoor noise and the indoor environment. Concrete can reduce the amount of sound that can move through a wall. An 8-in.-thick (200 mm) flat wall panel has a sound transmission coefficient (STC) of 58 and outdoor-indoor transmission class (OITC) of 50. For floors, an 8-in.-thick hollow-core with a carpet and pad has an STC of 50 with an impact insulation class (IIC) of 73.

EQc9: Acoustical Performance

This credit requires minimum composite STC ratings for adjacent spaces. The requirement states, "meet the composite sound transmission class (STCC) ratings listed in Table 1, or local building code, whichever is more stringent." The requirements in the table are much more stringent than national building codes. However, higher STC ratings are often achieved more-easily when using concrete.

Embraces Transparency

The cement and concrete industry has embraced environmental transparency for some time, publishing its first industry-average LCA in 2000.

MRc1: Building life-cycle impact reduction

This credit has 4 options; three of these are for reuse and up to five points are available reflecting USGBC's new focus on reuse. The durability of concrete can contribute to the three credits related to reuse.

For new construction, Option 4 in MRc1 requires that a whole building life-cycle assessment (LCA) be performed. The concrete industry has been providing life-cycle data since the early 2000s. There is relevant cement and concrete LCI data in the U.S. LCI database.[12]

To achieve points with this option, a minimum of 10% reduction in at least three of six impact categories compared to a reference building must be demonstrated. A whole-building LCA must be performed on the structure and enclosure of a reference building and on that of the proposed project building. The LCA must conform to ISO 14044,[13] and a minimum service life of 60 years must be modeled.

The 10% reduction must be shown in global warming potential (in kg CO_{2e}) and two of the following five impact categories for 3 points:

- Depletion of the stratospheric ozone layer in kg CFC-11
- Acidification of land and water sources in moles H+ or kg SO_2
- Eutrophication in kg N or kg Phosphate
- Formation of tropospheric ozone in kg NO_x or kg Ethene
- Depletion of non-renewable energy resources in MJ

MRc2: Building Product Disclosure and Optimization—Environmental Product Declarations

The intent of this credit is "To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts."

Two options are available: environmental product declaration (EPD) and multi-attribute optimization. The concrete industry developed a product category rule (PCR) for ready-mixed concrete in 2012,[14] and concrete manufacturers are in the process of developing EPDs for their products. The cement industry, and several

[12] www.nrel.gov/lci/13 www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=38498

[13] www.nrel.gov/lci/13 www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=38498

Concrete's durability opens up opportunities for reuse and reduces the environmental impact of a building over its life-cycle.

other concrete-related industries, are currently developing PCRs for North American use as well.

In the first method of compliance, the project team must use 20 permanently installed products—sourced from at least 5 different manufacturers—that:

- Have a product-specific declaration,
- Have an industry-wide (generic) EPD,
- Have a product-specific Type III EPD, or
- Conform to a USGBC-approved program.

It is possible that the credit could be interpreted such that the many products that comprise a concrete or masonry assembly could count toward the 20 permanently installed products. For instance, the cementitious materials, aggregate, and sealants would likely all count as separate products.

For the purpose of calculations, products are valued based on the stringency of the declaration as such:

- Products with a product-specific declaration are valued at ¼ of a product
- Products with an industry-wide (generic) EPD are valued at ½ of a product
- Products with a product-specific Type III EPD are valued as a whole product

For Option 2, 50% of the value of permanently installed products (by cost) must have:

- Extended producer responsibility, or
- Reduced environmental impact (per USGBC program).

The extended producer responsibility alternative values products at 50% of their cost. USGBC-approved programs for the reduced environment impact alternative of Option 2 are currently listed as those certification programs that verify impact reduction (below industry average) of products in three of the following categories:

- global warming potential,
- depletion of stratospheric ozone,
- acidification,
- eutrophication,
- formation of tropospheric ozone, or
- depletion of nonrenewable energy sources.

Products used to meet the criteria are also valued according to source. Values are:

- Products sourced within 100 miles of the project site are valued at 200% of their cost.
- Products sourced domestically within 500 miles of the project site are valued at 150% of their cost.

These distances are generally easily achieved for concrete products.

MRc4: Building product disclosure and optimization—material ingredients

The intent of this credit is to address human toxicity – an impact that is not addressed in the LEED v4 LCA requirements. The intent of the credit reads: "To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances." There are three options for this credit: Material Ingredient Reporting, and Material Ingredient Optimization, and Supply Chain Optimization.

The (Material Ingredient Reporting) option requires the use 20 permanently installed products—sourced from at least 5 different manufacturers—that comply with any of the following chemical-inventory programs:

- Manufacturer Inventory – basically an inventory of all ingredients,

[14] www.carbonleadershipforum.org/Carbon_Leadership_fourm/PCR.html ww.nrel.gov/lci/13 www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=38498

- Health Product Declaration (HPD) – product must have and HPD with full disclosure of known hazards in compliance with the HPD Collaborative standard,[15]
- Cradle to Cradle – product must be certified to the Cradle to Crade v2 Basic Level of the Cradle to Cradle v3 Bronze Level,[16] or
- USGBC-approved program.

Products must have chemicals inventoried to 1000 ppm.

For Option 2 (Material Ingredient Optimization), 25% of the value of permanently installed products (by cost) must use one of the following to comply:

- USGBC approved program,
- GreenScreen v1.2 Benchmark – product must have fully inventoried chemical ingredients to 100 ppm that have no Benchmark 1 hazards,[17]
- Cradle to Cradle Certified – product is valued based on the version and certification level of the various Cradle to Cradle programs,[18] or
- International Alternative Compliance Path – REACH Optimization – product cannot contain substance that meet REACH criteria for substances of very high concern.[19]

The Supply Chain Optimization option requires 25% of the value of permanently installed products (by cost) must be from product manufactures:

- who engage in validated and robust safety, health, hazard and risk programs, and
- with independent third party verification.

These are new requirements for the cement and concrete industries, but producers intend to work with architects and engineers to meet these new requirements in LEED v4.

PCA is a member of the United States Green Building Council

[15] http://hpdcollaborative.org/

[16] http://c2ccertified.org/product_certification

[17] http://www.greenscreenchemicals.org/

[18] c2ccertified.org/product_certification

[19] echa.europa.eu/support/guidance;jsessionid=708167B5EE5BFA01D7B314128B9CE43B.live1