Tech Spec Guide

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- Tech Spec 1: Glossary of Terms for Segmental Concrete Pavement
- Tech Spec 2: Construction of Interlocking Concrete Pavements
- Tech Spec 3: Edge Restraints for Interlocking Concrete Pavements
- Tech Spec 4: Structural Design of Interlocking Concrete Pavement for Roads and Parking Lots
- Tech Spec 5: Cleaning, Sealing and Joint Sand Stabilization of Interlocking Concrete Pavement
- Tech Spec 6: Operation and Maintenance Guide for Interlocking Concrete Pavement
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- Tech Spec 22: Geosynthetics for Segmental Concrete Pavements
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- Tech Spec 24: Structural Design of Segmental Concrete Paving Slab and Plank Pavement Systems
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Tech Spec 16

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Achieving LEED Credits with Segmental Concrete Pavement

Initiated in 1998 by the U.S. Green Building Council, Leadership in Energy and Environmental Design or LEED supports an ethos of energy and material conservation in building and site design, construction and operation. LEED evolved through several updates to version 4 (v4) released in late 2013. In 2019, LEED updated v4 to v4.1 and published a v4.1 reference guide in 2020. LEED supports creating environments that enhance human existence and natural processes. One of the primary motivations of LEED is to influence building design and codes toward zero environmental impacts, particularly concerning carbon emissions. Figure 1 explains this evolution, past, present and future.

Buildings and sites consist of tens of thousands of products that compose various systems. Among many things, LEED helps achieve project design goals via product/system selection that supports cost-effectiveness, environmental friendliness and social responsibility. For the site, pavement can be a significant investment with positive or negative economic, environmental and social impacts. In support of positive impacts, this technical bulletin focuses on LEED v4 credits supported by using products from the family of segmental concrete pavement. This family includes interlocking concrete pavement, permeable interlocking concrete pavement (PICP), paving slabs, and concrete grid pavements

LEED v4 provides ten credit categories from which projects can earn points toward certification. Pavement decisions typically focus on three credit categories: Sustainable Sites, Materials and Resources, and Water Efficiency. Open space, rain water management, and heat island mitigation credits are under Sustainable Sites. Materials and Resources credits have seen significant changes and these are presented later. This bulletin includes updates published as LEED v4.1.

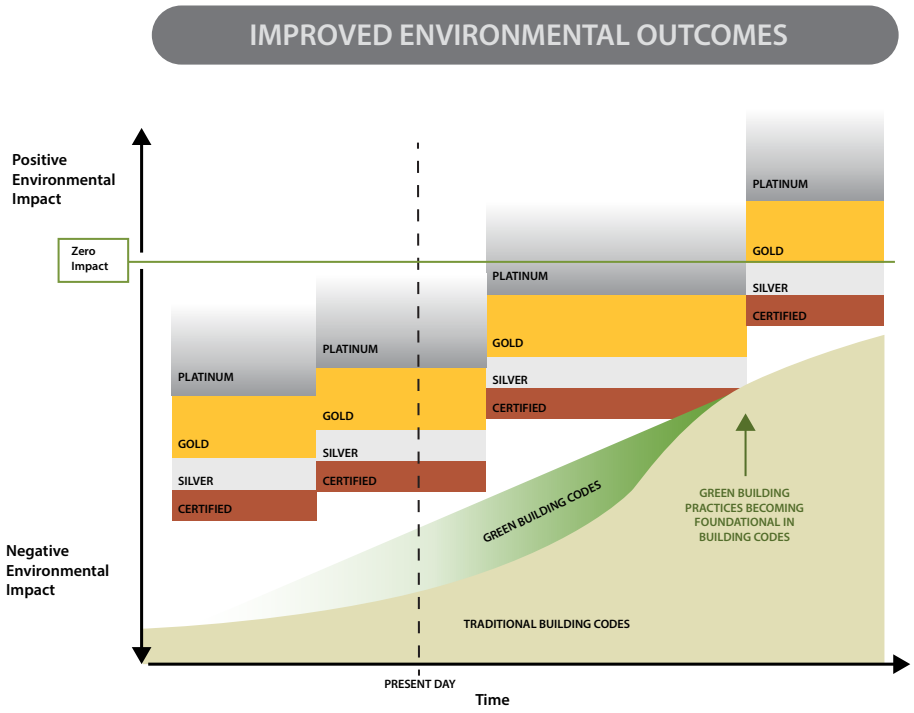

Figure 1. Proposed evolution of LEED toward zero impact design (from LEED M&R webinar)

The design criteria in LEED have been applied to many publicly funded projects and a growing number of private ones. The benefit of these criteria is reducing maintenance, life-cycle costs and environmental impacts. LEED is used in building projects to help provide project owners with positive economic benefits that also render environmental and social benefits. These benefits are best achieved by including all players in an integrated development process during the design stages of a project. LEED v4 recognizes the importance of this process by creating a new credit for this activity called Integrative Process and making it a prerequisite in all rating systems. Some examples of this integrated design process as they pertain to segmental concrete pavements are presented on pages 4 and 5.

LEED v4 Rating Systems are as follows:

- Building Design and Construction (BD+C)
- Interior Design and Construction (ID+C)
- Building Operations and Maintenance (O+M)
- Neighborhood Development (ND)
- Homes Design and Construction (HD+C)

This technical bulletin focuses on credits in the commonly used BD+C rating system. Points earned within each credit apply to the following building types most of which can include segmental concrete pavements.

- New Construction and Major Renovations
- Core and Shell Development
- Schools
- Retail Stores
- Data Centers
- Warehouses and Distribution Centers
- Hospitality Centers
- Healthcare Facilities
- Single Family and Multifamily Lowrise Buildings
- Multifamily Midrise Buildings

In this bulletin, green text provides a summary of each credit and related points. This text is excerpted from the LEED v4 BD+C Reference Guide (USGBC 2013). Commentary follows on how segmental concrete pavement can be used to address each credit. Specific BD+C credit categories that can be satisfied or supported with segmental concrete pavements are listed below and in Table 1:

- Integrative Process
- Sustainable Sites
- Water Efficiency
- Materials and Resources
- Innovation
- Regional Priority

Table 1. Summary of potential points earned with support from using segmental concrete pavements in the LEED V4.1 BD+C rating system.

LEED Credit Category	Potential Points Using Segmental Concrete Pavement
Integrative Process	1
Sustainable Sites	
Open Space	1
Rainwater Management	3
Heat Island Reduction	2
Water Efficiency	
Outdoor water use	1-2
Materials & Resources	
Building Product Disclosure and Optimization– Environmental Product Declarations	1-2
Building Product Disclosure and Optimization– Sourcing of Raw Materials	1-2
Building Product Disclosure and Optimization– Material Ingredients	1-2
Construction and Demolition Waste Management	1-2
Innovation	1-5
Regional priority	1-4
Range of potential points	14-26

BD+C credit categories that generally rely on other site and building products and systems include:

- Location & Transportation
- Energy & Atmosphere
- Indoor Environmental Quality

LEED certification is granted to projects based on earning points offered by the ten credit categories. The minimum required points for LEED certification is 40. Higher levels are shown in Table 2.

Table 2. LEED Certification levels

Level	Points
Certification	40-49
Silver	50-59
Gold	60-79
Platinum	80 or more

The Integrative LEED Process

The LEED process emphasizes transforming the design process. The process moves design professionals from working separately and linearly to working together early with idea exchanges, developing processes to include selected LEED credits, and continued dialog. Emphasis is on finding synergies among decisions on building design and site systems by relying on a wider range of viewpoints during the design process. Once project design goals are identified, promising LEED credits are ranked according to their support of those goals. The credits that offer the highest value become priorities for the design team to include in the project. These credit priorities and related points influence the achievable LEED certification level (i.e. silver, gold platinum).

Generally, one person on the design team coordinates and develops documentation required by each credit. Others on the design team may support this person by documenting specific credits that relate to their professional specialty such as storm-water management or building energy use. The process involves several meetings to identify design decisions and coordinate creating and delivery of supporting documentation based on the requirements of each credit.

Certification Process

To start the LEED certification process, the project is registered on the USGBC web site with payment of a registration fee plus a fee based on the total area of the building. The web site specifies materials to be submitted such as project plans, calculations, and documentation. Depending on the credit requirements, this documentation can come from the project team including product manufacturers, contractors, cost estimators, specification writers and designers.

Projects in Canada can be registered on this site as well. The Canadian Green Building Council (CaGBC) has moved away from a stand-alone Canadian LEED rating system. Instead, CaGBC will be developing Canadian-specific options for compliance with the v4 rating systems. These options are called alternative compliance paths or ACPs which will identify equivalent means for demonstrating compliance to specific credits. The release of ACPs should be monitored on www.cagbc.org.

Responsibility for managing the certification process varies with each project. This effort is often coordinated by a LEED Accredited Professional, one who has taken a USGBC/CaGBC course and an exam on the BD+C credits and their requirements. Project teams that include a LEED AP qualify for one point provided by the stand-alone LEED AP credit. Once documentation is submitted online, it is reviewed for acceptance for LEED credits. Additional documentation can be requested as needed. Final certification is granted within 30 days of receipt of all necessary documentation. While the USGBC/CaGBC provide certification of credits (and related points achieved), many project owners do not apply for LEED certification, and instead use LEED as a means to guide sustainable design, construction and performance decisions.

LEED in Specifications and Project Management

Upon registering a project for LEED certification, the project is compared to the applicable LEED credits thereby identifying which credits require the appropriate documentation or tests. This evaluation helps scope the level of certification to be attained by the project. Generally, the higher the certification, the more effort is placed into documentation and into building and site systems that comply with LEED requirements. A LEED project checklist helps identify responsibilities among the architect/engineer, contractor or owner for complying with applicable credits.

Besides identifying which parts of the building or site could comply with LEED requirements, the project team identifies which sections of the project specification will need to be written to include LEED requirements in Part 1, 2 or 3 of each Section in the project specifications. Division 01, General Conditions should include the owner's goals for achieving LEED credits, substitution procedures for green building products that contribute to LEED points, submittal procedures (which may be covered in

greater detail for each product in the relevant specifications sections), and a waste management plan. Submittals should occur before construction begins and substitutions should be conducted at the bid stage rather than during construction. The latest specification formats include sections for specifying sustainable building products.

Specific requirements and procedures for compliance to LEED credits for segmental concrete paving products should be included in the specifications. Examples of submittals from the contractor can include an environmental product declaration (EPD) from a paver manufacturer, waste management goals for reusing existing concrete pavers, or solar reflectance testing results on non-roof pavers. If segmental paving is indoors and sealed, or the joint sand stabilized with a liquid, such materials should comply with indoor air quality construction requirements in LEED.

Many projects have a pre-bid conference where the scope of the project is presented with details on the bid documents. The person running the conference should be familiar with LEED goals for the project and also review submittal requirements and substitution request procedures with prospective bidders. During construction, the owner's representative or contractor should appoint someone responsible for enforcing the contract provisions pertaining to achieving LEED requirements and documentation. The role of this person should be discussed at the pre-bid conference. This person could be responsible for fulfilling contractor related items on the project checklist.

LEED projects may not necessarily cost more than non-LEED projects as initial and lifetime costs vary with each project. Sometimes higher construction costs are offset by lower life-cycle costs. As such, some project owners are willing to trade higher initial costs for better lifetime economic and environmental performance. Along these lines, segmental concrete pavements should return lower maintenance costs during the life of the building and site.

Other Sustainable Design Evaluation Systems

Besides LEED, there are other environmental assessment and sustainability rating programs favorable to segmental concrete pavements. These include the following:

Green Globes www.greenglobes.com
Sustainable Sites Initiative www.sustainablesites.org
Greenroads www.greenroads.org
Envision www.sustainableinfrastructure.org/rating
Invest www.sustainablehighways.org

The latter four programs evaluate sites, roads and/or urban infrastructure. Also, some public transportation agencies have developed rating systems such as the Ontario Ministry of Transportation GreenPave program and the New York State Department of Transportation GreenLITES program.

LEED v4.1—Credits Applicable to Segmental Concrete Pavements

CATEGORY: INTEGRATIVE PROCESS

Intent

To support high-performance, cost-effective project outcomes through an early analysis of the interrelationships among systems.

Points: 1.

Requirements

This credit requires identifying opportunities to achieve synergies across design disciplines and building systems in the pre-design and design phases. The credit further requires an analysis of energy-related systems and water-related systems to investigate possible integration. Segmental concrete pavements can enter into such analyses and support mutual design objectives in the following ways:

- At grade and roof ballast interlocking concrete pavement with a roof garden, paving slabs or PICP with high reflectivity to reduce the heat island and related building cooling costs
- Light colored parking interlocking concrete pavement to reduce night lighting demand
- Grid pavements with grass to reduce the heat island and building cooling costs
- PICP to manage rainwater and reduce energy in processing combined sewage overflows by waste treatment plants, as well as reduced energy in creating drainage infrastructure and land used for detention facilities
- PICP for water harvesting for outdoor water use (irrigation)
- PICP combined with horizontal ground source heat pumps to supplement building heating/cooling.




Figures 2 – 5. An example of integrated water and energy design that could emerge from the Integrative Process credit: A horizontal ground source heat pump system is built within a permeable interlocking concrete pavement parking lot. The water in the pavement supports heating and cooling of an office building in the United Kingdom. (Source: Formpave UK)

Figures 2 through 5 illustrate 70,000 sf (6,500 m^2) of PICP used as a horizontal ground source heat pump to help provide heating and cooling for an office building in Stewartby, Bedfordshire, UK.

CATEGORY: SUSTAINABLE SITES

Open Space

Intent

To create exterior open space that encourages interaction with the environment, social interaction, passive recreation, and physical activities.

Requirements

Provide outdoor space greater than or equal to 30% of the total site area (including building footprint). A minimum of 25% of that outdoor space must be vegetated (turf grass does not count as vegetation) or have overhead vegetated canopy.

The outdoor space must be physically accessible and be one or more of the following:

- a pedestrian-oriented paving or landscape area that accommodate outdoor social activities;
- a recreation-oriented paving or landscape area that encourage physical activity;
- landscape area with two or more vegetation types and species that provide opportunities for year-round visual interest;
- a garden space dedicated to community gardens or urban food production;
- preserved or created habitat that meets the criteria of SS Credit Site Development—Protect or Restore Habitat and also includes elements of human interaction.

For projects that achieve a density of 1.5 floor-area ratio (FAR), and are physically accessible, extensive or intensive vegetated roofs can be used toward the minimum 25% vegetation requirement, and qualifying roof-based physically accessible paving areas can be used toward credit compliance. Wetlands or naturally designed ponds may count as open space if the side slope gradients average 1:4 (vertical : horizontal) or less and are vegetated.

Figures 6 – 11. Examples of open space with segmental concrete paving

The Open Space credit helps address the notion of 'environmental design' in the LEED acronym. The family of segmental concrete pavement products support outdoor social activities, recreation, and urban gardens. More broadly, these paving products support open spaces for commerce, they present a stage or platform for social gatherings and events, and provide access and mobility while assisting navigation. They support green infrastructure to attenuate stormwater runoff and the urban heat island on the ground and on roofs. Furthermore, PICP can eliminate or reduce the need for detention facilities, thereby creating opportunities for more open space. Various kinds of open space uses are shown in Figures 6 through 11.

Rainwater Management

Intent

To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region.

Requirements

Path 1. 80th percentile: 1 point (Healthcare 1 point); 85th percentile: 2 points Healthcare 2 points); 90th percentile: 3 points
In a manner best replicating natural site hydrology processes, retain (i.e. infiltrate, evapotranspirate, or collect and reuse) on site the runoff from the developed site for, at minimum, the 80th percentile of regional or local 24-hour rainfall depth using low-impact development (LID) / green infrastructure (GI) practices. GI and LID strategies can be either structural or non-structural. For all projects, the use of coal tar sealants shall be prohibited in any application exposed to stormwater, wash waters, condensates, irrigation water, snowmelt, or icemelt. Examples of acceptable techniques include the following:

- Planting rain gardens with native or adapted plant material (e.g. trees shrubs);
- installing a vegetated roof;
- Using permeable paving, consisting of porous above-ground materials (e.g., open pavers, engineered products), a base layer designed to drain water away from the building, and (often) a 6-inch-deep (150 millimeters) subbase; and
- Installing collection features (e.g., vegetated swale, rain garden, rainwater cistern) that can retain 100% of the runoff from at minimum, the 80th percentile of regional or local rainfall events.

A combination of LID approaches are recommended (but not required) as they are holistic measures which maximize benefits. In contrast to LID, conventional stormwater techniques include grey infrastructure, such as detention or retention ponds, pipes, and vaults. Conventional grey infrastructure devices may be accepted only if integrated within a holistic LID system (ie. a combination of LID techniques). Use daily rainfall data and the methodology in the U.S. Environmental Protection Agency (EPA) Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act to determine the percentile amount to be retained.

or

Path 2. Zero Lot Line projects only. 70th Percentile: 1 point (Healthcare 1 point); 75th percentile: 2 points (Healthcare 2 points); 80th percentile: 3 points
Zero lot line projects in urban areas with a minimum density of 1.5 floor area ratio (FAR): Treat run-off from pollutant-generating impervious surfaces (i.e. vehicle pavement, service courts, trash enclosures) using low-impact development (LID) practice/green infrastructure (GI) (or a traditional stormwater treatment device if LID/GI is not feasible for lack of space). Any above-ground setback area must be designed and used as a pedestrian-oriented space (e.g. restaurant seating, outdoor displays, private vendors, or related public purpose). In a manner best replicating natural site hydrology processes, retain on site the runoff from the developed site for, at minimum, the 70th percentile of regional or local rainfall events, using LID/GI.

PICP can help earn this LEED credit. Figure 12 illustrates a typical PICP cross section for runoff volume reduction. A typical design consists of paving units with openings filled with small, permeable, open-graded crushed stone. The units are bedded on a 2 in. (50 mm) thick layer of the similar aggregates. The bedding layer is compacted into the base consisting of washed, open-graded aggregate base supported by a subbase. They have sufficient space between stones to store water and allow it to infiltrate into the soil. The water storage capacity is typically 30% to 40% of the total volume of the base and subbase. This water is allowed to infiltrate into the soil usually within 24 to 72 hours. Water that does not infiltrate can be filtered through the base and drained through perforated pipes at the bottom of the sub-base.

PICP benefits:

- Can eliminate runoff
- Meet national/provincial/state stormwater regulations: part of best management practice (BMP) mix
- Conserves space: pavement integrated over/with a detention facility
- Reduces or eliminates surface retention requirements
- Filter and reduce nutrients, metals
- Promotes groundwater recharge

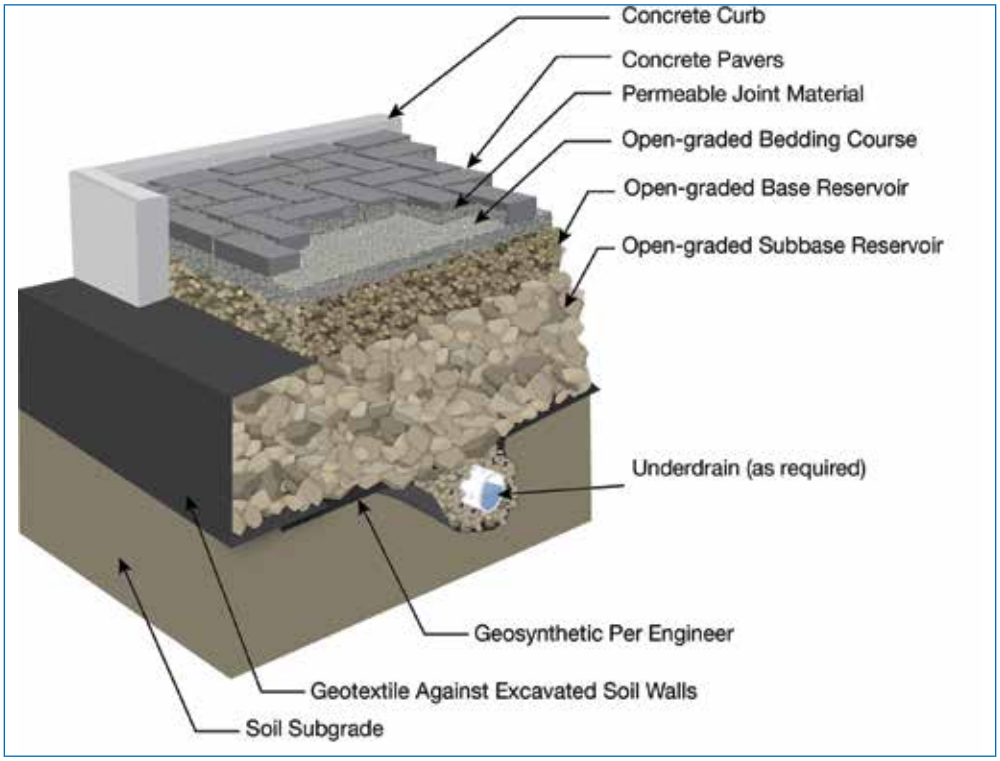

Figure 12. Permeable Interlocking Concrete Pavement (PICP)

- Lower peak flows/volume that helps preserve drainage system capacity while reducing downstream erosion
- Reduces runoff temperatures
- Potentially fewer drainage appurtenances
- Reinstatement of surface after repairs
- Filters oil drippings
- Resists frost heave and can be snowplowed
- Promotes decreased use of deicing salts and other deicers
- Visually attractive and more durable than other pervious/porous pavements

PICP infiltrates rain falling directly on it from all storms and the reservoir can be designed to accommodate additional water from adjacent impervious pavements. The infiltration rate of the soil, base thickness (reservoir capacity) and any runoff from contributing areas influence the ability of PICP to detain and infiltrate some or all of the runoff volume from the 95th percentile storm, and meet pre-development volumes. In cases with high infiltration rate soils, this can result in a runoff coefficient of zero for the PICP system.

The open-graded aggregate in the openings renders initial surface infiltration rates between 300 and 800 in./hr depending on the joint width and jointing stone gradation. Like all permeable pavements, PICP surfaces may collect sediment over time that must be removed periodically using regenerative air vacuum equipment capable of removing loose dirt, leaves, etc. Each PICP has different uses so vacuuming schedules should be based on removal accumulation of loose materials that, if left, would consolidate and clog the surface.

Ideally, there should be no water ponding on the surface immediately after storm. If puddles remain for more than an hour, the surface likely requires vacuum cleaning. For a quantitative assessment of surface infiltration rates, use ASTM C1781 *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems*. Generally, infiltration rates measured below 10 in./hr will require application of true vacuum (not regenerative air) cleaning equipment. If sediment is pressed or jammed into the surface and infiltration is low, a true vacuum machine may be required to remove the sediment and soiled jointing stone, and replacement of the soiled stones with clean aggregates. Additional information on PICP maintenance as well as design and construction can be found in the 5th Edition of the ICPI manual *Permeable Interlocking Concrete Pavements* (Smith 2017). Another resource is a national ASCE standard, ASCE 68-18 on permeable interlocking concrete pavements.

Calculations

The LEED Reference Guide suggests three ways to calculate runoff volumes and/or peak flows discharged from a stormwater control measure such as PICP. These include the Modified Rational Method, Technical Release or TR-55 published by the USDA Natural Resources Conservation Service (NRCS), and the US EPA Stormwater Management Model or SWMM. These methods require an estimate of C, the runoff coefficient for PICP, to calculate volumes and discharges. C values range between 0 and 1 with 0 indicating 100% infiltration of rainfall and 1.0 meaning all rainfall is converted to runoff from a surface.

Ferguson (2005) notes that C values vary with each storm. For many storms permeable pavements infiltrate all of the rainfall rendering a low or no runoff coefficient. In intense storms, and when the soil is saturated from antecedent rainfall, the runoff can occur from outflows when underdrains are present. Since sites receive a range of storm intensities and durations, the overall runoff coefficient for PICP is the sum of water volume released from underdrains divided by the total volume entering the surface for all rainstorms. Some PICP designs may infiltrate all water from all storms thereby making their runoff coefficient equal to zero. If PICP receives additional water from adjacent impervious surfaces (pavement and roofs), the average C value for both areas is calculated using weighted values based on the area of each surface.

Figure 13. Concrete grid pavement typically reduces runoff in a manner similar to grassed surfaces and are best used to earn heat island reduction points.

The NRCS TR-55 method relies on identifying a curve number (CN) that characterizes the amount of runoff depth from various land uses within a watershed catchment. The CN for PICP will vary with the reservoir storage capacity in the base/subbase and infiltration rate of the underlying soil. Typical CNs for PICP in sandy soils are in the 40s and for clay soils they can be in the 60s or 70s. For additional information see, Bean (2005) who characterized CNs for PICP, as well as the "effective SCS CN method" for permeable pavements developed by the *Metropolitan Nashville - Davidson County Stormwater Management Manual* (2016).

Some municipalities use computer models to simulate the impact of projects on urban drainage systems. Models are sometimes calibrated with field measurements of rainfall, runoff, flows and pollutant loads. The characteristics of PICP can be input into these models to simulate their benefits on urban hydrology. Along similar lines, ICPI offers Permeable Design Pro software (www.permeabledesignpro.com) to assist designers in modeling water discharge rates and volumes from PICP underdrains, as well as soil subgrade infiltration.

Concrete grid pavements (see Figure 13) are a type of permeable pavement. They are used for less intense vehicular applications than PICP such as overflow parking and emergency fire lanes. Unlike PICP, the base is typically dense-graded, compacted aggregate. This means grid pavements can absorb water similar to grassed areas but has little storage capacity from open-graded aggregate bases/subbase reservoirs common to PICP. Therefore, grids would generally not be used to earn points under this LEED credit but can earn credits as described in the next section on heat island reduction.

Heat Island Reduction

Intent

Minimize the effects on microclimates and human and wildlife habitats by reducing heat islands

Requirements

Option 1: Non-roof and Roof

Points: 2 except healthcare facilities which earn 1 point

Site surfaces must meet the following criteria:

$$\frac{\text{Area of Nonroof Measures}}{0.5} + \frac{\text{Area of High-Reflectance Roof}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

Alternatively, a solar reflection index for roof and solar reflectance for non-roofs may be weighted to calculate compliance as follows.

$$\frac{\left(\text{Area of high reflectance nonroof A} \times \frac{\text{SR of high reflectance nonroof A}}{\text{Required SR}}\right)^{1}}{0.5} + \frac{\text{Area of other nonroof measures}}{0.5} + \frac{\left(\text{Area of high reflectance roof A} \times \frac{\text{SRI of high reflectance roof A}}{\text{Required SR}}\right)^{2}}{0.75} + \frac{\text{Area of vegetated roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

1. Summed for all high-reflectance nonroof areas.
2. Summed for all high-reflectance roof areas.

Use any combination of the following strategies.

Nonroof Measures:

- Use the existing plant material or install plants that provide shade over paving areas (including playgrounds) on the site within 10 years of planting. Install vegetated planters. Plants must be in place at the time of occupancy permit and cannot include artificial turf.
- Provide shade with structures covered by energy generation systems, such as solar thermal collectors, photovoltaics, and wind turbines.
- Provide shade with architectural devices or structures that have a three-year aged solar reflectance (SR) value of at least 0.28. If three-year aged value information is not available, use materials with an initial SR of at least 0.33 at installation.
- Provide shade with vegetated structures.
- Use paving materials with a three-year aged solar reflectance (SR) value of at least 0.28. If three-year aged value information is not available, use materials with an initial SR of at least 0.33 at installation.
- Use an open-grid pavement system (at least 50% unbound).

High Reflectance Roof

Roof materials must comply with the following minimum solar reflectance values:

Roof Type	Slope	Initial SRI	3-year Aged SRI
Low-sloped roof	≤ 2:12	82	64
Steep-sloped roof	> 2:12	39	32

Another option is to use a vegetated roof.

Option 2: Parking Under Cover

Points: 1

Place a minimum of 75% of parking spaces under cover. Any roof used to shade or cover parking must

1. Have a three-year aged SRI of at least 32 (if three-year aged value information is not available, use materials with an initial SRI of at least 39 at installation);
2. Be a vegetated roof; or
3. Be covered by energy generation systems, such as solar thermal collectors, photovoltaics, and wind turbines.

Roof Applications

As in the previous LEED 2009 version, this credit continues using Solar Reflectance Index (SRI) to assess the reflectivity of roofing materials but with higher indices. The overall objective of the SRI is to encourage light colored surfaces that reduce surface temperatures. High SRI surfaces can help reduce the urban heat island, the dome of stationary, warm air over a city that increases summer air conditioning costs and traps air pollutants. Periodic surface cleaning may be required to maintain a minimum required SRI values on segmental concrete pavements. *ICPI Tech Spec 5–Cleaning, Sealing and Joint Sand Stabilization of Interlocking Concrete Pavement* provides additional guidance.

SRI is determined by combined albedo (reflectance) and emittance measurements. Albedo is the ratio of outbound

Figure 14. High SR paving slabs

or reflected solar radiation divided by the inbound radiation. Lighter colored surfaces indicate a higher albedo than dark surfaces. The highest albedo of 1.0 means all solar energy reflects back from a surface with no absorbed energy. The test method for determining albedo is ASTM E 903, *Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres*. Reflectance is measured over a range of wavelengths and averaged to provide a single albedo reflectance value.

Emittance measures a material's ability to release radiant heat (in watts/m^2) from a given wavelength spectrum. It is measured using ASTM E 408–*Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques.* Emittance and albedo measurements are combined to calculate SRI per ASTM E 1980 – *Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces*. As noted earlier, surface color affects albedo and indirectly affects emittance.

Some grey paving products made without pigments can be light in color and meet SRI requirements. White cement, selected pigments, light colored aggregates and/or surface treatments can boost albedos. Figure 14 shows an application with light colored paving slabs.

Since most manufacturers provide a range of colors, SRI measurements should be requested from manufacturers for specific product color or ranges, especially lighter colored products. Testing laboratories can provide requirements for test specimen sizes cut from segmental concrete paving products. Specimen sizes are generally 2 x 2 in. (50 x 50 mm) by ½ in. (13 mm) thick.

Non-roof Applications

For non-roof materials (i.e., interlocking concrete pavement, PICP and paving slabs) reflectance is measured using Solar Reflectance (SR) expressed as a percentage based on ASTM C1549 *Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer*. This test method is particularly suited for determining the solar reflectance of flat opaque materials in a laboratory or in the field using a commercial portable solar reflectometer. This device is calibrated using specimens of known solar reflectance to determine solar reflectance from measurements at four wavelengths in the solar spectrum: 380 nm, 500 nm, 650 nm and 1220 nm.

The SR test method is new to LEED v4. Meeting the LEED SR criteria of 0.33 for new surfaces and 0.28 for three-year old surfaces require lighter colored surfaces than SRI criteria. SR data should be requested from paver manufacturers. The area of paving surfaces meeting these requirements are counted as non-roof measures that mitigate the heat island. LEED recognizes permeable pavement (e.g., PICP) as a non-roof measure in calculating the area of non-roof surfaces on a site that help mitigate the heat island without meeting 0.33 or 0.28 SR values. If PICP is counted as a heat island mitigation measure, documentation must be provided on permeability. This can be done by the manufacturer providing surface infiltration test results using ASTM C1781 *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems*. The minimum recommended infiltration rate for new PICP is 100 in./hr (254 cm/hr).

Among several non-roof measures recommended in this credit is the use of grid pavements consisting of at least 50% unbound materials (typically grass and topsoil). While concrete grid pavements are typically applied as a non-roof material, they do not require an SR measurement.

Compared to asphalt, grassed grid pavements can reduce surface air temperatures by 2° to 4° F (1° to 2° C) and radiometric temperatures by 4° to 6° F (2° to 4° C) (Smith 1981 & 1984). Evapo-transpiration from the grass provides this cooling. As previously noted, concrete grid pavers are recommended for overflow or intermittent parking areas and are not intended where cars park regularly. Areas with regular parking and drives should be paved with PICP. Additional information on design, construction and maintenance of concrete grid pavements is found in *ICPI Tech Spec 8 – Concrete Grid Pavements.*

Calculations

Once SR and SRI values are provided by the manufacturer, the equations presented earlier can be used to calculate compliance to this credit for roof and non-roof heat island mitigating measures.

CATEGORY: WATER EFFICIENCY

Achieving this credit is required for LEED certification. Since it is a prerequisite, it offers no points.

Outdoor Water Use Reduction

Option 1. No Irrigation Required

Show that the landscape does not require a permanent irrigation system beyond a maximum two-year establishment period.

Or

Option 2. Reduced Irrigation

Reduce the project's landscape water requirement by at least 30% from the calculated baseline for the site's peak watering month. Reductions must be achieved through plant species selection and irrigation system efficiency, as calculated by the Environmental Protection Agency (EPA) WaterSense Water Budget Tool. See **www.epa.gov/watersense**.

Large quantities of water are used to irrigate landscaping and grass around buildings. Annual irrigation costs can be reduced or practically eliminated with water harvesting. Drip irrigation is replacing sprinkler systems and helping to pay back the initial cost for the irrigation system. Given these savings, one to two points can be earned under the Outdoor Water Use Reduction credit. A 50% reduction in water use earns one point and a 100% reduction earns two points.

PICP can be used to harvest, filter, store and transport roof and surface runoff into an underground reservoir for use in landscape irrigation. While roof runoff can be filtered and drain directly into above ground or underground storage systems, PICP can provide some filtering of runoff from site surfaces including impervious pavements. PICP surfaces and aggregates in the bedding, base and subbase provide filtering.

Figure 15 provides a schematic diagram. An impermeable liner is used to capture the water within the PICP base/subbase. Additional filtering will be needed as water exits the PICP base/ subbase and enters an underground storage tank. Storage tanks include pumps and timers to distribute water into the irrigation pipes. Landscape irrigation systems may include a backup water supply should the stored water supply become depleted.

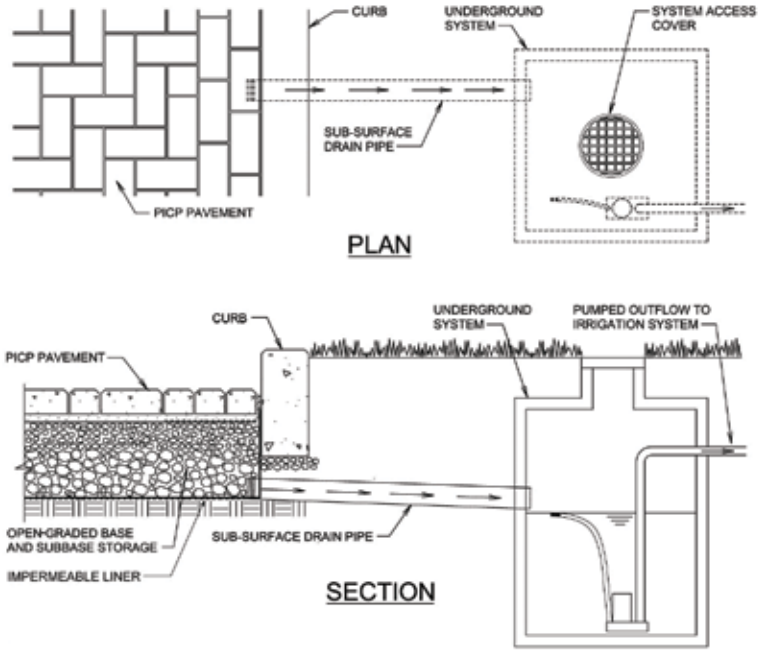

Figure 15. Water harvesting using PICP

The designer should keep in mind that low-water use plants can provide greater efficiency to the irrigation system. Commercial rainwater harvesting systems also provide design calculations for sizing and equipment selection.

CATEGORY: MATERIALS AND RESOURCES

This credit area intends to provide life cycle approach to building materials rather than concentrating on using recycled materials as in past LEED versions.. This includes material assessment and optimization, protection of human and ecological health, waste management and reuse. Figure 16 relates these areas to each other.

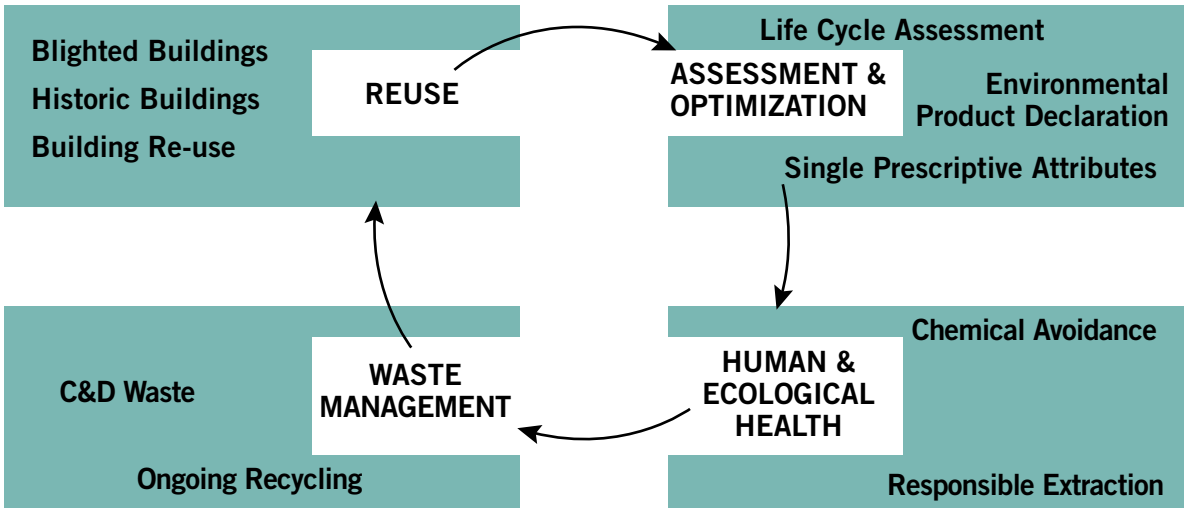

Figure 16. LEED life cycle integrated approach to sustainable materials (from LEED v4 advertisement)

Building Product Disclosure and Optimization—Environmental Product Declarations

Intent

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.

Requirements

Achieve one or more of the options below, for a maximum of 2 points.

Option 1. Environmental Product Declaration (EPD) (1 point)

Use at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the disclosure criteria below.

Requirements and related points

Life-cycle assessment and environmental product declarations.

- Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one whole product for the purposes of credit achievement calculation.
- Product-specific Type III EPD -- Internally Reviewed. Products with an internally critically reviewed LCA in accordance with ISO 14071. Products with product-specific internal EPDs which conform to ISO 14025, and EN 15804 or ISO 21930 and have at least a cradle to gate scope are valued as one whole product for the purposes of credit achievement calculation.
- Industry-wide Type III EPD -- Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator. Products with industry-wide EPDs, which conform to ISO 14025, and EN 15804 or ISO 21930 and have at least a cradle to gate scope are valued as one whole product for the purposes of credit achievement calculation.
- Environmental Product Declarations which conform to ISO 14025 and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
- Product-specific Type III EPD -- Products with third-party certification (Type III), including external verification and external critical review in which the manufacturer is explicitly recognized as the participant by the program operator are valued as 1.5 products for the purposes of credit achievement calculation.
- USGBC approved program – Products that comply with other USGBC approved environmental product declaration frameworks.

Calculate the number of products as follows:

Total # of products = {# of products with product specific declarations/industry specific declarations/internally verified type III EPDs* X 1} + {# of Type III EPDs with external verification and external critical review X 1.5}

Or

Option 2. Multi-Attribute Optimization (1 point)

Use products that comply with one of the criteria below for 10%, by cost, of the total value of permanently installed products in the project, or use at least 10 permanently installed products sourced from at least three different manufacturers. Products will be valued as below.

Life Cycle Impact Reduction Action Plan (value at 50% by cost or ½ product)

The manufacturer has produced a product specific LCA using EN 15804 or ISO 21930 for the product and has provided a publicly available action plan to mitigate or reduce life cycle impacts. The action plan must be product-specific using the specified PCR functional unit, be critically reviewed, and must include the following information:

- Description of the LCA conducted including the dataset, software or platform used by manufacturer to complete the analysis.
- Identification of the largest life cycle impact areas identified in the analysis and a narrative description of the impact areas targeted for reduction in the action plan.
- Description of specific steps anticipated in implementation of the action plan. Include proposed changes in formulation or manufacturing processes that are planned as part of impact reduction strategy.
- Specific dates and a full timeline for completion of all the steps described in the action plan.

Life Cycle Impact Reductions in Embodied Carbon

Products that have demonstrated environmental impact reductions for the specified functional unit based on a current third-party EPD or verified LCA that conforms to the comparability requirements of ISO 14025 and ISO 21930.

- The comparative analysis must show impact reduction in the global warming potential (GWP) impact category and must include a narrative describing how reductions in impacts were achieved. The published comparisons must be third-party verified (value at 100% by cost or 1 product).
- The comparative analysis must show impact reduction(s) of at least 10% in the global warming potential (GWP) impact category and must include a narrative describing how the impact reductions were achieved. The published comparisons must be third-party verified (value at 150% by cost or 1.5 products).
- The comparative analysis must show impact reduction(s) of at least 20% in the global warming potential (GWP) impact category, and demonstrate at least 5% reduction in two additional impact categories. A narrative describing how the impact reductions were achieved is required. The published comparisons must be third-party verified (value at 200% by cost or 2 products).

Impact categories:

- global warming potential (greenhouse gases), in CO_2e;
- depletion of the stratospheric ozone layer, in kg CFC-11e;
- acidification of land and water sources, in moles H+ or kg SO_2e;
- eutrophication, in kg nitrogen equivalent or kg phosphate equivalent;
- formation of tropospheric ozone, in kg NOx, kg O_3 equivalent, or kg ethene; and
- depletion of nonrenewable energy resources, in MJ using CML / depletion of fossil fuels in TRACI.

USGBC approved program – Products that comply with other USGBC approved multi-attribute frameworks.

For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at twice their base contributing cost (or number of products), up to a maximum of 200% of cost or 2 products.

Calculating the percentage cost of multi-attribute optimization materials:

% of materials cost = {product cost of materials with Life-Cycle impact reduction action plan X 50% X location valuation factor} + {product cost of materials with any Third-Party verified impact reductions in GWP impact category X 100% X location valuation factor}+{product cost of materials with Third-Party verified impact reductions with a minimum of 10% reduction in GWP impact category X 150% X location valuation factor} +{product cost of materials with Third-Party verified impact reductions with a minimum of 20% reduction in GWP impact category and a minimum of 5% reduction in 2 other impact categories x 200% X location valuation factor}

Calculating the total number of products with multi-attribution optimization:

Total # of products = {# of products with impact reduction action plans X 0.5 X location valuation factor} + {# of products with any Third-Party verified impact reductions in GWP impact category X 1 X location valuation factor}+{# of products with Third-Party verified impact reductions with a minimum of 10% reduction in GWP impact category x 1.5 X location valuation factor} +{# of products with Third-Party verified impact reductions with a minimum of 20% reduction in GWP impact category and a minimum of 5% reduction in 2 other impact categories X 2 X location valuation factor}

Where,
Product cost = cost of the product contributing toward credit. For assemblies, the cost amount contributing toward credit is based on weight
Location valuation factor = multiplier for the

EPDs and PCRs

An EPD is a standardized way of communicating the environmental impacts, such as global warming potential and energy resource depletion, of a product or system. A product category rule (PCR) defines how to standardize this information for a specific product type, such as flooring. The PCR defines scope, system boundary, measurement procedures, impact measures and other technical requirements for a life cycle assessment upon which an EPD is based. PCR development is the responsibility of the EPD Program Operator and is often organized through standards organizations or industry associations or sponsored by private or government organizations.

UL Environmental is planning to issue an updated PCR in 2020 for cradle-to-gate life cycle assessment and environmental product declarations issued by concrete paver manufacturers. Manufacturers should be contacted for EPDs on their products. To qualify for this credit, EPDs must be cradle to gate, i.e., a characterization of a paving product's environmental impacts during its life cycle from extraction (cradle) to the final product sold by the manufacturer (gate). The environmental impacts listed in an EPD were listed previously. Cradle to gate does not include transportation from the factory to distributors or customers. EPDs covering only manufacture (gate to gate) do not qualify for any credit.

For a manufacturer, the EPD process is as follows:

1. A manufacturer uses the product category rules for its product category (aka the product type).
2. The manufacturer conducts a life-cycle assessment, based on the product's goals and functional unit, global warming potential, primary energy demand, contribution to acidification and eutrophication, and other environmental indicators.
3. The manufacturer creates the EPD using this information and initiates verification by a third party, which determines whether the LCA followed the correct ISO processes and the EPD was created according to the PCR.
4. The manufacturer registers the declaration with a program operator which verifies the EPD according to ISO standards. Examples of program operators include UL Environmental, ICC-ES, NSF, FP Innovations, and the Institute for Environmental Research and Education.

Product-specific declarations are defined for this credit as declarations based on a life-cycle assessment of a product but not constituting a full EPD. To document this claim, the project team must provide the following information:

- Name (declaration holder or producer, typically the manufacturer)
- Contact information
- Product type
- Product name
- Product description
- Summary of impact categories measured and overall values
- Functional unit
- Standards met
- Independent review entity's name and statement

Documentation of EPDs

For industry-wide (generic) declarations and product-specific Type III declarations, the project team must provide the following:

- The bulleted items listed above
- EPD program operator (the entity that creates and registers the EPD)
- LCA verifier (the third-party entity that verifies the life-cycle assessment)
- Software programs used as well as calculators and tracking tolls
- PCR reviewer (the third-party entity that has reviewed the product category rules).

A Type III EPD summary includes the following information:

Building Product Disclosure and Optimization—Sourcing of Raw Materials

Intent

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.

Requirements

Option 1. Responsible Sourcing of Raw Materials (1–2 points)

Use products sourced from at least three different manufacturers that meet at least one of the responsible sourcing and extraction criteria below for at least 20%, by cost, of the total value of permanently installed building products in the project (1 point).

Use products sourced from at least five different manufacturers that meet at least one of the responsible sourcing and extraction criteria below for at least 40%, by cost, of the total value of permanently installed building products in the project (2 points).

- Extended producer responsibility. (See LEED v4 *Reference Guide for Building Design and Construction* for a complete explanation of options for fulfilling this responsibility.) Products purchased from a manufacturer (producer) that participates in an extended producer responsibility program or is directly responsible for extended producer responsibility. Products meeting extended producer responsibility criteria are valued at 50% of their cost for the purposes of credit achievement calculation. (Note: bullets on bio-based materials are omitted as they don't pertain to concrete paving products.)
- Materials reuse. Reuse includes salvaged, refurbished, or reused products. Products meeting materials reuse criteria are valued at 200% of their cost for the purposes of credit achievement calculation.
- Recycled content. Products meeting recycled content criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
    - Recycled content is the sum of post-consumer recycled content plus one-half the pre-consumer recycled content, based on weight.
    - The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.
- USGBC approved program. Other USGBC approved programs meeting responsible sourcing and extraction criteria.

For credit achievement calculation, products sourced (extracted, manufactured and purchased) within 100 miles (160 km) of the project site are valued at twice their base contributing cost, up to a maximum of 200% of cost or 2 products.

For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the base contributing cost of individual products compliant with multiple responsible extraction criteria is not permitted to exceed 100% its total actual cost (before regional multipliers) and double counting of single product components compliant with multiple responsible extraction criteria is not permitted and in no case is a product permitted to contribute more than 200% of its total actual cost.

Where:
Product cost = cost of the product contributing toward credit (see MR Overview, Determining Product Cost).
Criterion valuation factor = multiplier assigned to each sourcing criterion:

- Reused materials, value 2.0, by cost
- Postconsumer recycled materials, value 1.0, by cost
- Preconsumer recycled materials, value 0.5, by cost
- Location valuation factor = multiplier for the extraction, manufacture, and purchase location
- Extended producer responsibility is valued at 50%; that is, the valuation factor is 0.5. Products that are part of an extended producer responsibility program may be counted in their entirety even if only part of the product is recycled. Use the formula below to calculate material costs.

$$\%\ \text{of materials cost} = \frac{\left\{\left(\text{applicable product cost}_1\right)\left(\text{criterion}_1\ \text{valuation factor}\right)\left(\text{location valuation factor}\right)\right\} + \left\{\left(\text{applicable product cost}_2\right)\left(\text{criterion}_2\ \text{valuation factor}\right)\left(\text{location valuation factor}\right)\right\} + \cdots}{\text{Cost of all permanently installed products}} \times 100$$

Segmental concrete paving manufacturers can provide certification of pre- and postcomsumer content in their products. Supplementary cementing materials like silica fume, blast furnace slag and flyash are preconsumer recycled materials and are used to replace cement, thereby offsetting some carbon emissions. Glass is sometimes used in segmental concrete pavement products and it is considered a postconsumer recycled material. Paving product manufacturers and quarries should be contacted for letters certifying pre/postconsumer recycled content, as well as EPDs. All of this information is included in an Excel sheet provided by USGBC on **www.usgbc.org/resources/bpdo-calculator** to calculate the value of recycled or reused materials

with favorable weightings given to environmentally responsible material suppliers and manufacturers, distance from sources and EPDs from suppliers.

Building Product Disclosure and Optimization—Material Ingredients

Intent

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. To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.

Requirements

Option 1. Material Ingredient Reporting (1 point)

- Use at least 20 different permanently installed products from at least five different manufacturers that use any of the following programs to demonstrate the chemical inventory of the product to at least 0.1% (1000 ppm). (10 different permanently installed products from at least three different manufacturers for Core and Shell (CS) and Warehouses & Distribution Centers)
- Manufacturer Inventory. The manufacturer has published complete content inventory for the product following these guidelines:
    - A publicly available inventory of all ingredients identified by name and Chemical Abstract Service Registration Number (CASRN) and/or European Community Number (EC Number).
    - Materials defined as trade secret or intellectual property may withhold the name and/or CASRN/EC Number but must disclose ingredient/chemical role, amount and hazard score/class using either:
    - Greenscreen List Translator (LT) score and/or Full GreenScreen Benchmark (BM)
    - The Globally Harmonized System of Classification and Labeling of Chemicals rev.6 (2015) (GHS)

The hazard screen must be applied to each trade secret ingredient and the inventory lists the hazard category for each of the health hazards included in Part 3 of GHS (e.g. "GHS Category 2 Carcinogen").

- Health Product Declaration. The end use product has a published and complete Health Product Declaration with full disclosure of known hazards in compliance with the Health Product Declaration open Standard.
- Cradle to Cradle. Product has Material Health Certificate or is Cradle to Cradle Certified™ under standard version 3 or later with a Material Health achievement level at the Bronze level or higher.
- Declare. The Declare product label must meet the following requirements:
- Declare labels designated as Red List Free or Declared.
- Declare labels designated as LBC Compliant that demonstrate content inventory to 0.1% (1000 ppm).

Any compliant reports above with third-party verification that includes the verification of content inventory are worth 1.5 products for credit achievement calculations.

and/or

Option 2. Material Ingredient Optimization (1 point)

Use permanently installed products from at least three different manufacturers that document their material ingredient optimization using the paths below. Choose either 10 compliant products, or select products that constitute at least 10%, by cost, of the total value of permanently installed products in the project.

Material Ingredient Screening and Optimization Action Plan (value at 50% by cost or ½ product)

- The manufacturer has screened the product to at least 1,000 ppm and has provided a publicly available inventory meeting the requirements of Option 1 and completed a detailed action plan to mitigate or reduce known hazards using the principles of green chemistry. The action plan must be product-specific (not company, manufacturer or brand)

Advanced Inventory & Assessment (value at 100% by cost or 1 product):

- Manufacturer Inventory or Health Product Declaration (HPD): The product has demonstrated a chemical inventory to at least 0.01% by weight (100 ppm) with no GreenScreen LT-1 hazards or GHS Category 1 hazards. The HPD or Manufacturer Inventory must be third party verified.
- Manufacturer Inventory or HPD: The product has demonstrated a chemical inventory to at least 0.01% by weight (100ppm) and at least 75% by weight of product is assessed using GreenScreen Benchmark assessment. The remaining 25% by weight of product has been inventoried. The GreenScreen assessment must be publicly available. The HPD or Manufacturer Inventory must be third-party verified.
- Declare labels designated as Red List Free that are third-party verified.

- Cradle to Cradle Certified v3 product with Material Health category score of Bronze, or a certified Material Health Certificate at Bronze level.
- Material Ingredient Optimization (value at 150% by cost or 1.5 products)
- Manufacturer Inventory or HPD: The product has demonstrated a chemical inventory to at least 0.01% by weight (100ppm) and at least 95% by weight of product is assessed using

GreenScreen Benchmark assessment. No Benchmark 1 hazards (BM-1) are present in the end use product. The remaining 5% by weight of product not assessed has been inventoried and screened using GreenScreen List Translator and no GreenScreen LT-1 hazards are present in the end use product. The documents must be third party verified.

- Cradle to Cradle v3 certified product with Material Health category score of Silver or higher, or a Cradle to Cradle certified Material Health Certificate at Silver level or higher.
- International Alternative Compliance Path – REACH Optimization. End use products and materials have fully inventoried chemical ingredients to 100 ppm and assess each substance against the Authorization List – Annex XIV, the Restriction list – Annex XVII and the SVHC candidate list, (the version in effect June 2013,) proving that no such substance is included in the product. If the product contains no ingredients listed on the REACH Authorization, Restriction, and Candidate list, value at 100% of cost or 1 product.

Construction and Demolition Waste Management

Intent

To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.

A prerequisite to this credit is creating a waste management plan. This includes policies for off-site sorting and tracking of waste. Documentation on diverted waste from a waste-sorting facility is essential. The diversion rate is the total waste diverted divided by the total waste from the project multiplied by 100 to obtain a percentage.

Option 1. Diversion (1–2 points)

Path 1. Divert 50% and Two Material Streams (1 point)

Divert at least 50% of the total construction and demolition material; diverted materials must include at least two material streams.

OR

Path 2. Divert 50% using Certified Commingled Recycling Facility (1 Point)

Divert at least 50% of the total construction and demolition material. All commingled recycling must be sent to offsite sorting facility(ies) certified by the Recycling Certification Institute or approved equivalent.

OR

Path 3. Divert 75% and Three Material Streams (2 points)

Divert at least 75% of the total construction and demolition material; diverted materials must include at least three material streams.

OR

Path 4. Divert 75% using Certified Commingled Recycling Facility and One More Material Streams (2 points)

Divert at least 75% of the total construction and demolition material; diverted materials must include at least two material streams. All commingled recycling is required to be one of the streams and must be sent to offsite sorting facility(ies) certified by the Recycling Certification Institute or approved equivalent.

OR

Option 2. Reduction of Total (Construction and Demolition) Waste Material (2 points)

Salvage or recycle renovation and demolition debris and utilize onsite waste minimizing design strategies for new construction activities. Achieve the waste generation thresholds in Table 1 and create a narrative describing how a project is addressing waste prevention and/or achieving waste generation thresholds via design strategies and onsite waste minimization practices. Do not generate more than 7.5 pounds of construction waste per square foot (36.6 kilograms of waste per square meter) of the building's floor area for all BD&C projects except Warehouses and Distribution Centers.

For Option 2, the total construction waste generated is divided by the gross floor area of the project to obtain the weight per square foot.

Material streams are defined as material or material category diverted from a landfill, or diverted in a specific way. Like most

concrete, pavers can be crushed and recycled, or whole pavers removed and reinstated elsewhere on the site. The intent is to recycle construction waste on the site, or process it offsite and place it into the market for recycled materials.

Concrete removed from the site, processed and sold back to the same job site, or recycled material purchased from elsewhere and brought to the site can qualify for this credit. Examples are shipping used concrete pavers to a recycler, crushing them and purchasing them back for reuse on the site as base material. Another example is purchasing recycled, crushed concrete for a base under interlocking concrete pavements. If the project involves renovating an existing site, concrete pavers at the site can be re-used or directed to other appropriate sites. Concrete pavers can also be crushed and re-used for road base materials.

Recycled concrete aggregates (RCA) used with interlocking concrete pavement in vehicular areas should be from crushed sources certified by a state or provincial department of transportation as meeting specifications for gradation and hardness. These typically include limits on the percent passing the No. 200 (0.075 mm) sieve (generally <12%) and abrasion durability tests such as Los Angeles abrasion resistance or micro-Deval loss. No more than 30% RCA mixed with non-recycled (quarried/crushed) dense-graded aggregates are recommended for vehicular applications For pedestrian interlocking concrete pavements, up to 100% RCA can be used. However, there is an increased risk of efflorescence passed to the concrete paver surface. While not affecting structural performance, efflorescence may be unsightly and difficult to remove. Recycled asphalt materials should follow the aforementioned guidelines. RCA is not recommended for permeable interlocking concrete pavement in vehicular applications, but up to 100% may be used in pedestrian applications. is new to LEED v4. Meeting the LEED SR criteria of 0.33 for new surfaces and 0.28 for three-year old surfaces require lighter colored surfaces than SRI criteria.

Waste calculations do not include hazardous waste and excavated soil. Typically, waste containers are sized by volume and are weighed at the material recovery facility or landfill site. Typical factors for converting concrete paver volume to weight are 140 to 145 lbs/ft^3 (2240 to 2350 kg/m^3) for stacked pavers and approximately 100 lb/ft^3 (1600 kg/m^3) for loose pavers in a bin.

CATEGORY: INNOVATION

Intent

To encourage projects to achieve exceptional or innovative performance

Requirements

Project teams can use any combination of innovation, pilot, and exemplary performance strategies.

Option 1. Innovation (1 point)

Achieve significant, measurable environmental performance using a strategy not addressed in the LEED green building rating system.

Identify the following:

- the intent of the proposed innovation credit;
- proposed requirements for compliance;
- proposed submittals to demonstrate compliance; and
- the design approach or strategies used to meet the requirements.

AND/OR

Option 2. Pilot (1 point)

Achieve one pilot credit from USGBC's LEED Pilot Credit Library

AND/OR

Option 3. Additional Strategies

Innovation (1–3 points)

- Defined in Option 1 above.

Pilot (1–3 points)

- Meet the requirements of Option 2.

Exemplary Performance (1–2 points)

Achieve exemplary performance in an existing LEED v4 prerequisite or credit that allows exemplary performance, as specified in the LEED Reference Guide, v4 edition. An exemplary performance point is typically earned for achieving double the credit requirements or the next incremental percentage threshold.

An Option 1 Innovation example can be the use of photocatalytic cement or pigments on the surface of concrete paving units. Applied during manufacture, these coatings typically consist of titanium dioxide (TiO_2). Such coatings can reduce nitrogen oxide (NO_x) emissions. When mixed with ozone on hot days, NO_x mixes with it to form photochemical smog. TiO_2 demonstrate high measurable NO_x reduction in laboratory tests and can assist in reducing smog formation in urban envi-

ronments. In addition, these coatings are light colored and have a high solar reflectance. This characteristic can qualify TiO_2 coated pavers for non-roof urban heat island points under Sustainable Sites.

LEED Accredited Professional

Intent

To encourage the team integration required by a LEED project and to streamline the application and certification process.

Requirements

At least one principal participant of the project team must be a LEED Accredited Professional (AP) with a specialty appropriate for the project.

The LEED AP with specialty credential can be maintained through either of the following methods:

- Retaking and passing the LEED accreditation exam
- Earning 30 continuing education hours per credentialing period

A credential is considered active (and eligible for this credit) only if the credential holder has completed his or her credential maintenance through the GBCI Credential Maintenance Program. For more information, visit USGBC's website.

Regional Priority

Intent

To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities.

Requirements

Earn up to four of the six Regional Priority credits. These credits have been identified by the USGBC regional councils and chapters as having additional regional importance for the project's region. A database of Regional Priority credits and their geographic applicability is available on the USGBC website, **http://www.usgbc.org**. One point is awarded for each Regional Priority credit achieved, up to a maximum of four.

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