ICPI
INTERLOCKING CONCRETE PAVEMENT INSTITUTE ®
TECH SPEC
NUMBER 16

Achieving LEED® Credits with Segmental Concrete Pavement

Background

Rapidly rising energy and material costs have accelerated energy and natural resource conservation in design and construction. Sustainable development has evolved as a response and ethos to encourage conservation. It is also a framework for creating environments that enhance human existence and natural processes.

Broadly defined, sustainable development meets the needs of the present without compromising the ability of future generations to meet their needs. Within the North American design and construction community, a means for addressing sustainability or 'green building' is through LEED® or Leadership in Energy and Environmental Design. Developed by the U.S. Green Building Council (USGBC) in 1998, LEED® provides voluntary guidelines for reducing energy and wasted resources from building and site design. The Canadian Green Building Council (CaGBC) formed in 2003 published similar LEED® guidelines tailored to Canadian climates. U.S. and Canadian guidelines were developed by a range of representatives from the building industry and environmental science.

LEED® establishes a consensus-based means for measuring building and site performance. It promotes designs that integrate energy and resource conservation. LEED® is being applied to many publicly funded projects and a growing number of private ones. A primary objective of LEED® is to help facility owners reduce maintenance and life-cycle costs. This is accomplished by including all players in an integrated development process during the design stages of a project.

Figure 1. Sustainability for buildings extends to the site with sustainable paving that promotes infiltration and reflects radiant heat from sunlight.

Contents

Purpose

LEED® rating systems have been developed or are under development for:

- New Commercial Construction and Major Renovation projects (NC)
- Commercial and Retail Interiors
- Core and Shell
- Homes
- Neighborhood Development
- Schools, Healthcare and Retail
- Existing Building Operations and Maintenance

This publication provides guidance on applying the rating system for New Commercial Construction and Major Renovation projects or LEED-NC to the family of segmental concrete pavement products. This family includes interlocking concrete pavements, permeable interlocking concrete pavements, concrete grid pavements and precast concrete paving slabs. The products can also be used to satisfy the requirements in the other rating systems listed above.

LEED-NC version 3 is promulgated by the USGBC and the 2009 NC and CS (Core & Shell Development version) by the CaGBC. Excerpts from each version that relate to segmental concrete pavement are presented in this technical bulletin with application guidance. Each version has similar evaluation criteria for sustainable design and some minor differences. Readers should check with www.usgbc.org and www.cagbc.org for the most current versions including the *LEED® Reference Guide* (USGBC 2009).

The LEED® Process

The decision to apply for LEED® certification must occur early in the design process. The project owner and designers evaluate categories and associated criteria explained in the rating categories below for compatibility with the project, architectural program, budget and resulting environmental impact. This enables energy and cost-saving synergies for site and building design decisions.

To start the LEED® certification process, the project is registered on the USGBC or CaGBC web site with payment of a fee based on the total area of the project plus a registration fee. The web site specifies materials to be submitted such as project plans and documentation. The person seeking LEED® certification is sent a project checklist to evaluate aspects of the project might be eligible for LEED® credits. A letter template is also provided to help standardize documentation of credits. The registration fee enables access to the member-only parts of the web site and to access to the history of credit interpretations.

LEED® documentation can come from all involved on the project team including product manufacturers, contractors, cost estimators, specification writers and designers. Responsibility for managing this process will vary with each project. However, this effort is often coordinated by a LEED® Accredited Professional, one who has taken a course sponsored by USGBC or CaGBC and an exam on the credits and their requirements.

Once documentation is submitted with the LEED® application, they are reviewed for acceptance for LEED® credits. Additional documentation can be requested from the USGBC (or CaGBC) as needed and the project team has a specified amount of time to provide this. Final certification is granted within 30 days of receipt of all necessary documentation. LEED® certificates and a plaque are issued to the project design team.

LEED® Credits

For new commercial construction or LEED®-NC, the US and Canadian Green Building Councils grant certification based on the same number of points earned from each rating system. The minimum number of required points is 40. Higher ratings are shown in Table 1.

Table 1. LEED®-NC Points

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

New projects and major renovations earn points from six broad rating categories with specific subcategories. The major categories include:

- Sustainable Sites
- Water Use Efficiency (for building)
- Energy and Atmospheric Pollutants
- Materials and Resources
- Indoor Air Quality
- Innovative Ideas and Designs

The two primary categories that pertain to segmental concrete paving are Sustainable Sites and Materials and Resources. Within these categories, there are several subcategories for rating various aspects of the building and site for LEED® points. Key requirements and application guidance are provided in this bulletin. Blue typeface is quoted from the USGBC and CaGBC Reference Guides. The reader is encouraged to obtain the full documents and review them thoroughly.

LEED® in Specifications and Project Management

Upon registering a project for LEED® certification, a project checklist is provided by the USGBC or CaGBC that lists all of the LEED® credits in a table. The project is compared to the applicable LEED® credits thereby identifying which credits will 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. The LEED® project checklist can also be used to identify responsibility among the architect, contractor or owner for complying with applicable credits.

Besides identifying which parts of the building or site could comply with LEED® requirements, the project checklist identifies which sections of the specification will need to be written to include LEED® requirements, and into 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 for sustainable sites and materials and resources should be included in the specifications. Examples include a letter from the manufacturer stating the recycled content of the paving units could be a required submittal, waste management goals, or drainage calculations showing the required reduction of stormwater runoff contributed by permeable interlocking concrete pavement or grid pavements. 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 importance and role of this person should be presented at the pre-bid conference. This person could be responsible fulfilling contractor related items on the project checklist.

The additional project cost for compliance to LEED® certification is small and segmental concrete paving products used in the normal course of project design (roads, plazas, sidewalks, roof decks, etc.) can earn LEED® credits. Higher levels of certification (Silver, Gold, etc.) will likely increase project costs. However, the initial investment in sustainable design and construction should be returned to the owner in lower maintenance costs during the life of the building and site. When properly designed and installed, segmental concrete pavement has very low maintenance.

Life Cycle Assessment

According to Trusty and Horst (Trusty), "LCA is a methodology for assessing the environmental performance of a service, process, or product, including a building, over its entire life cycle. Although the technique is still maturing, especially the aspects dealing with ultimate impacts on human and ecosystem health, it has become the recognized international approach to assessing the comparative environmental merits of products or processes." LCA includes goal and scope definition, inventory analysis, impact assessment, and interpretation of social, environment and economic impacts of a project. The method is described in detail in the ISO 14000 series of standards (see ISO references). LCA has been used by major corporations to reduce costs for products through creating efficiencies that generate less impact on human and natural systems.

LCA consists of analyzing environmental impacts of a product or system. Impacts are weighted and their weightings are justified as part of the analysis. The impacts include:

- Global warming (from greenhouse gases)
- Acidification (typically from acid rain)
- Eutrophication (aging of water bodies through excess nutrient intake)
- Fossil fuel depletion
- Indoor air quality

- Habitat alternation
- Water intake
- Criteria air pollutants
- Smog
- Ecological toxicity
- Ozone depletion
- Human health

LEED® has developed a process that integrates LCA into their credit system. The credit is entitled Pilot Credit 1: Life Cycle of Building Assemblies and Materials. This methodology was developed for evaluating the environmental impacts of building structure and envelope assemblies. It can be used to evaluate roofing systems that include segmental concrete pavement systems. The current method develops an LCA score from an environmental impact calculator or EcoCalculator developed by the Athena Institute and USGBC credit calculator. LCA scores are then converted into LEED® points. For more information visit www.usgbc.org.

While this pilot LCA approach has not yet expanded to include site assemblies such as pavement, the user can develop an LCA-based rationale and receive points for non-structural and non-envelope materials. One point can be earned for assembly materials (such as pavements) that meet the requirements of Materials and Resources Credit 4 for recycled content. Another point is available for assembly materials that meet the requirements of Materials and Resources Credit 5 for regional materials. LEED® is expected to include LCA into building site and neighborhood rating systems in the next three to five years.

LCA is incorporated into British and European green building guides. The British *Green Guide to Specification* (BREAM 2009) is an LCA based methodology for assessing the human and environmental impacts of many building systems. Consideration is given to impacts from "cradle to grave" or from the energy used to extract natural resources to make the products, as well as manufacturing and recycling impacts. The Green Guide uses an A, B, C rating system where an A rating notes a low environmental impact, B is moderate and C is high. Table 2 illustrates the evaluation criteria and ratings of various pavement types with segmental concrete products receiving favorable ratings.

Another LCA example was conducted in Germany in 2009 (BFT 2009) which compared cradle to grave energy use and pollutants from asphalt pavement, interlocking concrete pavement, clay brick paving and natural stone paving. The study compared the base and surface paving materials in typically used in a parking lot or residential street over their life (typically 30 years). The research was sponsored by the SLG Precast Concrete Association and the Beton (Concrete) Marketing Deutschland GmbH. The results found that inter-

Table 2. British Green Guide *Life Cycle Assessment Rating of Various Pavement Materials*

Environmental Impacts	**Summary Rating**	**Climate change**	**Water Extraction**	**Mineral resource extraction**	**Ozone Depletion**	**Human Toxicity**	**Ecotoxicity to fresh-water**	**Nuclear waste**	**Ecotoxicity to land**	**Waste Disposal**	**Fossil Fuel Depletion**	**Eutrophication**	**Photochemical ozone creation**	**Acidification**	**Typical replacement interval, years**	**Embodied CO2 (kg CO2 equivalent)**	**Recycled content, kg**	**Recycled content, %**	**Recycled currently at EOL %**
Weightings, %		21.6	11.7	9.8	9.1	8.6	8.6	8.2	8.0	7.7	3.3	3.0	0.2	0.05					
Paving Type																			
Asphalt, 85 mm	A	A	A+	B	B	A+	A	A	A+	A+	D	A+	A+	A+	35	45	7.5	2	51
Clay pavers, 50 mm	A	B	A+	B	A	E	A	C	A	A	A	B	A+	A	60	70	0	0	90
Concrete pavers, 60 mm	A	A	A+	B	A+	A+	B	B	A	A	A	A+	A+	A+	60	57	6.6	1	90
Concrete paving slabs, 60 mm	A	A	A+	A	A+	A+	A	A	A	A	A+	A+	A+	A	60	47	6.8	2	90

All surfaces are on a prepared base

Application is lightly trafficked areas

Last 4 columns: assessed per square meter

EOL = End of Life

locking concrete pavement had the lowest energy use and pollution potential. The study made reasonable assumptions about pavement sources, manufacturing, hauling distances, and construction methods/equipment, as well as rehabilitation and recycling. Table 3 illustrates the LCA results in for a 1000 sf (100 m^2) area of each paving. The LCA for the natural stone was sensitive to transportation distances which can be significant for imported stone sources.

Other Evaluation Systems

Besides LEED®, there are other environmental assessment programs such as Green Globes (www.greenglobes.com). According to their web site Green Globes has an on-line auditing tool that enables designers, property owners and managers to assess and rate existing buildings against best practices and standards for sustainable design. Evaluations are done by those using their web site and third party assessments are at the user's option.

Table 3. Life cycle analyses results for various pavement systems in Germany (BFT 2009)

	Asphalt pavement	Interlocking concrete pavement	Brick paving	Natural stone paving
Primary energy consumption, non-renewable (MJ)	117,903	44,347	87,513	46,839
Primary energy consumption, renewable (MJ)	608	3,343	913	596
Global waming potential GWP (kg CO_2e)	4,040	3,169	5,485	3,025
Ozone depletion potential ODP [kg R11-equivalent]	1.19 E-04	1.24 E-04	1.74 E-04	1.19 E-04
Acidification potential EP [kg SO_2-equivalent]	12.8	9.72	15.6	16.3
Eutrophication potential EP [kg PO_4-equivalent]	1.60	1.38	1.91	1.93
Summer smog potential POCP [kg ethylene equivalent]	5.68	0.98	1.57	1.24

Abbreviations: megajoule (MJ), CO_2 equivalent (CO_2e)

LEED®-NC Version 3 Credits

Sustainable Sites

Credits applicable to segmental concrete paving products for sustainable sites include the following:

SS Credit 6.1 Stormwater Design: Quantity Control
SS Credit 6.2 Stormwater Design: Quality Control
SS Credit 7.1 Heat Island Effect: Non-roof
SS Credit 7.2 Heat Island Effect: Roof

USGBC LEED® SS Credit 6.1 Stormwater Design: Quantity Control

1 Point

Intent

To limit disruption of natural water hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants.

Requirements

CASE 1. SITES WITH EXISTING IMPERVIOUSNESS TO 50% OR LESS

OPTION 1

Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the one- and two-year 24-hour design storms.

OR OPTION 2

Implement a stormwater management plan that protects receiving stream channels from excessive erosion. The stormwater management plan must include a stream channel protection and quantity control strategies.

OR

CASE 2. SITES WITH EXISTING IMPERVIOUSNESS IS GREATER THAN 50%

Implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the two-year 24-hour design storm.

Potential Technologies & Strategies

Design the project site to maintain natural stormwater flows by promoting infiltration. Specify garden roofs and permeable paving to minimize impervious surfaces. Harvest and reuse stormwater volumes generated for non-potable uses such as landscape irrigation, toilet and urinal flushing and custodial uses in buildings.

Application of Credit SS 6.1

CASE 1. Existing Imperviousness is 50% or Less (Largely Undeveloped Sites)

OPTION 1. Discharge Rate and Quantity

Determine the predevelopment discharge rate and quantity for the project. These values are typically calculated by the civil engineer using the surface characteristics of the site and data on storm event frequency, intensity, and duration. Calculate the rate and quantity for the 1-year and 2-year 24-hour design storms.

Determine the postdevelopment discharge rate and quantity for the project consistent with the predevelopment calculations. The postdevelopment rate and quantity must be equal to or less than the predevelopment values.

OPTION 2. Stream Channel Protection

Describe the project site conditions, measures taken, and controls implemented as part of the project scope that prevent excessive stream velocities and resulting erosion. Include numerical values for predevelopment and post development conditions to demonstrate that the rate and quantity of storm water runoff in the postdevelopment condition are below critical values for the relevant receiving waterways.

CASE 2. Existing Imperviousness is Greater Than 50% (Largely Developed Sites)

Determine the predevelopment discharge rate and quantity for the project. These values are typically calculated by the civil engineer using the surface characteristics of the site and data on storm event frequency, intensity, and duration. Calculate the rate and quantity for the 2-year 24-hour design storm.

Determine the postdevelopment discharge rate and quantity for the project consistent with the predevelopment calculations. The postdevelopment rate and quantity must be at least 25% less than the predevelopment values.

Permeable interlocking concrete pavement (PICP) can help earn this LEED® credit. Figure 2 illustrates examples of PICP for runoff reduction. A typical design consists of paving units with openings filled with small, open-graded crushed stone. The units are bedded on a 2 in. (50 mm) thick layer of the same filling material. The bedding layer is compacted into the base consisting of 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:

- Meet national/provincial/state stormwater regulations: part of best management practice (BMP) mix
- Conserves space: pavement built on detention facility
- Reduces or eliminates retention requirements
- Filter and reduce nutrients, metals
- Groundwater recharge
- 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
- Visually more attractive than pervious/porous pavement alternatives

An in-depth presentation of design, specification, construction and maintenance is found in the ICPI publication, *Permeable Interlocking Concrete Pavements* (ICPI 2006). Most PICP will infiltrate runoff falling directly on it from most storms. The infiltration rate of the soil, base thickness (reservoir capacity) and any runoff from contributing areas will determine if PICP qualifies for reducing the peak discharge to the pre-development one and two year, 24 hour peak discharge rate. In most cases PICP will meet this requirement.

Pavement infiltration rates are a function of several factors including permeability of the fill material for the surface openings and for the base materials. No. 8 stone typically used in the openings has an infiltration rate exceeding 2,000 in./hr (50.8 m/hr). Infiltration rates of Nos. 57 and 2 stone used for the base and subbase exceed 4,000 in./hr (101.6 m/hr). Over time, the voids in these materials can become clogged, especially around the stone in the surface openings. Nearby sources of sediment can typically run onto the pavement. Periodic maintenance with vacuum sweeping will help maintain high surface infiltration rates. Research has shown that high infiltration rates can be maintained by removing the sediment captured in the first inch (25 mm) of the openings (Gerrits 2002). This has been demonstrated by practical experience with vacuum sweeping equipment.

According to Ferguson (2005), the runoff coefficient, C used in the rational method, will vary with each storm. For small storms permeable pavements will infiltrate all of the rainfall rendering a low runoff coefficient. In intense storms, and when the soil is saturated from antecedent storms, the runoff coefficient will be higher. Since most sites are exposed to a range of storm intensities and durations, the overall runoff coefficient of 0.25 to 0.35 can be assumed for PICP. This is a conservative estimate.

Figure 2. Examples of permeable interlocking concrete pavements for earning LEED® points. The photo on the left shows a hotel entrance in southern California. The photo on the right shows the driveway and parking lot for a fire station in Toronto.

Concrete grid pavements (see Figure 3) are another type of permeable pavement. They are typically 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. The grids are bedded in sand and the openings are filled with aggregate or topsoil and grass. If they have grass in the openings, the surface will require lawn maintenance such as mowing, seeding and fertilizing. *ICPI Tech Spec 8 Concrete Grid Pavements* (ICPI 2003) provides detailed information on applications, design, specifications, construction and maintenance. Concrete grid pavements can be used to earn this LEED® credit for runoff reduction. For Rational Method calculations a C value of 0.4 can be assumed if the grids are over a dense-graded aggregate base (Day 1980 & 1981).

A more sophisticated runoff calculation method for calculating peak flow is the U.S. National Resource Conservation Service (NRCS) TR-55 method. TR-55 relies on development of a Curve Number or CN that characterizes the amount of runoff depth from various land uses within a catchment. The CN for PICP will vary with the water storage capacity in the base and infiltration rate of the underlying soil. For example, a typical CN for permeable pavements in sandy soils is in the 40s and for clay soils it might be in the 60s. Bean (2005) has characterized CNs for PICP and grid pavements.

Some municipalities use computer models to characterize urban runoff and project impacts on drainage systems. Models are sometimes calibrated with field measurements of rainfall, runoff, flows and pollutant loads. The hydrological characteristics of PICP and grid pavements can be input into these models to simulate their benefits on urban hydrology. ICPI offers *Permeable Design Pro* software to assist designers in calculating water discharge rates and quantities from PICP. In both cases cited earlier, discharge will be from underdrains and not from the surface. *Permeable Design Pro* can model underdrain discharges as well as infiltration into the soil subrade.

For the purposes of calculating site perviousness, PICP should be counted as 100% pervious. The rationale is that with an open-graded material in the openings and base, the long-term conservative (un-maintained) pavement surface infiltration rate is approximately 6 in./hour (150 mm/hour). This well exceeds the the rainfall intensity of common rainfall events.

If runoff from an impervious area is directed to PICP, then PICP will be handling additional water other than rain falling directly on it. In such cases, calculate the average coefficient of runoff, C from the contributing area and the PICP and use the average for both areas. The averages would be weighted by the area of each surface. In these cases, the coefficient of runoff, C for PICP will likely be 0.25 to 0.4. Low C values should be used in high-infiltration sandy soils and higher values for lower-infiltration silt and clay soils.

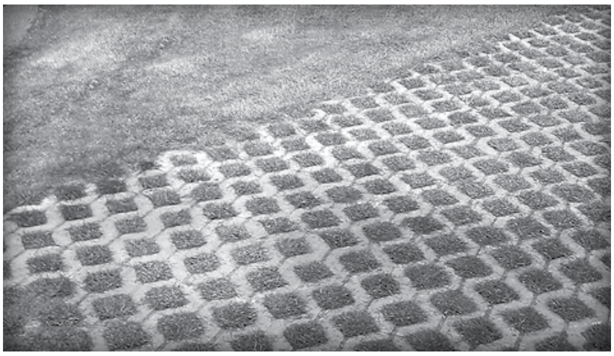

Figure 3. Concrete grid pavement substantially reduces runoff to levels approximating grass cover.

Concrete grid pavements with topsoil and grass have lower, long-term surface infiltration rates, typically 1 to 2 in./hour (25 to 50 mm/hour) (Smith, 1984). Like all pervious surfaces, grid pavement will infiltrate runoff from commonly occurring storms and eventually yield 100% runoff when saturated from concentrated high-intensity storms. The advantage of PICP systems is they will store runoff for a period of time and release it at saturation well after adjacent saturated soil and vegetated areas including grids. This storage and delay in generating runoff will help achieve the intent of this credit.

Integration with other LEED® Credits

Stored water can be harvested for landscape irrigation and other non-potable uses in building. This approach can earn Water Efficiency (WE) credit 1: Water Efficient Landscaping and WE Credit 3: Water use Reduction.

Conservation of open space by using PICP supports earning points under Sustainable sites (SS) Credit 5.1: Site Space. SS PICP can also help earn Credits 6.2: Stormwater Design–Quality Control (see page 10) and urban heat island reduction credits covered later in this bulletin.

USGBC LEED® SS Credit 6.2 Stormwater Design: Quality Control

1 Point

Intent

Limit disruption and pollution of natural water flows by managing stormwater runoff.

Requirements

Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of the average annual rainfall[1] using acceptable best management practices (BMPs).

BMPs used to treat runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if (1) they are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards, or (2) there exists in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.

Potential Technologies & Strategies

Use alternative surfaces (e.g., vegetated roofs, permeable pavement or grid pavers) and nonstructural techniques (e.g., rain gardens, vegetated swales, disconnection of impervious areas, rainwater recycling) to reduce imperviousness and promote infiltration thereby reducing pollutant loadings. Use sustainable design strategies (e.g., Low Impact Development, Environmentally Sensitive Design) to design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters, and open channels to treat stormwater runoff.

[1] There are three distinct climates in the United States that influence the nature and amount of rainfall. Humid watersheds are defined as those that receive at least 40 inches of rainfall each year, Semi-arid watersheds receive between 20 and 40 inches of rainfall per year, and Arid watersheds receive less than 20 inches of rainfall per year. For this credit, 90% of the average annual rainfall is equivalent to treating the runoff from the following (based on climate):
(a) Humid Watersheds – 1 inch of rainfall;
(b) Semi-arid Watersheds – 0.75 inches of rainfall
(c) Arid Watersheds – 0.5 inches of rainfall.

Application of SS Credit 6.2

As part of the stormwater management plan process, describe the best management practices employed on the project site to capture and treat stormwater runoff. Describe how each measure contributes to reducing imperviousness and/or increasing infiltration. The plan must also document how BMPs are used to capture and treat stormwater runoff from 90% of the average annual rainfall. Annual rainfall is determined by the watershed where the project is located. Humid watersheds are defined as those that receive at least 40 inches of rainfall each year; semiarid watersheds receive between 20 and 40 inches of rainfall per year; and arid watersheds receive less than 20 inches of rainfall per year. For this credit, managing 90% of the average annual rainfall is equivalent to treating the runoff from the amounts listed in Table 4:

Table 4. Runoff Treatment Equivalents

Watershed	Rainfall per 24 Hours (ins)
Humid	1
Semiarid	0.75
Arid	0.5

Roofs, sidewalks, driveways and streets (impervious cover) contribute additional runoff and pollution by denying infiltration of stormwater. These surfaces generate excessive amounts of runoff with sediment (total suspended solids or TSS) and water carrying nutrients (total phosphorous or TP and nitrogen forms) and metals. Other pollutants such as pesticides, detergent, fertilizer, oils, other chemicals and salts remain in suspension or solution in the flowing water which can damage wildlife and fish. Increased runoff flows and pollution are directed into waterways decreasing property values, fishing income and recreation opportunities. Some municipalities have older, combined sanitary and storm sewer systems. These discharge raw sewage into rivers when storm flows exceed the processing rate of the local waste treatment plant.

Since PICP reduces runoff through infiltration, it has the ability to reduce TSS and TP. Studies have demonstrated at least 80% reduction of TSS, a good indicator of pollutant treatment. Studies that document at least 80% TSS reduction include Van Seters (2007) and Clausen (2007). The studies compared reductions of pollutants from PICP to that from impervious pavements. In addition, the *LEED® Reference Guide (2009)* suggests a 60%-80% removal efficiency for permeable pavements.

Pre-treatment and filtering of runoff prior to entering PICP will assist in reducing TSS emissions. Practices such as bioswales and sand filters can receive and filter runoff prior to entering adjacent PICP as well as receive outflows from PICP. The entire flow path design for runoff should be considered, especially when PICP is designed to receive runoff from impervious surfaces.

USGBC LEED® WE Credit 1 Water Efficient Landscaping

2-4 Points

Intent

To limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation.

Requirements

OPTION 1: Reduce by 50% (2 points)

Reduce potable water consumption for irrigation by 50% from a calculated midsummer baseline case.

Reductions must be attributed to any combination of the following items:

- Plant species, density and microclimate factor
- Irrigation efficiency
- Use of captured rainwater
- Use of recycled wastewater
- Use of water treated and conveyed by a public agency specifically for nonpotable uses

Groundwater seepage that is pumped away from the immediate vicinity of building slabs and foundations may be used for landscape irrigation to meet the intent of this credit. However, the project team must demonstrate that doing so does not affect site stormwater or management systems.

OR

OPTION 2. No Potable Water Use or Irrigation (4 points)
Meet the requirements for Option 1.

AND

PATH 1

Use only captured rainwater, recycled wastewater, recycled graywater or water treated and conveyed by a public agency specifically for nonpotable used for irrigation.

OR

PATH 2

Install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within one year of installation.

Application of WE Credit 1

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. PICP can be used as a medium 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 2 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.

The USGBC *LEED® Reference Guide* provides a method to estimate irrigation water demand for vegetation. This enables an estimate of the total water (in gallons or liters) that needs to be applied to the vegetation. 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. If the reduction of potable water is at least 50%, then two points are earned. If climate, evaporation, rainfall, water storage and vegetation selection allow complete (100%) elimination of potable water use for irrigation then four points are earned.

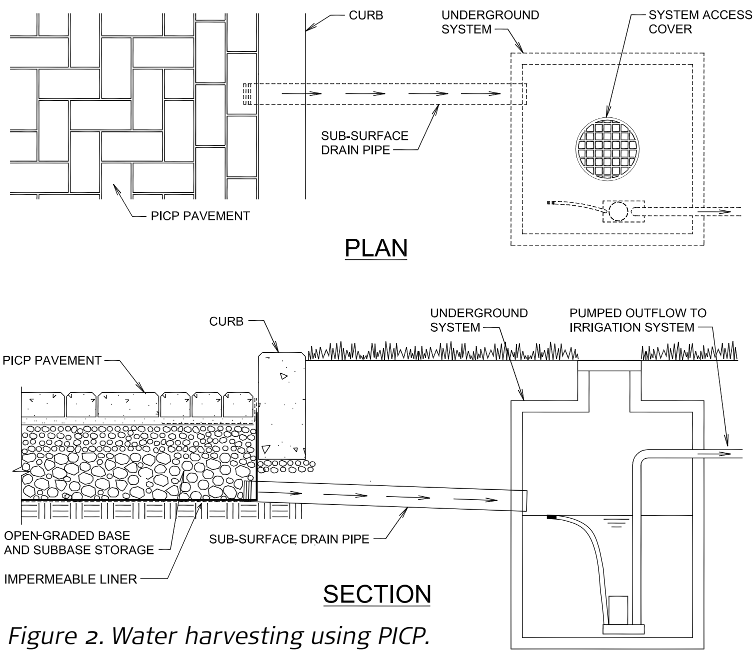

Figure 2. Water harvesting using PICP.

USGBC LEED® SS Credit 7.1 Heat Island Effect: Non-Roof

1 Point

Intent

To reduce heat islands[1] to minimize impacts on microclimates and human and wildlife habitats.

Requirements

OPTION 1

Use any combination of the following strategies for 50% of the site hardscape (including roads, sidewalks, courtyards and parking lots):

- Provide shade from the existing tree canopy or within 5 years of landscape installation. Landscaping (trees) must be in place at the time of occupancy.
- Provide shade from structures covered by solar panels that produce energy used to offset some nonrenewable resource use.
- Provide shade from architectural devices or structures that have a solar reflectance index[2] (SRI) of at least 29.
- Use hardscape materials with an SRI of at least 29.
- Use an open-grid pavement system (at least 50% pervious).

OR

OPTION 2

Place a minimum of 50% of parking spaces under cover[3]. Any roof used to shade or cover parking must have an SRI of at least 29, be vegetated green roof or be covered by solar panels that produce energy used to offset some nonrenewable resource use.

Potential Technologies & Strategies

Shade constructed surfaces on the site with landscape features and utilize high-reflectance materials for hardscape. Consider replacing constructed surfaces (i.e. roof, roads, sidewalks, etc.) with vegetated surfaces such as vegetated roofs and open grid paving or specify high-albedo materials to reduce the heat absorption.

[1]Heat islands are defined as thermal gradient differences between developed and undeveloped areas.
[2]The Solar Reflectance Index (SRI) is a measure of the constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. To calculate the SRI for a given material, obtain the reflectance value and emittance value for the material. SRI is calculated according to ASTM E 1980-01. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371. Default values for some materials are available in the LEED®-NC v3 Reference Guide.
[3]For the purposes of this credit, under cover parking is defined as parking underground, under deck, under roof, or under a building.

Applications of SS Credit 7.1

Environmental Issues

The use of dark, nonreflective surfaces for parking, roofs, walkways, and other hardscapes contributes to the heat island effect by absorbing the sun's warmth, which then radiates into the surroundings. Because of heat island effect, ambient temperatures in urban areas are artificially elevated by 2º to 10ºF compared with surrounding suburban and undeveloped areas. The result is increased cooling loads in the summer, requiring larger heating, ventilating, and air-conditioning (HVAC) equipment and greater electricity consumption, both of which generate greenhouse gasses and pollution. Heat islands are detrimental to site habitat, wildlife, and animal migration corridors. Plants and animals are also sensitive to large fluctuations in daytime and nighttime temperatures and may not thrive in areas affected by heat islands.

Economic Issues

The energy used to cool a building represents a substantial portion of the operating budget over its lifetime. Reducing heat islands can significantly lower cooling costs. According to the Department of Energy's Lawrence Berkeley National Laboratory, the annual energy savings potential of heat island reduction measures, studied in the metropolitan areas of Sacramento, Baton Rouge, and Salt Lake City, range from $4 million to $25 million.

Solar Reflectance Index (SRI) of Segmental Concrete Paving Products—SRI consists of combined albedo (reflectance) and emittance measurements. Albedo is the ratio of outbound 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* (ASTM 2005). Reflectance is measured over a range of wavelengths and averaged to provide a single albedo reflectance value.

According to the *LEED® Reference Guide* (2009) new gray concrete made with gray cement has an SRI of 35 and weathered (unwashed) concrete is 19. New concrete made with white cement generally has an SRI of 86 and 45 when weathered. White cement is about twice as expensive as grey cement. However, some normal cement can be light in color and be cost competitive as well as supplementary cementitious materials like slag. Cement and aggregate colors influence concrete color. For segmental concrete paving products, light colored aggregates and surface treatments with white cement can contribute to a higher albedo. Figure 4 shows an application with light colored paving slabs. By comparison, asphalt SRI is 0 when new and 6 when weathered.

Emittance measures a material's ability to release radiant heat (in watts/m²) from a given wavelength spectrum. It is measured using *ASTM*

E 408 – Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques (ASTM 2005). 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. 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 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.

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 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. *ICPI Tech Spec 5–Cleaning, Sealing and Joint Sand Stabilization of Interlocking Concrete Pavement* provides additional guidance.

Grid pavement—LEED® defines open-grid pavement as having less than 50% imperviousness. This includes concrete grid pavements with grass.

Figure 4. Light colored paving units reflect light and help reduce mico-climatic temperatures.

Compared to asphalt, grassed grid pavements will 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). Evapo-transpiration from the grass provides this cooling. Concrete grid pavers are recommended for overflow or intermittent parking areas and aren't intended where cars park regularly. Grids and grass will provide heat reducing benefits for these areas. Areas with regular parking should be paved with PICP. Both grids and PICP benefit shade trees by allowing air and water to reach roots.

USGBC SS Credit 7.2 Heat Island Effect: Roof

1 Point

Intent

To reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.

Requirements

OPTION 1

Use roofing materials with a solar reflectance index (SRI) equal to or greater than the values in the table below for a minimum of 75% of the roof surface.

Roofing materials having a lower SRI value than those listed below may be used if the weighted rooftop SRI average meets the following criteria:

$$\frac{\text{Area Roof Meeting Minimum SRI}}{\text{Total Roof Area}} \times \frac{\text{SRI of Installed Roof}}{\text{Required SRI}} \geq 75\%$$

Roof Type	Slope	SRI
Low-sloped roof	≤ 2:12	78
Steep-sloped roof	> 2:12	29

OR

OPTION 2

Install a vegetated roof for at least 50% of the roof area.

OR

OPTION 2

Install a vegetated roof that covers at least 50% of roof area.

OPTION 3

Install high-albedo and vegetated roof surfaces that, in combination, meet the following criteria:

$$\frac{\text{Area Roof Meeting Minimum SRI}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.5} \geq \text{Total Roof Area}$$

Roof Type	Slope	SRI
Low-sloped roof	≤ 2:12	78
Steep-sloped roof	> 2:12	29

Environmental Issues

The use of dark, nonreflective roofing surfaces contributes to the heat island effect by absorbing the sun's warmth, which then radiates into the surroundings. As a result, ambient temperatures in urban areas are artificially elevated, increasing cooling loads, electricity consumption, and emissions of greenhouse gases and pollution. Heat island effect is also detrimental to site habitat, wildlife, and animal migration corridors. Plants and animals are sensitive to large fluctuations in daytime and nighttime temperatures and may not thrive in areas affected by heat islands. Projects that earn SS Credit 7.2 by providing vegetated roofs contribute to increased habitat areas for birds, insects, and other wildlife.

Economic Issues

The energy used to cool a building represents a substantial portion of the operating budget over its lifetime. Vegetated roofs and roof surfaces with high SRIs can reduce costs associated with HVAC equipment. Vegetated roofs typically require additional investment; cool roofs that effectively reflect the sun's energy could cost the same as more conventional roofing systems. However, any upfront investment is likely to result in energy cost savings throughout the life cycle of the project. An increasing number of jurisdictions are beginning to require the use of cool roofs on new building projects.

Figure 5. Light colored paving on low-slope roofs reflects light saving on air-conditioning costs while protecting the waterproofing.

Calculations

Obtain the roofing material's SRI value from the manufacturer and complete the following steps.

STEP 1

Determine the total roof surface area of the project building (square feet).

STEP 2

Determine the area of the roof covered by mechanical equipment, solar energy panels, and appurtenances, and deduct these areas from the total roof surface area.

STEP 3

Determine whether the areas of qualifying reflective and vegetated roofing are adequate to meet the credit requirements, using Equation 1. If more than 1 type of low-slope or steep-slope material is used, determine the weighted rooftop SRI average and verify that 75% or more of the roof area complies with the credit requirements.

Equation 1

$$\left(\frac{\text{Area of Low–Slope SRI Material}}{78 \ \text{X} \ \frac{0.75}{\text{SRI Value}}} + \frac{\text{Area of Steep–Slope SRI Material}}{29 \ \text{X} \ \frac{0.75}{\text{SRI Value}}} + \frac{\text{Vegetated Roof Area}}{0.5} \right) \geq \left(\text{Total Roof Area} - \text{Deducted Area} \right)$$

Materials and Resources

USGBC LEED® Credits applicable to segmental concrete paving products include the following:

- Credit MR 2 Construction Waste Management
- Credit MR 3 Materials Reuse
- Credit MR 4 Recycled Content
- Credit MR 5 Regional Materials

USGBC LEED® MR Credit 2 Construction Waste Management

1-2 Points

Intent

To divert construction and demolition debris from fill disposal in landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites.

Requirements

Recycle and/or salvage of non-hazardous construction and demolition debris. Develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or comingled. Excavated soil and land-clearing debris do not contribute to this credit. Calculations can be done by weight or volume, but must be consistent throughout. The minimum percentage debris to be recycled or salvaged for each point threshold is as follows:

Recycled or Salvaged	Points
50%	1
75%	2

Potential Technologies & Strategies

Establish goals for diversion from disposal in landfills and incinerators and adopt a construction waste management plan to achieve these goals. Consider recycling cardboard, metal, brick, acoustical tile, concrete, plastic, clean wood, glass, gypsum wallboard, carpet and insulation. Designate a specific area(s) on the construction site for segregated or commingle collection of recyclable materials, and track recycling efforts throughout the construction process. Identify construction haulers and recyclers to handle the designated materials. Note that diversion may include donation of materials to charitable organizations and salvage of materials on-site.

Application of Credits MR 2

High tipping fees at landfills and threat of soil pollution have forced recycling of construction and demolition waste. The US EPA estimates that construction waste accounts for 48% of all solid waste (USGBC 2009). A key consideration is that waste material reused on-site or processed and shipped off-site cannot be used for other LEED® credits such as those from Resource Reuse, Recycled Content or Regional Materials content credits. These three credits are based on costs. Like most concrete, pavers can be crushed and recycled, or whole pavers removed and reinstated elsewhere on the site.

The intent of Credit MR 2 is to recycle construction waste on the site, or process and place it into the market for recycled materials. These actions do not involve a purchase transaction. The types of demolition waste from a site should be estimated (by weight or volume) and listed in a waste management plan. Their ultimate destination should also be identified as well as the percentage of waste that remains on the site.

The crowded nature of construction in dense urban areas will almost always require collection of concrete in waste bins for shipment to off-site processing. Other projects may have sufficient space on the site to separate and process waste construction materials. In such cases, local regulations for processing should be followed.

In contrast, 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 Recycled Content and Regional Materials credits. Examples are shipping used concrete pavers to a recycler, crushing them and purchasing them back for re-use on the site as base material. Another example is purchasing recycled, crushed concrete for a base under interlocking concrete pavements. These two examples could earn Recycled Content and Regional Materials content credits.

Documentation

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. A list of the total construction waste is required, measured by weight or volume, specifying those that will be diverted from the landfill. This list is typically prepared by the company responsible for waste management on the site. Calculations can be in weight or volume, but they must be consistent. They 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.

The following equation is used to calculate the percent recycled:

$$\%\ \text{Recycled} = \frac{\text{Recycled Waste}}{\text{Recycled Waste} + \text{Garbage}}$$

Where Garbage is the land-filled material and the Recycled Waste is the recycled construction, demolition and land clearing wastes.

USGBC LEED® MR Credit 3 Materials Reuse

1-2 Points

Intent

Reuse building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources.

Requirements

Use salvaged, refurbished or reused materials such that the sum of which constitutes at least 5% or 10%, based on cost, of the total value of materials on the project. The minimum percentage materials reused for each point threshold is as follows:

Reused Materials	Points
5%	1
10%	2

Mechanical, electrical and plumbing components and specialty items such as elevators and equipment cannot be included in this calculation. Include only materials permanently installed in the project. Furniture may be included, if it is included consistently in MR Credits 3: Materials Reuse through MR Credit 7: Certified Wood.

Application of Credit MR 3

A material salvaged during a building renovation can be applied to this credit only if it can no longer serve its original function and has been reprocessed and installed for a different use. An example would be crushing salvaged concrete pavers for reuse as pavement base material. However, on a project where an existing building is being demolished or deconstructed the material salvaged and installed on the new site can be used to comply to this credit.

Documentation

To calculate the percentage of salvaged material, list all of the salvaged materials and their costs. If the cost of the salvaged material is below market value, use the replacement cost. For example, salvaged concrete pavers may be purchased for $.50/ft² ($5.38/m²) and new pavers would cost $2.50/ft² ($26.90/m²). For this credit, use the new cost in the following salvage calculation:

$$\text{\% Salvage Rate} = \frac{\text{Market value of salvage materials if purchased new}}{\text{Total project material costs}}$$

For example, total material costs on a project are $1,600,000 (excluding labor and equipment costs). Existing concrete pavers on the site are salvaged and reused for a 35,000 ft² (3,500 m²) parking lot at a potential new cost of $2.50/ft² ($26.90/m²). The market value of new replacement material is $87,500. Therefore, 5.4% of the materials costs are spared through salvaging and reuse. This qualifies for one point with all other re-used materials on the project. An additional point is earned if other salvaged materials from the project are added to this to bring this calculation to over 10%.

USGBC LEED® MR Credit 4 Recycled Content

1-2 Points

Intent

To increase demand for building products that incorporate recycled content materials, therefore reducing impacts resulting from extraction and processing of virgin materials.

Requirements

Use materials with recycled content[1] such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% or 20% based on cost of the total value of the materials in the project. the minimum percentage materials recycled for each point threshold is as follows:

Recycled Content	Points
10%	1
20%	2

The recycled content value of a material assembly is determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

Mechanical, electrical and plumbing components and specialty items such as elevators shall not be included in this calculation. Include only materials permanently installed in the project. Furniture may be included, providing it is included consistently in MR Credits 3: Materials Reuse through MR Credit 7: Certified Wood.

Potential Technologies & Strategies

Establish a project goal for recycled content materials and identify material suppliers that can achieve this goal. During construction, ensure that the specified recycled content materials are installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.

Application of Credits MR 4

Segmental concrete paving products can be made with recycled materials that contribute to this credit. A portion of the cement can be replaced with flyash (coal combustion by-product), silica fume (by-product of silicon production), ground granulated blast furnace slag (from steel production), and recycled aggregate. They are called supplementary cementitious materials or SCMs.

There is a growing amount of evidence that release of CO_2 from combustion and methane gases contribute to global warming. For every ton of cement produced about a ton of CO_2 is released into the atmosphere. (Compare this to one gallon (3.8 l or 2.8 kg) of gasoline generates about 20 lbs (9 kgs) of CO_2.) Cement production comprises approximately 5% of CO_2 generated throughout the world. Replacing a portion of cement with SCMs reduces CO_2 output.

The potential for replacing cement will vary among paver manufacturers based on their location, which affects price and availability of recycled materials. Consult with an ICPI producer member to determine use of cement substitutes in paving products. Some cement suppliers to paver producers may provide cement with SCMs. Recycled content within cement does not count toward this credit unless the cement supplier provides a statement of recycled content for the cement.

Documentation

The percentage requirements in this LEED® credit are based on cost. Post-consumer recycled content refers to recycled materials or products recovered and recycled after use by the consumer, e.g. glass bottles. Manufactured concrete pavers can include glass in the calculation. Preconsumer waste for concrete pavers means recycled materials or products recovered and traded such as flyash, slag or silica fume. These materials should meet the ASTM and CSA definitions for SCMs.

In the case of supplementary cementitious materials (SCMs) used in concrete pavers recycled from other operations, the recycled content value can be based on the mass of the cementitious materials only, rather than on the entire concrete mix. For example, if 150 pounds of coal fly ash is used per yard of concrete, the fly ash would represent only a small fraction (5%) of the roughly 3,000 pounds of concrete. The project team can choose instead to calculate it as a fraction of the cementitious materials by obtaining the value of the cementitious materials (separate from the total cost of the concrete) from the concrete supplier (Example 1). Fly ash is a preconsumer recycled-content material.

Example 1. Sample Supplementary Cementitious Materials Calculation

Mix #	Mass of Portland Cement* (lbs)	Mass of recycled SCMs (lbs)	Mass of total cementitious materials (lbs)	SCMs as a percentage of total cementitious materials (%)	Dollar value of all cementitious materials (from concrete supplier)	Recycled content value per yard [(SCM/2) x dollar value]
2	200	50	250	20%	$35	$3.50
3	300	100	400	25%	$45	$5.63
*This column also includes any other cementitious ingredients that are not recycled.						

USGBC LEED® MR Credit 5

1-2 Points

Intent

To increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation.

Requirements

Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500 miles of the project site for a minimum of 10% or 20%, based on cost, of the total materials value. If only a fraction of the material is extracted, harvested or recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value. The minimum percentage regional materials for each point threshold is as follows:

Regional Materials	Points
10%	1
20%	2

Potential Technologies & Strategies

Establish a project goal for locally sourced materials, and identify materials and material suppliers that can achieve this goal. During construction, ensure that the specified local materials are installed and quantify the total percentage of local materials installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.

Application of Credit MR 5

Segmental concrete paving products can earn these credits since most extraction of cement, aggregate and sand from quarries and the manufacturing plant are often within 500 miles (800 km) of the project site.

Documentation

Credit 5 is met by the contractor providing costs to the designer for all materials that meet these requirements. The invoice cost is typically used but must exclude transportation costs. In addition, a letter from the manufacturer should indicate the location of the manufacturing facility and location of the source(s) of extracted materials. Material product sheets can be provided instead of a letter if the sheets clearly state the manufacturing location and resource extraction locations.

A single letter from a manufacturer can certify compliance with more than one credit. For example, a single letter can be supplied for concrete pavers with a recycled content and production within 500 miles (800 km) of the project.

The general contractor should work with subcontractors and suppliers to verify availability of materials that are extracted, harvested, or recovered and manufactured locally. The contractor should run preliminary calculations based on the construction budget or schedule of values during the preconstruction phase. This will allow the construction team to focus on those materials with the greatest contribution to this credit as early as possible.

Calculate the percentage local materials according to Equation 1.

The project achieves 1 point when the percentage of local material is 10% or greater, and 2 points when the percentage of local materials is 20% or greater.

Reused and Salvaged Materials

Reused and salvaged materials that satisfy the requirements of MR Credit 3 may also contribute to MR Credit 5. Use the location from which they were salvaged as the point of extraction, and use the location of the salvaged goods vendor as the point of manufacture. On-site salvaged materials automatically qualify.

For materials with more than 1 point of manufacture or extraction, all within the 500-mile radius, list the component with the greatest distance. If a portion of the material was either manufactured or extracted beyond the 500-mile radius, list only that portion and associated cost satisfying the credit requirement.

For assemblies or products manufactured within the 500-mile radius that contain some components extracted father away, use multiple lines when listing purchases. Base the proportionality of such products' costs on the weight of their various components (see the example for concrete in Tables 5 and 6.)

Equation 1.

$$\text{Percentage Local Materials} - \frac{\text{Total Cost of Local Materials (\$)}}{\text{Total Materiasl Cost (\$)}} \times 100$$

Table 5. Sample Assembly Percentage Regionally Extracted Calculation for Concrete

Components	Weight (lbs)	Distance between Project & Extraction Site (miles)	Weight Contributing to Regional Extraction (lbs)
Cement	282	1,250	0
Fly Ash	282	125	282
Water	275	1	275
Slag	750	370	750
Recycled Concrete & Aggregate	1,000	8	1,000
Sand	1,200	18	1,200
Component Totals	3,789	NA	3,507
Percent Regionally Extracted Materials (3,507/3, 789)			92.6%

Table 6. Sample Spreadsheet for Regional Materials

Product	Manufacturer	Distance between Project & Manufacturer (miles)	Distance between Project & Extraction/ Harvest (miles)	Product Cost ($)	Value Qualifying as Regional	Information Source
Plant material	Green's Landscape	5	5	$6,770	$6,770	Contractor submittal
Concrete	Joe's Concrete	15	15	$21,000	$21,000	Contractor submittal
Insulation	UR Warm	105	1,080	$9,250	-	Product cut sheet
Gypsum	Gypsum R US	75	288	$8,550	$8,550	Letter from manufacturer
Carpet	Fiber Good	355	721	$15,333	-	Letter from manufacturer
Casework	Top Counter	18	320	$12,200	$12,200	Contractor submittal
Lumber	My Mill	110	320	$38,990	$38,990	Contractor submittal
Wood Doors	Closeby	71	320	$7,000	$7,000	Contractor submittal
Total Cost of Regional Materials						$94,510
Total Materials Cost (Divisions 2-10)						$751,000
Percent Regional Materials						13%
Points Earn						1

Other Sources of LEED® Credits

Innovation and Design Processes—USGBC LEED® Credits applicable to segmental concrete paving products include one to five points for Innovation in Design and an additional point for using a LEED® Accredited Professional. Innovation in Design encourages new ideas in sustainability to gain recognition. The LEED® Accredited Professional encourages designers to have a person with this credential on the design team.

The USGBC and CaGBC LEED® Credit 1 for Innovation in Design are almost identical. See below and page 23. Likewise, USGBC LEED® Credit 2.1 and CaGBC LEED® Credit 2 for Accredited Professional are almost identical. See page 18.

USGBC LEED® ID Credit 1 Innovation in Design

1 to 5 Points

Intent

To provide design teams and projects the opportunity to be awarded points for exceptional performance above the requirements set by the LEED® Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED® Green Building Rating System.

Requirements

NC, SCHOOLS & CS

Credit can be achieved through any combination of the paths below:

PATH 1. Innovation in Design (1-5 points for NC and CS, 1-4 points for Schools)

In the LEED 2009 for New Construction and Major Renovations, LEED 2009 for Core and Shell Development or LEED 2009 for Schools Rating Systems.

One point is awarded for each innovation achieved. No more than 5 points (for NC and CS) and 4 points (for Schools) under IDc1 may be earned through PATH 2—Innovation in Design.

Identify the following in writing:

- The intent of the proposed innovation credit.
- The proposed requirement for compliance.
- The proposed submittals to demonstrate compliance.
- The design approach (strategies) used to meet the requirements.

PATH 2. Exemplary Performance (1-3 points)

Achieve exemplary performance in an existing LEED 2009 for Schools prerequisite or credit that allows exemplary performance as specified in the LEED Reference Guide for Green Building Design & Construction, 2009 Edition. An exemplary performance point may be earned for achieving double the credit requirements and/or achieving the next incremental percentage threshold of an existing credit in LEED.

One point is awarded for each exemplary performance achieved. No more than 3 points under IDC1 may be earned through PATH2—Exemplary Performance.

Potential Technologies & Strategies

Substantially exceed a LEED® performance credit such as energy performance or water efficiency. Apply strategies or measures that demonstrate a comprehensive approach and quantifiable environment and/or health benefits.

Application of Credit 1

This credit category enables designers to incorporate innovative improvements in building materials and design into the LEED® rating system. Besides original innovative design, credits may be awarded if a project achieves exceptional performance under an existing LEED® credit for that project. Examples include exceeding or using water exfiltrated from PICP for landscape irrigation or grey water reuse in the building. As a general rule of thumb, ID credits for exceptional performance are awarded for doubling the credit requirements and/or achieving the next incremental percentage threshold.

USGBC LEED® ID Credit 2 LEED® Accredited Professional

1 Point

Intent

To support and encourage the design integration required by LEED® to streamline the application and certification process.

Requirements

At least one principal participant of the project team shall be a LEED® Accredited Professional (AP).

Benefits and Issues to Consider

LEED APs have the expertise required to design a building to LEED standards and to coordinate the documentation process that is necessary for LEED certification. The LEED AP understands the importance of integrated design and the need to consider interactions between the prerequisites and credits and their respective criteria. Architects, engineers, consultants, owners, and others who have a strong interest in sustainable building design are all appropriate candidates for accreditation. The LEED AP should champion the project's LEED application and be an integral member of the project team. The LEED AP can also educate other team members about LEED and green buildings.

CaGBC LEED®-NC & CS 2009 Credits

Sustainable Sites

Credits applicable to segmental concrete paving products for sustainable sites include the following:
SS Credit 6.1 Stormwater Management, Rate and Quality
SS Credit 6.2 Stormwater Management, Treatment
SS Credit 7.1 Heat Island Effect, Non-roof
SS Credit 7.2 Heat Island Effect, Roof

CaGBC LEED® SS Credit 6.1 Stormwater Management, Rate and Quantity

1 point

Intent, requirements and strategies are the same as USGBC LEED®

CaGBC LEED® SS Credit 6.2 Stormwater Management, Treatment

1 point

Intent, requirements and strategies are the same as USGBC LEED®

CaGBC LEED® SS Credit 7.1 Heat Island Effect: Non-Roof

1 Point

Intent, requirements and strategies are the same as USGBC LEED®

CaGBC LEED® SS Credit 7.2 Heat Island Effect: Roof

1 Point

Intent, requirements and strategies are the same as USGBC LEED®

CaGBC LEED® WE Credit 1 Water Efficient Landscaping

2-4 Points

Intent, requirements and strategies are the same as USGBC LEED®

Materials and Resources

CaGBC LEED® Credits applicable to segmental concrete paving products include the following:
Credit MR 2 Construction Waste Management:
Credit MR 3 Resource Reuse
Credit MR 4 Recycled Content

Intent, requirements and strategies are the same as USGBC LEED®

CaGBC LEED® MR Credit 5 Regional Materials

1-2 Points

Intent

To increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportations.

REQUIREMENTS: NC & CS

Use building materials or products that have been extracted, harvested, recovered and processed within 800 km (500 miles) (2,400 km if shipped by rail or water) of the final manufacturing site.

Demonstrate that the final manufacturing site is within 800 km (500 miles) (2,400 km if shipped by rail or water) of the project site for these products.

If only a fraction of a product or material is extracted, harvested, recovered, processed and manufactured locally, then only that percentage (by weight) must contribute to the regional value. The minimum percentage of regional materials for each point threshold is as follows:

Regional Materials	Points
20%	1
30%	2

Mechanical, electrical and plumbing components and specialty items such as elevators and equipment must not be included in this calculation. Include only materials permanently installed in the project. Furniture may be included if it is included consistently in MR Credits 3: Materials Reuse through MR Credit 7: Certified Wood (MR Credit 6 in Core and Shell).

Potential Technologies & Strategies

Establish a project goal for regionally sourced materials and identify materials and material suppliers that can achieve this goal. During construction, ensure that the specified regional materials are installed and quantify the total percentage of local materials installed.

CaGBC LEED® RP Credit 2 Durable Building

1 Point

Intent

To minimize materials use and construction waste over a building's life resulting from premature failure of the building and its constituent components and assemblies.

Requirements

Develop and implement a Building Durability Plan, in accordance with the principles in *CSA S478-95 (R2007) – Guideline on Durability in Buildings*, for the components within the scope of the Guideline, for the construction and pre-occupancy phases of the building as follows:

- Design and construct the building to ensure that the predicted service life exceeds the design service life established in *Table 2* in *CSA S478-95 (R2007) – Guideline on Durability in Buildings*.
- Provide the owner's expectation of design service life.
- Where components and assembly design service lives are shorter than the design service life of the building, design and construct those components and assemblies so that they can be readily replaced, and use a design service life in accordance with *Table 3* in *CSA S478-95 (R2007) – Guideline on Durability in Buildings*, as follows:
    - For components and assemblies whose categories of Failure are 6, 7 or 8 in *Table 3*, use a design service life equal to the design service life of the building.
    - For components and assemblies whose categories of Failure are 4 or 5 in *Table 3*, use a design service life equal to at least half of the design service life of the building.
- Demonstrate the predicted service life of chosen components or assemblies by documenting demonstrated effectiveness, modeling of the deterioration process or by testing in accordance with *Clause 7.3. 7.4 or 7.5*. Complete *Tables A1, A2 & A3* from *CSA S478-95 (R2007) – Guidelines on Durability in Buildings* or the *LEED® Canada Durable Building Tables, which correspond to CSA S478 Tables A1, A2 and A3.*
- Develop and document the quality management program in accordance with *CSA S478-95 (R2007) - Guideline on Durability in Buildings*.
- Document the elements of quality assurance activities (including design and field reviews) carried out in the format contained in Table 1, Quality Assurance and the Building Process, of *CSA S478-95 (R2007) - Guideline on Durability in Buildings*.
- Utilize a qualified building science professional to develop and deliver the Building Durability Plan who:
    - Is employed by a firm with an Engineering Certificate of Authorization or an Architectural Certificate of Practice.
    - Has experience in performing building science reviews focused on the envelope durability for at least two prior buildings.
    - One of the following:
        - Has successfully completed at least 35 hours of instruction in building science courses that address envelope durability within the last 10 years.

        OR
        - Has a certificate demonstrating building envelope expertise from a building warranty program (e.g., TARION).

        OR
        - Is independent of the architectural firm of record.

POTENTIAL TECHNOLOGIES & STRATEGIES

Design strategies for building durability that will minimize premature deterioration of the walls and roof, while harmonizing and integrating Architectural, Mechanical, Landscape, and Electrical performance requirements, and meet the needs of the Owner and Contractor. Appropriate technology and strategies must be appropriate to the region, for example: rain screen walls, overhangs, etc.

- Document the elements of quality assurance activities to be carried out to ensure the predicted service life is achieved, in the format contained in *Table 1, Quality Assurance and the Building Process, of CSA S478-95 (R2001) – Guidelines on Durability in Buildings*.

Develop and document the quality management program for the project that ensures the quality assurance activities are carried out, in accordance with the elements identified in Clause 5.3, Elements of Quality Management, *CSA S478-95 (R2001) – Guidelines on Durability in Buildings*.

Application of Credit RP 2—This credit requires development of a building durability plan according to *CSA S478 Guideline on Durability for Buildings* (CSA 2007). This guideline encourages use of readily replaced construction components and assemblies and design strategies that allow for ease of access for repairs, replacements and alterations of components and assemblies throughout the construction phase and service life of the building. The modular nature of all segmental paving products enables easy access to underground utility repairs and reinstatement of the same paving units with no waste or damage to the surface. *ICPI Tech Spec 6 – Reinstatement of Interlocking Concrete Pavements* provides technical guidance on this topic (ICPI 2005). In addition, roof applications with segmental concrete products and sand bedding or pedestals enable easy access to waterproofing and drains. These unique characteristics of segmental paving enable it to contribute to the building durability plan.

CaGBC LEED® ID Credit 1: Innovation in Design

1–5 Points

Intent, requirements and strategies are the same as USGBC LEED®

CaGBC LEED® ID Credit 2: LEED® Accredited Professional

1 Point

Intent, requirements and strategies are the same as USGBC LEED®

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