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Ready Mixed Concrete Industry LEED Reference Guide Update
February 2009

The United States Green Building Council (USGBC) will transition their Leadership in Energy and Environmental Design (LEED) rating system from LEED 2.2 to LEED 2009 as of March 1, 2009. Projects registered prior to March 1 will have the option of meeting the requirements of LEED 2.2 or LEED 2009 while projects registered after that date will fall under the 2009 version. The current version of the *Ready Mixed Concrete Industry LEED Reference Guide* addresses the LEED 2.2 version. The RMC Research & Education, partnering with the National Ready Mixed Concrete Association (NRMCA), is working to update the Guide to incorporate the new changes in version 2009 regarding the use and treatment of ready mixed concrete. The revised Guide will be available this summer.

Until the revised Guide is available, we have included with the current Guide an article written for *Concrete inFocus* by NRMCA's Lionel Lemay, senior vice president of sustainable Development and Erin Mack Ashley, senior director of sustainable construction that details changes included in LEED 2009. The article is included as an insert in the Guide hardcopy and as an addendum at the end of the electronic version.

Should you have any questions, please contact the Foundation's Jennifer LeFevre at 240-485-1151 or at jlefevre@rmc-foundation.org. If you have specific questions related to the LEED program, please contact Lionel Lemay at 847-918-7101 or at llemay@nrmca.org or Erin Mack Ashley at 410-796-7975 or at eashley@nrmca.org.

Ready Mixed Concrete Industry

LEED Reference Guide

Updated with LEED Version 2.2 Information

RMC Research Foundation

NRMCA

PCA

The Ready Mixed Concrete Industry LEED Reference Guide

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This document was underwritten by the Ready Mixed Concrete (RMC) Research Foundation and the Portland Cement Association (PCA). It was researched and written by Steven Winter Associates, Inc. (SWA), 50 Washington Street, Norwalk, CT 06854 (www.swinter.com). SWA is an independent research and consulting firm with a long-standing commitment to achieving energy-, cost-, and resource-efficient buildings. SWA works closely with project architects, building owners, developers, and other industry representatives to apply sustainable, "whole building" strategies in a wide variety of building types: commercial, residential, educational, and institutional. SWA possesses expertise in material selection, systems engineering and specification, environmental performance, affordability, reduced construction and operating costs, HVAC control strategies, durability and affordability. The guide was revised in 2006 by an industry working group and is published by the RMC Research Foundation.

The RMC Research Foundation is a non-profit organization dedicated to improving the concrete industry through achieving its mission of promoting education and research projects that will strengthen and improve an already superior product in an industry committed to excellence. PCA is an organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, and public affairs work. NRMCA is a leading industry advocate working to expand and improve the ready mixed concrete industry through leadership, promotion, education and partnering, ensuring that ready mixed concrete is the building material of choice.

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Abstract: Ready mixed concrete offers opportunities for designers, architects, engineers, contractors, concrete producers and others in the building industry to maximize credits offered by the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED®) New Construction (NC) version 2.1 standard. This document will guide the reader in understanding the LEED program and areas where ready mixed concrete can be applied in a project to earn LEED points, enhancing its sustainability.

Keywords: Energy conservation, environmental factors, innovative design, LEED, ready mixed concrete, recycling, sustainability.

Reference: Steven Winter Associates, Inc., *Ready Mixed Concrete Industry LEED Reference Guide*, RMC Research Foundation, Silver Spring, Maryland, USA, October, 2005.

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PREFACE - Potential LEED Credits for Ready Mixed Concrete

Concrete contributes to this LEED Credit		
Incidental concrete use in this LEED Credit		
Prereq 1	**Erosion & Sedimentation Control**	Required
Credit 1	**Site Selection**	1
Credit 2	**Urban Redevelopment -** 60,000 sf/acre Development Density	1
Credit 3	***Brownfield Redevelopment***	*1*
Credit 4.1	**Alternative Transportation**, Proximity to Mass Transit	1
Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations (3% of Parking)	1
Credit 4.4	**Alternative Transportation**, Parking Capacity	1
Credit 5.1	***Reduced Site Disturbance**, Protect or Restore Open Space*	*1*
Credit 5.2	**Reduced Site Disturbance**, Development Footprint (25% Reduction)	1
Credit 6.1	**Stormwater Management**, 25% Reduction in Rate & Quantity or No Net Increase	1
Credit 6.2	**Stormwater Management**, Treatment	1
Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
Credit 7.2	***Landscape & Exterior Design to Reduce Heat Islands**, Roof*	*1*
Credit 1.1	***Water Efficient Landscaping**, Reduce by 50%*	*1*
Credit 1.2	***Water Efficient Landscaping**, No Potable Water Use or No Irrigation*	*1*
Credit 2	***Innovative Wastewater Technologies***	*1*
Credit 3.1	**Water Use Reduction**, 20% Reduction	1
Credit 3.2	**Water Use Reduction**, 30% Reduction	1
Prereq 1	**Fundamental Building Systems Commissioning**	Required
Prereq 2	**Minimum Energy Performance** ASHRAE 90.1-1999.	Required
Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
Credit 1.1	**Optimize Energy Performance**, 15% New / 5% Existing.	1
Credit 1.2	***Optimize Energy Performance**, 20% New / 10% Existing*	*1*
Credit 1.3	***Optimize Energy Performance**, 25% New / 15% Existing*	*1*
Credit 1.4	***Optimize Energy Performance**, 30% New / 20% Existing*	*1*
Credit 1.5	***Optimize Energy Performance**, 35% New / 25% Existing*	*1*
Credit 1.6	***Optimize Energy Performance**, 40% New / 30% Existing*	*1*
Credit 1.7	***Optimize Energy Performance**, 45% New / 35% Existing*	*1*
Credit 1.8	***Optimize Energy Performance**, 50% New / 40% Existing*	*1*
Credit 1.9	***Optimize Energy Performance**, 55% New / 45% Existing*	*1*
Credit 1.10	***Optimize Energy Performance**, 60% New / 50% Existing*	*1*
Credit 2.1	**Renewable Energy**, 5% (2.5%)	1
Credit 2.2	**Renewable Energy**, 10% (7.5%)	1
Credit 2.3	**Renewable Energy**, 20% (15.5%)	1
Credit 3	**Additional Commissioning** DD, CD, & submittal review + recommissioning manual & 1yr system operations review.	1
Credit 4	**Ozone Depletion -** No HCFC's and Halons	1
Credit 5	**Measurement & Verification** Continuous monitoring of 10 key building systems (IPMVP).	1
Credit 6	**Green Power** 2 Year Contract Tradable Renewable Certificates available for 1.5-2.5 cents Kw.	1

Prereq 1	**Storage & Collection of Recyclables**	Required
Credit 1.1	***Building Reuse**, Maintain 75% of Existing Shell*	*1*
Credit 1.2	***Building Reuse**, Maintain 100% of Shell*	*1*
Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
Credit 2.1	**Construction Waste Management**, Divert 50% of C&D waste from landfill.	1
Credit 2.2	**Construction Waste Management**, Divert 75% Divert 75% of C&D waste from landfill.	1
Credit 3.1	**Resource Reuse**, Specify 5% Based on material cost, this would require the project to purchase salvaged materials equal to at least 5% of the total material costs.	1
Credit 3.2	**Resource Reuse**, Specify 10%	1
Credit 4.1	**Recycled Content**, Specify 5%.	1
Credit 4.2	**Recycled Content**, Specify 10%.	1
Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally (w/in a 500-maile radius).	1
Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
Credit 6	**Rapidly Renewable Materials** 5% of materials from renewable resources	1
Credit 7	**Certified Wood** 50% of Wood FSC Certified	1
Prereq 1	**Minimum IAQ Performance -** ASHRAE 62-2001	Required
Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
Credit 2	**Increase Ventilation Effectiveness -** Air Exchange Effectiveness >= 0.9 (ASHRAE 127-1997)	1
Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy(Flush-out)	1
Credit 4.1	***Low-Emitting Materials**, Adhesives & Sealants*	*1*
Credit 4.2	***Low-Emitting Materials**, Paints*	*1*
Credit 4.3	***Low-Emitting Materials**, Carpet*	*1*
Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
Credit 5	***Indoor Chemical & Pollutant Source Control***	*1*
Credit 6.1	**Controllability of Systems**, Perimeter - 1 operable window & 1 lighting control/ 200 sf.	1
Credit 6.2	**Controllability of Systems**, Non-Perimeter - Individual airflow, temp, & lighting control for 50% of non-perimeter occupants.	1
Credit 7.1	***Thermal Comfort**, Comply with ASHRAE 55-1992*	*1*
Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
Credit 8.1	**Daylight & Views**, Daylight 75% of Regularly Occupied Spaces	1
Credit 8.2	**Daylight & Views**, Views for 90% of Regularly Occupied Spaces	1
Credit 1.1	**Innovation in Design**: Exemplary Performance.	1
Credit 1.2	**Innovation in Design**: Site Wide VOC Reduction.	1
Credit 1.3	**Innovation in Design**: 40% Reduction in the use of Portland Cement.	1
Credit 1.4	**Innovation in Design**: Open	1
Credit 2	**LEED™ Accredited Professional**	1
Project Totals		**69** Points
Certified 26-32 points Silver 33-38 points Gold 39-51 points Platinum 52-69 points		

EXECUTIVE SUMMARY

Of all the green building design and construction evaluation programs in the Unites States, the United States Green Building Council's (USGBC) LEED Rating System is the most widely adopted standard. Public and private companies, government agencies, trade groups, and other entities throughout the United States construction industry have adopted LEED as the standard for determining a building's degree of sustainability. Recognizing the importance of LEED, NRMCA, PCA, and the RMC Research Foundation commissioned the development of a LEED Reference Guide that could be used by architects, developers, clients, builders, manufacturers, suppliers, and others in the construction industry to determine how the use of ready mixed concrete can contribute to sustainable building.

Concrete offers several opportunities for building projects to gain LEED points.

The resulting document presents a detailed discussion of the LEED program, how LEED points are assigned, how material uses and construction methods must be documented, and what issues must be carefully considered in using ready mixed concrete to enhance a building's sustainability.

Potential LEED points gained through the use of ready mixed concrete are discussed in the following areas: stormwater management; landscape paving; minimizing energy use; optimizing energy performance; managing construction waste; recycled content; use of regional materials; use of certified wood; innovation in design; site-wide VOC reduction; and reduction in the use of portland cement. The document also covers plant waste water disposal; on-site wash water disposal; solid waste; and site protection. In each of these areas, the Reference Guide presents information useful to the designer, the contractor, and the ready mixed concrete supplier in achieving LEED points. This information is supplemented by extensive lists of citations, references, and other resource documents, trade groups, and websites.

INTRODUCTION

Established in 1998, the LEED Green Building Rating System for New Construction (LEED-NC) is a voluntary, consensus-based national standard for designing and building high-performance, sustainable buildings. LEED was developed by members of the USGBC representing many segments of the building industry and environmental science.

LEED's mission is to: define that which qualifies as a "green building" by establishing a common standard of measurement; promote integrated, whole-building design practices; recognize environmental leadership in the building industry; stimulate green competition; raise consumer awareness of green building benefits; and transform the building market. While the current number of registered LEED projects only accounts for about 5% of the United States Commercial and Institutional Building market, this number has grown from 12 registered LEED projects in 1999 to 2,164 by August 2005.

LEED Certification can be achieved at a Certified, Silver, Gold, or Platinum level based on how many of the 69 LEED-NC Credits are awarded after a project meets seven LEED Prerequisites. The LEED-NC Rating System divides these credits and prerequisites into six categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation in Design. Prerequisites and Credits are based mostly on established governmental, trade group, or laboratory standards, such as the USEPA's "Stormwater Management for Construction Activities," or the standards for energy efficiency and ventilation effectiveness of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). The number of points a project earns by satisfying the environmental performance criteria of the various LEED Credits determines the level at which a project can be certified.

While the LEED-NC Rating System was initially designed for commercial high-rise office buildings, the system can be used for a wide variety of projects. LEED-NC Version 2.1, released in November 2002, includes requirements suitable for multi-family residential high-rise projects. Also, the USGBC modified and added to the LEED-NC Rating System to create two new LEED Rating Systems; LEED-CI for Commercial Interiors and LEED-EB for existing buildings. In addition, LEED-CS for Core and Shell and LEED-H for Homes and LEED-CI for Commercial Interiors are currently in the pilot phase with approximately 98 projects registered between them. The USGBC is currently developing guidelines for residential and laboratory projects, and is making the final revision to the LEED-EB Rating System for Existing Buildings.

The LEED Certification Process

LEED is a voluntary rating system. An environmentally conscious building owner or developer may choose to design and construct a building to minimize environmental impact using the LEED rating system as a guide. LEED certification quantifies the level of environmental performance for a building. Typically the owner's representative, who is usually an architect, is directed to design the building to meet a certain level of LEED certification. Some building owners have committed to having all of their projects LEED certified and others have committed to certifying only selected buildings. For example, several public agencies such as city governments or

federal agencies have declared that all of their new buildings shall be LEED certified. Some private companies have built new headquarters using LEED certification.

A project formally begins the LEED Certification process by having it registered as a LEED project on the USGBC website (www.usgbc.org) by one of the project team members. This process requires completing an online form that asks for information on the project and the design team. Registering also requires a fee based on the total square footage of the project. The registration fee ranges from $750 to $3,000 depending on project size. The registration process entitles the project team access to member-only portions of the USGBC's website and to two free Credit Interpretation Requests (CIR). CIRs are made to the USGBC online when a project deems that compliance with a credit's intent can be met without meeting the letter of a given Credit Requirement. The member's-only portion of the USGBC website includes access to all prior CIRs made by registered projects and subsequent USGBC responses or "Rulings."

Informally, most project representatives begin the LEED process by evaluating criteria of the various LEED Credits and targeting those most compatible with the project scope, budget, and environmental goals. Representatives who start this process in the early stages of the design process are usually more successful because they can take advantage of synergies between LEED Credits and because they do not need to make design changes to meet LEED Criteria.

The process of documenting compliance with LEED Criteria can begin early in the design, but many of the credits related to construction activities and building materials require documentation that is not available until the final stages of Construction Administration, or even Substantial Completion. While the building commissioning (the process of making final checks and adjustments to construction and building operations), may need to continue beyond substantial completion for seasonal or deferred testing, projects are usually able to assemble all the documentation needed to submit a LEED Application to the USGBC at about the same time as Substantial Completion.

The LEED Application includes documentation or letters declaring compliance for all LEED Prerequisites and targeted LEED Credits. The USGBC website includes detailed information on the required format for the LEED Application. Once a representative has submitted the two copies of the application to the USGBC, the USGBC forwards one copy to a contracted reviewer and the LEED third party review process begins. The USGBC will issue a formal review of the LEED Application within 30 days. This first formal preliminary review will detail which credits are accepted, which credits need additional documentation, and which credits are being audited. The preliminary review provides descriptions of the additional documentation materials required. The project team then has 30 days to provide the requested materials to the USGBC. The final Certification then occurs

within 30 days from the date in which the USGBC receives the additional requested materials. At that time, a set of 10 LEED Certified, Silver, Gold, or Platinum Certificates are issued to the design team in recognition of the LEED Rating earned. The actual LEED Plaque is then ordered and is usually available within four to six weeks.

LEED encourages and rewards an integrated approach to design and construction that involves all team members in the project, including the design and construction team, owners, product suppliers and manufacturers, construction managers, cost estimators, specification writers, and others. LEED documentation is the responsibility of several team members, although it is typically coordinated by a LEED-accredited professional, who also prepares CIRs, the final submittal, and the responses to the USGBC during the review period.

The Ready Mixed Concrete Industry LEED Reference Guide

The document is organized into 11 sections that offer the best opportunities for achieving LEED Credits through the use of ready mixed concrete. The term "ready mixed concrete" and "concrete" are used interchangeably throughout this publication and meant to describe concrete that is delivered to the project site in the plastic state in concrete trucks. The 11 sections are organized under four categories: "Sustainable Sites," "Energy and Atmosphere," "Materials and Resources," and "Innovation in Design." These four categories are taken directly from the LEED-NC standard. A fifth section, "Incidental Ready Mixed Concrete Use in Other Credits," offers guidance in how the material can enhance opportunities for gaining LEED Credits in other areas.

In each section, the discussion of the LEED-NC Credits relevant to ready mixed concrete is separated into those issues primarily affecting the project designers (in the section "Design Issues") and those primarily affecting the concrete trade professionals (in the section "Trade Contractor and Manufacturer Issues"). However, each group needs to read both portions, as both groups are often responsible for completing documentation requirements. In general, "Design Issues" deals with issues that must be decided before the project begins construction, while "Trade Contractor and Manufacturer Issues" is concerned with actual construction and close-out.

A final section of the document addresses environmental considerations in using ready mixed concrete with reference to plant waste water disposal, on-site wash water disposal, solid waste, and site protection.

USING READY MIXED CONCRETE TO ACHIEVE LEED-NC CREDITS

Sustainable Sites PREREQUISITE AND CREDITS

LEED Credit SS-C6.1 Stormwater Management - Rate and Quantity

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

Requirements

If existing imperviousness is less than or equal to 50%, implement a stormwater management plan that prevents the post-development 1.5 year, 24 hour peak discharge rate from exceeding the pre-development 1.5 year, 24 hour peak discharge rate;

OR

If existing imperviousness is greater than 50%, implement a stormwater management plan that results in a 25% decrease in the rate and quantity of stormwater runoff. LEED will also give credit for rainwater collected and reused on-site.

LEED Credit SS-C6.2 Stormwater Management - Treatment

Intent: Limit disruption of natural water flows by eliminating stormwater runoff, increasing on-site infiltration and eliminating contaminants.

Requirements

Construct a site stormwater treatment system designed to remove 80% of the average annual post-development total suspended solids (TSS) and 40% of the average annual post-development total phosphorous (TP) based on the average annual loadings from all storms less than or equal to the 2-year/24-hour storm. Do so by implementing Best Management Practices (BMPs) outlined in Ch. 4, Part 2 (Urban Runoff), of the USEPA's *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, Jan. 1993 (Document No. EPA-840-B-93-001c) or the local government's BMP document (whichever is more stringent).

Example of uncontrolled water run-off.

Summary of Concrete Applications and Materials Relevant to the Credits

LEED includes Stormwater Management and Treatment Credits to reduce the negative effects of runoff created by development. Roofs, sidewalks, parking lots, driveways, streets and other impervious surfaces prevent water from naturally infiltrating soil, filtering pollutants and recharging aquifers. As a result, large volumes of sheet runoff must be collected, concentrated, and directed into waterways. These volumes of stormwater carry sediment and other

contaminants that compromise water quality. Expensive infrastructure works are necessary to control the erosion and flooding that occur when stormwater is concentrated and released into waterways.

Stormwater runoff picks up pollutants such as spilled oil, tire particles, detergents, pesticides, fertilizer, de-icing salt, pathogens, chemicals, sand, and many other substances. These pollutants are then deposited into waterways with concentrated stormwater. Some municipalities route stormwater through sewage treatment facilities, and when heavy storms cause flow rates to exceed treatment plant capacity, untreated sewage is discharged into waterways.

Concrete can be an important part of strategies to achieve these two credits: first, by controlling the rate and quantity of stormwater runoff; and second by removing some of the most important pollutants from the runoff.

These conventional uses of concrete for stormwater management such as piping, collection systems and waste water treatment are important, but are commonly used and are well-documented. This report will concentrate on pervious pavement made from concrete, a very promising technology that is rapidly gaining popularity throughout the United States.

DESIGN ISSUES

Pervious Concrete Paving

Pervious paving allows water to percolate to the ground, filter contaminants and recharge groundwater and aquifers. Pervious concrete consists of specially formulated mixtures of portland cement, uniform, open-graded coarse aggregate, and water. It usually contains little or no sand. It has enough void space to allow rapid percolation of liquids through the pavement.

Pervious concrete paving example – placing pervious screed.

The pervious pavement surface is typically placed over a highly permeable layer of open-graded gravel and crushed stone. Voids in the aggregate layers act as a storage reservoir for stormwater. A filter fabric may be placed beneath the gravel and stone layers to screen out fine soil particles. The amount of storage in the stone reservoir beneath the pavement can be varied. If the soil has low permeability, or is highly vulnerable to freeze-thaw cycles, perforated pipes can be added near the top of the reservoir to discharge excess stormwater after the reservoir has been filled. Urban infill projects or projects without adequate room for the required stone reservoir may not be appropriate candidates for pervious paving.

Pervious paving has many advantages in addition to meeting LEED credit requirements. It is a consistently improving technology that shows great promise, with benefits that are still being discovered by the industry.

Maintenance

The advantages of pervious pavement can only be realized if it is designed and maintained to prevent clogging. To ensure success, employ design strategies to help prevent clogging. Grade site areas away from paving to prevent the flow of dirt and debris into pervious paving (alternatively, "pretreatment" borders can be added to filter out particles before they flow onto the pavement). Only employ pervious paving in appropriate areas under suitable conditions (see "Design Guidelines" below).

Maintenance could include vacuum sweeping or pressure washing on a periodic basis commensurate with the level and type of debris that might come onto the pavement surface. The pavement should be inspected several times during the first few months following installation and annually thereafter. Annual inspections should take place after large storms, when puddles will make any clogging obvious. The condition of adjacent pretreatment devices should also be inspected.

Provide maintenance guidelines for the building owner. Consider posted signage on-site to identify pervious pavement areas. These can also serve an educational and environmental promotion function.

Filtering and Treating Stormwater with Pervious Concrete Paving

Pervious pavement pollutant removal mechanisms include absorption, straining, and microbiological decomposition in the soil. An estimate of pervious pavement pollutant removal efficiency is provided by two long-term monitoring studies conducted in Rockville, MD, and Prince William County, VA. These studies indicate removal efficiencies of between 82% and 95% for sediment, 65% for total phosphorus, and between 80% and 85% of total nitrogen. The Rockville, MD, site also indicated high removal rates for zinc, lead, and chemical oxygen demand. There is some question of how closely these results reflect other situations, but the treatment effectiveness of properly designed and maintained pervious pavement is not in doubt.

Table 2. Effectiveness of porous pavement pollutant removal (Schueler, 1987)

	Pollutant Removal (%)				
Study	**TSS**	**TP**	**TN**	**COD**	**Metals**
Prince William County, VA	82	65	80	-	-
Rockville, MD	95	65	85	82	98–99

Some key factors (other than maintenance) that increase pollutant removal include a drainage time of at least 24 hours, and the use of clean-washed aggregate.

"Stormwater hot spots" are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. Since pervious pavement is an infiltration practice, it should not be used at stormwater hot spots due to the potential for ground water contamination. These areas include commercial nurseries, auto recycle facilities, fueling stations, storage areas, marinas, outdoor container storage of liquids, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing/steam cleaning facilities.

Recharging Ground Water Below Pervious Concrete Paving

Pervious paving can be used either to recharge ground water, or to store stormwater for later reuse (and/or diversion into stormwater conveyance systems), or both. This section discusses its ground water recharge function.

Some data suggest that as much as 70% to 80% of annual rainfall will go toward ground water recharge (Gburek and Urban, 1980). These data will vary depending on design characteristics and underlying soils. Per the USEPA, systems that rely on soil absorption require deep pervious soils at separation distances of at least 4' between the bottom of the structure and seasonal high ground water levels. In theory, pretreatment and treatment by the pervious paving should reduce the depth of soil above seasonal high ground water levels.

Another source lists the following criteria:

Pervious pavements allow for groundwater recharging while also assisting with water pollution removal.

- Soils need to have permeability between 0.5" and 3.0" per hour. If this criterion is not met, a combination of an aggregate base and drainage pipes can be used to channel the excess water to a holding medium.
- The bottom of the stone reservoir should be flat so that infiltrated runoff will be able to infiltrate through the entire surface.
- Porous pavement should be sited at least 2' to 5' above the seasonally high ground water table, and at least 100' away from drinking water wells.

Designs also require the inclusion of devices to convey to the storm drain system excess water from storms that exceed the design flow rate. One option is to use storm drain inlets set slightly above the elevation of the pavement. This configuration would allow for some ponding above the surface, but would bypass flows that are too large to be treated by the system, or that occur if the surface clogs.

Retention/Attenuation (or Tanked) Systems

The gravel underlying the paving can be used for the storage (retention) of stormwater, substituting for expensive or land-consuming retention structures elsewhere on the property. This function of pervious paving incorporates base and sub-base storage in conjunction with standard drainage infrastructure to provide a delayed stormwater discharge. Retention systems can also enable reuse of stormwater for some domestic purposes such as irrigation.

Two ways of modifying pervious pavement systems to function as reservoirs are (1) varying the amount of storage in the stone reservoir beneath the pavement and (2) adding perforated pipes near the top of the reservoir to discharge excess stormwater after the reservoir has been filled. Some municipalities have also added stormwater reservoirs (in addition to stone reservoirs) beneath the pavement. These reservoirs should be designed to accommodate runoff from a design storm. For more information, see design criteria from the United States Environmental Protection Agency Office of Water, Washington, D.C., document: EPA 832-F-99-023, dated September 1999.

Benefits and Costs

As with most stormwater runoff reduction measures, the initial incremental costs need to be compared to the costs of infrastructure that may be required by municipal or other authorities for which pervious paving is an acceptable alternative (i.e. detention tanks). Maintenance costs, such as required vacuuming of pervious paving, should also be considered.

Limitations

Several studies indicate that, with proper maintenance, porous pavement can retain its permeability (e.g., Goforth et al., 1983; Gburek and Urban, 1980; Hossain and Scofield, 1991). Many pavement engineers and contractors lack expertise with this technology. Therefore, it is suggested that specifications require pervious concrete installers be NRMCA Pervious Concrete Contractor (or Technician) Certified. For infiltrating systems (the great majority of cases), the use of pervious pavement does create risk of ground water contamination, depending on soil conditions and aquifer susceptibility. Fuel may leak from vehicles and toxic chemicals may leach from asphalt and/or binder surface. Infiltration-type treatment systems, including pervious paving, are not designed to treat these pollutants. Likewise, nitrates and chlorides may continue to move through the soil profile and into the ground water, possibly contaminating drinking water supplies. Therefore, until more scientific data is available, it is not advisable to construct porous pavement near ground water drinking supplies.

Because pervious paving is not in wide use, special planning and expertise will be necessary until it becomes routine. Retrofit may not be possible in many cases without redesigning and rebuilding the sub-base for proper drainage. Anaerobic conditions may develop in underlying soils if the soils are unable to dry out between storm events. This

situation may impede microbiological decomposition.

Codes and Standards

Any paving must meet requirements for material quality, compressive strength, water absorption, and freeze-thaw resistance. The NRMCA publication *Freeze-Thaw Resistance of Pervious Concrete provides guidance for freeze-thaw resistance.* In areas where codes have not caught up with new technologies, requirements for curbing, gutters, stormwater piping and other standard civil engineering measures may compromise the use of pervious paving. In these cases, rationalization must be prepared and justified with the appropriate agencies.

Regulatory agencies may require review and approval regarding the recharging of underground aquifers or the horizontal movement of water under the paving, when the water may contain undesirable chemicals or pathogens.

Integration with Other LEED Credits

Pervious concrete is also known as percolating concrete, no-fines concrete, and pervious or porous paving. Like porous asphalt pavement or porous precast concrete pavers, it may be an option for the achievement of three LEED Credits in addition to the Stormwater Management points:

- Because concrete is much lighter in color than asphalt, it may help satisfy the requirement for LEED Credit SS-7.1(See Heat Island Reduction Credit).
- The gravel sub-base under porous pavement can be used to store stormwater for irrigation, helping to satisfy LEED Credit WE-1. If no irrigation is required for a project, two points may be earned.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

The specifications will likely include a new section number, but otherwise, should be self explanatory with regards to meeting the LEED criteria for these credits. See the specifications of this report for LEED Performance and Submittal Requirements related to LEED Materials or Site Credit specification issues.

Installation

The equipment used to place pervious concrete is different from that used to place standard concrete. Deposit concrete directly

Pervious concrete finishing uses similar equipment as for finishing standard concrete; technique is the key.

into final position since pervious concrete has little or no flowability. Do not pull or shovel into final position. After the paving is struck off and compacted, don't do any other

finishing. Typically, compacting is completed by rolling and is different from traditional finishing. Personal protective equipment used for placing pervious concrete is the same as with placing standard concrete and includes: hardhat, safety shoes, protective eyewear, chemical resistant gloves, and a chemical resistant knee board, if necessary. Initial set occurs quickly, in about one hour (1.5 hours with a set retarding admixture). Covering with plastic sheets is the recommended curing method. Recommended curing time is seven days. Do not allow truck traffic for 10 days or passenger car/light truck traffic for seven days.

If random cracks are not desired, form control (contraction) joints at 20 foot intervals to one-fourth the depth of the pavement.

Traditional portland cement pavement testing procedures based on strength, air content and slump control are not applicable to this type of pavement material. Most commonly, the quality of pervious pavements is assessed by measuring the unit weight of both plastic and cured concrete. This assessment is used to estimate the voids content that influences the storage capacity. See NRMCA's *Pervious Concrete Pavements* for more information.

Required LEED Documentation

Data regarding the runoff coefficient will likely be secured by the architect or landscape architect prior to the Construction Documents.

If the concrete producer has reflectance test results (see Credit SS-7) for the pervious concrete mix used on the project, he may choose to submit a letter to the contractor (and architect) indicating the results of the tests. See Appendix B for a sample letter.

REFERENCES AND INFORMATION SOURCES

Resource Websites

www.nrmca.org – The National Ready Mixed Concrete Association in Silver Spring, MD, provides up-to-date information on the application, placing and maintenance of pervious concrete. Of particular relevance are the recent publications:

- *Pervious Concrete Pavements*
- *Freeze-Thaw Resistance of Pervious Concrete*
- *2006 Concrete Technology Forum Conference Proceedings*

www.rmc-foundation.org – The RMC Research Foundation is a non-profit organization dedicated to improving the concrete industry through achieving its mission of promoting education and research projects that will strengthen and improve an already superior product in an industry committed to excellence.

RMC Research Foundation's pervious concrete research compilation can be found at www.rmc-foundation.org/newsite/images/Pervious%20Concrete%20Compilation.pdf

www.pervious pavement.org – This website specifically on pervious concrete pavement includes details about the pavements environmental benefits, applications, performance, engineering properties, mix

design and materials, design, construction, maintenance and an FAQ section.

www.concreteparking.org – This website provides useful information on concrete paving, parking lots and parking structures. Discusses the economic, environmental, curb appeal and fast placement benefits of conventional concrete, Pervious Concrete, White Topping, Ultra-Thin White Topping and Concrete Paths.

www.greenrooftops.org – Information on waterproof concrete systems that has proven itself as a fast, smart and economical system that can boost the green roof industry.

www.gcpa.org/specification.htm – This, one of the few published specifications for pervious concrete paving, is available on this website for the Georgia Concrete and Products Association.

www.concretehelp.org – Website from NRMCA that provides a variety of concrete resources, including information about the materials "green" characteristics, cost, durability attributes and many other topics.

www.epa.gov/owow/protecting – This document, "Protecting and Restoring America's Watersheds," contains useful information on pervious paving.

www.cncpc.org/pages/pervious.html – California Nevada Cement Promotion Council site with general information and photos of concrete pervious paving.

www.concrete.net.au/search.php?category=Paving&menu=4 – "Pervious Concrete Pavements – a-state-of-the-art report," Cement & Concrete Association of Australia, February 2004. This is a concise and useful summary of available information on pervious cast-in-place concrete paving. It was an important reference source for this report.

www.tarmacamerica.com/tarmac/products/readymix/ – This is the website of a large mid-Atlantic ready-mix company is included because it contains useful data on different kinds of concrete and applications. The company makes a product that has no fine aggregate.

www.epa.gov/owm/mtb/porouspa.pdf – A 1999 USEPA document from its Municipal Technology Branch, Office of Water Management. Detailed recommendations for porous pavement used for stormwater control, including cost data for asphalt porous paving. The pavement itself only accounts for one-fourth of the total cost of the installation.

www.fcpa.org – Florida Concrete and Products Association

www.icpi.org – Interlocking Concrete Pavement Institute includes general and technical information, specifications and details for pervious segmental paving options.

www.millermicro.com/porpave.html

dep.state.ct.us/wtr/stormwater/manual/CH11_PP_S-6.pdf

cfpub.epa.gov/npdes/stormwater/menuofbmps/post_21.cfm – An overview and one of a series of USEPA BMPs (Best Management Practice) Guides in its National Pollutant Discharge Elimination System (NDPES) program.

epa.gov/owow/nps/mmsp/Section-4-5.pdf –

USEPA, National Management Measures to Control Nonpoint Source Pollution from Marinas and Recreational Boating, Section 4. Although directed at marinas, this document contains some useful information (some quoted in this report).

www.cwp.org – Center for Watershed Protection, 8391 Main St., Ellicott City MD 21043-4605, Phone: 410-461-8323

United States Environmental Protection Agency, Office of Water, 1200 Pennsylvania Avenue N.W., Washington DC 20460, Email: ow-general@epa.gov

Resource Documents

Center for Watershed Protection (CWP). 1998. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection (CWP). 1997. *Stormwater BMP Design Supplement for Cold Climates*. Prepared for: USEPA Office of Wetlands, Oceans and Watersheds. Washington, DC.

Ferguson, Bruce, 2005, *Porous Pavements*, CRC Press, Boca Raton, FL.

Field, R., et al., 1982, "An Overview of Porous Pavement Research," *Water Resources Bulletin*, Volume 18, No. 2, pp. 265-267.

Galli, J. 1992. *Preliminary Analysis of the Performance and Longevity of Urban BMPs Installed In Prince George's County, Maryland*. Department of Natural Resources, Annapolis, MD.

Gburek, W., and J. Urban, 1980. *Stormwater Detention and Ground Water Recharge Using Porous Asphalt—Experimental Site*. In Proceedings: International Symposium on Urban Storm Runoff. University of Kentucky, Lexington, KY, p. 89–97.

Goforth, G., E. Diniz, and J. Rauhut. 1983. *Stormwater Hydrological Characteristics of Porous and Conventional Paving Systems*. United States Environmental Protection Agency, Office of Research and Development, Cincinnati, OH.

Hossain, M., and L. Scofield, 1991. *Porous Pavement for Control of Highway Runoff*. Arizona Department of Transportation, Phoenix, AZ.

Metropolitan Washington Council of Governments, 1987, *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*.

Metropolitan Washington Council of Governments, 1992, *A Current Assessment of Best Management Practices: Techniques*

for Reducing Nonpoint Source Pollution in a Coastal Zone.

Portland Cement Association, 2004, *Pervious Concrete Pavements,* Skokie, Illinois.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington, DC.

Southeastern Wisconsin Regional Planning Commission, 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures*, Technical Report No. 31.

Stenmark, C. 1995. An Alternative Road Construction for Stormwater Management. *Water Science and Technology* 32(1):79–84.

USEPA, 1981, *Best Management Practices Implementation Manual*.

USEPA, 1992, *Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices*. EPA 833-R-92- 006.

Washington State Department of Ecology, 1992, *Stormwater Management Manual for the Puget Sound Basin*.

Watershed Management Institute (WMI), 1997, *Operation, Maintenance, and Management of Stormwater Management Systems*, prepared for the USEPA Office of Water, Washington, DC.

LEED CREDIT SS-C7.1 LANDSCAPE AND EXTERIOR DESIGN TO REDUCE HEAT ISLAND EFFECT

Intent: Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat. This credit is for non-roof applications.

Requirements

Comply with one of the following:

- Provide shade (within five years) on at least 30% of non-roof impervious surfaces on the site, including parking lots, walkways, plazas, etc., OR,
- Use light-colored/high-albedo materials (reflectance of at least 0.3) for 30% of the site's non-roof impervious surfaces, OR
- Place a minimum of 50% of parking space underground OR
- Use open-grid pavement system (net impervious area of LESS than 50%) for a minimum of 50% of the parking lot area.

Summary of Concrete Applications and Materials Relevant to the Credit

Ready mixed concrete products can help significantly in gaining not only this credit, but Innovation Credits based on exemplary achievement of this credit (see Innovation Credits, Exemplary Performance).

DESIGN ISSUES

Details

One strategy for achieving this Credit is to use concrete instead of asphalt for more than 30% of the non-roof impervious surface paving on a given project. Solar reflectance includes not just visible light, but also infrared heat and UV, and is measured by the surface's "albedo." An albedo of 0.3 means that 30% of all the solar energy striking a surface is reflected back into the atmosphere, while 70% is absorbed by the surface, raising its temperature. According to research conducted by Lawrence Berkeley National Laboratory, ordinary gray cement concrete has an initial albedo in the range of 0.35 to 0.45; the more expensive white cement concrete has an albedo of 0.7 to 0.8. By comparison, the albedo of asphalt is from 0.05 to 0.10 when new, weathering to 0.10 to 0.15 over time.

The use of light-colored concrete and good landscaping are a winning combination for the reduction of heat-island effects.

The USGBC has allowed this credit if the unprotected surface area of a garage (exposed sidewalls and roof) is 50% or less of the total garage floor area. Whether a fully enclosed above-ground garage can meet the requirement depends on its plan area relative to its sidewall area. Any below-grade elevation will have no exposed sidewalls and so will improve any calculation.

Concrete Pavement: Portland cement

concrete pavements for parking areas, roadways, drives, plazas, and sidewalks are used extensively. The albedo of ordinary concrete often exceeds the 0.30 LEED requirement. However, concrete albedo can sometimes fall just below 0.30. Concrete containing slag cement is sometimes naturally lighter than ordinary concrete at no added cost, and makes use of a post-industrial recycled material. This could help in achieving the Credit by increasing the albedo over a smaller area to achieve the desired average. Fly ash may sometimes lower the albedo of the concrete. When using either slag cement or fly ash, the actual albedo of the concrete would need to be verified by testing.

It is recommended to have the albedo tested by a lab that can perform reflectance tests compliant with ASTM E 903 or ASTM C 1549. This will require a sample of approximately 4" in diameter and just 1" thick in order to fit within the dimensions of the testing equipment. The concrete surface finish affects albedo, with a rougher finish lowering the value. The same finish as will be used on the in-place concrete is recommended. Also, the curing and drying time affect albedo. Concrete should be allowed to dry a sufficient time before testing.

Information on how to construct conventional concrete paving is widely available, and will not be repeated here. Adding coloring to the concrete mix may reduce its albedo. In these cases, the actual albedo of the concrete used must be tested. Note that you cannot take credit for the high albedo of the top deck of a parking garage, which is considered a building and not paving.

Whitetopping: Portland cement concrete overlays over existing hot-mix asphalt (HMA) pavements have been available as a rehabilitation option for roadways and parking areas for many years. Coined *whitetopping* by the industry, these overlays have been used on airports, interstates, highways, secondary roads, and parking lots to improve the performance, durability and riding quality of deteriorated HMA surfaces. There are three types of whitetopping:

- Conventional (thickness greater than 8")
- Thin (thicknesses from four to 8"), and
- Ultra-thin - UTW (thickness less than 4")

Ultra-Thin Whitetopping (UTW) is a bonded, fiber reinforced concrete overlay. It can be used as a road surface course where traditional paving materials have failed due to shoving, rutting, or general deterioration.

Whitetopping is gaining in popularity in fixing deteriorating hot-mix asphalt pavements and includes the benefit of having a higher albedo, better performance and increased durability over asphalt.

UTW provides an economical, durable, and long-lasting pavement surface if the underlying road course is sound.

The concern about the “heat island effect” that led to this credit SS-C7.1 is generating an interest in light-colored paving for Green construction. However, this is a relatively new issue, and has not percolated down to everyday pavement design.

New software under development will help engineers develop cost-effective specifications for UTW in particular situations. While intended primarily for resurfacing projects, the software can be applied to new construction.

UTW is placed as follows: the existing roadway is milled to a uniform depth of 4” (1/2 inch) and cleaned. The UTW concrete is placed directly on the milled asphalt surface using a conventional vibratory screed to consolidate the concrete and bring the concrete to final grade. The fresh concrete may be finished with a tined, broomed, or burlap dragged finish. The UTW concrete is then jointed using an early entry, or green cut saw. Joint spacing is usually laid out in three-foot squares. The proper joint spacing is critical to control random cracking of the concrete surface.

Concrete pavement has a service life several times greater than that of asphalt pavement. Concrete pavement is naturally light gray in color, and can be periodically pressure-washed to remove dirt and stains and to help retain its reflective qualities.

Benefits and Costs

UTW costs approximately $1.50 to $2.50 per square foot installed excluding surface preparation. Conventional concrete paving costs $2.00 to $6.00 per square foot. Benefits derived include highly reflective surfaces and a high level of durability.

Integration with Other LEED Credits

If the concrete used is porous and has the required albedo, it can help meet both this credit and credit SS-C6.1. However, porous concrete is not considered to meet the requirements of open-grid paving per the USGBC Credit Interpretation Ruling SS-7.1 dated 10/18/2004. The contribution of open grid paving to reducing the heat island effect depends upon evaporation from the plant material within the grid, and not on its ability to transmit water. Porous concrete can only contribute to this credit under the high albedo option.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

Credit 7.1 requires the use of "light colored/high albedo materials (reflectance of at least 0.3) for 30% of the site's non-roof impervious surfaces." The reflectance level of applicable materials must be adequately documented to earn this credit.

Include reflectance documentation from the American Concrete Pavement Association or Lawrence Berkeley National Laboratory, making sure to indicate the original source of the research data and the reflectivity category that relates to your

concrete mix. Alternatively, testing labs can be found using the ASTM lab directory at www.astm.org. Testing fees should be approximately $200 for ASTM E 903. ASTM Test Method C 1549, "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer" is also recommended. The lab will choose the test method and explain how to prepare test samples. Also include a site plan showing where concrete will be used.

For the concrete portion of the site, it is acceptable to use the reflectivity rate for new concrete for this credit, as this will meet the intent of the credit at the time of construction. Existing old concrete cannot be considered in the square footage for high albedo materials, unless its reflectance can be measured to be 0.3 or greater, and documentation is provided showing this reflectance. Pressure washing can be a solution for increasing the albedo of dirty, weathered concrete. However, if the albedo of the various impervious surfaces (including pervious paving) is measured and documented, the areas and albedos of each material can be averaged to achieve the credit, as explained in the CIR Ruling dated 12/05/01.

The concrete producer may choose to have concrete mixes used for parking areas and plazas pre-tested to determine reflectance values. In such cases, the producer should provide a letter to the contractor and architect stating the mix design was tested in accordance with ASTM E 903 or ASTM C 1549 and provide the reflectivity values. See Appendix B for a sample letter.

REFERENCES AND INFORMATION SOURCES

Resource Websites

eetd.lbl.gov/HeatIsland/

www.secement.org/PDFs/RT3.05.pdf – American Concrete Pavement Association, R&T Update #3.05, June 2002

www.pavement.com/techserv/RT3.05.pdf – Ultra-Thin Whitetopping

www.whitetopping.com/news.asp#iprf

www.tfhrc.gov/pubrds/02jul/09.htm

www.paconcrete.com/paconcrete/streetsandroads/ultrathinwhitetopping.asp

Resource Documents

www.secpa.org/PDFs/RT3.05.pdf

Effects of Composition and Exposure on the Solar Reflectance of Portland Cement Concrete, 2001, Lawrence Berkeley National Laboratory, Berkeley, CA.

History of Credit Interpretations

10/18/04 - Ruling: Porous concrete is considered 100% impervious for purposes of this credit. If using a grid that is more than 50% impervious, but over a larger area, follow the averaging method detailed in the 12/5/2001 CIR.

6/27/03 - Ruling: This ruling explains how to establish the albedo of concrete. It also confirms that the albedos required are those of new, and not aged, materials.

12/5/01 - Ruling: This ruling details the

calculation method for averaging to meet the credit, in this case with regard to option 2.

6/26/01 - Ruling: Shading of non-roof impervious site surfaces is calculated on June 21 at solar noon. It is possible to combine the effects of different measures, with proper documentation.

6/25/01 - Ruling: This ruling explains that achieving this credit using option 3 with a parking garage requires engineering calculations showing that the net exposed surface area of the garage roof and elevations are less than 50% of all parking surfaces on-site. Also, it suggests obtaining Innovation Credit points for satisfying more than one of the options. It is not clear whether in fact three points would be awarded if the requirements are met independently three different ways.

ENERGY AND ATMOSPHERE PREREQUISITE AND CREDITS

LEED EA-P2 MINIMUM ENERGY PERFORMANCE

Intent: Establish the minimum level of energy efficiency for the base building and systems.

Requirements

Design the building to comply with ASHRAE/IESNA Standard 90.1-1999 (without amendments) or the local energy code, whichever is more stringent.

LEED EA-C1 OPTIMIZE ENERGY PERFORMANCE

Intent: Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

Requirements

Reduce design energy cost compared to the energy cost budget for regulated energy components described in the requirements of ASHRAE/IESNA Standard 90.1-1999 (without amendments), as demonstrated by a whole building simulation using the Energy Cost Budget Method described in Section 11, by the following:

New Buildings	Existing Buildings	Points
20%	10%	2
30%	20%	4
40%	30%	6
50%	40	8
60%	50%	10

Regulated energy systems include HVAC (heating, cooling, fans and pumps), service hot water and interior lighting. Non-regulated systems include plug loads, exterior lighting, garage ventilation and elevators (vertical transportation). Project teams are encouraged to apply for Innovation Credits if the energy consumption of non-regulated systems is also reduced.

Summary of RMC Applications and Materials Relevant to the Prerequisite and Credit

There are a number of ready mixed concrete technologies that have an important role in energy saving. Credit EA-P2 requires a minimum energy performance that meets ASHRAE 90.1-1999, while Credit EA-C1 provides up to 10 Credit Points for achieving better energy performance. The primary role of ready mixed concrete in improving energy performance is in reducing heat loss and gain through foundation and building walls, using relatively new insulated wall technologies. The mass effect of concrete can also play a role in satisfying the prerequisite and in achieving points under LEED Credit EA-C1, by reducing overall energy consumption.

DESIGN ISSUES

Details

Insulated wall technologies fall into three categories: Insulating Concrete Form (ICF) systems, in which the insulation is outside the concrete; and sandwich construction, either tilt-up or vertically cast, in which a layer of insulation is sandwiched between two wythes of concrete, or conventionally insulated wall systems which consist of one

layer of concrete with a single layer of insulation on the interior or exterior, either tilt-up or vertically cast.

Insulating Concrete Forms: Insulating Concrete Form (ICF) systems use forms made of rigid insulation, or combinations of insulation and concrete that typically remain in place as part of the finished wall after concrete hardens.

ICF buildings have long been known to be particularly energy efficient.

The great majority of ICF systems utilize EPS (expanded polystyrene, "beadboard") or XPS (extruded polystyrene), with polyisocynurate (polyiso) rarely used. These systems have been used extensively in the homebuilding industry and are gaining popularity in commercial construction. There are a few systems using hollow blocks made of concrete and mineralized wood chips or foam chips.

ICF systems can be classified in two ways:

By Configuration of Concrete – *Flat* systems result in a solid concrete wall of constant thickness, from four to 12" thick. *Waffle-Grid* systems result in a continuous concrete wall of varying thickness, as in a waffle, with a typical grid being 12" OC vertically and 16" OC horizontally. A 2" thick web and 6"-8" cores are typical. *Screen-Grid* systems resemble waffle systems without the concrete web, with the cores at 12" OC in both directions (although spacing varies from system to system). *Post-and-Beam* systems are similar to the screen-grid systems, but with wider spacing (up to 4' for columns and between 4' and 8' for beams).

By Form Types – *Panel* systems are similar to standard plywood forms, ranging in size from 1'-3" x 8'-9" to 4'-0" x 12'-0". *Plank* systems consist of long, narrow planks 8" to 12" high, and 4' to 8' long. Both panel systems and plank systems can be shipped flat. *Block* systems resemble large concrete masonry units (CMU's), and range in size from 8" x 16" to 16" x 48". They vary in how they interlock. Most are shipped as blocks in their final configuration but some are shipped with hinged ties that allow the blocks to be shipped flat.

Tilt-up Construction: Tilt-up walls are cast horizontally on-site and lifted, or tilted, into final vertical position once the concrete reaches adequate strength, usually three to five days after casting. Tilt-up walls, long used to build large, simple buildings such as warehouses, are rapidly gaining in popularity for use in a wide variety of building types.

Tilt-up walls can be used in a sandwich panel configuration or conventional single wythe configuration. For sandwich panel configuration: Using the floor slab as a form bed, the outer layer of concrete is cast face down with proprietary metal or plastic ties cast into connect the inner and outer layer of the sandwich panel. A layer of polystyrene insulation specially configured to fit over the ties is installed next, over which is cast the inner reinforced structural wall layer. The resulting sandwich panel is then erected, forming an extremely durable, economical, and well-insulated wall system. For single wythe configuration: Using the floor slab as a form bed, the outer or inner layer of concrete is cast face down. Ties and insulation are either placed into the plastic concrete while the panel is in the horizontal position or attached to the hardened concrete once the panel is erected. In many cases, tilt-up walls are insulated using fiberglass or other batt insulation applied using furring strips or metal framing on the inside face of the wall.

Tilt-up construction is often used to save on energy costs.

Removable form systems can also be used to construct sandwich panels or single wythe insulated walls. For residential and small commercial buildings, the insulation is held in the center or to one side of ordinary removable standing forms by the special metal or plastic structural ties. Ready mixed concrete is then placed into the forms, creating a sandwich wall or single wythe wall in its final upright position. In many cases, concrete walls are insulated using fiberglass or other batt insulation applied using furring strips or metal framing on the inside face of the wall.

In both tilt-up and standing form systems, the most energy efficient systems are those that use plastic ties which do not create “cold bridges” because they do not readily conduct heat.

Mass Effect of Concrete: The “thermal mass effect” (thermal storage-and-release) of both interior and exterior concrete is well-documented. In principle, excess heat is absorbed by constructed mass and released later. In cold weather, excess heat supplied by the sun or gained from internal sources can be released at night to warm the building. In warm weather, unwanted solar heat or excess heat from internal sources is temporarily stored in massive construction during hours of expensive on-peak electricity use, and released later when it can be tempered using lower cost off-peak electricity or cool nighttime air.

The economic benefit of thermal mass is

determined in part by the extent to which the exterior temperature "swings" or oscillates between a maximum and minimum around the ideal interior temperature. Typically, passive solar buildings (or portions of buildings, such as a glazed south-facing gallery or atrium) are designed to undergo substantial temperature swings, to maximize the benefit of the mass effect. The mass effect is most pronounced in dry climates with large temperature swings such as are found at high altitudes in the western states. In such climates, sunny days where solar energy can readily be collected and stored regularly alternate with cold nights, where the stored energy can be used to good effect. Thermal mass works well in any season or climate where the outdoor temperature varies above and below the balance point of the building, generally between 50° and 60° F.

However, all other things being equal, a building in which the required structural elements are created with conventional concrete will typically have somewhat better thermal performance than a building constructed with lighter-weight materials. Continuous concrete exterior walls such as ICFs, tilt-up, or removable form systems also save energy by significantly reducing air infiltration.

The design of the ICF assembly limits the air infiltration resulting in an interior space that is "neutral." The result is an ambient temperature within the wall that shows little variance. Therefore, with the use of the ICF assembly, credit EQ2, Increased ventilation Effectiveness, is easily gained by the HVAC designer. ICFs also reduce the temperature and humidity variables which facilitate the maintenance and comfort ranges for Credit EQ7, Thermal Comfort.

Prerequisite EA-P2 requires that the building meet the more stringent of ASHRAE 90.1-1999 or the local energy code. This can be demonstrated by the same Energy Cost Budget calculations used to gain points under Credit EA-C1, described below. Alternatively, it can be satisfied using prescriptive requirements customized for the location and climate of the project. ASHRAE 90.1 and many energy codes require less insulation for mass walls than for frame walls. In many milder climates, no additional insulation is required for above or below grade concrete walls. In appropriate climates, the mass effect of concrete is taken into account as a way to reduce building envelope energy consumption. In these cases, the use of ready mixed concrete can help achieve the prerequisite by contributing to the mass effect.

Gaining points under Credit EA-C1, Improved Energy Performance, requires that the "design case" – the building being constructed – be compared with a simulated "base case" – a lightweight frame building, but lacking the "energy efficiency measures" (EEMs) that make the design case more energy conserving than the base case. An energy model that simulates annual energy use on an hourly energy basis is required; only these types of models correctly accommodate mass effects.

The LEED scoring system automatically rewards the mass effect in the following way.

Suppose better equipment, lighting, and insulation (all allowable EEMs) save 10,000,000 BTUs per year in the design case, as compared with the base case. If the base case building is light weight, and uses 58,000,000 BTUs per year, the design case saves 17.25% and is eligible for one point under Credit EA-C1. However, if a massive building of similar design results in 1,000,000 BTUs savings per year from the mass effect and the same 10,000,000 BTUs savings per year from equipment, lighting, and insulation is 19% of the total usage, the line is crossed to gain an additional Credit point. In general, using a concrete frame and cost-effective insulation strategies can lower energy costs 15% to 25% depending on the building and climate.

Benefits and Costs

All insulated wall systems use materials that are non-biodegradable, which eliminates problems of rot (see Limitations for a discussion of termite concerns). The walls have excellent insulating and acoustical properties, and inhibit air infiltration in systems where through-joints in the forms are sealed by finishes, or by a continuous wythe of concrete.

Tilt-up concrete systems have long proven to be economical for “big box” type construction such as large warehouse and retail buildings, but their use is rapidly expanding to include other buildings types such as offices, schools, churches, and multi-family residences.

ICF and standing form sandwich wall systems have primarily been used for residential construction, even though first cost is higher than wood-frame construction, which can be significantly higher than typical wood-frame construction. However, their use in commercial applications has been increasing rapidly because their cost is comparable to other types of insulated concrete, steel, and CMU walls.

Sandwich construction also has the advantage of having continuous concrete inside and out, allowing it to be used for applications that require hard surfaces inside and out, such as foundations and industrial buildings.

Mass-Effect: As noted above under “Details,” the value of the mass effect of concrete depends in part upon the extent to which the interior temperature is allowed to deviate from the set point – the more deviation (or “swing”), the more benefit. The distribution of the mass, its relation to

Sandwich construction is gaining in popularity for commercial building use.

incoming solar energy, its thickness, its color, and the extent to which it is “coupled” to other building elements also have roles to

play in its usefulness as a thermal storage medium. For example, the concrete in a 4" slab without floor covering, directly irradiated by the sun, will have a noticeable mass effect. In addition, most of the concrete in a 12-inch-thick wall in a space without windows will significantly delay and moderate energy loads, thus reducing peak load and overall energy consumption. The peak load will always be reduced; the energy consumption will be significantly reduced if the outdoor air temperature is between 50° and 80° F for any portion of the day.

Installation

Utility runs in concrete walls are best located in advance, with sleeves installed before pouring.

Attachment of casework, electrical boxes, and interior trim should be planned in advance. Some ICF and sandwich panel systems have furring strips or attachment surfaces at regular intervals making attachment more convenient. Heavy hanging objects can be directly attached to the concrete with a variety of concrete anchors. All systems should be evaluated carefully with regard to ease of construction, reliability, cost, etc.

Integration with Other LEED Credits

Any recycled material used in the stay-in-place formwork, concrete, and reinforcement, can contribute to LEED MR-C4 Recycled Content. Similarly, these materials can contribute to LEED MR-C5 Regional Materials.

The LEED credit MR4, Recycled Content, is applicable for some manufacturers of ICF systems. The expanded polystyrene used for the forms may contain post-industrial waste. The concrete mix for the ICF may contain a high percentage of fly ash which is 100% post consumer recycled. For LEED calculations, the recycled fraction is determined by weight and then multiplied by the cost of assembly to determine the recycled content value.

Availability

There are many manufacturers of ICF systems distributing directly to contractors. Tilt-up contractors are available in most parts of the country. Removable form wall construction for below-grade applications are readily available in most parts of the country. Removable form wall construction for above-grade applications is at present limited to a small number of contractors.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

Trade contractors should only need to meet standard specifications issued. Energy efficiency issues in terms of LEED performance requirements will have been modeled by the project A&E team and specified accordingly.

Required LEED Documentation

The project A&E team typically creates the document required for this credit. No particular LEED documentation should be required of the contractors or concrete producer in reference to Optimize Energy

Performance Requirements. See Documentation Requirements for Material and Resources Credits 4, 5, and 7.

REFERENCES AND INFORMATION SOURCES

Associations

Insulating Concrete Forms Association
1807 Glenview Road
Suite 203
Glenview, IL 60025
847-657-9730
FAX: 708-657-9728
www.forms.org

Cement Council of Texas –
www.cementcounciloftexas.org/
They maintain directory of builders, architects, manufacturers, and projects done within the state.

ICF Hotline
888-333-4840
www.concretehomes.com

List of manufacturer members and contractor/distributor members available by State/Province.

ICC Evaluation Service
5360 Workman Mill Road
Whittier, California 90601
562-699-0543
Fax: 562-695-4694
www.icc-es.org

National Ready Mixed Concrete Association
900 Spring Street
Silver Spring, MD 20910
301-587-1400
888-846-7622
Fax: 301-585-4219
www.nrmca.org

Portland Cement Association
5420 Old Orchard Road

Skokie, IL 60077-1083
847-966-6200
www.cement.org
www.concretehomes.com
Publications
800-868-6733

Tilt-up Concrete Association
113 First Street West
P.O. Box 204
Mount Vernon, IA 52314

319-895-6911

Fax: 319-895-8830

www.tilt-up.org

Concrete Foundations Association
113 First Street West
P.O. Box 204
Mount Vernon, IA 52314
319-895-6940
Fax: 319-895-8830
www.cfawalls.org

Books and Publications

Advanced Buildings: Energy Benchmark for High Performance Buildings, New Buildings Institute, White Salmon, Washington, 2003. www.newbuildings.org

Advanced Energy Design Guide for Small Office Buildings: Achieving 30% Energy Savings Over ASHRAE 90.1, American Society for Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, 2004. www.ashrae.org

Insulating Concrete Forms for Residential Design and Construction, VanderWerf, Pieter A., Feige, Stephen J., Chammas, Paula, and Lemay, Lionel A., "," McGraw-Hill (1997), New York, New York.

ICF Points to LEED, Insulating Concrete Form Association, Greenview, IL, 2006. www.forms.org

Investigation of Wind Projectile Resistance of Insulating Concrete Form Homes, Keisling and Carter, Texas Tech University, (1999). Portland Cement Association, Skokie, IL.

Design Criteria for Insulating Concrete Form Wall Systems, John Roller, CTL, (1996). Portland Cement Association.

Insulating Concrete Forms: Installed Cost and Acoustic Performance, by Farkas and Pesce, NAHB Research Center (1999). HUDUSER, Rockville, MD.

Insulating Concrete Forms, Construction Manual, Successful Methods and Techniques, Vanderwerf and Munsell, Portland Cement Association (1996). Available through PCA and McGraw-Hill.

Insulating Concrete Forms: Comparative Thermal Performance, Farkas and Johnson, NAHB Research Center, (1999). PCA, HUDUSER.

Design of Tilt-Up Concrete Wall Panels, Gerald Joseph Weiler, University of British Columbia (1979).

Tilt Up Concrete Structures, American Concrete Institute, 1992.

"Tilt-up concrete construction: tips on choosing materials for tilt-up panels," (Material Selection Guide), article from: *Concrete Construction* [HTML], Joe Nasvik, Bill Palmer, Hanley Wood, Inc., (2003).

Tilt-up Site Cast Concrete: An Architect's Viewpoint, R. Anderson, Cement and Concrete Association, (1974).

Tilt-Up Building: Methods and Marketing, Editors of *Concrete Construction* magazine, Hanley Wood, Inc. (1988).

The Tilt-Up Design and Construction Manual, Hugh Brooks, HBA Publications, (1997).

Tilt-Up Design & Construction Manual, 6th edition, Tilt-Up Concrete Association, (2000).

Construction Manual: Concrete and Formwork, T.W. Love, Craftsman Book Company, (1973)

Using Concrete to Obtain Energy Points for LEED-NC, Medgar L. Marceau and Martha G. Van Geem, Portland Cement Association, 2005.

Formwork For Concrete Structures, R. L. Peurifoy, G. D. Oberlender, McGraw-Hill Professional, 3rd edition (1995).

Resource Videos

Building With Insulating Concrete Forms Video Training Series – Contact Portland Cement Association

PCA Wind Tunnel Tests – Contact Portland Cement Association.

MATERIALS AND RESOURCES CREDITS

LEED Credit MR-C2 CONSTRUCTION WASTE MANAGEMENT

Intent: Divert construction, demolition and land clearing debris from landfill disposal. Redirect recyclable recovered resources back to the manufacturing process. Redirect reusable materials to appropriate sites.

Requirements

Develop and implement a waste management plan, quantifying material diversion goals. Calculations can be done by weight or volume, but must be consistent throughout.

Credit 2.1 (1 Point): Recycle and/or salvage at least 50% of construction, demolition, and land clearing waste. Remember that salvage may include the donation of materials to charitable organizations such as Habitat for Humanity.

Credit 2.2 (1 Point): Recycle and/or salvage an additional 25% (75% total) of the construction, demolition, and land clearing debris.

Summary of Concrete Applications and Materials Relevant to the Credit

The USEPA has estimated that C&D debris accounts for 23% of all municipal solid waste. By crushing and recycling concrete waste material, this diverts usable resources from landfills, which is the intent of credit MR-C2, Construction Waste Management. In addition, concrete producers recycle returned concrete, aggregate and wash water during the construction process which can contribute to this credit.

Concrete taken from demolition sites may be recycled by crushing and reuse as backfill or as a base for road construction.

DESIGN ISSUES

Details

Concrete is an easy material to keep segregated on-site, or to separate from combined site construction waste by an off-site recycler. Demolition waste concrete is recycled by crushing it and, when necessary, removing rebar. Typically, this material is employed as clean fill for backfill applications or road base applications. In a few areas there might even be a market for the use of recycled concrete as aggregate in the production of new concrete (see discussion of concrete aggregate under credit MR-C4 Recycled Content). When used as clean fill, crushed concrete may be combined on-site with other crushed demolition debris such as brick, mortar, and concrete masonry units.

It is important to note that C&D Waste Materials reused on-site as clean fill or other applications will count towards this credit only and not towards the Resource Reuse, Recycled Content or Regional Materials

Credits. Resource Reuse, Recycled Content and Regional Materials Credits are all based on cost, and thus materials must be purchased for the project to apply to these credits.

LEED does not consider fresh concrete that is returned from the job site to be recycled (this issue is discussed in more detail in the section "Other Environmental Issues"). However, if returned concrete is not credited to the project (that is, subtracted from the cost of delivered concrete), then it can be added to the quantity of concrete diverted from landfills under this credit.

Benefits and Costs

In some areas of the country where tipping fees are high or where C&D Waste has to be hauled great distances, there could be some savings due to reduced tipping fees. However, in these parts of the country, recycling has become standard practice.

There is some cost to segregating site waste, but pieces of broken concrete are likely to be set aside in a separate pile in any case, so additional cost is unlikely.

Integration with Other LEED Credits

Waste crushed concrete reused on-site or off-site counts toward this credit, because it is diverted from a landfill. However, waste concrete reused on-site does not count towards the Resource Reuse, Recycled Content or Regional Materials Credits as noted above. If, on the other hand, waste crushed concrete from another project is purchased and used as clean fill on a LEED project, the material value of the fill can be applied towards the Recycled Content and Regional Materials Credit. It does not count toward credit MR-C4 Recycled Content, which is aimed in part toward developing a market for recycled products. Crushed concrete aggregate or backfill material meets the criteria for recycled content only if it is purchased at an off-site location.

Technically, it is possible for this material to gain credit for recycled content in the following way. Waste concrete from the site is sent to a recycler, who crushes it and sells it back for use as backfill or concrete aggregate. While the material is now counted toward both credits MR-C2 and MR-C4, it is very unlikely the particular pieces of concrete from the site would be segregated from other waste concrete. Instead, both the diverted waste concrete from the site and the recycled crushed concrete become part of a market for recycled materials, which is the intent of the USGBC.

If this same process occurs entirely on-site – that is, there is a crushing plant on-site that makes aggregate from waste concrete, and this aggregate is used for backfill – the material can only be counted toward this credit MR-C2, and not toward Recycled Content credit MR-C4, as it never becomes part of the recycled material market.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

To achieve this credit, the project specifications will typically include a section in the front end or general conditions called Construction Waste Management. This

section will either contain a job-specific Construction Waste Management Plan, or will require the CM or GC to prepare one. Individual sections that generate C&D Waste then reference this section in an article entitled "Related Work in Other Sections" or a similar title.

Projects located in dense urban environments will likely employ off-site separation and recycling. In this circumstance, the concrete contractor will dispose of waste materials in a single container which is then taken to an off-site facility where the concrete and other recyclables are separated and sent to appropriate recyclers. This type of C&D Waste management has the least impact on concrete contractors.

Job sites with more area may employ on-site separation. In this circumstance, multiple containers will be on-site and should be clearly labeled according to the type of material in which a contractor is allowed to dispose of waste material. Attention should be paid to specifications requiring on-site separation as they may require attendance at training sessions and there may be penalties for non-compliance. In situations where new concrete must be removed because it was placed incorrectly or otherwise fails to pass acceptance tests, it may be necessary to break-out the concrete from the rebar and dispose of them in separate containers. The ready mixed concrete producer must track the amounts of returned concrete and the individual amounts (volume and/or weight) of the coarse aggregate, sand and water that is recycled rather than landfilled.

Integration with Other LEED Credits

This credit does not generally integrate with other credits. A common misconception is that waste material reused on-site can contribute towards Resource Reuse, Recycled Content, or Local Manufacture credits. However those credits are all based on cost. Therefore, if a material is not purchased from a market source, then it cannot be applied to those credits. Waste or salvaged materials from a project site that are reused either on or off the project site count only towards the Construction Waste Management Credit.

Required LEED Documentation

LEED will require the completion of a template that includes the total weight or volume of construction waste and a list of materials diverted from the landfill, measured by weight or volume. Typically, this table is completed by the party responsible for the project's C&D Waste Management Plan. If the concrete contractor was responsible for any waste disposal or reuse, data on the weight or volume will need to be provided to the party responsible for the overall project C&D Waste Management Plan. The concrete producer should provide a letter stating the amounts of returned concrete and individual amounts (volume and/or weight) of coarse aggregate, fine aggregate, and water that was diverted from landfills. See Appendix B for a sample letter.

The following is an example of such a template:

Waste Management Plan for Demolition Debris

DESTINATION OF WASTE Project Name: _____

Type of Material	Salva	Recycled	Landfilled	Name of Destination	Address	Telephone #
Wood						
Dimensional Lumber						
Finished Millwork						
0						
0						
Metals						
Structural Steel						
Miscellaneous Metals						
0						
0						
Concrete/Asphalt						
Concrete						
Asphalt						
Bricks/Blocks						
0						
Other						
Landscaping Material						
Roofing						
Gypsum Board						
Windows/Glass						
Carpeting						
Plumbing Fixtures						
Electrical Devices						
Debris/Non-Recyclables						
0						
0						
0						

Source: Demolition Waste Management Plan Specification Guide for Engineers, Solid Waste Agency of Lake County, Ill.

REFERENCES AND INFORMATION SOURCES

Trade Associations

Construction Materials Recycling Association – www.cdrecycling.org

Cement Association of Canada www.cement.ca/cement.nsf: PowerPoint presentation on advantages of crushing waste concrete.

National Ready Mixed Concrete Association
900 Spring Street
Silver Spring, MD 20910
301-587-1400
888-846-7622
Fax: 301-585-4219
www.nrmca.org

Resource Websites

The Whole Building Design Guide's Construction Waste Management Database: www.wbdg.org/tools/cwm.php

The City of New York Department of Design and Construction and Demolition Waste Management: http://www.nyc.gov/html/ddc/html/ddcgreen/documents/waste.pdf

Environmental Council of Concrete Organizations: www.ecco.org/

The Way to Go, Construction and Demolition Debris Management:

www.sustainablenc.org/thewaytogo/main/cd.htm

Resource Documents

Contractor's Guide to preventing Waste and Recycling: www.resourceventure.org/publications.htm

Sustainable Design Guide, University of Minnesota: www.sustainabledesignguide.umn.edu/MSDG/text/01690.pdf

Recycling Concrete and Other Materials for Sustainable Development. ACI Symposium Publication 219, 2004, 164 pp.

History of Credit Interpretations

Credit MR-C2: Credit Interpretation Request 2/05/03, with ruling 2/26/03. This covers the complex issue of assigning credit to MR-C1 through MR-C4 for material reprocessed on-site.

Credit MR-C3: Credit Interpretation Request 7/28/03, with ruling 8/14/03. This covers the credit assignment of recycled masonry materials crushed on-site and used for backfill.

LEED CREDITS MR-C4.1 AND MR-C4.2 RECYCLED CONTENT

Intent: Increase the demand for building products that have incorporated recycled content material reducing the impacts resulting from the extraction of new material.

Requirements for MR-C4.1

Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the post-industrial content constitutes at least 5%* of the total value of materials in the project.

Requirements for MR-C4.2

Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the post-industrial content constitutes at least 10%* of the total value of materials in the project.

* Percentages are calculated in terms of total dollar value for materials. Exclusions: labor costs; all mechanical and electrical material and labor costs; and project overhead and fees.

Summary of Concrete Applications and Materials Relevant to the Credits

Ready mixed concrete nearly always contains one or more materials that can directly contribute in the achievement of the Recycled Content Credit. These include "supplementary cementitious materials" or SCMs, such as fly ash, slag cement, or silica fume that have recycled content; recycled aggregate; recycled water; steel reinforcement; and recycled wood products used for non-rented wood formwork.

Using SCM's, recycled aggregate or recycled water as a way to contribute to achieving this LEED Credit will affect project design and concrete trade professionals. Concrete specifications for large-scale commercial LEED buildings are typically developed by the project structural engineer. As the LEED Rating System grows in use, engineers, contractors and producers will need to increase their familiarity with issues related to recycled content in concrete design mixes. Regardless of who develops the design mix specifications, LEED documentation requirements will require new submittal data from concrete contractors and manufacturers.

Crushing concrete and then using the material for aggregate is an opportunity to qualify for recycled content credit.

About one ton of CO_2 is released in the production of one ton of portland cement. Cement production constitutes about 1.5% of CO_2 generation in the United States as a result of an aggressive effort by the industry to reduce emissions. Replacing part of the portland cement in concrete with SCMs reduces the emission of CO_2, a primary greenhouse gas (GHG). However, only recycled SCMs qualify for this LEED credit. Other natural SCMs such as calcined clay

and shale do not qualify for this LEED credit despite reducing GHGs. See the "Intent" above. In addition, see the discussion on LEED Credit ID-C1 on the reduction in use of portland cement.

Cement producers are also replacing fossil fuels with recycled materials such as used tires and spent solvents that are used in the cement manufacturing process. Many also incorporate post-industrial recycled content materials, such as bottom ash, foundry sand, iron slag, etc., to replace conventional materials used to produce portland cement. This process reduces material sent to landfills and in some cases reduces the energy required to pyro-process the cement clinker. This recycled content can count toward the achievement of this credit if the manufacturer publishes a recycled content for the portland cement itself.

Post-Consumer Recycled Content refers to materials or finished products that have been recovered after they have served their intended consumer use and have been discarded by the consumer (e.g., a plastic bottle from a soft drink).

Post-Industrial Recycled Content refers to materials such as scrap, tailings, or waste by-products from industrial sources that have been traded through the market.

DESIGN ISSUES

A. Supplementary Cementitious Materials (SCMs) with Recycled Content

There is a large amount of information regarding SCMs with recycled content. For clarity, this section goes into some detail about cement and concrete chemistry in an attempt to clarify how SCMs are best used in concrete. This technology is a dynamic area, with new SCMs in the offing. A basic understanding of the underlying chemistry will help in evaluating the use of these new products, as they become available.

The raw materials most commonly used in making portland cement are limestone to provide calcium oxide; and clay and shale to provide silica, alumina, and iron oxide. Sand (for silica), bauxite (for alumina) and iron ore (for iron oxide) are also used. These materials are ground together and either fed into a rotary kiln dry (dry process), or in a slurry (wet process). In the kiln, it is heated to 800˚C -900˚C ("calcined") to drive off CO_2, then burnt at temperatures from 1,300˚C to 1500˚C (approximately 2,500˚F) to partially fuse the components into hard balls of ceramic-like material called "clinker." When cool, the clinker is mixed with a small amount of gypsum (calcium sulfate) and ground to a fine powder called portland cement and is the most common of the broad category of materials called hydraulic cement.

Typically, portland cement is combined with SCMs by concrete producers to make concrete. However, in some cases, SCMs are combined with portland cement by the cement manufacturer during the grinding phase. If combined with more than 5% of SCMs, the product is called "blended cement."

The most common SCMs are fly ash, slag cement, and silica fume. These materials, when used in conjunction with

hydraulic or blended cement, contribute to the properties of the hardened concrete through hydraulic or pozzolanic activity or both. A hydraulic cement (such as portland cement) is one that directly forms cementitious calcium-silicate hydrate (CSH) in the presence of water. CSH is the essential binding material that constributes to strength and durability of concrete. In the process, calcium hydroxide is produced, which does not contribute to the strength and durability of the concrete. A pozzolan is a siliceous or aluminosiliceous material that reacts with the calcium hydroxide to form additional CSH, which results in improvements in strength and durability properties of the concrete.

Types of SCMs

Fly ash: A pozzolanic by-product of the combustion of pulverized coal in thermal power plants. It is removed by the dust collection system as a fine particulate residue from the combustion gases before they are discharged into the atmosphere.

There are two classes of fly ash defined by ASTM C 618: Class F and Class C, each available in various types with special properties. ASTM C 618 characterizes fly ash into the C and F classes based on the sum of (SiO_2 + AlO_2 + FeO_2) content. Class F materials are generally low-calcium (less than 15% CaO) with a residual carbon content typically less than 5%, but sometimes as high as 10%. Class C materials are often high-calcium (>20% to 30% CaO), with a carbon content less than 2%.

Fly ash typically decreases the permeability of the concrete and allows lower water contents, thus improving overall performance for concrete subjected to harsh conditions such as freeze-thaw and sulfate attack. Class F fly ash greatly improves sulfate resistance, while Class C fly ash has no effect, or can even decrease sulfate resistance. Fly ash is also used to mitigate deleterious expansive cracking of concrete due to alkali silica reactions.

Silica fume: A pozzolan by-product of the production of silicon and ferrosilicon metals created by the reduction of high quality quartz in electric arc furnaces. Silica fume has been found to improve compressive strength and bond strength, and abrasion resistance. It also can significantly reduce permeability, thus helping to protect reinforcing steel from corrosion. Silica fume is typically used in low dosages. Two examples cited in the Silica Fume Association website (www.silicafume.org) are a parking garage with 6% silica fume and a high-rise with 13%.

Ground Granulated (Iron) Blast Furnace Slag (frequently abbreviated GGBFS in LEED references, herein referred to as "slag cement"): Formed by diverting the hot slag that forms on top of molten iron leaving a blast furnace, and suddenly cooling it with high-pressure water jets. This causes the material to form small, glassy granules, which are then ground to a fine powder similar to portland cement. It is a "latent" hydraulic material in that it hydrates more

slowly than portland cement. It also forms some CSH from the calcium hydroxide generated by the hydration of portland cement and, in this respect, behaves like a pozzolan, increasing strength in the long run. Slag cement also enhances durability of concrete related to reduced heat of hydration, reduced permeability and improved sulfate resistance and deterioration from alkali silica reactions.

Rice hull ash: This material offers promise as an SCM, although its use in the United States has typically been limited to laboratories. As with any SCM, quality control of the material is important.

New Products: Experiments are underway at Columbia University to use dredged clay from New York harbor, treated to remove hazardous metals, as an SCM. Whether this would be considered "recycled" by the USGBC would need to be decided through the CIR process. Many other SCMs are being tested, and when proven market-ready, will become available. Fly ash, now in common use, was a radical innovation only 30 years ago.

Concrete Properties and SCMs

Strength: Strength is improved by the substitution of some SCMs for portland cement. Class C fly ash and slag cement improve strength more than Class F fly ash. In applications where high strength is critical (such as high-rise buildings) a combination of SCMs (slag cement, fly ash, and silica fume) with portland cement can result in compressive strengths of 15,000 psi and higher.

Slow Setting and Strength Gain: Early setting and strength gain speeds up slab finishing and form removal. Although cement substitutes often create stronger and more durable concrete in the end, many harden more slowly than portland cement. Slow strength gain can set an economic limit on the percentage of slag cement or fly ash that can be used. In order from fast to slow strength gain, they generally rank: portland cement; slag cement; Class C fly ash; and Class F fly ash. Reducing the water to cementitious materials ratio partly compensates for slow strength gain. A drastic reduction in water to cementitious materials ratio, along with water-reducing admixtures, allows the use of high percentages of SCMs (60% or more) without excessively slow strength gain, but such mixes are uncommon, and require careful quality control. Ten percent to 25% Class F fly ash, 15% to 25% Class C fly ash, or 30% to 60% slag cement by weight of cementitious materials (or combinations) tend to produce a practical balance between recycled content and strength gain. Where high early strength is unimportant (footings, for example), higher percentages can be used. The use of silica fume does not create a delay in strength gain, but strongly affects the amount of water needed in the mix.

Color: SCMs may slightly alter the color of hardened concrete. Color effects are related to the color and amount of the material used in concrete. Many SCMs resemble the color of portland cement and therefore have little effect on color of the hardened concrete. Some silica fumes may

give concrete a slightly bluish or dark gray tint and tan fly ash may impart a tan color to concrete when used in large quantities. Slag cement and metakaolin (a clay SCM without recycled content) can make concrete lighter. Slag cement can initially impart a bluish or greenish undertone that disappears over time as concrete is allowed to dry.

Durability: Several types of concrete durability are affected, either positively or negatively, by the use of SCMs:

Freeze-Thaw Resistance: Chemical air-entraining admixtures are added to the concrete mix to improve freeze-thaw resistance. Higher carbon content in the fly ash will increase the amount of air-entraining admixtures needed to obtain a specific air content. However, fineness, alkali content, organic material content, loss on ignition, and presence of impurities in the fly ash also influence the amount of air-entraining admixture required for a certain air content in the concrete. The use of silica fume will rapidly increase the amount of air-entraining admixture required.

Cold-Weather Concreting: Concrete must reach 500 psi compressive strength before being exposed to temperatures below 32˚F. Admixtures are available to insure that high amounts of an SCM do not increase the likelihood of freezing damage at the time of concreting.

De-Icer Scaling: Chemicals used for snow and ice removal on horizontal surfaces such as a parking lot or the top deck of a parking garage can cause or aggravate surface scaling in concrete with inadequate air-entrainment. Properly designed and placed air-entrained concrete will withstand deicers for many years. Normal dosages of supplementary cementing materials should not affect scaling resistance of properly designed, placed, and cured concrete. The ACI 318 building code allows up to 10% silica fume, 25% fly ash, and 50% slag cement as part of the cementing materials for deicer exposures.

Permeability: The constituents of some SCMs combine with calcium hydroxide in concrete to reduce its permeability and the ability for harmful chloride ions to migrate through concrete and cause corrosion of steel reinforcement. Concrete made with SCMs are desirable for use in roadways, bridges, parking structures and marine structures.

Alkali-Silica Reaction (ASR): Reactive forms of silica in some aggregates can react with alkali hydroxides in the concrete and in the presence of moisture can create ASR, causing internal expansion that could potentially lead to cracking of the concrete. SCMs, especially slag cement, tie up the alkalis in the concrete. Class C fly ash varies in this ability, while Class F fly ash is very effective. A number of ASTM tests evaluate ASR; ASTM C 441, C 1567 and C 1293 can be used to determine the effectiveness of SCMs in inhibiting ASR.

Sulfate Attack: Concrete made with 60% or more slag cement is very effective in mitigating attack by sulfates, found in some arid soils, seawater and waste water. The pozzolanic action of fly ash also contributes

to sulfate resistance. The United States Bureau of Reclamation publishes a test for wet-dry sulfate resistance, and ASTM is developing a new test for this purpose. ASTM C 1012 evaluates sulfate resistance of cementitious materials. Guidance for evaluating sulfate resistance in concrete mixtures is provided in ACI 201.

Chloride Ion Penetration: Properly designed and cured concrete with high percentages of SCM will have an exceptionally high resistance to chloride ion penetration.

Benefits and Costs of Using SCMs

All SCMs have the dual benefit of replacing energy-intensive portland cement and of using material that may otherwise be landfilled. Small percentages of fly ash or slag cement will reduce concrete cost by replacing higher-cost portland cement. As the percentage of substitutes rise and water content falls to control strength gain, water-reducing admixtures and more precise control begin to raise the cost.

Limitations of SCMs

In the case of slag cement, some waste product is imported, somewhat reducing its positive energy impact. Typical replacement percentage (which is the criterion for LEED certification) ranges from 15% to 25% for fly ash although there are special cases where this may go higher. However, up to 1.5 units of fly ash may be used to replace a unit of portland cement, so the percentage of fly ash may be higher than the replacement percentage. All SCMs used in higher than common dosages (above 25% fly ash or 60% slag) would require pre-qualification testing to verify quality concrete. These include properties to ensure durability, pump-ability, and set time. Rice hull ash and other potential substitutes are not yet being marketed.

Some codes set an upper limit on the use of SCMs of various types for concrete exposed to de-icing salts. Detailed evidence may be required to show that the design mix meets the desired performance standards, even with higher levels of SCM.

The primary ASTM Standards for SCMs and blended cement are:

- ASTM C618 "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete."
- ASTM C 989 “Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.”
- ASTM C 1240 “Standard Specification fo Use of Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout.”
- ASTM C595 "Standard Specification for Blended Hydraulic Cements" is one of the three portland cement standards, covering five classes of blended portland cements for both general and special applications, using slag cement, pozzolan or both, with portland cement or portland cement clinker or slag cement with lime.
- ASTM C1157 "Standard Performance Specification for Hydraulic Cement" is a performance specification covering

portland cements for both general and special applications. There are no restrictions on the composition of the cement or its constituents. The specification classifies cements by type based on specific requirements for general use, high early strength, resistance to attack by sulfates, heat of hydration, and low reactivity with alkali-reactive aggregates.

Availability of SCMs

Most concrete suppliers stock either fly ash or slag cement or both. Also available are blended cements (ASTM C 595) with a specific percentage of portland cement and SCM. Blended cements are often designed to be used with locally available pozzolans or slag cements to keep flexibility in mix design. Rice hull ash is not commercially available as a cement substitute. The United States Geological Survey reveals that blended cement usage is less than 2% of the total portland cement used.

DESIGN ISSUES

B. Recycled Aggregate

Many materials are being examined as candidates to replace the sand and/or gravel or crushed aggregates in conventional concrete: air-cooled blast furnace slag (an entirely different material from slag cement), fiberglass waste materials, granulated plastics, paper and wood products and wastes, sintered sludge pellets, and others. However, crushed recycled concrete is by far the most commonly used aggregate substitute, along with glass cullet (in specialty applications). Air cooled blast-furnace slag is used as an aggregate and has no cementitious value. Water-cooled [rapidly quenched] ground granulated blast-furnace slag is the material used as a cement replacement (see above). These resources are two different forms of slag that cannot be used interchangeably.

Crushed Recycled Concrete Aggregate

Recycling concrete for aggregate requires breaking, removing, and crushing existing concrete into a material with a specified size and quality. Rebar and other embedded items, if any, must be removed, and care must be taken to prevent contamination by other materials such as asphalt, soil and clay balls, chlorides, glass, gypsum board, sealants, paper, plaster, wood, and roofing materials. This applies to crushed concrete from existing structures and pavements. Another source of crushed concrete would be from returned concrete to concrete plants. This material will not have contamination like construction debris.

Crushed recycled concrete aggregate generally has a lower specific gravity and higher water absorption than natural stone aggregate. New concrete made with such aggregate typically has good workability, durability, and resistance to saturated freeze-thaw action. Fine recycled aggregate should only be used in very limited quantities. Use of recycled fine crushed concrete will increase drying shrinkage and creep and decrease the modulus of elasticity. Concrete strength using only coarse aggregate replacement is similar to that of concrete using natural aggregates. Recycled concrete must be

"clean," that is, without absorbed chemicals, clay coatings, or other fine materials in concentrations that could alter the hydration and bond of the cement paste. Also, paving concrete in colder climates is likely to contain de-icing salts, which can cause premature corrosion of rebar. Recyclers do not separate paving concrete from other concrete. It is much safer to crush concrete from a known source specifically for use in the project. Note that crushed concrete aggregate made from on-site concrete qualifies for credit points under Credit MR-C2 Construction Waste Management, and not MR-C4 Recycled Content.

Crushed and Screened Waste Glass

Glass is generally not recommended because of alkali-silica reactions. Glass may be used as a sand substitute in concrete for non-structural applications such as bike paths, footpaths, and gutters. Nearly any waste glass can be used in concrete applications, including glass that cannot be recycled in ordinary ways, such as clear window glass or fluorescent bulbs with (small amounts of) contaminants. Some types of glass aggregate can improve concrete durability by arresting cracks. The installation of concrete using recycled concrete or glass is basically the same as for conventional concrete.

Benefits and Costs of Recycled Aggregate

Recycled concrete aggregate is about one-half the cost of non-recycled aggregate used for construction purposes depending on the specifications (size limitations) for the aggregate and local availability.

Limitations of Recycled Aggregate

Testing is required to account for variations in the aggregate properties, such as its higher absorption and lower specific gravity compared to conventional aggregate. Recycled aggregates may be contaminated with asphalt, chlorides, soil and clay balls, glass, gypsum board, joint sealants, or lightweight brick and concrete.

An alkali-silica reaction between cement paste and glass aggregate can decrease long-term strength and durability. Research is progressing on ways to stop or decrease the alkali-silica reaction by using additives and by restricting the types of glass used. However, further research is needed before glass cullet can be used as aggregate in structural applications.

Codes and Standards for Recycled Aggregate

There are no standards regulating the use of alternative concrete aggregate for engineered use and structural applications. For non-structural applications, codes generally do not restrict the use of aggregate that has no known deleterious effects on the finished concrete properties. ASTM C33, Specification for Concrete Aggregates, recognizes crushed concrete as a viable coarse aggregate. Some state and local codes specifically address the use of alternative aggregate, for example, the Washington State Department of Transportation. Verify applicable regulations on a project-by-project basis. ACI Committee 555 provides guidance on the use of crushed concrete as recycled

aggregate. The Recycled Materials Research Center at the University of New Hampshire is a good resource for information (www.rmrc.unh.edu/).

Availability of Recycled Aggregate

Crushed recycled concrete is widely available for other uses, but aggregate in a particular size range may command a price premium. Crushed glass is less widely available than recycled concrete, and is not usually sold as aggregate.

Integration with Other LEED Credits

Aggregate made by crushing concrete that is found on-site CANNOT be used to obtain LEED Credit MR-C4. To count as recycled by LEED, the material must be obtained from outside sources. On-site concrete that is re-used for a purpose other than that for which it was originally intended (for example, crushed and used either for backfill or for concrete aggregate) can contribute to LEED Credit MR-C2, because it has been diverted from a landfill.

Rebar steel usage is an excellent opportunity for gaining a recycled content credit.

DESIGN ISSUES

C. Reinforcement

LEED allows a default of 25% post-consumer recycled content for all steel. In most cases, the actual recycled content is substantially higher than this, approaching 100% post-consumer in some cases. It is nearly always advantageous to include rebar as a recycled content material.

DESIGN ISSUES

D. Non-Rented Wood Formwork

As explained under LEED Credit MR-C7, “non-rented” formwork includes any wood formwork that is constructed for the project, even if it is used again; and excludes any that was constructed as formwork for a previous job and reused on this job. Although uncommon, any dimension lumber or plywood previously used for another purpose on another project (for example, for fencing or temporary structures), and reused as formwork on this project, would qualify as post-consumer recycled materials. More likely would be the use of a composite wood material such as OSB that has recycled content. Wood formwork that is specified to be FSC Certified under Credit MR-C7 is not available as recycled material, as there is no established market for such wood at this time. If the project is seeking an Innovation in Design credit for site-wide VOC reduction, it may be desirable to specify that any composite wood formwork be free of added

urea-formaldehyde resins (as required for Credit EQ-4.4 within the building envelope). Composite wood without added UF resins is available with recycled content.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Trade professionals providing ready mixed concrete for LEED projects should be required in the project specifications to provide submittal information to demonstrate the amount of recycled content for a given design mix and for related steel reinforcement. Generally, design teams experienced with the LEED process will include submittal requirements for this information in each specification section where the materials is specified. However, design teams new to the LEED process often include the submittal requirements in a Division 1 specification covering LEED documentation, or neglect to include documentation requirements at all. Regardless of how well the specifications are developed on a given LEED job, the concrete trade contractor will need to provide information on the material cost and recycled content for materials provided. The concrete producer should document and provide a letter to the contractor indicating the amount of recycled content and costs of materials in each concrete mixture used on the project.

Materials Cost

Since the LEED Recycled Content Credit is based on cost, the concrete contractor should be prepared to provide either the construction manager or another member of the design team with a “materials only” cost for the concrete, rebar, and non-rented wood formwork (see Credit MR-C7). This value should represent the cost of the concrete materials installed without any costs associated with labor or equipment included. It will be necessary to separate the cost of the steel reinforcement (rebar) and non-rented formwork from the cost of the rest of the concrete design mix, because they will have very different percentages of recycled content. Often the concrete producer will need to provide the cost breakdown for the design mix constituents (i.e. cement, SCMs, aggregate and water).

Percentage of Recycled Content

Typically, standard design mix submittals will include percentage breakdowns of design mix constituents. For design mixes that only use recycled content materials for the replacement of portland cement, the standard design mix submittal should suffice providing it indicates, for example, the percentage of fly ash. If recycled aggregate is used, that percentage will need to be included in addition if not stated on the design mix submittal. The concrete contractor will need to provide a letter from the steel reinforcement manufacturer that explicitly states the amount of post-consumer and post-industrial recycled content in that material. This requirement also applies to any recycled wood used for non-rented formwork.

Sample Spreadsheets

The following is a spreadsheet that covers most of the calculations and record-keeping that might be involved in pursuing

SAMPLE LEED SPREADSHEETS FOR CONCRETE MATERIALS

LEED CREDIT CALCULATIONS

Material		Recycled Content				Regional Manufac'r*	Regional Harvest		FSC Certified Wood	
Description	Cost	% PC	% PI	% Comb	Recycled $	Reg Mfr $	Reg Har %	Reg Har $	FSC %	FSC $
Other concrete materials	$790,097	0.0%	0.0%	0.0%	$0	$790,097	9504.0%	$753,688	0.0%	$0
Recycled coarse aggregate	$144,578	0.0%	100.0%	50.0%	$72,289	$144,578	100.0%	$144,578	0.0%	$0
Fly ash	$21,951	0.0%	100.0%	50.0%	$10,976	$21,951	0.0%	$0	0.0%	$0
Slag	$38,554	0.0%	100.0%	50.0%	$19,277	$38,554	0.0%	$0	0.0%	$0
Silica Fume	$4,819	0.0%	100.0%	50.0%	$2,410	$4,819	0.0%	$0	0.0%	$0
Rebar	$250,000	40.0%	55.0%	67.5%	$168,750	$250,000	0.0%	$0	0.0%	$0
FSC cood formwork	$300,000	0.0%	0.0%	0.0%	$0	$300,000	100.0%	$300,000	30.0%	$90,000
Recycled wood formwork	$700,000	0.0%	62.0%	31.0%	$217,000	$700,000	0.0%	$0	0.0%	$0
Total	**$2,250,000**				**$490,702**	**$225,000**		**$1,198,266**		**$90,000**

* Except in very unusual cases, 100% of ready mixed concrete materials are regionally manufactured.

BREAKDOWN OF CONCRETE MATERIALS BY MIX DESIGN

	Mix Design #1			Mix Design #2			Combined		
Material	Weight	% of Mix by Weight	% of Mix in Total Yardage	Weight	% of Mix by Weight	% of Mix in Total Yardage	% of Concrete Cost	Material Cost	Reg Har %
Portland cement	500	12.0%	40.0%	600	14.6%	60.0%	13.6%	$135,998	100.0%
Conventional coarse aggregate	0	0.0%	40.0%	1,500	36.6%	60.0%	22.0%	$219,512	100.0%
Fine aggregate	1,200	28.9%	40.0%	1,300	31.7%	60.0%	30.6%	$305,907	100.0%
Water	350	8.4%	40.0%	400	9.8%	60.0%	9.2%	$92,272	100.0%
Admixtures	150	3.6%	40.0%	150	3.7%	60.0%	3.6%	$36,409	0.0%
Subtotal other concrete mtls								**$790,097**	**95.4%**
Recycled coarse aggregate	1,500	36.1%	40.0%	0	0.0%	60.0%	14.5%	$144,578	100.0%
Fly ash	0	0.0%	40.0%	150	3.7%	60.0%	2.2%	$21,951	0.0%
Slag	400	9.6%	40.0%	0	0.0%	60.0%	3.9%	$38,554	0.0%
Silica fume	50	1.2%	40.0%	0	0.0%	82.0%	0.5%	$4,819	0.0%
Total	**4,150**	**100.0%**		**4,100**	**100.0%**		**100.0%**	**$1,000,000**	

LEED Credits for Recycled Content (MR-4), Regional Materials (MR-5), and FSC Certified Wood (MR-C7), for concrete materials. There are two spreadsheets. The first one is used to establish the costs of recycled, regional, and FSC concrete materials. From this, it is easy to derive the percentages necessary for the final calculations for those Credits.

The second spreadsheet shows how to calculate the percentage of recycled and regional content for the concrete materials alone. It establishes the percentage of each material in each mix design by weight, and distributes them according to the yardage of each mix used in the project. These data are then transferred to the first spreadsheet.

REFERENCES AND INFORMATION SOURCES

American Coal Ash Association
15200 Girard Avenue, Suite 3050
Aurora, Colorado 80014-3988

720-870-7897
Fax: 720-870-7889
www.acaa-usa.org

American Concrete Institute
38800 Country Club Drive
Farmington Hills, Michigan 48331
248-848-3700
Fax: 248-848-3701
www.concrete.org

Environmental Building News: Building Green, Inc.
122 Birge Street, Suite 30
Brattleboro, VT 05301
802-257-7300
Fax: 802-257-7304
www.buildinggreen.com

Fly Ash Library
Dr. Thomas L. Robl, Associate Director
University of Kentucky Center for Applied Energy Research
2540 Research Park Drive
Lexington, KY 40511-8410
859-257-0272
Fax: 859-257-0360
www.fly-ash.info

Headwaters, Inc. (Low carbon fly ash)
Corporate Offices
10653 S River Front Parkway
Suite 300
South Jordan, UT 84095
801-984-9400
Fax: 801-984-9410
www.hdwtrs.com

National Concrete Masonry Association, Inc.
13750 Sunrise Valley Drive
Herndon, VA 20171
703-713-1900
Fax: 703-713-1910
www.ncma.org

National Ready Mixed Concrete Association
900 Spring Street
Silver Spring, MD 20910
301-587-1400
888-846-7622
Fax: 301-585-4219
www.nrmca.org

Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077
847- 966 – 6200
www.cement.org

Recycled Materials Research Center
University of New Hampshire
Durham, NH 03824
603- 862.4334
www.rmrc.unh.edu/

Silica Fume Association
38860 Sierra Lane
Lovettsville, VA 20180
(540) 822.9455
www.silicafume.org

Slag Cement Association
P.O. Box 2615
Sugar Land, Texas 77487-2615
281-494-0782
Fax: 281-494-0784
www.slagcement.org

LEED CREDIT MR-C5.1 AND MR-C5.2 REGIONAL MATERIALS

Intent: Increase demand for building products that are manufactured locally, thereby reducing the environmental impacts resulting from their transportation and supporting the local economy.

Requirements

Credit 5.1 (1 point): Specify a minimum of 20% of building materials that are manufactured regionally within a radius of 500 miles.

Credit 5.2 (1 point): Of these regionally manufactured materials, specify a minimum of 50% that are extracted, harvested, or recovered within 500 miles.

Fresh, unhardened ready mixed concrete is considered a regionally manufactured building material.

Summary of Concrete Applications and Materials Relevant to the Credit

Ready mixed concrete materials are regionally manufactured in almost every case. Exceptions such as form oils or curing agents manufactured at a remote location are usually too small a component to break out as a separate cost. Rebar that is fabricated (cut and bent) at a remote location might also be an exception. Most concrete materials are regionally harvested. Exceptions might be rebar, formwork wood, special cement, SCM, or admixtures. Because of this, projects with large amounts of concrete typically can achieve both Regional Materials Credit points, and may qualify for an Innovation and Design Credit for exemplary performance.

It should be noted that if a project employs greater than 20% locally manufactured materials, it does not mean it has to employ increasing amounts of local raw resources to earn credit 5.2. LEED allows projects to select a portion of locally manufactured materials equal to 20% and demonstrate that 50% of that figure represents locally extracted raw resources to earn the point.

DESIGN ISSUES

Details

For the first point (C5.1), LEED defines the term “Manufactured” as the place where the final assembly of components into the building product furnished and installed by the tradesmen. The 2.1 LEED Reference Guide states that, “if the hardware comes from Dallas, Texas, the lumber from Vancouver, British Columbia and the joist is assembled in Kent, Washington; then the location of the final assembly is Kent, Washington.”

The raw material sources required for C5.2 are fairly obvious for some materials like aggregate and sand (quarry location).

However, other materials like steel may be more difficult to define in terms of the origins of the raw resources. The USGBC reviews issues like this on a case-by-case basis via the Credit Interpretation and Application Review process. However, it is generally understood that raw resource point of origin for steel is where it is smelted, wood where it is harvested, stone where it is quarried, etc.

Benefits and Costs

There is typically no additional cost associated with specifying locally manufactured materials for concrete. There may be additional cost for specifying locally harvested material for some concrete materials although the amount depends on the region of the country and the availability of quality aggregate. With regard to rebar, formwork, insulation, and other materials associated with ready mixed concrete, there may be incremental costs associated with specifying locally extracted materials, but the local manufactured threshold can usually be met with little or no incremental cost. Of course, this determination will depend on where a project is located.

Integration with Other LEED Credits

Credit MR-C5.1 Regional Materials – 20% Manufactured Regionally and Credit MR-C5.2 Regional Materials – 50% Extracted Regionally are strongly related. All the materials counted toward credit MR-C5.2 must be materials that qualify for credit MR-C5.1. Tradeoffs must sometimes be made between counting a material toward recycled content and other LEED credits, versus counting it toward regional manufacture.

An additional complication arises with regard to credit MR-C5.2. To obtain that credit, you must first achieve credit MR-C5.1 such that at least 20% of the total materials (calculated according to the LEED formula) need to be regionally manufactured. Of these materials, half (or 10% of the total materials) need to be regionally extracted.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

LEED Requirements for Regional Manufacture and Extraction Credits may appear in several places. Project professionals with experience on LEED jobs will likely include the requirements under a LEED Building Performance Requirements article in Section 1 of each relevant specification in Divisions 2-10. Other projects may only include the requirements in a Division 1 Specification. In some cases, the requirements are not explicitly stated at all, but there is an article stating that the contractor is required to comply with LEED requirements. The extent to which LEED Documentation requirements are included in the project specifications follow along the same lines. When a contractor is bidding on a LEED job, and the LEED requirements are not clearly stated in the specifications, it is recommended that an RFI be issued to spell out the LEED requirements that the contractor will be responsible for and must document prior to submitting bids.

Required LEED Documentation

Whether or not the specifications indicate the documentation requirements for LEED

projects pursuing the two points available in the Regional Manufacture and Extraction Credits (MR-C5.1 & C5.2), the Construction Manager or the Architect will likely request the following information to determine overall compliance with this credit:

- The material value for each material. Since it is based on cost, projects need the material value for all materials that contribute towards this credit. The material cost is the cost of the material without any labor, equipment or overhead included. Essentially, it is the invoice cost to the subcontractor for the material.
- A letter from the product manufacturer indicating the location of manufacture and, if applicable, extraction of a given product. The letter needs to be signed, dated and on the manufacturer's company letterhead. The letter also needs to reference the project. Alternately, if material product data sheets clearly indicate the location of manufacture and extraction, they may be used instead of a letter.

  It should be noted that a single letter from a manufacturer can certify compliance with more than one credit. For example, if a material has both recycled content and is manufactured within 500 miles of the project, then the manufacturer need only provide one letter to demonstrate compliance with both credits. The following text is a sample of what an acceptable letter would say:

  To whom it may concern,

  This letter is to certify that the steel reinforcement produced by ZuBor Steel for the Moneymaker Industries World Headquarters project is comprised of 95% recycled content of which 50% is Post-Consumer and 45% is Post-Industrial recycled content. This material is manufactured in Soggy Bottom, PA which is approximately 250 miles from the project site.

Concrete producers should document and provide a letter to the contractor and the A&E design team that includes the amounts of constituent materials in each mix, the recycled content, the location where the concrete was manufactured and proximity to the project site, and the location where the constituent materials were extracted and their proximity to the project site. A sample letter is provided in Appendix B.

History of Credit Interpretations

Credit MR-C5.2: The Credit Interpretation Request for credit MR-C5.2 dated 10/14/03, with Ruling dated 12/1/03, states that an Innovation and Design credit can be obtained by doubling *either* credit MR-C5.1 *or* credit MR-C5.2, as the two credits are considered independently. This means that Credit MR-C5.2 can be achieved if 10% or more of the materials used on the project (that are also regionally manufactured) are regionally harvested. This ruling supersedes an earlier ruling under Credit MR-C5.1 dated 10/18/01.

LEED CREDIT MR-C7 CERTIFIED WOOD

Intent: Encourage environmentally responsible forest management.

Requirements

Use a minimum of 50% of wood-based materials and products, certified in accordance with the Forest Stewardship Council's Principles and Criteria, for wood building components including, but not limited to, structural framing and general dimensional framing, flooring, finishes, furnishings, and non-rented temporary construction applications such as bracing, concrete formwork and pedestrian barriers.

Background: the Forest Stewardship Council (FSC)

The FSC is an independent, not-for-profit, non-government, international organization based in Bonn, Germany. It was

Wood usage in LEED construction projects must meet guidelines set forth by the Forest Stewardship Council.

founded in 1993 (originally in Oaxaca, Mexico), and provides standard setting, trademark assurance and accreditation services for companies and organizations interested in responsible forestry. Its standards are based on its 10 Principles and Criteria of Responsible Forest Management:

1) COMPLIANCE WITH LAWS AND FSC PRINCIPLES: Forest management shall respect all applicable laws of the country, in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria.

2) TENURE AND USE RIGHTS AND RESPONSIBILITIES: Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.

3) INDIGENOUS PEOPLES' RIGHTS: The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognized and respected.

4) COMMUNITY RELATIONS AND WORKER'S RIGHTS: Forest management operations shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.

5) BENEFITS FROM THE FOREST: Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.

6) ENVIRONMENTAL IMPACT: Forest management shall conserve biological

diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest.

7) MANAGEMENT PLAN: A management plan -- appropriate to the scale and intensity of the operations -- shall be written, implemented, and kept up to date. The long term objectives of management, and the means of achieving them, shall be clearly stated.

8) MONITORING AND ASSESSMENT: Monitoring shall be conducted -- appropriate to the scale and intensity of forest management -- to assess the condition of the forest, yields of forest products, chain of custody, management activities and their social and environmental impacts.

9) MAINTENANCE OF HIGH CONSERVATION VALUE FORESTS: Management activities in high conservation value forests shall maintain or enhance the attributes which define such forests. Decisions regarding high conservation value forests shall always be considered in the context of a precautionary approach.

10) PLANTATIONS: Plantations shall be planned and managed in accordance with Principles and Criteria 1 - 9, and Principle 10 and its Criteria. While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world's needs for forest products, they should complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests.

Over the past 10 years, 42 million hectares in more than 60 countries have been certified according to FSC standards while several thousand products carry the FSC trademark. FSC operates through its network of National Initiatives in more than 30 countries.

The FSC uses a chain of custody system that connects responsible forest management practices and products with consumers. When a forest owner, manager, company, town or community is certified as complying with FSC standards, their details are listed in a database.

FSC provides accreditation services to certification bodies, national initiatives, and national standards. The accreditation program is based on international standards. Monthly updates on the certificates issued by FSC accredited certification bodies, accessible via a link on the FSC website.

The FSC International Center sets the framework for the development and maintenance of international, national and sub-national FSC standards. The process is clear and accessible ("transparent"), balances the interests of all stakeholders ("independent"), and strives to involve all interested people and groups ("participatory").

DESIGN ISSUES

Details

Compliance with this credit requires that 50% of the material value of all wood materials used on the project be attributable to FSC Certified wood materials. The level of difficulty depends on the amount of wood used on the job. LEED applicants are required to include all wood materials purchased for use on a project including concrete formwork and temporary barriers when demonstrating compliance.

Projects that do not have a lot of finish casework or wood paneling usually have to specify FSC Certified wood doors and plywood concrete formwork. Incremental costs are currently higher for these materials than they are for finished wood materials; however, the cost of FSC Certified formwork (plywood) has been dropping steadily as more manufacturers bring this material to market.

Only wood formwork materials purchased for use on a project need to be applied to this credit. Rented or previously used forms are exempt. Reclaimed wood, post-consumer recycled wood and wheat-board millwork substrates are also exempt from this credit.

Benefits and Costs

The environmental benefits of employing FSC Certified wood are many. Virgin timberlands are preserved, impacts from erosion are mitigated and the social conditions of laborers and indigenous people living in or near FSC forests are respected. Incremental costs range widely depending on the type of wood materials used on a job. The additional costs for all wood materials on a given job can range from anywhere from 5% to 35%. Costs and availability of Certified Wood continues to be an issue for LEED projects. Constructing the building envelope out of concrete (ICF/Tilt Up) results in a reduction in the amount of total wood, thus making it easier and more economical to meet the 50% Certified Wood requirement to obtain the LEED point.

Availability

The number of companies that offer FSC Certified plywood is limited, but growing. The first step in seeking this credit when using FSC Certified wood formwork is to insure that a reliable source is available at an acceptable cost.

Integration with Other LEED Credits

Achieving the FSC Certified credit may involve a trade-off with credit EQ-C4.4 (Low-Emitting Materials – Composite Wood). If a project uses a substantial amount of MDF specified without added urea formaldehyde to meet IEQ Credit 4.4, the total wood value for the job will increase. However, there are many wheat-based millwork substrates available without added urea formaldehyde that do not need to be included in the total wood value. Also, if the project has many solid core wood doors, specifying a product that is both FSC Certified and free of added urea formaldehyde may be cost prohibitive.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

Requirements for FSC Certified wood formwork is likely to be found in one or more of three places: a Division 1 LEED Section, in the performance requirements or Products sections of Division 3 specifications or within the rough carpentry section. If there are no specifications that clearly state requirements for FSC Certified formwork on a given LEED job, the contractor should issue an RFI and determine if this credit is being pursued before issuing a bid.

Required LEED Documentation

Whether or not the specifications indicate the documentation requirements for LEED projects pursuing the Certified Wood Credit, the Construction Manager or the Architect will likely request the following information to determine a project's overall compliance with this credit:

- The material value for each wood material within the contractor's scope. The material cost is the cost of the material without any labor, equipment or overhead included. Essentially, it is the invoice cost to the subcontractor for the material.

  Note: This credit is often audited by the USGBC. In the audit process, the USGBC has asked to see contractor invoices to substantiate material value and FSC Certification. The contractor should either submit their invoice for wood materials when available or keep on hand in the event of an audit.

- The vendor's or manufacturer's Forest Stewardship Council Chain-of-Custody certificate number. The chain of custody certificate number is available from the manufacturer or vender and is printed on an actual certificate provided by the FSC. It is recommended that you provide a copy of the actual certificate with the standard material data sheet submittal.

- Invoices indicating materials costs.

What to Look for During Installation

FSC Certified wood products usually have a green stamp or tag with the FSC logo. Otherwise, there is little to distinguish FSC and non-FSC Certified wood materials.

REFERENCES AND INFORMATION SOURCES

Trade Associations

Forest Stewardship Council
FSC International Center
Charles-de-Gaulle 5
53113 Bonn Germany
Phone: ++ 49 (228) 367 66 0
www.fsc.org/en/

Forest Stewardship Council of Canada
1 Eva Road, Suite 205
Toronto, ON M9C 4Z5
Canada
416-778-5568
1-877-571-1133
www.fsccanada.org/boreal/index.shtml

American Forest & Paper Association
1111 Nineteenth Street, NW, Suite 800
Washington, DC 20036
www.afandpa.org

Metafore – Founded in 1997, Metafore is a non-profit organization that provides marketing assistance to responsible businesses wishing to conserve, protect and restore the world's forests. It maintains a "Certification Resource Center" that includes a comprehensive list of FSC Certified products as well as those certified by other competing groups that are not recognized by LEED at this time. The Center is available at: www.certifiedwood.org/search-modules/SearchProducts.aspx

Standard, Code, and Regulatory Groups

International Organization for Standard
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Resource Websites

Forest Certification Resource Center
http://www.certifiedwood.org/

Resource Documents

Forest Certification in North America, Oregon State University Extension Services
eesc.orst.edu/agcomwebfile/edmat/EC1518.pdf
www.certifiedwood.org/search-modules/SearchProducts.aspx

INNOVATION IN DESIGN CREDITS

GENERAL DISCUSSION

The LEED Version 2.1 Reference Guide uses the following language to describe the Innovation in Design (ID) Credits, Section 6 of the LEED-NC Rating System:

The LEED Green Building Rating System was devised to address current sustainable issues involved in commercial building design. However, the building industry is constantly evolving and introducing new sustainable strategies and measures. It is important to stay abreast of current developments in sustainable building and incorporate those strategies and products that optimize built spaces. Innovation Credits are the vehicle by which LEED recognizes and awards such accomplishments.

Additionally, Innovation in Design may be awarded if a project achieves exemplary performance under an existing LEED credit. Points for exemplary performance are available only for those credits where the outcome provides substantial benefits (and, it should be added, where the applicant has already achieved the LEED credit).

The USGBC goes on to note that, as with all sustainable design strategies and products, it is important to consider the related impacts to the environment and occupant well-being, and to assure that other building aspects are not adversely impacted by the proposed innovation. They also caution that some measure be provided as to the cost-effectiveness of the proposed innovation, recommending the use of life-cycle costing where appropriate.

Several potential ID Credits have been identified that relate to ready mixed concrete. This is by no means a complete list, as it only records those innovations that have a track record: either they have been successfully used on a previous project, or they were encouraged by the USGBC upon submittal as a "Credit Interpretation Request."

Exemplary Performance: Exceeding the requirements of existing credits by a significant margin. Several relevant credits are discussed.

Use of High Percentage of Cement Substitute: Moving beyond the usual modest percentage of fly ash, slag cement, or silica fume.

Innovative Structure: Either taking unusual advantage of concrete in the structure, or using "high-tech" concrete to achieve an exception effect that improves the building's sustainability.

Site-Wide Reduction in VOC Levels: Extending the LEED limits on sealant, adhesive, and paint VOC levels that apply only to inside spaces, to include all such products, and all other liquid-applied products, throughout the site. This involves several products used in association with concrete.

Relevant CIR Rulings

5/4/2004 - Credit Interpretation Request: May a project team include more than four Innovation Credits (IDc1) in its LEED application submittal? That way if some

proposals are denied, others can fill the void.

5/4/04 – Ruling: While your team is obviously highly motivated and enthusiastic, it is USGBC policy to only review four ID Credits at one time for each certification submittal. This approach maintains fairness and consistency for all projects.

Should an ID Credit be denied in the Preliminary LEED Review, you may replace it with another proposal in the supplementary submittal at no additional cost. Note, however, that this will only afford that new proposal one opportunity to be evaluated.

4/14/03 - Credit Interpretation Request: We have just submitted a LEED Certification Package for the 1st of three buildings comprising a corporate campus. Submitted with this Certification Package for the 1st building were three potential Innovation Credits. These credits dealt with the campus as a whole and are applicable to all three buildings. Should the Innovation Credits be awarded for the 1st building, will the two remaining buildings of the campus be eligible for these same Innovation Credits?

5/5/03 – Ruling: The strategies and documentation for achieving site credits may be "duplicated" in your applications, but a clear description of how the whole site achieves the intended credits is necessary. It must be clear that none of the required areas or facilities is counted twice. Each credit should be carefully assessed and treated fairly, respective of overall site issues (e.g., pervious surfaces) versus individual building issues (e.g., roofing). For example, if the project is applying for SSc5.2, which requires that permanent open space be designated adjacent to the building, the area of this open space must reflect the combined footprints of all of the buildings.

How to Submit for ID Credits

Provide the proposal(s) within the LEED Letter Template (including intent, requirement, submittals and possible strategies) and relevant evidence of performance achieved.

LEED CREDIT ID-C1 EXEMPLARY PERFORMANCE IN MEETING CREDIT REQUIREMENTS

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

Credit ID-C1.1 (1 point): Identify the intent of the proposed innovation credit, the proposed requirements for compliance, the proposed submittals to demonstrate compliance, and the design approach (strategies) that might be used to meet the requirements. Four points (Credits ID-C1.1 - 1.4) are available for Innovation in Design.

Summary of Concrete Applications and Materials Relevant to the Credit

For some of the LEED Credits where ready mixed concrete can help achieve the credit point, it is possible to go beyond the target set by the USGBC and achieve what is generically called "exemplary performance" in that Credit.

Typically, exemplary performance is defined as reaching the next logical step in a sequence, but there are exceptions, which are noted below.

DESIGN ISSUES

Details

Each Credit will be examined in turn, citing the limit or limits in each case that will achieve an Innovation Credit.

Credit SS-P1, Erosion & Sedimentation Control: No CIRs have been submitted for innovation points relative to this credit. One possible route to exemplary performance is to adopt a Low-Impact Development strategy. USEPA documents relating to Low-Impact Development can be found at http://www.epa.gov/owow/nps/lid/ "Low Impact Development Strategies, An Integrated Approach" is highly informative, although directed primarily to residential subdivisions.

Using these documents, the applicant should devise a program tailored to the project that covers exemplary performance not only for this credit, but for Credits SS-C6.1 and SS-C6.2. It is conceivable that such a strategy might gain more than one Innovation Credit point.

Credit SS-C6.1, Stormwater Runoff Reduction: A CIR dated 2/12/02 requests an Innovation Credit for exceeding stormwater runoff control requirements. The method proposed is to contain all stormwater runoff in a detention basin, then pump the water for irrigation and flushing water closets. The associated ruling offers an Innovation Credit for decreasing the rate and quantity of flow by an additional 25% over the requirement of the Credit. The existing site was more than 50% impervious, so the project had to reduce the runoff by 50%.

No CIRs have been submitted for the other case, where a project's existing imperviousness is less than 50%. It is likely

that the USGBC would require a 25% reduction, relative to the existing site, in the flow rate and quantity resulting from a 1.5 year 24-hour storm. A CIR should be submitted to confirm this supposition.

If water is collected and sent to a storage tank for reuse, it is not enough simply to calculate the amount of water collected. A water balance calculation is needed, based on daily expected demand and rainfall over a one-year period, because supply and demand vary independently, and some stored water will not be usable.

Achieving Credit SS-C6.1 when the existing site is less than 50% impervious requires that the design imperviousness not exceed that amount. It is not obvious what the next step would be to achieve an Innovation Credit for exemplary performance. One possibility is to achieve a reduction in flow rate and quantity of 25% over the existing one, but this must be checked with the USGBC through the CIR process.

Credit SS-C6.2, Stormwater Treatment: An Innovation point for this credit would involve exceeding the rates of TSS and TP removal, plus removing other compounds that commonly pollute ground water. A CIR would be necessary to confirm higher limits with the USGBC. Quoting from Prerequisite SS-P1, above:

One possible route to exemplary performance is to adopt a Low-Impact Development (LID) strategy. USEPA documents relating to LID can be found at http://www.epa.gov/owow/nps/lid/ "Low Impact Development Strategies, An Integrated Approach" is highly informative, although directed primarily to residential subdivisions.

Using these documents, the applicant should devise a program tailored to the project that covers exemplary performance not only for this credit, but for Credits SS-6.1 and SS-6.2. It is conceivable that such a strategy might gain more than one Innovation Credit point.

Credit SS-C7.1, Non-roof Heat Island Reduction: As noted in the discussion under this Credit, there are several combinations of

Increasing the amount of high-albedo materials and implementing non-roof heat-island reduction techniques such as using light-colored concrete for walkways and landscaping may help contribute toward gaining an Innovation Credit.

measures that will achieve one or more Innovation Credits. Multiple credit points can be obtained by satisfying the Credit's requirements in two or more independent ways.

With regard to albedo, CIRs have indicated that the target is an average albedo over all non-roof impervious surfaces of 12.5%. This number is derived by assuming

that the low-albedo areas are asphalt with an albedo of 0.05. Thus, the average albedo derives from the formula 70% at 0.05 plus 30% at 0.30.

Based on this number, it is possible to achieve an Innovation Credit by at least doubling this number, so that the average albedo of all non-roof impervious surfaces is 25% or greater. We are unsure whether the USGBC would award a second Innovation Credit point for increasing this number to 37.5%, or perhaps for doubling it again to 50%. However, the question is worth asking through a CIR, if the opportunity should arise (for example, by paving with a combination of highly reflective pavers or white ready mixed concrete for pedestrian ways, plus grey ready mixed concrete for roadways).

As noted in the Ruling on the CIR dated 12/16/03 for ID Credits, it is important not to double count. The example used is a partially underground parking garage, which gains the credit point because it is more than 50% shaded. The USGBC would not let the applicant also to count the top level of the garage as a low-albedo pavement. This logic would apply, for example, to paving that was shaded to achieve the credit. The shaded portion of the paving would have to be excluded from the paving counted as having an average albedo of 12.5%.

Credits EA-P2, Minimum Energy Performance, and EA-C1, Optimize Energy Performance: Exemplary performance for Credit EA-C1, would be difficult to achieve. However, passive solar energy strategies involving thermal mass could involve the increased use of ready mixed concrete for walls and floors.

Credits MR-C2, Construction Waste Management: The next logical step after the 50% and 75% limits for the two Credits is 100%. As this level is not realistic, a CIR ruling under MR credit 2 dated 1/11/05 sets the limit at 95%. The requirements for exemplary performance are the same as for the Credits.

Credits MR-C4, Recycled Content: Paraphrasing the CIR Ruling for this Credit, dated 1/17/02 (because it refers to the calculation method used under LEED-NC version 2.0, it has been edited to reflect the system used under LEED-NC version 2.1):

...it is necessary to document an additional 5% of recycled content building materials in the same manner as described for the initial 5% and 10% required for Credits MR-C4.1 and MR-C4.2, respectively.

Refer to “Potential Innovation and Design Credit: 40% Reduction in the Use of Portland Cement” for an extended discussion of the use of substantial amounts of fly ash, slag cement, or other substitutes for portland cement. All of these products are recycled, and should help contribute to achieving at least Credit MR-C4.2, if not an Innovation Credit for exemplary performance under MR-C4.

Credits MR-C5, Regional Materials: A CIR ruling defines the requirements for exemplary performance under Credit MR-C5:

8/31/04 – Ruling: ...separate Innovation Credits can be earned for both MR-C5.1 and

MR-C5.2. To achieve an Innovation Credit for MR-C5.1, the total percentage of locally manufactured materials must be at least 40% of the total materials cost; for MR-C5.2 the percentage must be at least 20% of the total materials cost.

Credit MR-C7, Certified Wood: Exemplary performance under this Credit would require that 100% of the wood used on the project (discounting miscellaneous blocking) would have to be FSC Certified. While achieving this prerequisite is possible, the impact on concrete would be that all "non-rented" wood formwork would have to be FSC Certified. This requirement differs from achieving Credit MR-C7 only with regard to the extent of FSC wood. In both cases, note that wood formwork purchased for this job but also reused on other projects are subject to the requirement. Wood formwork reused from a previous job is exempt.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Required LEED Documentation

The Credit Requirements ask the applicant to specify four items:

- The intent of the proposed innovation credit;
- The proposed requirements for compliance;
- The proposed submittals to demonstrate compliance; and
- The design approach (strategies) that might be used to meet the requirements.

Both the submittals and the design approach will reflect that used to achieve the Credit.

LEED CREDIT ID-C1 FORTY PERCENT REDUCTION IN THE USE OF PORTLAND CEMENT

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

Credit 1.1 (1 point): Identify the intent of the proposed Innovation Credit, the proposed requirements for compliance, the proposed submittals to demonstrate compliance, and the design approach (strategies) that might be used to meet the requirements. Four points (Credits ID-C1.1-1.4) are available for Innovation in Design.

Summary of Concrete Applications and Materials Relevant to the Credit

This proposed Innovation Credit rewards a 40% reduction in the CO_2 emissions required to produce the concrete needed for a particular application. This reduction can be accomplished by redesigning the mix to reduce the quantity of portland cement, by replacing portland cement with SCMs such as fly ash, slag cement and silica fume, or by any combination of these strategies that results in a net 40% reduction in CO_2. Because these SCM's are also recycled products, they can contribute to achieving Credit MR-C4.

Supplementary cementitious materials. From left to right, fly ash (Class C), metakaolin (calcined clay), silica fume, fly ash (Class F), slag, and calcined shale.

DESIGN ISSUES

Details

The primary factor limiting the use of high percentages of SCMs is that many of these materials delay strength gain compared with portland cement. This issue is fully discussed in the section of LEED Credit MR-C4. The conclusion that can be drawn from that article is that a 40% reduction in the use of portland cement is feasible at the high end of the normal percentage range of fly ash, and well below the maximum for slag cement. Some changes may be necessary or desirable in the construction, as suggested by the EcoSmart Foundation, to adjust to the lengthened hardening time:

- The schedule of stripping may need to be adjusted.
- The proportions of the mixture have to be optimized for higher early-age strength by adjusting different parameters such as the cementitious materials content, the proportion of SCMs, the water-to-cementitious materials ratio, the use of superplasticizer and accelerator.

- The design stripping strength may need to be re-evaluated by the contractor on the project.
- The in situ concrete strength may need to be measured more precisely by using in situ tests.

Be aware that acceptance times for concrete strength with higher SCM mixtures may be extended to 56 or 90 days instead of the standard 28 days to accommodate this credit.

Set time can be reduced by adding more cement to the mix or with accelerating admixtures. When more cement is used, be careful not to confuse the required 40% reduction in portland cement, and a 40% fraction of SCMs in the mix. If more cementitious materials are being used overall, the 60% portland cement fraction will constitute less than a 40% reduction relative to a standard mix, and the percentage of SCM in the mix must rise to insure a 40% reduction in portland cement.

Requirements and Documentation

The requirements for this Credit are spelled out in the following CIR Ruling. The example found in the Ruling is misleading, and has not been reproduced:

1/23/03 – Ruling: An Innovation Point will be awarded for reducing total portland cement content of cast-in-place concrete. To obtain this Innovation Credit point, the following requirements must be met:

A minimum of 40% reduction of CO_2 by weight for all cast-in-place concrete must be demonstrated against standard baseline mixes.

Applicant must demonstrate that cast-in-place concrete makes up a significant portion of the work on the project - a point will not be awarded for negligible quantities in relation to the total work.

The reduction of portland cement usage may also contribute to the earning of LEED credits.

For purposes of this credit, the following must be applied:

- One pound of portland cement is equivalent to one pound of CO_2.
- Baseline mixes shall be standard, 28-day strength regional mix designs.
- Temperature range shall be accounted for and documented. Documentation for cold weather mix designs shall include temperature on day of pour.
- Pozzolans allowed for displacement of portland cement are fly ash, slag cement, silica fume, and rice hull ash. [Note: The USGBC incorrectly lists GBBFS as a pozzolan – see discussion under Credit MR-C4.].

Required Documentation:

- Total cubic yards of cast-in-place concrete for project.
- Standard 28-day strength concrete mix designs from the concrete producer, in accordance with ACI 301, for each concrete mix required for project (2,500 psi, 3,000 psi, 5,000 psi, etc.) and quantity of portland cement for each mix in pounds per cubic yard.
- Quantity of portland cement reduced and/or replaced for each mix in pounds per cubic yard.
- Temperature on day of pour if cold weather mix is used.
- Calculation demonstrating that a minimum 40% average reduction [in the amount of portland cement] has been achieved over standard concrete mix designs for the total of all cast-in-place concrete.

The four SCMs listed in the above CIR Ruling are all recycled products. A non-recycled SCM such as metakaolin can also be used, but more portland cement must be removed from the mix to compensate for the added CO_2 used in the production of the non-recycled SCM.

REFERENCES AND INFORMATION SOURCES

EcoSmart ™ Foundation Inc.
501-402 West Pender Street
Vancouver, British Columbia, Canada
V6B 1T6

In addition to those listed under Credit MR-C4:

Phone: 604-689-4021
Fax: 604-689-4043
information@ecosmart.ca

www.ecosmart.ca/facts_faq.cfm

LEED CREDIT ID-C1 SITE-WIDE VOC REDUCTION

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

Credit 1.1 (1 point): Identify the intent of the proposed Innovation Credit, the proposed requirements for compliance, the proposed submittals to demonstrate compliance, and the design approach (strategies) that might be used to meet the requirements.

Summary of RMC Applications and Materials Relevant to the Credit

Ready mixed concrete use involves several chemicals that need to be controlled if this Innovation Credit is to be pursued.

DESIGN ISSUES

Details

Pursuing an Innovation Credit for a site-wide reduction in Volatile Organic Compound (VOC) and toxic chemical use requires diligent attention to potential sources of these materials throughout the project. A CIR Ruling suggests that VOCs from solid materials might be considered. The wording is as follows:

11/4/02 – Ruling: "Generally, the low-emitting materials credits are considered as a body of credits that together represent a goal to reduce VOCs. To achieve an innovation in this category, it would be necessary to demonstrate that the project had addressed VOC control as a whole. Since there are already four points available in this category, additional innovations would require substantial effort, and clear documentation of achievement above and beyond existing credit requirements."

Chemical use must be monitored closely for a project to qualify for the Site-wide VOC Reduction Credit.

It is possible to infer that the USGBC is encouraging the inclusion of urea-formaldehyde emissions from composite wood (the pollution source addressed under Credit EQ-4.4) within the scope of a site-wide VOC control Innovation Credit. Formaldehyde in small concentrations is a normal part of our environment. Outdoor air levels of formaldehyde are usually between 0.01 and 0.05 parts per million (ppm). The most common guideline for acceptable formaldehyde levels is 0.10 ppm; very few people will have any health problems if they are exposed to levels below 0.10 ppm.

This comment should alert the applicant to look for VOC emissions and toxic chemicals wherever they may be found. For

example, if an alternative roofing system were available that reduced or eliminated VOC emissions relative to vat-heated bitumen, the use of that produce might support achieving this credit. If concrete paving were used in lieu of bituminous, that could be noted as an action in support of an overall site-wide strategy.

Note, however, that a rigorous examination of *all* the impacts from use of a product would include relative durability, maintenance, hazards to workers; extraction or acquisition impacts, recycled content, and toxicity of the raw materials; the energy use, waste, and hazards to workers during manufacture; transportation energy use; and final disposition (reusability, recyclability, disposal). This sort of analysis has been done on a number of materials, and where such data are available, they should be cited in support of the actions taken to achieve the credit. If there is not a great deal of difference between the options with regard to these issues, this can also be cited to support the exclusion of the product from consideration in reducing emissions.

For example, concrete paving has lower embodied energy than asphalt paving, reinforcing the appropriateness of switching to concrete in support of a site-wide low-emissions credit. Using bituminous paving or roofing while seeking the credit is likely to be acceptable, but weakens the applicant's position instead of strengthening it.

The extensive use of exposed ready mixed concrete, including stained and pigmented concrete, in lieu of paint and carpeting can be part of an overall strategy to reduce site-wide VOC levels.

The USGBC has chosen to adopt published standards for liquid-applied

Concrete sealers are regulated as part of the LEED process so their use must follow specific standards.

products, carpeting, and added urea-formaldehyde resins. Exemplary performance can be demonstrated by extending the use of these standards throughout the site, and by adhering to additional published standards for other products (such as asphalt). Typically, the bulk of the effort to lower VOC levels site-wide involve identifying and eliminating VOC emissions from liquid-applied materials (including stains, sealers, curing agents, form release agents, etc. used to produce and finish the concrete) and secondarily, from sheet goods such as waterproofing membranes. For this reason, we will focus this discussion on efforts to reduce VOC emissions from liquid-applied materials.

Codes and Standards

The LEED VOC limits in Credits EQ-4.1 and EQ-4.2 do not cover materials that are not indoors. The USGBC defines "indoors" as "within the weather-protected envelope,"

which would include concrete inside the air-barrier but excludes concrete outside the air-barrier. Regulated materials related to concrete include:

- Curing compounds.
- Sealers.
- Stains.
- Other coatings.
- Joint sealants and primers.
- Cleaning agents.

When these are to be included, the USGBC directs the submitter to use one of these two standards:

- Southern California Air Quality Management Board (SCAQMD) Rule 1113.
- California Air Resources Board (CARB), "Suggested Control Measures for Architectural Coatings" (SCM), June 22, 2000.

These are very similar, but differ in subtle ways. Both organizations have technical staff to answer telephone questions concerning which category a particular material falls into.

Typical categories of materials that might apply to ready mixed concrete include:

Adhesives	
Adhesive primer for traffic marking tape	150 g/L
Sealants	
Architectural sealants	250 g/L
Marine deck sealants	760 g/L
Roadway sealants	250 g/L
Interior Coatings	
Non-flat interior paint	150 g/L
Exterior Coatings	
Bond breakers	350 g/L
Floor coatings	250 g/L
Industrial maintenance coatings	250 g/L
Pre-treatment wash primers	450 g/L
Primers, sealers and undercoaters	200 g/L
Specialty primers, sealers, and undercoaters	350 g/L
Stains	250 g/L
Swimming pool coatings	340 g/L
Traffic marking coatings	150 g/L
Waterproofing sealers	250 g/L

Benefits and Costs

On some projects, extending the VOC limits of Credits EQ-4.1 and EQ-4.2 to include all liquid-applied materials is relatively straightforward, given adequate record-keeping and submittal processes. Aside from administrative cost, little if any additional cost is involved, as standard products are available for most applications that meet these criteria.

Supporting the credit by changing bituminous paving to concrete or by

switching from bituminous to some other roofing system may involve added cost.

Limitations

It is difficult to spot and keep track of every bit of liquid-applied material. While self-policing is involved, the USGBC reviewers have a good idea of products that would ordinarily be present in a project, and may audit the credit if important ones were omitted. Also, it is often difficult to decide which category a product belongs to. While each of the agencies mentioned above have technical staff available to help categorize the material, a better source is a manufacturer who sells product in California, where these limits originate.

Integration with Other LEED Credits

To gain what amounts to exemplary performance for Credits EQ-4.1 and EQ-4.2, the applicant must have already achieved both these credits. In addition, it is advisable to achieve Credit EQ-4.3 and EQ-4.4. Whether to extend the requirements of Credit EQ-4.4 (no added UF resins in composite wood and agrifiber) to include all such materials site-wide is a matter of discretion. Clearly, it would improve the chances of achieving the ID Credit.

INCIDENTAL READY MIXED CONCRETE USE IN OTHER CREDITS

DESIGN ISSUES

Concrete plays a role in the achievement of many LEED Credits. In some cases, the type of concrete or method of application has a direct impact on a project's ability to earn a particular LEED Credit (see summaries of concrete applications and materials relevant to the credits). In other cases, as this section will summarize, concrete is commonly used in some capacity to achieve the credit. In other cases, some aspect of concrete may influence the choice of materials to fulfill the Credit requirements; or, achieving the Credit may be made easier because of some characteristic of concrete.

SS-3 Brownfield Redevelopment [1]

Develop on a site documented as contaminated (by means of an ASTM E1903-97 Phase II Environmental Site Assessment)

OR,

On a site classified as a brownfield by a local, state or federal government agency, effectively remediate site contamination.

Incidental concrete application: Cement can be used to solidify and stabilize contaminated soils and reduce leaching concentrations. Cement for small remediation projects may be purchased through a ready mixed concrete producer.

SS-5.1 Reduced Site Disturbance – Protect Open Space [1]

On greenfield sites, limit site disturbance including earthwork and clearing of vegetation to 40' beyond the building perimeter, 5' beyond primary roadway curbs, walkways and main utility branch trenches, and 25' beyond constructed areas with permeable surfaces (such as pervious paving areas, stormwater detention facilities and playing fields) that require additional staging areas in order to limit compaction in the constructed area;

OR,

On previously developed sites, restore a minimum of 50% of the site area (excluding the building footprint) by replacing impervious surfaces with native or adapted vegetation.

Incidental concrete application: Special concrete applications are possible to limit the disturbance around construction areas. For example, placing concrete with a boom pump or using self-compacting concrete (SCC) which is fluid enough that large slab areas can be placed from one point, eliminating the need for a transit-mix truck to drive around the pour area.

The use of ICF construction may aid the designer in achieving the Sustainability Credit 5.1. ICF construction may reduce the impact on a construction site. Bracing for the ICF wall is often erected on the interior of the wall/structure, therefore, limiting construction activity on the perimeter of the site.

SS-7.2 Landscape and Exterior Design to Reduce Heat Islands – Roof [1]

Use ENERGY STAR® compliant (highly reflective) AND high emissivity roofing (emissivity of at least 0.9 when tested in

accordance with ASTM 408) for a minimum of 75% of the roof surface;

OR,

Install a green (vegetated) roof for at least 50% of the roof area. A combination of high albedo and vegetated roof can be used providing they collectively cover 75% of the roof area.

Incidental concrete application: Lightweight concrete topping can be used to create the sloping deck of a green roof system. Concrete structured systems are often used to support the heavy loads caused by soil needed for green roofs.

WE-1 Water – Efficient Landscaping [2]

Use high efficiency irrigation technology; OR,

Use captured rain or recycled site water to reduce potable water consumption for irrigation by 50% over conventional means, for one point;

Reduce potable water consumption for irrigation a further 50% (100% total reduction), for an additional point;

Using collected stormwater and/or treated black water for 100% of the building's irrigation needs will satisfy the criteria for two points;

OR,

Do not install permanent landscape irrigation systems, for two points.

Incidental concrete application: Concrete is a suitable material for the construction of cisterns used for the collection of rainwater or greywater. Concrete is likely to have lower embodied energy than a plastic tank, for smaller volumes. Integrate with other WE Credits and with Low Impact Development (see discussion under Innovation Credits – Exemplary Performance – Prerequisite SS-P1 and Credit SS-6).

WE-2 Innovative Waste Water Technologies [1]

Reduce the use of municipally provided potable water for building sewage conveyance by a minimum of 50%; OR

Treat 100% of waste water on-site to tertiary standards.

Incidental concrete application: Concrete is a likely material to form the large storage tanks needed for the storage of stormwater or greywater for reuse, and for the storage of treated or untreated sewage. Concrete is likely to have lower embodied energy than a plastic tank, for smaller volumes. Integrate with other WE Credits and with Low Impact Development (see discussion under Innovation Credits – Exemplary Performance (Credit SS-6)).

MR-1 Building Reuse [2]

Reuse large portions of existing structures during renovation or redevelopment projects.

Maintain at least 75% of existing building structure and shell (exterior skin and framing excluding window assemblies) for one point; OR,

Maintain an additional 25% (100% total) of existing building structure and shell

(exterior skin and framing excluding window assemblies) for two points.

Incidental concrete application: An existing building with a concrete structure or skin is more likely than many others to be re-usable.

Investigate attaching new concrete to existing walls, columns, floor plates, to allow leaving existing structure in place.

Use lightweight fill in existing buildings to level floors without adding much weight.

MR-6 Rapidly Renewable Materials [1]

Use rapidly renewable building materials and products (made from plants that are typically harvested within a ten-year cycle or shorter) for 5% of the total value of all building materials and products used in the project.

The minimum threshold is typically difficult for a large project to meet. Wood of any type does not qualify for this credit.

Incidental concrete application: There are many bio-based form release agents on the market that are not only low-VOC, but also derived from vegetable, rapeseed, soy or other rapidly renewable materials that can make a small contribution toward earning this Credit.

EQ-4.1 Select Low-Emitting Materials – Adhesives and Sealants [1]

Adhesives must meet or exceed the VOC limits of South Coast Air Quality Management District Rule # 1168 AND all sealants used as filler must meet or exceed Bay Area Air Resources Board Reg. 8, Rule 51.

Incidental concrete application: Low-VOC adhesives and sealants (used as fillers as opposed to coatings) must be used in conjunction with any concrete work that is exposed to the inside of the building.

"Inside" is defined as all areas within the outer air/moisture barrier.

See "Potential Innovation and Design Credit: Site-Wide VOC Reduction"

EQ-4.2 Select Low-Emitting Materials – Paints and Coatings [1]

VOC emissions from interior paints and coatings must not exceed the VOC and chemical component limits of Green Seal's Standard GS-11 requirements.

Incidental concrete application: Low-VOC paints and coatings must be used in conjunction with any concrete work that is exposed to the inside of the building.

"Inside" is defined as all areas within the outer air/moisture barrier.

See "Potential Innovation and Design Credit: Site-Wide VOC Reduction"

EQ-4.3 Select Low-Emitting Materials – Carpet Systems [1]

Carpet systems must meet or exceed the Carpet and Rug Institute Green Label Indoor Air Quality Test Program. A point is potentially possible if the finished concrete floor has a lesser IAQ impact than the carpets that are required for this point.

EQ-5 Indoor Chemical and Pollutant Source Control [1]

Design to minimize pollutant cross-contamination of regularly occupied areas:

1) Employ permanent entryway systems (grills, grates, etc.) to capture dirt, particulates, etc. from entering the building at all high volume entryways.

2) Where chemical use occurs (including housekeeping areas and copying/printing rooms), provide segregated areas with deck to deck partitions with separate outside exhaust at a rate of at least 0.50 cubic feet per minute per square foot, no air re-circulation and maintaining a negative pressure of at least 7 PA (0.03" of water gauge).

3) Provide drains plumbed for appropriate disposal of liquid waste in spaces where water and chemical concentrate mixing occurs.

Incidental concrete application: The likely involvement of concrete in achieving this Credit is the need to cast in the necessary recesses for installing walk-off grilles at important entrances.

EQ-7.1 Thermal Comfort: Compliance with ASHRAE 55-1992 [1]

Comply with ASHRAE Standard 55-1992, Addenda 1995, for thermal comfort standards within established ranges per climate zone. Humidity control is no longer required.

For naturally ventilated buildings, utilize the adaptive comfort temperature boundaries, using the 90% acceptability limits as defined in the California High Performance Schools (CHPS) Best Practices Manual, Appendix C "A Field Based Thermal Comfort Standard for Naturally Ventilated Buildings," Figure 2.

Incidental concrete application: In a naturally ventilated building, internal concrete and other high-mass materials may provide important forms of thermal storage. However, the design must be careful to avoid conditions which create condensation problems.

OTHER ENVIRONMENTAL ISSUES

LEED addresses most of the environmental impacts of ready mixed concrete, and, once placed, the material is among the most environmentally benign products available. Even so, there are life-cycle considerations for concrete where environmental controls can and should be specified in any "green" project. Categories include waste water, solid waste, and site protection.

Plant Waste Water Disposal

The costs of water procurement and disposal have precipitated great progress in curbing waste water discharge.

Water settling basins separate solids from water and allow for the recycling of waste and wash water at concrete plants.

After considerable effort from NRMCA to formulate more stringent and updated requirements, two new standards were developed. These were ASTM C 1602/C 1602M-04 "Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete;" and ASTM C 1603/C 1603M-04 "Standard Test Method for Measurement of Solids in Water." As explained by NRMCA's Colin Lobo, Vice President of Engineering, in the Winter 2005 edition of *Concrete inFocus* magazine, "The major source of contention in gaining approval of the standard was establishing testing frequencies for the qualification of water for use in concrete. The result constitutes the best consensus attainable within ASTM. Testing frequencies for wash water are governed by the density of combined water proposed for use."

By following these badly needed standards, an up-to-date plant can operate with virtually zero discharge of polluted water. These life-cycle considerations may be of particular interest for projects pursuing LEED certification. Using these standards, project stakeholders who wish to expand environmental consciousness beyond LEED criteria can specify that the ready mixed concrete supplier be up-to-date on waste water control and include waste water recycling in MR-CR2 calculations.

On-site Wash Water Disposal

The ASTM standards make it possible to reuse not only water generated within the plant, but scavenged wash water collected at the job site during the washdown of equipment. Despite local controls (which tend to be more stringent in larger cities), existing United States standards for on-site control of equipment washdown waste are lax. The USEPA allows the discharge of process water with a pH up to 9.0, which may be toxic to fish and wildlife if it enters streams and lakes. NRMCA is working closely with the

USEPA to improve wash water treatment through cooperation and improved job site practices.

On some job sites where water is collected rather than dumped, it is typically stored in a 12-foot-square "washout pit" consisting of a plastic liner supported by a ring of hay bales. An improvement over direct dumping, this technique is still problematic. First, some equipment cannot be washed out into the pit. Second, when the pit is "emptied" the residual solids and the plastic are disposed of, but residual highly alkaline water is usually left to soak into the ground. Five-cubic-yard steel sludge boxes (waste containers) lined with plastic are also used, with results similar to the washout pits. When full, they are typically emptied of alkaline water; and they tend to leak.

One solution for environmentally conscious builders is to engage one of the growing number of contractors who collect, treat, and recycle on-site waste water from concrete operations. Transit mix trucks increasingly are equipped with easy to use, attachable devices that collect the wash water and return it to the drum for disposal at the ready mixed concrete plant for recycling. At a minimum, site crews should designate a wash area where any runoff that occurs will not pollute aquifers, damage surrounding vegetation, or flow into waterways untreated.

Situations where designers have specified exposed aggregate present another area of concern. Collecting the water used to wash away cement and fine aggregate from the concrete's surface is difficult or impossible. A document published by the British Columbia Ready Mixed Concrete Association, *Exposed Aggregate Concrete Wash-Off Water*, provides very helpful guidelines with details on constructing disposal areas, typically under the exposed aggregate slabs themselves. This document is available online at www.bcrmca.bc.ca/ExpAgg/expagg.html.

Solid Waste

LEED directly rewards reduction of C&D Waste. According to estimates in the *AIA Environmental Resource Guide,* analysis of job sites found that C&D Waste is as much as two-thirds concrete by weight and over half by volume. However, the great bulk of this material is demolition waste – newly placed concrete generates very little construction waste. Even so, the industry has developed several creative ways to handle material from returned loads and partial loads. Unset returned concrete can be used to make utilitarian products like jersey barriers or retaining wall blocks; or it can be washed to recycle the coarse aggregate. Special set retarding admixtures can be added to returned concrete which temporarily halts the hydration process to allow for storage and future use with a reactivation admixture.

Producers can make use of concrete reclaimers that recover water, sand and coarse aggregate for reuse in new concrete mixes. Ready mixed concrete producers can consider if the reclaimer is appropriate for their operations. Several producers have

found that a use of a reclaimer reduces disposal costs and can be a profit center.

Perhaps the best way to minimize construction waste from ready mixed concrete is to estimate concrete quantities carefully.

Site Protection

Protecting a building site's natural features should be the responsibility of every building trade, including concrete contractors. As noted in the article on Incidental LEED Credit in section SS-C5.1 Reduced Site Disturbance--Protect Open Space, it is advantageous to avoid compacting and disturbing soil around the building at the job site, especially soil over tree roots. In addition, the area under tree drip lines should be fenced and made off-limits to all foot and vehicular traffic, and tree trunks and exposed branches should be well protected with strong wood barriers. Arranging truck access to minimize the need for trucks to reposition or turn around will also help protect the site.

REFERENCES AND INFORMATION SOURCES

www.bcrmca.bc.ca/ExpAgg/expagg.html

"Cement and Concrete: Environmental Considerations," Environmental Building News, Volume 2, Number 2, March/April 1993.

APPENDIX A – Sample Letter from Ready Mixed Concrete Producer

The following is a sample letter a concrete producer could use to submit to a contractor and the architect/engineer. The letter provides details needed to complete LEED documentation.

To whom it may concern:

This letter is to certify that the concrete supplied by Super Rock Concrete for the Moneymaker Industries World Headquarters project has the properties, quantities, and costs related to the following LEED credits.

Credit SS-C7.1

Landscape and Exterior Design to Reduce Heat Island Effect

Mix 1 – PRV030 (Pervious Concrete Parking Areas) has been previously tested in accordance with ASTM E 903 and has a reflectance value of 0.35.

Mix 2 – PCP040 (Conventional Concrete Parking Area) has been previously tested in accordance with ASTM E 903 and has a reflectance value of 0.40.

Credit MR-C2

Construction Waste Management

Three percent by volume of all concrete for this project was returned to the ready mixed concrete production facilities used for this project. Of that amount, 100% was diverted from landfills by collecting wash water and aggregate for reuse in concrete for this and other projects.

Credit MR-C4

Recycled Content

Mix 1 PRV030 (Pervious Concrete Parking Areas)

Material	Quantity (lbs/yd3)	Cost ($/lb)	Recycled Content (%)	
			Post-Consumer	Post-Industrial
Portland Cement	500	0.045	0	0
Fly Ash	150	0.025	0	100
Water	200	0.0005	0	10
Large Aggregate	2500	0.0075	0	0

Mix 2 PCP040 (Conventional Concrete Parking Areas)

Material	Quantity (lbs/yd3)	Cost ($/lb)	Recycled Content (%)	
			Post-Consumer	Post-Industrial
Portland Cement	400	0.045	0	0
Slag	200	0.035	0	100
Water	300	0.0005	0	10
Fine Aggregate	1000	0.0075	0	0
Large Aggregate	2000	0.005	0	0

Mix 3 STR040 (Concrete Structure)

Material	Quantity (lbs/yd3)	Cost ($/lb)	Recycled Content (%)	
			Post-Consumer	Post-Industrial
Portland Cement	350	0.045	0	0
Slag	150	0.035	0	100
Fly Ash	100	0.025	0	100
Water	300	0.0005	0	10
Fine Aggregate	1000	0.0075	0	0
Large Aggregate	2000	0.005	0	0

Credit MR-C5

Regional Materials

Mix 1 PRV030 (Pervious Concrete Parking Areas)

Material	Quantity (lbs/yd3)	Cost ($/lb)	Manufacturing Location/ Distance	Harvesting Location/ Distance
Portland Cement	500	0.045	Rocktown/10 mi.	Rockville/200 mi.
Fly Ash	150	0.025	Rocktown/10 mi.	Electro/450 mi.
Water	200	0.0005	Rocktown/10 mi.	Rocktown/10 mi.
Large Aggregate	2500	0.0075	Rocktown/10 mi.	Quarrytown/40 mi.

Mix 2 PCP040 (Conventional Concrete Parking Areas)

Material	Quantity (lbs/yd3)	Cost ($/lb)	Manufacturing Location/ Distance	Harvesting Location/ Distance
Portland Cement	400	0.045	Rocktown/10 mi.	Rockville/200 mi.
Slag	200	0.035	Rocktown/10 mi.	Steeltown/800 mi.
Water	300	0.0005	Rocktown/10 mi.	Rocktown/10 mi.
Fine Aggregate	1000	0.0075	Rocktown/10 mi.	Quarrytown/40 mi.
Large Aggregate	2000	0.005	Rocktown/10 mi.	Quarrytown/40 mi.

Mix 3 STR040 (Concrete Structure)

Material	Quantity (lbs/yd3)	Cost ($/lb)	Manufacturing Location/ Distance	Harvesting Location/ Distance
Portland Cement	350	0.045	Rocktown/10 mi.	Rockville/200 mi.
Slag	150	0.035	Rocktown/10 mi.	Steeltown/800 mi.
Fly Ash	100	0.025	Rocktown/10 mi.	Electro/450 mi.
Water	300	0.0005	Rocktown/10 mi.	Rocktown/10 mi.
Fine Aggregate	1000	0.0075	Rocktown/10 mi.	Quarrytown/40 mi.
Large Aggregate	2000	0.005	Rocktown/10 mi.	Quarrytown/40 mi.

Best Regards,

Robert Rock III
President
Super Rock Concrete

Appendix B - LEED 2.2 Changes

The *LEED Reference Guide* was published with LEED version 2.1 in effect. The newest version 2.2 of LEED for New Construction and Major Renovation came into effect January 1, 2006. Many credits have been altered to some degree. This chart covers changes made in Version 2.2.

The major changes affecting the concrete industry are:

1. MR Credit 4 – Recycled Content – The recycled content of concrete can now be based on the recycled content of just the cementitious materials rather than the recycled content of concrete.
2. SS Credit 7.1 – Heat Island Effect: Non-Roof – Solar Reflectance Index is now used rather than solar reflectance.
3. EA Credit 1 – Optimize Energy Performance – The percent energy savings that must be demonstrated are lower, but are calculated differently so the end result may be similar.
4. MR Credit 5.1 and 5.2 – Requirements for regional materials are less stringent and have changed.

The remainder of this document highlights the changes from version 2.1 to 2.2 that are significant to the cement, concrete, and allied industries. The table below shows the credit name and number, a brief description of what has changed, the relevant sections from LEED NC showing the old and new text, and the significance to the cement, concrete, and allied industries.

Credit name and number and what has changed	**Version 2.2**	**Version 2.1**	**Significant to the cement, concrete, and allied industries**
SS Credit 5.1 – Site Development: Protect or Restore Habitat	Site Development: Protect or Restore Habitat	Reduce Site Disturbance: Protect or Restore Open Space	Concrete parking garages within buildings can be used to limit site disturbance, including earthwork and clearing vegetation. For example, one LEED

Name change			criterion is to limit site disturbance to 12 m (40 ft) beyond the building perimeter. Parking garages within buildings help maintain existing natural areas that would be consumed by paved parking. This credit is worth 1 point.
SS Credit 5.2 – Site Development: Maximize Open Space Name change Open space definition has been refined to address both urban and suburban settings	Site Development: Maximize Open Space For projects located in urban areas that earn SS Credit 2 (Development Density & Community Connectivity), pedestrian oriented hardscape areas can contribute to credit compliance as open space. For such projects, a minimum of 25% of the open space counted must be vegetated.	Reduce Site Disturbance: Development Footprint	Concrete parking garages on the lower floors of a building can be used to help reduce the footprint of the development. In this context the building footprint includes the building, access roads, and parking. Parking garages within buildings reduce the building footprint by reducing paved parking areas. This requirement can be met by exceeding the local zoning's open space requirement for the site by 25%. This credit is worth 1 point.
SS Credit 6.1 – Stormwater Design: Quantity Control	Stormwater Design: Quantity Control	Stormwater Management: Rate and Quantity	The intent of this credit is to limit disruption and pollution of natural water flows by managing stormwater runoff. Using pervious concrete pavements will reduce the rate and quantity of storm

Name change			water runoff because they increase infiltration of stormwater. Pervious concrete contains coarse aggregate, little or no fine aggregate, and insufficient cement paste to fill the voids between the coarse aggregate. It results in concrete with a high volume of voids (20% to 35%) and a high permeability that allows water to flow through easily. On building sites where the existing imperviousness is greater then 50%, this credit requires reducing the rate and quantity of stormwater runoff by 25%. On building sites where the existing imperviousness is less than 50%, the requirement specifies that the post-development discharge rate and quantity from the site shall not exceed the pre-development rate and quantity. This credit is worth 1 point.
SS Credit 6.2 – Stormwater Design: Quality Control Name change New performance target	Stormwater Design: Quality Control …capture and treat the stormwater runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs). BMPs used to treat	Stormwater Management: Rate and Quantity …remove 80% of the average annual post-development total suspended solids (TSS) and 40% of the average annual post-development total	The intent of this credit is similar to that of the one above. Using pervious pavement can contribute to earning this credit, worth 1 point.

	runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports.	phosphorous (TP) based on the average annual loadings from all storms less than or equal to the 2-year/24-hour storm.	
SS Credit 7.1 – Heath Island Effect: Non-Roof New performance metric (Solar Reflectance Index)	Provide any combination of the following strategies for 50% of the site hardscape (including roads, sidewalks, courtyards and parking lots): • Shade (within 5 years of occupancy) • Paving materials with a Solar Reflectance Index (SRI) of at least 29 • Open grid pavement system OR Place a minimum of 50% of parking spaces under cover (defined as under ground, under deck, under roof, or	…for paving, landscaping (list species) and building footprint demonstrate that: • A minimum of 30% of non-roof impervious surfaces areas are constructed with high-albedo materials and/or open grid pavement and/ or will be shaded within five years • OR a minimum of 50% of parking spaces have been placed underground or are covered by structured parking • OR an open-grid pavement system (less than 50%	The requirement can be met by using concrete rather than asphalt for at least 50% of the impervious surfaces. Another option is to place a minimum of 50% of parking spaces under cover such as underground, under deck, under roof, or under a building. Any roof used to shade or cover parking must have an SRI of at least 29. The SRI is calculated from solar reflectance and emissivity. Solar reflectance is the ratio of the amount of solar radiation reflected from a material to the amount that shines on the material. Solar radiation includes the infrared and ultraviolet as well as the visible spectrum. Generally, light-colored surfaces have a high reflectance, but this is not always the case. Surfaces with lower reflectance absorb more solar radiation. The absorbed radiation is converted into heat and the surface gets hotter. Where paved

	under a building). Any roof used to shade or cover parking must have an SRI of at least 29.	impervious) has been used for a minimum of 50% of the parking lot area.	surfaces are required, using materials with higher reflectance will reduce the heat island effect—consequently saving energy by reducing the demand for air conditioning—and improve air quality. As the temperature of urban areas increases, so does the probability of smog and pollution. Smog episodes rarely occur when the temperature is below 21°C (70°F).
SS Credit 7.2 – Heat Island Effect: Roof New performance metric (Solar Reflectance Index)	Use roofing materials having a Solar Reflectance Index (SRI) equal to or greater 78 for low-sloped roof for a minimum of 75% of the roof surface. OR Install a vegetated roof for at least 50% of the roof area. OR Install high albedo and vegetated roof surfaces that, in combination, meet the following criteria: (Area of SRI Roof / 0.75) +	Use ENERGY STAR® compliant (highly reflective) AND high emissivity roofing (emissivity of at least 0.9 when tested in accordance with ASTM 408) for a minimum of 75% of the roof surface. OR Install a “green” (vegetated) roof for at least 50% of the roof area. Combinations of high albedo and vegetated roof can be used providing they collectively cover 75% of the roof area.	One method of obtaining credit is to install a vegetated roof for at least 50% of the roof area. Concrete roof decks are often needed to provide structural support for the heavy, moist soil in a vegetated roof. Lightweight concrete topping can be used to create a sloping deck to provide drainage for the system. More information on vegetated or green roofs is available at www.greenroofs.org. This credit is worth 1 point.

	(Area of vegetated roof / 0.5) >= Total Roof Area		
EA Prerequisite 2 – Minimum Energy Performance Updated Referenced Standard (ASHRAE 90.1-2004)	Design the building project to comply with both— • the mandatory provisions of ASHRAE Standard 90.1-2004 (without amendments); and • the prescriptive requirements or performance requirements (Section 11) of ASHRAE Standard 90.1-2004 (without amendments).	Design the building to comply with ASHRAE Standard 90.1-1999 (without amendments) or the local energy code, whichever is more stringent.	The requirements of the ASHRAE standard are cost-effective and not particularly stringent for concrete. Insulating to meet or exceed the requirements of the standard is generally a wise business choice. Determining compliance for the envelope components is relatively straightforward using the tables in Chapter 5 of the ASHRAE standard. Minimum requirements are provided for mass and non-mass components such as walls and floors. Components constructed of concrete generally are considered ”mass.“ This means the components have enough heat-storage capacity to moderate daily temperature swings. Buildings constructed of cast-in-place, tilt-up or insulating concrete forms (ICF), possess thermal mass to help moderate indoor temperature extremes and reduces peak heating and cooling loads. In many climates, these buildings use less energy than non-massive buildings with walls of similar thermal resistance. When buildings are properly designed and optimized, incorporating thermal mass can lead to a reduction in heating, ventilating, and air-conditioning equipment

			capacity. Reduced equipment capacity can represent energy and construction cost savings. This item is required and is not worth any points.
EA Credit 1 – Optimize Energy Performance Updated Referenced Standard (ASHRAE 90.1-2004) New energy modeling protocol includes plug loads New (lower) performance requirement *Note: the two changes above may offset each other* New prescriptive compliance paths	Demonstrate a percentage improvement in the proposed building performance rating compared to the baseline building performance rating per ASHRAE Standard 90.1-2004 (without amendments) by a whole building project simulation using the Building Performance Rating Method in Appendix G of the Standard. The minimum energy cost savings percentage for each point threshold is as follows: • new buildings 1 to 10 points for 10.5 to 42% energy cost savings	Reduce design energy cost compared to the energy cost budget for energy systems regulated by ASHRAE Standard 90.1-1999 (without amendments), as demonstrated by a whole building simulation using the Energy Cost Budget Method described in Section 11 of the Standard. The minimum energy cost savings percentage for each point threshold is as follows: • new buildings 1 to 10 points for 15 to 60% energy cost savings • existing building renovations 1 to 10 points for 5 to 50% energy cost	Many engineering consulting firms have the capability to perform whole building energy simulations to determine energy savings as required using a computer based program such as DOE2 or EnergyPlus. When concrete is considered, it is important to use a program like these that calculate yearly energy use on an hourly basis. Such programs are needed to capture the beneficial thermal mass effects of concrete. Insulated concrete systems, used in conjunction with other energy savings measures, will most likely be eligible for points. The number of points awarded will depend on the building, climate, fuel costs, and minimum requirements of the standard. Studies show that using concrete walls that are insulated to exceed minimum code requirements by a modest amount (about the same as minimum requirements for frame walls) can contribute to earning 1 to 3 points, depending on the building type, orientation, and climate.

(two)	• existing building renovations 1 to 10 points for 3.5 to 35% energy cost savings Appendix G of Standard 90.1-2004 requires that the energy analysis done for the Building Performance Rating Method include ALL of the energy costs within and associated with the building project. Two prescriptive compliance paths are also allowed: *ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004* for 4 points and *Advanced Buildings Benchmark™ Version 1.1* for 1 point.	savings Regulated energy systems include HVAC (heating, cooling, fans and pumps), service hot water and interior lighting. Non-regulated systems include plug loads, exterior lighting, garage ventilation and elevators (vertical transportation).	
MR Credit 1.2 – Building Reuse	Maintain an additional 20% (95% total, based on	Maintain an additional 25% (100% total) of existing	This credit should be obtainable when renovating buildings with concrete walls, since concrete in

New (lower) performance requirement for Credit 1.2	surface area) of existing building structure (including structural floor and roof decking) and envelope (exterior skin and framing, excluding window assemblies and non-structural roofing material).	building structure and shell (exterior skin and framing, excluding window assemblies and nonstructural roofing material).	buildings generally has a long life. This is worth 1 point if 75% of the existing building structure/shell is left in place (MR 1.1) and 2 points if 95% is left in place (MR 1.2).
MR Credit 4 – Recycled Content User of recycled content of cementitious materials as the recycled content of concrete New (higher) performance requirement Updated Referenced Standard (ISO 14201)	Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% (based on cost) of the total value of the materials in the project. An additional credit is awarded is the total above is increase to 20%. The recycled content value of a material assembly shall	Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the post-industrial content constitutes at least 5% of the total value of the materials in the project. An additional credit is awarded is the total above is increase to 10%. The value of the recycled content portion of a material or furnishing shall be	The requirements of this credit are for using materials with recycled content. One point is awarded if the sum of the post-consumer recycled content plus one-half of the pre-consumer recycled content constitutes at least 10% (based on cost) of the total value of the materials in the project. The value of the recycled content of a material is the weight of the recycled content in the item divided by the weight of all materials in that item, and then multiplied by the total cost of the item. Supplementary cementitious materials, such as fly ash, silica fume, and slag cement are considered pre-consumer. **LEED-NC v2.2 allows the recycled content of concrete to be based on the recycled content of the cementitious materials. An example calculation is provided in the LEED-NC v2.2**

	be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value. Recycled content shall be defined in accordance with ISO 14021—Environmental labels and declarations—Self-declared environmental claims	determined by dividing the weight of recycled content in the item by the total weight of all material in the item, then multiplying the resulting percentage by the total value of the item.	**Reference Guide.** Furthermore, using recycled concrete or slag as aggregate instead of extracted aggregate would qualify as post-consumer. Although most reinforcing bars are manufactured from recycled steel, in LEED, reinforcing is not considered part of concrete. Reinforcing material should be considered as a separate item. This credit is worth 1 point for the quantities quoted above and 2 points if the quantities are doubled to 20%.
MR Credit 5.1 – Regional Materials Name change New requirements on what constitutes "regional" New (lower) performance requirement	Regional Materials: 10% Extracted, Processed & Manufactured Regionally 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% (based on cost) of the total materials	Regional Materials: 20% manufactured regionally Use a minimum of 20% of building materials and products that are manufactured regionally within a radius of 500 miles. Manufacturing refers to the final assembly of components into the	This credit supports the use of indigenous (local) materials and reduced transportation distances. Concrete will qualify if ready-mix and precast plants are within 800 km (500 miles) of a job site, and if the materials to make the concrete were extracted within 800 km (500 miles). Aggregates (sand and gravel) are usually extracted within this distance, and cement and supplementary cementitious materials are usually manufactured within this distance. Calculations can also include concrete either manufactured or extracted locally. This credit is worth 1 point for the quantities quoted above, and 2

	value. Mechanical, electrical and plumbing components and specialty items such as elevators and equipment shall not be included in this calculation. Only include materials permanently installed in the project. Furniture may be included, providing it is included consistently in MR Credits 3–7.	building product that is furnished and installed by the tradesmen.	points for double the amount, or 20%.
MR Credit 5.2 – Regional Materials Name change New requirements on what constitutes "regional" New (lower)	Regional Materials: 20% Extracted, Processed & Manufactured Regionally Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500 miles of the project site for an additional 10% beyond MR	Regional Materials: 50% extracted regionally Of the regionally manufactured materials documented for MR Credit 5.1, use a minimum of 50% of building materials and products that are extracted, harvested or recovered (as	

performance requirement	Credit 5.1 (total of 20%, based on cost) of the total materials value.	well as manufactured) within 500 miles of the project site.	

Notes

Concrete's Contribution to LEED® 2009

By Erin Ashley, Ph.D., LEED AP, Senior Director, Sustainable Construction, NRMCA & Lionel Lemay, P.E., LEED AP, Senior Vice President, Sustainable Development, NRMCA

Using concrete in new buildings and major renovation projects can facilitate the process of obtaining LEED® 2009 for New Construction (NC) and Major Renovations certification. Leadership in Energy and Environmental Design (LEED) is a point rating system devised by the United States Green Building Council (USGBC) to evaluate the environmental performance of a building. The system is credit-based, allowing projects to earn points for environmentally friendly strategies employed during the design and construction process.

LEED was launched in an effort by the USGBC to develop a "consensus-based, market-driven rating system to accelerate the development and implementation of green building practices." The program is not rigidly structured, i.e., not every project must meet identical requirements to qualify. LEED for New Construction (NC) rating system is currently in its third major iteration with LEED 2009 NC being introduced in March 2009. Both new buildings and major renovation projects can be certified using LEED 2009 NC. This paper details credits associated with the LEED 2009 NC where the use of ready mixed concrete can contribute to achieving LEED points.

LEED 2009 NC rating system has five main credit categories: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, and Indoor Environmental Quality. Each credit category is divided into credits and outlines the intent, requirements, technologies, and strategies for meeting each credit. Credits are broken down into individual points. Additional points can be earned for Innovation & Design Process credits and meeting specific Regional Priority Credits.

Credit Category	Points Available
Sustainable Sites (SS)	26
Water Efficiency (WE)	10
Energy & Atmosphere (EA)	35
Materials & Resources (MR)	14
Indoor Environmental Quality (EQ)	15
Innovation & Design Process (ID)	6
Regional Priority Credits (RP)	4
Total Points Available	110

Points for Certification

A building requires at least 40 points for basic certification level. Silver level requires 50 points, gold level requires 60 points, and platinum level requires 80 points. There are a total of 110 points available.

LEED Certification Levels	Points Required
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80+

Concrete and LEED

The following are suggestions for earning LEED points through the use of ready mixed concrete products. The paragraph headings below correspond to the credit categories and the credit numbers in the LEED 2009 NC rating system.

Development Density & Community Connectivity (Sustainable Sites Credit 2)
The intent of this credit is to channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources. One strategy to achieve this credit is to construct or renovate a building on a previously developed site AND in a community with a minimum density of 60,000 square feet per acre. This necessitates construction of multistory buildings. Concrete has long been the material of choice for multi-story construction. Its strength, economy, and versatility make it ideal for residential and commercial construction in urban settings. Features such as long spans, low floor-to-floor heights, and energy efficiency also contribute to environmental performance that can be used to gain LEED points in other credit categories. This credit is worth 5 points.

Concrete has long been the material of choice for multi-story construction, a requirement for meeting Sustainable Sites Credit 2 in LEED 2009 NC.

Brownfield Redevelopment (Sustainable Sites Credit 3)
Cementitious materials can be used to solidify and stabilize contaminated soils and reduce leaching concentrations to below regulatory levels. Although not typical, ready mixed concrete trucks and plants have been used to mix and deliver cementitious slurries for solidification and stabilization projects. To achieve this credit, documentation is required indicating the site was contaminated or a site defined as a brownfield and the remediation performed. This credit is worth 1 point.

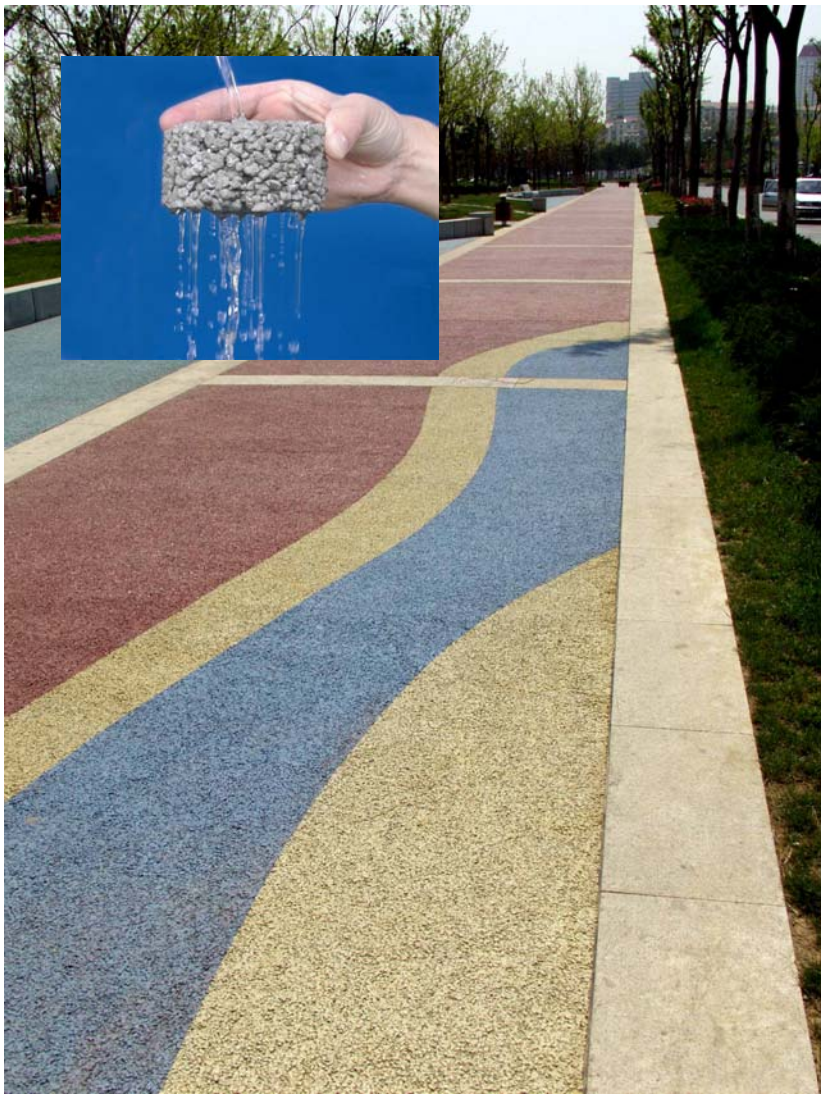
Site Development: Protect or Restore Habitat (Sustainable Sites Credit 5.1)
The intent of this credit is to conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity. Strategies include stacking the building program and using tuck-under parking. Concrete parking garages within buildings can be used to limit site disturbance. Parking garages located within a building helps maintain

existing natural areas that would otherwise be consumed by surface parking. Using a pervious concrete parking area to store and treat rainwater thereby eliminating or minimizing land required for detention ponds help protect and restore habitat. This credit is worth 1 point

Site Development: Maximize Open Space (Sustainable Sites Credit 5.2)
The intent of this credit is to provide a high ratio of open space to development footprint to promote biodiversity by meeting specific ratios of open space to developed space. Parking garages on the lower floors of a building can be used to help reduce the footprint of a site development. Pervious concrete parking areas can eliminate or reduce land required for detention ponds can help maximize open space. This is worth 1 point.

Stormwater Design: Quantity Control (Sustainable Sites Credit 6.1)
The intent of this credit is 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. Using pervious concrete pavements will reduce the rate and quantity of stormwater runoff because they increase infiltration of stormwater. Pervious concrete contains coarse aggregate, little or no fine aggregate, and sufficient cementitious paste to bind the aggregate but provide a network of interconnected voids between the coarse aggregates. The result is concrete with a high volume of voids (15% to 25%) and high permeability that allows water to flow through easily. Vegetated roofs (green roofs) are also identified as a strategy to achieve this credit. Reinforced concrete is often used as the structural system to support the heavy loads of vegetated roofs. This credit is worth 1 point.

Stormwater Design: Quality Control (Sustainable Sites Credit 6.2)
The intent of this credit is to limit the disruption of natural water flows by managing stormwater runoff. To achieve this credit, a best management practice that removes 80% or more of the total suspended solids in stormwater must be used. Pervious concrete systems generally remove over 80% of total suspended solids and are considered a best management practice for treating stormwater. Vegitated roofs (green roofs) can also be used to meet the intent of this credit which are often supported by concrete structural systems. This credit is worth 1 point.



Pervious concrete pavements help control quantity and quality of stormwater (Sustainable sites Credit 6.1 and 6.2) and help conserve water resources (Water Efficiency Credit 1.1, 1.2, 2, and 3)

Heat Island Effect: Non-Roof (Sustainable Sites Credit 7.1).
The intent of this credit is to reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat. Strategies include providing shade for at least 50% of hardscaped surfaces or provide hardscaped surfaces with solar reflectance index (SRI2) of at least 29. The requirement for SRI can be met by using concrete rather than asphalt for 50% of all sidewalks, parking lots, drives and other impervious surfaces.

Solar reflectance is the ratio of the amount of solar radiation reflected from a material to the amount that shines on the material. Generally, light-colored surfaces have a high SRI. Where paved surfaces are required, using materials with higher SRI will reduce the heat island effect—consequently saving energy by reducing the demand for air conditioning—and improve air quality.

Concrete generally has an SRI of greater than 29. Concretes made with white cements or slag can have SRI greater than 78. As a comparison, new asphalt generally has an SRI of

approximately 0, and asphalt five or more years old has an SRI of approximately 6. This credit is typically achieved when parking areas, walks and plazas are paved with concrete.

Another strategy to achieve this credit is to place a minimum of 50% of parking spaces under cover including underground, under deck, under roof, or under building. Concrete is typically the material of choice for parking structures. This credit is worth 1 point.

Concrete pavement can be used to reduce urban heat islands (Sustainable Sites Credit 7.1)

Heat Island Effect: Roof (Sustainable Sites Credit 7.2)
The intent of this credit is to reduce heat islands (thermal gradient between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat. The requirement is to use highly reflective/high emissivity roofing for a minimum of 75% of the roof surface; or install a vegetated roof for at least 50% of the roof surface; or a combination of both for 75% of the roof area. Concrete with high SRI can be used for roofing and concrete structural systems are ideal for supporting the heavy loads of vegetated roofs. This credit is worth 1 point.

Water Efficient Landscaping: Reduce by 50% (Water Efficiency Credit 1.1)
Water Efficient Landscaping: No Potable Water Use or No Irrigation (Water Efficiency Credit 1.2)
The intent of these credits are to reduce 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. Strategies include using only captured rainwater, recycled wastewater, recycled greywater for irrigation. Cisterns for capturing rainwater are often built using concrete. Pervious concrete systems and other stormwater management

systems can be used to capture stormwater for collection into cisterns for later use for irrigation. Credit 1.1 is worth 2 points for 50% reduction from the mid-summer baseline case and Credit 1.2 is worth an additional 2 Points for 100% reduction.

Innovative Wastewater Technologies (Water Efficiency Credit 2)
The intent of this credit is to reduce the generation of wastewater and potable water demand, while increasing the local aquifer recharge. Strategies include the use of non-potable water, recycled greywater, and on-site treated wastewater for sewage conveyance. Concrete cisterns and treatment tanks can be used to fulfill the requirements of this credit. This credit is worth 2 points.

Water Use Reuse Reduction (Water Efficiency Credit 3)
The intent of this credit is to further increase water efficiency within buildings to reduced the burden on municipal water supply and wastewater systems. Employ strategies that in aggregate use less water than a typical building. Strategies include using alternate on-site sources of water, such as rainwater and stormwater. Pervious concrete systems in combination with concrete cisterns can be used to fulfill the requirements for this credit. This credit is worth 2, 3, or 4 points for 30%, 35%, and 40% reduction of water use from the baseline.

Minimum Energy Performance (Energy & Atmosphere Prerequisite 2)
To achieve any level of LEED certification, buildings must demonstrate a 10% improvement for new buildings or a 5% improvement for existing building renovations in the proposed building performance rating compared to the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2007. The requirements of the ASHRAE standard are cost-effective and support the use of thermal mass for building components. Insulating to exceed the requirements of the standard is generally a wise business choice.

Building components constructed of concrete generally exhibit a property known as thermal mass. This means the components have enough heat-storage capacity to moderate daily temperature swings. Buildings constructed of cast-in-place frame, tilt-up, or insulating concrete forms (ICF) along with precast concrete and concrete masonry possess thermal mass which helps moderate indoor temperature extremes and reduces peak heating and cooling loads. In many climates, these buildings have lower energy consumption than non-massive buildings with walls of similar insulation; and heating, ventilating, and air-conditioning needs can be met with smaller-capacity equipment. This credit is prerequisite for certification and is not worth any points.

Optimize Energy Performance (Energy & Atmosphere Credit 1)
This credit is awarded if energy cost savings beyond a baseline can be demonstrated compared to a baseline building that meets the requirements of ANSI/ASHRAE/IESNA 90.1-2007. Performance must be measured by a whole building project simulation using the Building Performance Rating Method in Appendix G of the Standard. Many engineering consulting firms have the capability to model a building to determine energy savings as required using a computer-based program such as DOE2. When concrete is considered, it is important to use a program like DOE2 that calculates yearly energy use

on an hourly basis. Such programs are needed to capture the beneficial thermal mass effects of concrete.

Insulated concrete systems, used in conjunction with other energy savings measures, will most likely be eligible for points under this credit. The number of points awarded will depend on the building, climate, fuel costs, and minimum requirements of the standard. From 1 to 19 points are awarded for energy cost savings of 12% to 48% for new buildings and 8% to 44% for existing buildings.

High performance concrete building systems such as insulating concrete forms, tilt-up concrete and concrete frame construction help a building meet the requirements of LEED 2009 NC energy performance requirements.

Building Reuse (Materials & Resources Credit 1.1)

The purpose of this credit is to leave the existing building structure and shell in place when renovating. The building shell includes the exterior skin and structural system but excludes window assemblies, interior walls, floor coverings, and ceiling systems. This

credit should be obtainable when renovating buildings with a concrete frame and/or skin since concrete in buildings generally has a long life. This credit is worth 1 point if 55% of the existing building structure and shell is left in place and 2 points if 75% is left in place and 3 points for 95% is left in place.

Construction Waste Management: Divert 50% From Disposal (Materials & Resources Credit 2.1)
Construction Waste Management: Divert 75% From Disposal (Materials & Resources Credit 2.2)
These credits are provided for diverting construction, demolition, and land clearing waste from landfill and incinerator disposal. It is awarded based on diverting at least 50% by weight of the above listed materials. Since concrete is a relatively heavy construction material and is frequently crushed and recycled into aggregate for road bases or construction fill, this credit should be obtainable when concrete buildings are demolished. In addition, returned concrete that is diverted from landfills by making landscaping blocks or recycling into new concrete can be considered for this credit. MR Credit 2.1 is worth 1 point if 50% of the construction, demolition, and land clearing waste are recycled or salvaged and MR Credit 2.2 is worth 1 additional point if 75% is diverted.

Recycled Content: 10% (post-consumer + ½ pre-consumer) (Materials & Resources Credit 4.1)
Recycled Content: 20% (post-consumer + ½ pre-consumer) Materials & Resources Credit 4.2)
The intent of these credits are to increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials. The requirements are to use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% of the total value of the materials in the project to receive 1 point (MR Credit 4.1) and 20% to receive 1 additional point (MR Credit 4.2). Supplementary cementitious materials, such as fly ash, silica fume, and slag cement are considered pre-consumer recycled content. Furthermore, using recycled concrete as aggregate instead of virgin aggregates would qualify as post-consumer recycled content. Although not considered part of concrete, most reinforcing bars are manufactured from recycled steel and considered post-consumer recycled content.

This credit is worth 1 point for 10% recycled content (MR Credit 4.1) and 1 additional point for 20% recycled content (MR Credit 4.2.).

Regional Materials, 10% Extracted, Processed & Manufactured Regionally (Materials & Resources Credit 5.1)
Regional Materials, 20% Extracted, Processed & Manufactured Regionally (Materials & Resources Credit 5.2)
The intent of these credits is 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 transportation. The requirements of these credits are to 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% (based on cost) of the total materials value for 1 point and 20% for 2 points. If only a fraction of a product or material is extracted, harvested or recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value. Ready mixed concrete will almost always qualify since ready mixed concrete plants are generally within 500 miles of a job site and most of the ingredient materials are harvested within 500 miles. The percentage of materials is calculated on a cost basis.

This credit is worth 1 point if 10% of the building materials are regional (MR Credit 5.1) and 1 additional point if 20% of the building materials are regional (MR Credit 5.2).

Daylight & Views: Daylight 75% of Spaces (Indoor Environmental Quality Credit 8.1)
Daylight & Views: Views for 90% of Spaces (Indoor Environmental Quality Credit 8.2)
The intent of these credits are to provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building. The strategy is to design the building to maximize interior daylighting and views to the outdoors through building orientation, shallow floor plates, and increased building perimeter. Concrete floor systems can span large distances with shallow floor plates and column free spaces to help achieve these credits. You can also use exposed concrete ceilings to reflect light deep into interior spaces. This credit is worth 1 point if 75% of the space has daylight (Credit 8.1) and 1 additional point if 90% of the space has views to the outdoors.

Concrete floor systems can span large distances with shallow floor systems helping improve daylights and views (Indoor Environmental Quality Credit 8.1 and 8.2)

Innovation in Design (Innovation & Design Process Credit 1)
These points can be applied for if an innovative green design strategy is used that does not fit into the point structure of the five LEED categories or if it goes significantly beyond a credit requirement in one of the existing credit categories. For example, if the project team used materials on the project such that 30% of the materials were extracted, processed & manufactured regionally then the project could receive an extra point in going significantly beyond the requirements of Materials and Resources Credit 5.2. Concrete contributes significantly to this credit category and therefore could be used to achieve an Innovation in Design credit.

Another example would be if the design team used materials on the project such that they have over 30% recycled content thereby exceeding Materials and Resources Credit 4.2 by 10 percentage points. Concrete made with some percentage of recycled aggregate in combination with supplementary materials can contribute significantly to this credit.

One strategy that has been used to obtain a LEED point in the Innovation in Design credit category is to reduce CO_2 in concrete by 40%. One way to accomplish this is by using high volumes of fly ash, slag, or silica fume in concrete such that the result is a decrease in embodied CO_2 by 40% over typical mixes in the area.

Another potential innovation is to use exposed concrete for walls, floors, and ceilings. This strategy would eliminate a significant quantity of wall and floor coverings along with ceiling materials, all of which are common sources of volatile organic compounds (VOCs) that can degrade indoor air. This strategy could significantly improve indoor air quality.

1-5 points are available under the Innovation & Design Credit.

LEED Accredited Professional (Innovation & Design Process Credit 2)
The intention of this credit is to encourage the design integration required by a LEED 2009 for New Construction green building project and to streamline the application and certification process. To achieve this credit, at least one principal participant of the project team shall be a LEED Accredited Professional (AP). Most LEED projects will have a LEED AP as a member of the design team. In addition, the concrete industry has many LEED Accredited Professionals available to help maximize points for concrete. This credit is worth 1 point.

Regional Priority Credit (Regional Priority Credit 1)
These regional bonus credits are identified by USGBC Chapters and Regional Councils for each “environmental zone” and a maximum of 4 points are available for project teams to pursue in this credit category. Each USGBC Region will have the authority to create 6 potential bonus credits, of which one may pursue a maximum of four. This is a new category of credits available under LEED 2009. This allows for the "regional authority" to designate targeted credits that are of particular importance for a region, and potentially give additional credits for projects that meet criteria in existing credit categories.

For example, in a region where urban heat island reduction is identified as an important goal, the USGBC Chapter could increase the points available for Sustainable Sites Credit 7.1 and 7.2 to 2 points each instead of 1 point thus creating greater incentive for design teams to employ heat island reduction strategies of these credits. Since concrete contributes to most credit categories it will play a significant role in achieving Regional Priority Credits. 1-4 points are available for this credit.

Benefits of LEED Certification

LEED certification is a voluntary program. However, obtaining a LEED certification demonstrates a positive environmental image to the community. Additionally, implementing green building practices can result in energy and cost savings over the life of the structure. Other advantages include better indoor air quality and plenty of daylight. Studies have shown that workers in these environments have increased labor productivity, job retention, and days worked. These benefits contribute directly to a company's profits because salaries—which are about ten times higher than rent, utilities, and maintenance combined—are the largest expense for most companies occupying building space. Students in these environments have higher test scores and lower absenteeism.

Detailed information on the LEED program and project certification process is available on the USGBC website, www.usgbc.org. More information about the environmental benefits of concrete can be found at www.nrmca.org/greenconcrete.

Sidebar:

Concrete's Potential Contribution to LEED 2009 Certification

Credit Category	Points for Concrete
Sustainable Sites (26 Points Available)	
SS Credit 2: Development Density & Community Connectivity	5
SS Credit 3: Brownfield Redevelopment	1
SS Credit 5.1: Site Development: Protect or Restore Habitat	1
SS Credit 5.2: Site Development: Maximize Open Space	1
SS Credit 6.1: Stormwater Management: Quantity Control	1
SS Credit 6.2: Stormwater Management: Quality Control	1
SS Credit 7.1: Heat Island Effect: Non-Roof	1
SS Credit 7.2: Heat Island Effect: Roof	1
Water Efficiency (10 Points Available)	
WE Credit 1.1: Water Efficient Landscaping: Reduce by 50%	2
WE Credit 1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation	2 additional
WE Credit 2: Innovative Wastewater Technologies	2
WE Credit 3: Water Use Reduction	
30% Reduction	2
35% Reduction	1 additional
40% Reduction	1 additional
Energy & Atmosphere (35 Points Available)	
EA Prerequisite 2: Minimum Energy Performance	required
EA Credit 1: Optimize Energy Performance:	
12-48% New Buildings or 8 -44% Existing Buildings	1-19
Materials & Resources (14 Points Available)	
MR Credit 1.1 Building Reuse: Maintain Existing Walls, Floors & Roof	
55% Building Reuse	1
75% Building Reuse	1 additional
95% Building Reuse	1 additional
MR Credit 2.1 Construction Waste Management, Divert 50% From Disposal	1
MR Credit 2.2 Construction Waste Management, Divert 75% From Disposal	1 additional
MR Credit 4.1 Recycled Content, 10% (post-consumer + ½ pre-consumer)	1
MR Credit 4.2 Recycled Content, 20% (post-consumer + ½ pre-consumer)	1 additional
MR Credit 5.1 Regional Materials, 10% Extracted, Processed & Manufactured Regionally	1
MR Credit 5.2 Regional Materials, 20% Extracted, Processed & Manufactured Regionally	1 additional
Indoor Environmental Quality (15 Points Available)	
EQ Credit 8.1: Daylight & Views: Daylight 75% of Spaces	1
EQ Credit 8.2: Daylight & Views: Views for 90% of Spaces	1
Innovation and Design Process (6 Points Available)	
ID Credit 1: Innovation in Design	1-5
ID Credit 2: LEED Accredited Professional	1
Regional Priority (4 Points Available)	
RP Credit 1: Regional Priority Credit	1-4
Total	**37-62**

LEED 2009 Scoring System	
Certified	40-49 points
Silver	50-59 points
Gold	60-79 points
Platinum	80+ points