Ready Mixed Concrete Industry

LEED Reference Guide

Updated Third Edition with LEED 2009 Information

RMC RESEARCH & EDUCATION FOUNDATION

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The Ready Mixed Concrete Industry LEED Reference Guide

Third Edition

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This document was underwritten by the Ready Mixed Concrete (RMC) Research & Education Foundation and the Portland Cement Association (PCA). The original version was researched and written by Steven Winter Associates, Inc. (SWA), (www.swinter.com). The Third Edition was edited and revised by Lionel Lemay, PE, SE, LEED AP, CAE and Erin Mack Ashley, PhD, LEED AP of the National Ready Mixed Concrete Association (NRMCA). The project was managed by NRMCA.

The RMC Research & Education 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 U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED®) 2009 for New Construction and Major Renovations (LEED 2009 NC). This document will guide the reader in understanding the LEED system 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 & Education Foundation, Silver Spring, Maryland, USA, October, 2009.

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EXECUTIVE SUMMARY

Of all the green building design and construction evaluation programs in the Unites States, the U.S. 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 & Education 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 green 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; 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. A summary of how concrete contributes to LEED 2009 NC is provided in Table 1.

TABLE 1 - Potential LEED Credits for Ready Mixed Concrete

Concrete contributes to this LEED Credit		
Incidental concrete use in this LEED Credit		
Sustainable Sites		**26 Possible Points**
Prerequisite 1	Construction Activity Pollution Prevention	Required
Credit 1	Site Selection	1
Credit 2	Development Density and Community Connectivity	5
Credit 3	Brownfield Redevelopment	1
Credit 4.1	Alternative Transportation—Public Transportation Access	6
Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
Credit 4.4	Alternative Transportation—Parking Capacity	2
Credit 5.1	Site Development—Protect or Restore Habitat	1
Credit 5.2	Site Development—Maximize Open Space	1
Credit 6.1	Stormwater Design—Quantity Control	1
Credit 6.2	Stormwater Design—Quality Control	1
Credit 7.1	Heat Island Effect—Nonroof	1
Credit 7.2	Heat Island Effect—Roof	1
Credit 8	Light Pollution Reduction	1
Water Efficiency		**10 Possible Points**
Prerequisite 1	Water Use Reduction	Required
Credit 1	Water Efficient Landscaping	2-4
Credit 2	Innovative Wastewater Technologies	2
Credit 3	Water Use Reduction	2-4
Energy and Atmosphere		**35 Possible Points**
Prerequisite 1	Fundamental Commissioning of Building Energy Systems	Required
Prerequisite 2	Minimum Energy Performance	Required
Prerequisite 3	Fundamental Refrigerant Management	Required
Credit 1	Optimize Energy Performance	1-19
Credit 2	Onsite Renewable Energy	1-7
Credit 3	Enhanced Commissioning	2
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement and Verification	3
Credit 6	Green Power	2
Materials and Resources		**14 Possible Points**
Prerequisite 1	Storage and Collection of Recyclables	Required
Credit 1.1	Building Reuse—Maintain Existing Walls, Floors and Roof	1-3
Credit 1.2	Building Reuse—Maintain Existing Interior Nonstructural Elements	1
Credit 2	Construction Waste Management	1-2
Credit 3	Materials Reuse	1-2
Credit 4	Recycled Content	1-2
Credit 5	Regional Materials	1-2
Credit 6	Rapidly Renewable Materials	1
Credit 7	Certified Wood	1
Indoor Environmental Quality		**15 Possible Points**
Prerequisite 1	Minimum Indoor Air Quality Performance	Required
Prerequisite 2	Environmental Tobacco Smoke (ETS) Control	Required
Credit 1	Outdoor Air Delivery Monitoring	1
Credit 2	Increase Ventilation	1
Credit 3.1	Construction Indoor Air Quality Management Plan—During Construction	1
Credit 3.2	Construction Indoor Quality Management Plan—Before Occupancy	1

Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
Credit 4.3	Low-Emitting Materials—Flooring Systems	1
Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
Credit 5	Indoor Chemical & Pollutant Source Control	1
Credit 6.1	Controllability of Systems—Lighting	1
Credit 6.2	Controllability of Systems—Thermal Comfort	1
Credit 7.1	Thermal Comfort—Design	1
Credit 7.2	Thermal Comfort—Verification	1
Credit 8.1	Daylight and Views—Daylight	1
Credit 8.2	Daylight and Views—Views	1
Innovation and Design Process		**6 Possible Points**
Credit 1	Innovation in Design	1-5
Credit 2	LEED Accredited Professional	1
Regional Priority		**4 Possible Points**
Credit1	Regional Priority	1-4
Total Points		**110 Possible Points**
Certified 40-49 points Silver 50-59 points Gold 60-79 points Platinum 80 points and above		

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. Several versions of the LEED rating system have been issued since its inception including LEED 2.0, 2.1, 2.2, and most recently, LEED 2009. LEED 2009 for New Construction and Major Renovations (LEED 2009 NC) was approved by USGBC members in November 2008 and officially issued for public use in April 2009. June 27, 2009, was the last date projects could register under the old LEED NC version 2.2 system. All new projects registering after June 27, 2009 must use LEED 2009 NC.

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 number of registered LEED projects started slowly, this number has grown dramatically from 12 registered LEED projects in 1999 to 24,789 by June 2009. The number of LEED certified projects reached 3,111 in June 2009 equating to 385 million square feet of LEED certified commercial space.

LEED certification can be achieved at a Certified, Silver, Gold, or Platinum level based on how many of the 110 LEED 2009 NC Credits are awarded after a project meets eight LEED Prerequisites. The LEED 2009 NC Rating System divides these credits and prerequisites into seven credit categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design, and Regional Priority. 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 2009 NC includes requirements suitable for multi-family residential high-rise projects, institutional buildings, and hotels. Existing projects undergoing significant renovation such as HVAC renovation, significant envelope modifications, and major interior rehabilitation can also use LEED 2009 NC. USGBC created several additional rating systems for other project types; LEED for Commercial Interiors, LEED for Existing

Buildings, LEED for Core and Shell, LEED for Schools, and LEED for Homes. Several new rating systems are under development including LEED for Neighborhood Development, LEED for Healthcare, LEED for Retail, LEED for Retail Interiors, and LEED for Existing Schools. This document addresses only LEED 2009 NC for New Construction and Major Renovations.

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 Green Building Certification Institute (GBCI) website (www.gbci.org). GBCI was created by USGBC to manage project and personnel certification programs. Project registration is initiated 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. The registration fee is $450 for USGBC members and $600 for non-members. The registration process entitles the project team access to LEED Online, a special website designed to help project team members navigate through the project certification process and Credit Interpretation Requests (CIR). CIRs are made through LEED Online when the team members deem that compliance with a credit's intent can be met without meeting the letter of a given Credit Requirement. 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 an application for LEED certification to the GBCI at about the same time as Substantial Completion.

The application for LEED certification includes documentation supporting compliance for all LEED Prerequisites and targeted LEED credits. The application is accompanied by a certification fee that can range from $2,250 to $22,500 for USGBC members ($2,750 to $27,500 for non-members) depending on the type of certification and size of the building in square feet. The application, submitted through LEED Online, includes detailed information on the required format for the LEED application. Once the project representative has submitted the application to GBCI, a review process begins. The GBCI will issue a preliminary review of the LEED application within 25 business days. This first formal preliminary review will detail which credits are accepted, which credits need additional documentation. The preliminary review provides descriptions of the additional documentation materials required. The project team then has 25 business days to provide the requested materials to the GBCI. The final review then occurs within 15 business days from the date in which the GBCI receives the additional requested materials. There is also an appeals process if the project team disagrees with GBCI review rulings.

If upon final review the project meets requirements for certification, a set of LEED Certified, Silver, Gold, or Platinum Certificates are issued to the design team in recognition of the LEED Rating earned. A LEED plaque is then ordered for display on the project.

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 GBCI during the review period.

The Ready Mixed Concrete Industry LEED Reference Guide

This document presents 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 document is 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 2009 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 2009 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 2009 NC CREDITS

Sustainable Sites

SS Credit 6.1: Stormwater Design - Quantity Control

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

Requirements

CASE 1. Sites with Existing Imperviousness 50% or Less

OPTION 1

Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the 1- and 2-year 24-hour design storms.

OR,

OPTION 2

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

CASE 2. Sites with Existing Imperviousness Greater Than 50%

Implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the 2-year 24-hour design storm.

SS Credit 6.2: Stormwater Management - Quality Control

Intent: To limit disruption of natural water flows by managing stormwater runoff

Requirements

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

BMPs used to treat runoff must be capable of removing 80% of the average annual post-development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if:

They are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards,

OR,

There exists infield performance monitoring data demonstrating compliance with the criteria Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP] Washington State Department of Ecology) for BMP monitoring.

Summary of Concrete Applications and Materials Relevant to the Credits

LEED includes Stormwater Management 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.

Common and well documented uses of concrete for stormwater management include piping, collection systems and wastewater treatment. 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. Pervious paving has many advantages in addition to meeting LEED credit requirements. It is a consistently improving technology 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, including rain gardens and bio-retention swales, can be added to filter out particles before they flow onto the pavement).

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.

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

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

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. Pervious pavement is an infiltration practice, and may not be appropriate at stormwater hot spots due to the potential for groundwater contamination. These areas include commercial nurseries, auto recycle facilities, fueling stations, 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.

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

Recharging Groundwater Below Pervious Concrete Paving

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

Some data suggest that as much as 70% to 80% of annual rainfall will go toward groundwater 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 groundwater levels. In theory, pretreatment and treatment by the pervious paving should reduce the depth of soil above seasonal high groundwater levels.

Other criteria include:

- The pervious pavement system should be designed such that the water stored in the aggregate base reservoir drains down within 5 days after a storm. In some cases, where infiltration rates of the in-situ soils are relatively low, a combination of an aggregate base, drainage pipes, rain gardens, and bio-retention swales can be used to channel the excess water to holding ponds or underground storage (French drain).
- Generally, the bottom of the stone reservoir should be flat so that infiltrated runoff will be able to infiltrate through the entire surface.
- Consider placing pervious pavement at least 2' above the seasonally high groundwater table, and at least 100' away from drinking water wells.

Designs may also require the inclusion of devices to convey to the storm drain system excess water from storms that exceed the design storage capacity of the pervious pavement system. 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.

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 Certified, preferably at the Installer or Craftsman level. For infiltrating systems (the great majority of cases), the use of pervious pavement does create risk of groundwater 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 groundwater, possibly contaminating drinking water supplies. Therefore, until more scientific data is available, it is not advisable to construct porous pavement near groundwater drinking supplies.

Special planning and expertise is necessary for proper placement and design of pervious pavement. Retrofit may require redesigning and rebuilding the sub-base for proper drainage.

Codes and Standards

Any paving must meet requirements for material quality, strength, porosity, 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 stormwater control 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 SS Credit 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 WE Credit 1. If no irrigation is required for a project, four 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.

Installation

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

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

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. Allow traffic after seven day curing period.

If random cracks are not desired, form control (contraction) joints at 20 foot intervals (or shorter) 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 SS Credit 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 letters.

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 & Education 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.

www.perviouspavement.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 – Specifications for pervious concrete paving is available on this website for the Georgia Concrete and Products Association.

www.concreteanswers.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.

http://www.epa.gov/npdes/pubs/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 information.

http://www.ct.gov/dep/lib/dep/water_regulating_and_discharges/stormwater/manual/CH11_PP_S-6.pdf provides a description of permeable pavement as a stormwater BMP.

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

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

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SS Credit 7.1: Heat Island Effect - Nonroof

Intent: Reduce heat islands to minimize impact on microclimate and human and wildlife habitats.

Requirements

OPTION 1

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

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

OR,

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

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

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

than 50% of the non-roof impervious surface paving on a given project or less than 50% when combined with other strategies. 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.

Another strategy involving concrete is to place 50% of the parking spaces on a project undercover, including underground, under deck, or under roof, or under a building. Examples include two story parking decks with concrete surface top level, an underground parking area with vegetated roof or concrete roof, or a parking deck within the footprint of a building. Concrete is typically the material of choice for parking structures.

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. In rare cases, concrete albedo can fall just below 0.30. Concrete containing slag cement is sometimes naturally lighter than ordinary concrete, and makes use of a pre-consumer recycled material. Fly ash may sometimes lower the albedo of the concrete and in other case increase it. When using either slag cement or fly ash, the actual albedo of the concrete should 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 should be tested. *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,

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.

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. 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 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 and therefore whitetopping has not experienced widespread use. However, as existing roadways and parking lots are being resurfaced, whitetopping becomes a viable option for achieving this credit.

UTW is placed as follows: the existing roadway is milled to a uniform depth 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 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 pervious and has the required albedo, it can help meet both this credit and credit SS Credit 6.1. However, pervious concrete is not considered to meet the requirements of open-grid paving since it is less than 50% pervious. 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. Pervious concrete can only contribute to this credit under the high albedo option.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

SS Credit 7.1 requires the use of "light colored/high albedo materials (reflectance of at least 0.3) for 50% of the site's non-roof impervious surfaces," or less if combined with other strategies for reducing heat islands. The reflectance level of applicable materials must be adequately documented to earn this credit. Project teams do not need to provide project-specific data measuring SRI values of new gray or white concrete. Documentation certifying that the concrete mix used for a project is equivalent to a previously used and tested mix is acceptable. Alternatively, the SRI values for typical paving materials provide in the USGBC LEED reference guide which lists new gray concrete as SRI of 35.

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. 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.

REFERENCES AND INFORMATION SOURCES

Resource Websites

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www.whitetopping.com/news.asp#iprf

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

http://www.concreteparking.org/Whitetopping

Resource Documents

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ENERGY AND ATMOSPHERE

EA Prerequisite 2: Minimum Energy Performance

Intent: To establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental impacts associated with excessive energy use.

Requirements

In general, this prerequisite will require that the building team demonstrate a 10% improvement in the proposed building performance rating for new buildings, or a 5% improvement in the proposed building performance rating for major renovations to existing buildings, compared with the baseline building performance rating using ANSI/ASHRAE/IESNA Standard 90.1-2007. There are other options for meeting the requirements of this credit but this is the one that will be used in most cases.

EA Credit 1: Optimize Energy Performance

Intent: To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

Requirements

There are three options for achieving this credit. Only Option 1 will be presented here since this is the only option that incorporates the benefits of concrete in achieving this credit.

Demonstrate a percentage improvement in the proposed building performance rating compared with the baseline building performance rating. Calculate the baseline building performance according to Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without amendments), using a computer simulation model for the whole building project. The minimum energy cost savings percentage for each point threshold is as follows:

New Buildings	Existing Building Renovation	Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

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. EA Prerequisite 2 requires a 10% improvement on energy performance that meets ASHRAE 90.1-2007, while EA Credit 1 provides up to 19 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 and roof, using insulated wall and roof technologies. The mass effect of concrete can also play a role in satisfying the prerequisite and in achieving points under EA Credit 1, 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.

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 beads.

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

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

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

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.

Removable Form Systems: 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, Indoor Air Quality IAQ Credit 2, Increase Ventilation, is easily gained by the HVAC designer. ICFs also reduce the temperature and humidity variables which facilitate the maintenance and comfort ranges for IAQ Credit 7, Thermal Comfort–Design.

EA Prerequisite 2 requires that the building demonstrate 10% improvement over the base case building. ASHRAE 90.1 requires 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 EA Credit 1, Optimized 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 rating 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 three points under EA Credit 1. 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 often higher than 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 is gaining in popularity for commercial building use.

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 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 in contact with the sun's rays, 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 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 MR Credit 4: Recycled Content. Similarly, these materials can contribute to MR Credit 5: Regional Materials.

MR Credit 4: 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
1730 Dewes Street, Suite #2
Glenview, IL 60025
Phone: 888-864-4232
Fax: 847-657-9728
www.forms.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
www.concretebuildings.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: 320-213-5555
www.tilt-up.org

Concrete Foundations Association
113 First Street West
P.O. Box 204
Mount Vernon, IA 52314
319-895-6940
Fax: 320-213-5556
www.cfawalls.org

Books and Publications

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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

MATERIALS AND RESOURCES CREDITS

MR Credit 2: Construction Waste Management

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

Requirements

Develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on site or comingled. Calculations can be done by weight or volume, but must be consistent throughout. Excavated soil and land clearing debris do not contribute to this credit.

This credit is worth 1 point if the project recycles and/or salvages at least 50% of construction and demolition, debris. The credit is worth 2 points if the project recycles or salvages at least 75% of construction and demolition debris. Remember that salvage may include the donation of materials to charitable organizations such as Habitat for Humanity.

Summary of Concrete Applications and Materials Relevant to the Credit

The USEPA has estimated that construction and demolition (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 MR Credit 2, 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 MR Credit 4, 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 Material Reuse, Recycled Content or Regional Materials Credits. Material 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 Materials 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 MR Credit 4, 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 MR Credit 2 and MR Credit 4, 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 Credit 2, and not toward the Recycled Content credit, MR Credit 4, 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 construction manager (CM) or general contractor (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 Material Reuse, Recycled Content, or Regional Materials 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

A project’s construction waste management plan should, at a minimum, identify the diversion goals, relevant construction debris and materials to be diverted, implementation protocols and parties responsible for implementing the plan.

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

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 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: http://www.sustainabledesignguide.umn.edu/

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

MR Credit 4: Recycled Content

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

Requirements for MR Credit 4

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 materials in the project for one point, 20%* of the total value of materials on the project for 2 points.

* 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; steel reinforcement; and recycled wood products used for non-rented wood formwork.

Using SCM's and recycled aggregate 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 ID Credit 1 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 pre-consumer 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).

Pre-consumer 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 1,500˚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 contributes 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.

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 in Concrete."
- ASTM C989 “Standard Specification for Slag Cement for Use in Concrete and Mortars.”
- ASTM C1240 “Standard Specification for Silica Fume Used in Cementitious Mixtures.”
- ASTM C 595 "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 C595) 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 MR Credit 2, Construction Waste Management, and not MR Credit 4, 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 MR Credit 4. 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 MR Credit 2, because it has been diverted from a landfill.

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 90% 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 MR Credit 7, “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 MR Credit 7 may be available as recycled material at the discretion of the project team. 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 IEQ Credit 4.4 within the building envelope). Composite wood without added UF resins is available with recycled content.

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

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/or 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 MR Credit 7). 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 pre-consumer recycled content in that material. This requirement also applies to any recycled wood used for non-rented formwork.

Sample Spreadsheets:

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**	

The above is a spreadsheet that covers most of the calculations and record-keeping that might be involved in pursuing LEED Credits for Recycled Content (MR Credit 4), Regional Materials (MR Credit 5), and FSC Certified Wood (MR Credit 7), 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.

Two calculation methods exist for the Recycled Content Credit when supplementary cementitious materials are used. The first method is the standard calculation where the recycled content is calculated as a fraction of the total concrete mix. The second calculation method allows for the recycled content value to be based on the mass of the cementitious materials only, rather than the entire concrete mix. Typically, in concrete mixes where the recycled content is limited to supplementary cementitious material, the second calculation method provides a larger recycled content value.

NRMCA has developed a LEED calculator which aids the concrete producer or designer in the MR Credit 4 and MR Credit 5 calculations. The Recycled Content and Regional Material Calculator for the Concrete Industry (LEED calculator) is an Excel-based program which calculates the concrete's contribution to the LEED Recycled Content and Regional Material credits, specifically, LEED credits MR 4 - Recycled Content and MR 5 - Regional Materials. The calculator allows input on project information, concrete producer and other applicable information. For MR Credit 4, the Recycled Content credit, the calculator quantifies both calculation method and provides the results in the method which yields the highest recycled content value. The program provides the results in a single page letter which can be provided to the LEED Accredited Professional, project manager or building owner. The calculator is available for purchase on NRMCA's website: www.nrmca.org.

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

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

MR Credit 5: Regional Materials

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

Requirements

Use a minimum of 10% for one point, 20% for two points, of building materials that are extracted, harvested or recovered, as well as manufactured within a radius of 500 miles of the project site.

If only a fraction of a product or material is extracted, harvested, or recovered and manufactured locally, then only that percentage (by weight) must contribute to the regional value.

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.

DESIGN ISSUES

Details

For this credit LEED defines the term "Manufactured" as the place where the final assembly of components into the building product furnished and installed by the tradesmen. For example, from the LEED 2009 Reference Guide, "…if the hardware comes from Dallas, the lumber from Vancouver, and the joist is assembled in Kent, Washington, then the location of the final assembly is Kent, Washington."

The raw material sources required for MR Credit 5 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.

TRADE CONTRACTOR AND MANUFACTURER ISSUES

Specifications

LEED Requirements for the Regional Materials 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 a request for information (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 Material Credit (MR Credit 5), 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 record of the manufacturer's names, product costs, distances between the project and manufacturer, and distances between the project and the extraction site.
- A letter from the product manufacturer indicating the location of manufacture and, if applicable, extraction of a given product may be required. 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 Pre-consumer recycled content. 5% of this material is extracted and 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.

NRMCA has developed a LEED calculator which aids the concrete producer or designer in the MR Credit 4 and MR Credit 5 calculations. The Recycled Content and Regional Material Calculator for the Concrete Industry (LEED calculator) is an Excel-based program which calculates the concrete's contribution to the LEED Recycled Content and Regional Material credits, specifically, LEED credits MR 4 - Recycled Content and MR 5 - Regional Materials. The calculator allows input on project information, concrete producer and other applicable information. The program provides the results in a single page letter which can be provided to the LEED Accredited Professional, project manager or building owner. The calculator is available for purchase on NRMCA's website: www.nrmca.org.

MR Credit 7: Certified Wood

Intent: Encourage environmentally responsible forest management.

Requirements

Use a minimum of 50% (based on cost) of wood-based materials and products,

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

certified in accordance with the Forest Stewardship Council's Principles and

Criteria, for wood building components. These components include at a minimum, structural framing and general dimensional framing, flooring, sub-flooring, wood doors and finishes. Wood products purchased for temporary use on the project (e.g., formwork, bracing, scaffolding, sidewalk protection and guard rails) may be included in the calculations at the project team's discretion.

Background: the Forest Stewardship Council (FSC)

The FSC is an independent, not-for-profit, non-government, international organization based in Bonn, Germany. It was 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, over 100 million hectares in 79 countries have been certified according to FSC standards while several thousand products carry the FSC trademark.

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 this project only 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 IEQ Credit 4.4 (Low-Emitting Materials – Composite Wood and Agrifiber Materials). 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
1, rue de Varembé, Case postale 56
CH-1211 Geneva 20, Switzerland
Telephone +41 22 749 01 11
www.iso.org

Canadian Standards Association
178 Rexdale Boulevard
Toronto, Ontario, M9W 1R3, Canada
Tel: 416-747-4000
1-866-797-4272
www.certifiedwood.csa.ca

INNOVATION IN DESIGN CREDITS

Sustainable design strategies and measures are constantly evolving and improving. New technologies are continually introduced to the marketplace, and up to date scientific research influences building design strategies. The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies.

For LEED NC 2009, two Innovation in Design credits exist, ID Credit 1 and ID Credit 2. The intent of ID Credit 1 is to provide design teams and projects the opportunity to achieve exceptional performance above and beyond what is provided in the LEED credits and/or innovative performance in green building that is not addressed by the current LEED credits. For ID Credit 1, one point is awarded for each innovation achieved for a maximum of 5 points.

The intent of ID Credit 2 is to support and encourage the design integration required by LEED to streamline the application and certification process. For ID Credit 2, one point is awarded if one principal participant of the project team is a LEED Accredited Professional.

GENERAL DISCUSSION

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.

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."

The Credit Interpretation Request (CIR) and ruling process is designed to allow Project Teams to obtain technical and administrative guidance on how LEED requirements including Minimum Program Requirements, Prerequisites, and Credits pertain to their projects. Existing CIRs are available on the USGBC website.

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.

How to Submit for ID Credits

Provide the proposal(s) within the LEED Letter Template. Document the process by which the project team has worked to develop and/or implement environmental benefits beyond the requirements set forth by the LEED Green Building Rating System and/or innovative performance in other areas. Track development and implantation of the specific exceptional and innovative strategies used.

ID Credit 1: Exemplary Performance

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.

Achieving SS Credit 6.1, Stormwater Design – Quantity Control, 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.

SS Credit 6.2, Stormwater Design – Quality Control: An Innovation point for this credit would involve exceeding the rates of TSS and TP removal, plus removing other compounds that commonly pollute groundwater. A CIR would be necessary to confirm higher limits with the USGBC.

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.

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.

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

SS Credit 7.1, Heat Island Effect - Nonroof: As noted in the discussion under this Credit, there are several combinations of 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, past 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).

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%.

EA Prerequisite 3, Minimum Energy Performance, and EA Credit 1, Optimize Energy Performance: Exemplary performance for EA Credit 1, 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.

MR Credit 2: 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 previous 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.

MR Credit 4, Recycled Content: This credit provides 1 point for 10 percent recycled content and 2 points for 20 percent recycled content. The next logical step in the credit requirement would be 30% recycled content to achieve an ID point. By using concrete with exceptionally high recycled content (SCMs, Aggregates, etc.), concrete could contribute to an ID credit here.

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 MR Credit 4, if not an Innovation Credit for exemplary performance under MR Credit 4.

MR Credit 5: Regional Materials: To achieve this credit, the project must have 10% regional materials for 1 point and 20% for 2 points. Presumably, to achieve an Innovation Credit for MR Credit 5, the total percentage of regionally extracted and manufactured materials must be at least 30% of the total materials cost.

MR Credit 7, 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 requirement 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 MR Credit 7 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.

ID Credit 1: Innovation In Design

Summary of Concrete Applications and Materials Relevant to the Credit

Forty Percent Reduction in the Use of Portland Cement

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 MR Credit 4.

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 MR Credit 4. 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 a past CIR.

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.

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 MR Credit 4.].

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.

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

- 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

RP Credit 1: Regional Priority

Intent: To provide an incentive for the achievement of credits that address geographically-specific environmental priorities.

Requirements: Earn 1-4 of the 6 Regional Priority credits identified by the USGBC regional councils and chapters.

Summary of Concrete Applications and Materials Relevant to the Credit

These regional bonus credits are identified by USGBC Chapters and Regional Councils for each “environmental zone” and a maximum of four points are available for project teams to pursue in this credit category. Each USGBC Region will have the authority to create six 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. Since concrete contributes to many credit categories it will play a significant role in achieving Regional Priority credits. 1-4 points are available for this credit. 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.

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 Credit 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 Credit 5.1: Site Development - Protect or Restore Habitat

On greenfield sites, limit site disturbance including earthwork and clearing of vegetation to 40' beyond the building perimeter, 10' beyond surface walkways, patios, surface parking and utilities less than 12" in diameter, 15' beyond primary roadway curbs, walkways and main utility branch curbs and main 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) or 20% of the total site area (including 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 SS 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 Credit 7.2: Heat Island Effect - Roof

Use roofing materials with solar reflectance index (SRI) of 78 or higher for roofs with less than 2:12 slope and SRI of 29 or higher for roofs with greater than 2:12 slope.

OR,

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

OR,

A combination of high albedo and vegetated roof.

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 Credit 1: Water Efficient Landscaping

Reduce potable water consumption for irrigation by 50% from a calculated midsummer baseline case for two points. Eliminate potable water consumption for irrigation for an additional 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 –SS Credit 6.1 and 6.2).

WE Credit 2: Innovative Waste Water Technologies

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

OR,

Treat 50% 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 (SS Credit 6.1 and 6.2).

MR Credit 1.1: Building Reuse - Maintain Existing Walls, Floors and Roof

Maintain the existing building structure (including structural floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and nonstructural roofing materials).

Maintain at least 55% of the existing structure for 1 point, 75% for 2 points and 95% for 3 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 Credit 6: Rapidly Renewable Materials

Use rapidly renewable building materials and products (made from plants that are typically harvested within a ten-year cycle or shorter) for 2.5% of the total value of all building materials and products used in the project, based on cost, for one point.

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.

IEQ Credit 4.1: Low-Emitting Materials – Adhesives and Sealants

Adhesives must meet or exceed the VOC limits of South Coast Air Quality Management District Rule # 1168.

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"

IEQ Credit 4.2: Select Low-Emitting Materials – Paints and Coatings

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"

IEQ Credit 4.3: Low-Emitting Materials – Floor Systems

The intent of this credit is to reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well being of the occupants. All carpet and carpet cushion installed in the building must meet the testing and product requirements of the Carpet and Rug Institute Green Label Plus program. All carpet adhesive must meet the requirements of IEQ Credit 4.1. All hard surface flooring must be compliant with the FloorScore Standard by an independent third party. Concrete, wood, bamboo and cork floor finishes such as sealer, stain and finish must meet the requirement of South Coast Air Quality Management District Rule 1113, Architectural Coatings, rules In effect on January 1, 2004.

A second option for achieving this credit is to have all flooring elements installed in the building interior meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions using small scale environmental chambers.

IEQ Credit 5: Indoor Chemical and Pollutant Source Control

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

1) Employ permanent entryway systems of at least 10 foot long (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) sufficiently exhaust each space to create negative pressure when the doors are closed. Provide segregated areas with self closing doors and 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 5 PA (0.02" of water gauge) on average and 1 Pa (0.004" of water gauge) at a minimum when the doors to the rooms remain closed.

3) In mechanically ventilated buildings, install new air filtration media in regularly occupied areas prior to occupancy. These filters must provide a minimum efficiency reporting value (MERV) of 13 or higher. Filtration should be applied to process both return and outside air that is delivered as supply air.

4) Provide containment 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.

IEQ Credit 7.1: Thermal Comfort - Design

Comply with ASHRAE Standard 55-2004 for thermal comfort standards within established ranges per climate zone. Humidity control is no longer required.

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.

After considerable effort from NRMCA to formulate more stringent and updated requirements, two new standards were developed. These were ASTM C 1602/C 1602M-06 "Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete;" and ASTM C 1603/C 1603M-05a "Standard Test Method for Measurement of Solids in Water." As explained by NRMCA's Colin Lobo, Senior 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."

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

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 Credit 2 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.

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 SS

Credit 5.1, 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

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

APPENDIX A – Sample Letter from Ready Mixed Concrete Producer

Two Options Exist for Sample Letters provided by the ready mixed concrete producer for a LEED project. The first option provides exact mix designs and price information for all materials and allows the LEED AP to perform the credit calculations. The second option is available when the concrete producer has completed the requisite calculations and provides a summary of the information needed by the LEED AP to verify the credit.

Option 1:
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.

SS Credit 7.1
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.

MR Credit 2
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.

MR Credit 4
Recycled Content

<u>Mix 1 PRV030 (Pervious Concrete Parking Areas)</u>

Material	Quantity (lbs/yd3)	Cost ($/lb)	Recycled Content (%)	
			Post-Consumer	Pre-consumer
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	Pre-consumer
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	Pre-consumer
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

MR Credit 5

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

Option 2:

In this case, the ready mixed concrete producer performs the calculations and provides a summary letter to the contractor or LEED AP on the project. NRMCA has software to help perform the calculations call the NRMCA LEED Calculator available at www.nrmca.org. This sample letter was provided as an output by the NRMCA LEED Calculator.)

Super Rock Concrete
123 Oak Ave.
Rockville, MD 12345
(123) 456-7890

January 1, 2009

Bob Smith
Bob's Construction
456 Smith Ave.
Washington, DC 12345

To whom it may concern:

This letter is to certify that the concrete supplied by Super Rock Concrete for the Bob's Construction Project has the properties, quantities, and costs related to the following LEED credits.

MR Credit 4
Recycled Content

The total cost of concrete supplied to this project is $600,000. 0.00% of the concrete is post-consumer recycled content (by weight) and 8.33% of the concrete is pre-consumer recycled content (by weight). The total recycled content value of the concrete on this project is $25,000. More information on the concrete components can be provided as needed.

MR Credit 5
Regional Materials

The concrete provided for this project was manufactured 25 miles from the project site and contributes to the regional materials credit. The total value of the concrete provided is $600,000.00, 90.6% of which was extracted regionally. The total value of the concrete contributing to the regional materials credit is $543,600.00. Information on individual mix designs can be found on the following page(s).

Best Regards,
Robert Rock III
Super Rock Concrete

Notes

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