

Concrete and Leed



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Sustainable development is becoming an important component of building and construction throughout the world. Many organizations, agencies and governments are developing standards and rating systems as tools to promote sustainable or 'green' construction. In fact, the International Code Council is currently working on an International Green Construction Code (IGCC), for which a draft is out for comment. This code would address many sustainability items, especially energy efficiency. One of the alternative compliance paths available in the proposed IGCC is the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 189.1, for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings.

One of the premier rating systems already available for use has been developed by the US Green Building Council (USGBC). It is referred to as LEED™, which stands for Leadership in Energy and Environmental Design. The LEED rating system is actually a suite of various tools for different applications, ranging from large commercial projects, to neighborhood developments and homes. The flagship rating system is for New Construction and Major Renovations (NC), covering commercial, institutional and large residential (greater than three story) projects. The focus of this article is an overview of the current version of LEED

™ for New Construction and Major Renovations and its potential relationship to the concrete industry.

In April of 2009, the USGBC launched LEED™ version 3.0. LEED™ for New Construction and Major Renovations within this version is currently referred to as LEED™-NC 2009. This rating system can be used on a voluntary basis for development, or may be specified as a standard by a governing body.

LEED™-NC 2009 contains a group of various requirements that must be met on a project, and then a listing of various credit options that may be chosen from to further green objectives. A project can then be certified by a sister organization of the USGBC, the Green Building Certification Institute (GBCI), as a 'green building' if it meets the required components of this rating system and also earns a sufficient number of points as available in the various credits. There are various levels of certification of a project, all which must first adhere to the required items, and then are classified on various levels of certification based upon the number of optional credit points earned. A project is classified as 'certified' with at least 40 points and 'platinum' with a minimum of 80 of the available 110 points, with 'silver' and 'gold' levels in between.

The required items and the optional items that can be followed for acquiring LEED™-NC 2009 certification are sorted into eight categories which are centered about environmental topics or other issues. These eight groupings are:

- (1) Minimum Program Requirements (MPR)

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- (2) Sustainable Sites (SS)
- (3) Water Efficiency (WE)
- (4) Energy and Atmosphere (EA)
- (5) Materials and Resources (MRs)
- (6) Indoor Environmental Quality (IEQ)
- (7) Innovation in Design (ID)
- (8) Regional Priorities (RP)

Of these eight, the Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality categories represent the main 'green' concepts for a project to consider. They provide listings of various energy and environmental impacts that can be addressed to earn specific points. The following sections describe the overall aspects of each of these eight groupings, the required components of each, the credits available in each and some examples of interface with the concrete industry based on the references as noted.

1. Minimum Program Requirements (MPR)

The Minimum Program Requirements are new to version 3.0 of LEED[™]. They consist of a list of seven aspects related to a project that are requirements from the GBCI in order to register that project for potential certification. They are as follows:

- (1) must comply with Environmental Laws
- (2) must be a Building
- (3) must use a Reasonable Site Boundary
- (4) must comply with Minimum FTE(Fulltime Employee Equivalent) and Floor Area Requirements
- (5) must comply with Minimum Occupancy Rates
- (6) must allow USGBC Access to Whole-Building Energy and Water Usage Data
- (7) must comply with the Minimum Building Area to Site Area Ratio

These requirements for the overall project are not

specifically applicable to the concrete industry, but are mainly based on the project scope, legislative requirements, and location. There are no credit points available in this category.

2. Sustainable Sites (SS)

The Sustainable Sites category mainly covers environmental issues outside of the building, on the land and in the local regional area. The prerequisite and credits are listed in Table 1, as are the range of points available for the various credits. There is one prerequisite (labeled SSp1), and eight credit subcategories (labeled SSc1-8), in which there may be multiple credits and in which a project may earn one or more points. The prerequisite mainly covers appropriate erosion, sedimentation and dust control during the construction phase of a project. These construction pollution prevention practices are already required by local or state regulations on most construction projects in the United States. LEED[™] requires them on all projects. Many of these control measures are not directly related to the concrete and cement industries. However, some of the common practices can use concrete products. Specifically construction drives and many of the erosion sedimentation dams can be made from demolished concrete aggregate, providing sustainability in the project and aiding in obtaining other credit points such as in the Materials and Resources category. The SS credit subcategories can be summarized as follows:

SSc1 Site Selection relates to choosing a site, and developing on the site, so that several sensitive environmental features are properly considered. These include threatened species habitat, prime farmland, flood plains, parklands and wetlands. The credit is not directly related to concrete.

SSc2 Development Density & Community Connectivity refers to building in areas that already have many services or existing infrastructure in order to support these already developed resources, or to build

in such a way that there are various services available to the project to avoid having to build additional infrastructure to link the project and these services. Although this subcategory does not appear to be directly related to concrete, it actually has a large concrete component. In this newer version of LEED™ SSc2 has been given a fairly high point value. Rehabilitation of existing concrete infrastructure items may become an important part of this sustainability item.

SSc3 Brownfield Redevelopment encourages developers to build on sites which are considered to be brownfields, which means sites where there is some existing contamination. Appropriate rehabilitation or consideration of the contamination is also required. This subcategory is not directly related to concrete, although concrete may be used in some remediation strategies.

SSc4 Alternative Transportation has four individual credits worth varying points. They are Public Transportation Access, Bicycle Storage and Changing Rooms, Low Emitting & Fuel Efficient Vehicles and Parking Capacity (Car/Vanpooling). The main objectives are to have alternatives to single-occupancy vehicles so that their use is reduced, and to reduce the need for extensive parking.

SSc5 Site Development has two main credit parts, Protect or Restore Habitat and Maximize Open Space. The first part encourages the use of native or adaptive landscaping, and the second part encourages any type of landscaping. In dense urban areas, outdoor pedestrian spaces with hardscapes, such as concrete, and at least a minimum amount of landscaping in the pedestrian areas, can be considered for the credit points.

SSc6 Stormwater Design is composed of two parts, Quantity Control and Quality Control. It encourages practices which prevent the impacts of stormwater runoff and stormwater pollution. Permeable pavements such as pervious concrete and concrete pavers are some of the applicable materials which may aid in obtaining these credits.

SSc7 Heat Island Effect has two credits, one for Non-roof surfaces and one for Roof surfaces. It encourages using surface types or other features that will aid in mitigating the urban heat island effect, which is a phenomenon that occurs in urban areas, where the heat storage capacity of urban materials, in addition to large energy uses, create higher temperatures than in surrounding less urban or natural regions. The three main avenues for mitigation in Option 1 for non-roof surfaces currently accepted by the USGBC are shading, a high solar reflectance index (SRI), and open grid surfaces with vegetation. Concrete is a very important material for all three mitigation paths. Concrete can be used for making architectural shading devices. Most concrete mixes have high SRIs (they reflect sunlight due to their lighter color), and there are concrete based options for grid-type permeable pavement systems that grow grass in the open areas. Pervious concrete is not currently accepted for this third mitigation pathway of Option 1. However, there is ongoing research into its potential benefits in mitigating the urban heat island effect due to its porous nature, and this may eventually lead to acceptance for innovative credit points. A second option for non-roof surfaces is to provide covered parking, which involves concrete in the development of covered parking structures. For the second credit (Roof surfaces), lighter color concrete roof surfaces will be appropriate for obtaining the credit.

SSc8 Light Pollution Reduction is a credit which considers the total light escaping from interiors of buildings during non-business hours, the amount of lighting on the site's exterior and the escape of light from a site to neighboring sites and into the night sky. Using concrete for exterior hardscapes is considered to be a pathway to aid in obtaining this credit since its lighter color may aid in maintaining adequate site visibility using lower levels of lighting.

3. Water Efficiency (WE)

The Water Efficiency category has one prerequisite and three credit subcategories which are detailed in Table 1. They encourage designs and practices which reduce the use of potable water, encourage re-use of waters and decrease the wastewater loads, both within a building and outside. The main connection to concrete and concrete structures is the use of various devices for capturing, treating, storing and distributing water which are made from concrete materials.

4. Energy and Atmosphere (EA)

The Energy and Atmosphere category has three prerequisites and six credit subcategories which are listed in Table 1 along with the various available points for the credits. The category can be sub-divided into four main areas of focus.

- (1) commissioning
- (2) reducing energy use
- (3) encouraging the use of renewable energies
- (4) reducing the use of certain refrigerants and fire protection chemicals

Commissioning is a process whereby a commissioning agent evaluates the various systems in a building to determine if they can be more efficient, and then makes sure that they are operational. Only the energy systems are focused on in the prerequisite Ap1 (Fundamental Commissioning of Building Energy Systems) and the credit subcategory EAc3 (Enhanced Commissioning). Concrete is not a usual component in most energy systems, but may be important in a possible exemplary performance point in the credit for commissioning the building envelope.

The portion of this category with the most influence on certification is energy efficiency and is very important in the design of concrete and concrete structures. There is both a minimal requirement in the prerequisite EAp2 (Minimum Energy Performance), enhanced energy performance in the credit

subcategory EAc1 (Optimize Energy Performance), and validation of the achievement of the energy goals in the credit subcategory EAc5 (Measurement and Verification). The use of concrete can aid in attaining many of the energy goals. Structures can be designed using the thermal mass aspects of concrete to minimize the use of energy for heating and cooling. Consideration can also be given to the reflective characteristics of concrete for potentially reducing lighting energy.

Both of the credit subcategories, EAc2 (On-site Renewable Energy) and EAc6 (Green Power), encourage the use of renewable energy sources both on-site and from off-site, respectively. Concrete structures are indirectly involved as structural supports or footings for many of the on-site and off-site renewable energy equipment.

The last grouping in this category deals with the reduction of the use of certain chemicals frequently used in refrigeration and fire suppression which may impact ozone levels in the stratosphere. The Refrigerant Management prerequisite and credit subcategory are listed as EAp3 and EAc4 in Table 1. The use of concrete is not directly related to these items.

5. Materials and Resources (MR)

The design and use of concrete in structures affects nearly all the credit subcategories in the Materials and Resources category. The one prerequisite, MRp1 (Storage & Collection of Recyclables) is not directly related to concrete as it deals with normal facility recycling of items used by the occupants such as paper, glass and aluminum. This prerequisite and the following credit subcategories are listed in Table 1.

The first credit subcategory is Building Reuse which means reusing existing structures in a major renovation or addition project. The first credit (MRc1.1) covers the reuse of existing structural components in a building and the second credit (MRc1.2) deals with reusing existing interior finishes

such as tiles, doors, casework and sheetrock. The three possible points available for reusing existing structural components are important to the concrete rehabilitation, repair and maintenance industry.

The second credit subcategory MRc2 (Construction Waste Management) is intended to limit the amount of construction and demolition debris going to landfills. Both concrete waste from the construction phase and any demolished concrete from the project that is reused either on-site or off-site contribute to this credit.

MRc3 (Materials Reuse) basically promotes the use of salvaged materials, where salvaged materials are items such as used brick or wood beams, salvaged from other projects, that are reused in a similar form on the current project. Items such as cinder blocks (CMUs) may be included.

MRc4 (Recycled Content) encourages the use of recycled materials on a project. Concrete may be a large contributor to this credit subcategory in many ways. Using any recycled materials for aggregate count, as does using supplementary cementitious materials (SCMs) which are wastes from other industries such as slag and fly ash. The USGBC has a special calculation specifically for SCMs. Many of the credits in the Materials and Resources category are based on using the value of the materials as a percent of the value of certain applicable materials on the project. When the recycled content is only a portion of a composite material or building component, then its 'recycled' value is based on a mass percent of the total mass of that item. Since cementitious materials are not the largest mass component of concrete, but are the major value component, the USGBC allows for this particular recycled allocation to be made as a percent of the mass of all cementitious materials and the value of the primary, non-recycled cement.

MRc5 (Regional Materials) encourages projects to procure materials that are extracted, salvaged or harvested, and then processed and/or manufactured and sold 800 kilometer radius of the project site.

Concrete is typically produced within this radius and most of the major components of concrete (by mass) are also from the region. In most cases, concrete is one of the largest contributors to obtaining points for Regional Materials.

MRc6 is a credit subcategory that encourages the use of Rapidly Renewable Materials, meaning materials that are grown in under ten years. Concrete does not fit into this category, but if any novel fibers or other materials manufactured from rapidly renewable materials are used in concrete then they apply.

Certified Wood (MRc7) is the final Materials and Resources subcategory. It encourages environmental stewardship in the use of new wood products and applies to materials permanently installed in a project. Temporary project materials used during the construction phase may also be included at the discretion of the project. In the latter case, it applies to the concrete industry with respect to wood formwork.

6. Indoor Environmental Quality (IEQ)

Very few of the prerequisites or credits in the Indoor Environmental Quality category relate directly to the concrete industry. They are listed in Table 1 along with the credit points available.

One of the prerequisites (IEQp1) and two of the credit subcategories (IEQc1 and 2) all deal with ventilation. The other prerequisite restricts smoking in most indoor spaces and near building openings.

The two Construction IAQ Management Plan credits (IEQc3.1 and IEQc3.2) all deal with Indoor Air Quality (IAQ). They encourage good housekeeping practices on a construction site such as preventing dust and chemicals from entering the various heating and air-conditioning systems or already occupied spaces, and keeping materials that might mold or mildew from getting wet.

The fourth credit subcategory, Low-Emitting Materials, encourages the use of adhesives and

sealants (IEQc4.1), paints and coatings (IEQc4.2), flooring systems such as carpeting and tiling (IEQc4.3), and various composite wood and agrifiber products (IEQc4.4) that do not emit high levels of various volatile organic compounds (VOCs). Exterior applications that do not affect the interior spaces (i.e. those which are outside of the weather-proofing system) are not a part of this subcategory. The various coatings, sealants and adhesives that might be used in conjunction with interior concrete building components would be included. The encouragement and development of products that are both low VOC and effective to use with interior concrete building components would be beneficial to both the concrete industry and indoor air quality. In addition, if concrete finishes which have little or no VOC emissions are substituted for other interior surfaces which may emit these chemicals, then they might constitute a greener alternative.

The next two credit subcategories in the Indoor Environmental Quality category; Indoor Chemical and Pollutant Source Control (IEQc5) and Controllability of Systems (IEQc6.1-Lighting and IEQc6.1-Thermal Comfort) are not specific to concrete or concrete products. The first deals with separating indoor spaces from potential air pollutants, such as providing floor to ceiling partitions between occupied spaces and chemical storage rooms. The second allows for occupant comfort in being able to have more control over either the lighting or the thermal aspects of the occupied spaces, such as with individual lighting units or thermostats.

IEQc7 also deals with Thermal Comfort, but with the design, and then the verification aspects of occupant thermal comfort. There are many building design alternatives being developed that are intended to provide greater thermal comfort and energy efficiency such as radiant floor heating or phase change materials in walls or floors. Many of these alternatives will be embedded within concrete slabs, or use the thermal mass properties of concrete in their overall system designs.

The last two credits in this category; IEQc8.1 (Daylight) and IEQc8.2 (Views), encourage the increased use of outside natural lighting in building interiors and providing views for occupants. Neither directly relates to concrete materials, except perhaps in the case of really novel concrete mixes such as the transparent or translucent concretes.

7. Innovation in Design (ID)

Points can be earned in two additional categories in LEED™-NC 2009. The first is in the Innovation in Design category. One point may be earned if an active project team member is a LEED Accredited Professional. This accreditation is earned by testing and experience in green construction, and the process is overseen by the GBCI.

Up to five additional points can be earned by a combination of having exemplary performance in some of the credits already described, or incorporating other innovative green technologies or practices in the project not otherwise listed in LEED™. The various credits which might earn an exemplary performance (EP) point for exceeding the credit goals are noted in <Table 1>. A maximum of three of these may be used towards the ID count total. Innovation points may be given for up to five innovations, less the number of EP points counted. Innovation may include not only technologies but also educational and other green outreach programs. Therefore, up to five additional points may be related to green concrete practices if they are chosen to be included in this category.

8. Regional Priorities (RP)

The Regional Priorities category is new to LEED™ 2009. It allows for an additional point to be counted from each of four credits in the SS, WE, EA, MR and IEQ categories. These four must be from a possible list of six applicable credits which are specific to a certain region. These priority credits were chosen by local and regional USGBC chapter members. The regions are listed by zip code in the United States.

Table 1. LEED™ – NC 2009 SS, WE, MR, EA and IEQ Credits, Prerequisites and Points

Item	Possible Points	EP Points
SSp1 : Construction Activity Pollution Prevention	required	na
SSc1 : Site Selection	1	-
SSc2 : Development Density & Community Connectivity	5	1 (option 1)
SSc3 : Brownfield Redevelopment	1	-
SSc4.1 : Alternative Transportation - Public Transportation Access	6	1 (1 for overall plan or 1 for SSc4.1)
SSc4.2 : Alternative Transportation - Bicycle Storage and Changing Rooms	1	
SSc4.3 : Alternative Transportation - Low - Emitting & Fuel - Efficient Vehicles	3	
SSc4.4 : Alternative Transportation - Parking Capacity (Car/Vanpooling)	2	
SSc5.1 : Site Development - Protect or Restore Habitat	1	1
SSc5.2 : Site Development - Maximize Open Space	1	1
SSc6.1 : Stormwater Design - Quantity Control	1	1 for overall plan
SSc6.2 : Stormwater Design - Quality Control	1	
SSc7.1 : Heat Island Effect - Non-roof	1	1
SSc7.2 : Heat Island Effect - Roof	1	1 (green roof)
SSc8 : Light Pollution Reduction	1	-
WEp1 : Water Use Reduction Required	required	na
WEc1 : Water Efficient Landscaping (50 ~ 100%)	2 ~ 4	-
WEc2 : Innovative Wastewater Technologies	2	1
WEc3 : Water Use Reduction (30 ~ 40%)	2 ~ 4	1
EAp1 : Fundamental Commissioning of Building Energy Systems	required	na
EAp2 : Minimum Energy Performance	required	na
EAp3 : Fundamental Refrigerant Management	required	na
EAc1 : Optimize Energy Performance - [New 12 ~ 48% (Existing 8 ~ 44%)]	1 ~ 19	1
EAc2 : On-site Renewable Energy (1 ~ 13%)	1 ~ 7	1
EAc3 : Enhanced Commissioning	2	1
EAc4 : Enhanced Refrigerant Management	2	-
EAc5 : Measurement and Verification	3	-
EAc6 : Green Power (35% ~ 2 yr)	2	1
MRp1 : Storage & Collection of Recyclables	required	na
MRc1.1 : Building Reuse-Maintain Existing Walls, Floors & Roof (55 ~ 95%)	1 ~ 3	-
MRc1.2 : Building Reuse-Maintain Existing Interior Non - Structural Elements	1	-
MRc2 : Construction Waste Management (50 ~ 75%)	1 ~ 2	1
MRc3 : Materials Reuse(5 ~ 10%)	1 ~ 2	1
MRc4 : Recycled Content (10 ~ 20%)	1 ~ 2	1
MRc5 : Regional Materials (10 ~ 20%)	1 ~ 2	1
MRc6 : Rapidly Renewable Materials	1	1
MRc7 : Certified Wood	1	1
IEQp1 : Minimum Indoor Air Quality Performance	required	na
IEQp2 : Environmental Tobacco Smoke (ETS) Control	required	na
IEQc1 : Outdoor Air Delivery Monitoring	1	-
IEQc2 : Increased Ventilation	1	-
IEQc3.1 : Construction IAQ Management Plan - During Construction	1	-
IEQc3.2 : Construction IAQ Management Plan - Before Occupancy	1	-
IEQc4.1 : Low-Emitting Materials - Adhesives and Sealants	1	-
IEQc4.2 : Low-Emitting Materials - Paints and Coatings	1	-
IEQc4.3 : Low-Emitting Materials - Flooring Systems	1	-
IEQc4.4 : Low-Emitting Materials - Composite Wood and Agrifiber Products	1	-
IEQc5 : Indoor Chemical and Pollutant Source Control	1	-
IEQc6.1 : Controllability of Systems - Lighting	1	-
IEQc6.2 : Controllability of Systems - Thermal Comfort	1	-
IEQc7.1 : Thermal Comfort - Design	1	-
IEQc7.2 : Thermal Comfort - Verification	1	-
IEQc8.1 : Daylight and Views - Daylight	1	1
IEQc8.2 : Daylight and Views - Views	1	1

Concrete industry representatives should become familiar with the credits that are considered to be regional priorities in the various markets. There are currently no regional priority listings for other countries, but it is the intention of the USGBC to include other countries as regional priorities are established there. Green building advocates and industry representatives in other countries may wish to involve themselves in this international decision making process.

LEED™ is an evolving rating system. There is much opportunity for concrete products and concrete structures to play an important role in furthering sustainable development and for the industry to involve itself in future development of this green rating tool. □

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| 한국콘크리트학회 편 | 393쪽 | ISBN 978-89-6225-188-3 93540 |
| 비회원 25,000원, 회원 20,000원 | 출판사 기문당 | 2009. 12 발행 |

□ 소 개

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