BUILDINGS

An Engineer's Guide to: Building Green with Concrete

Points for Concrete in LEED

Using concrete can facilitate the process of obtaining LEED® Green Building certification. Leadership in Energy and Environmental Design (LEED) is a point rating system devised by the U.S. Green Building Council (USGBC) to evaluate the environmental performance of a building and encourage market transformation towards sustainable design. The system is credit-based, allowing projects to earn points for environmentally friendly actions taken during the construction and use of a building. LEED was launched in an effort to develop a "consensus-based, market-driven rating system to accelerate the development and implementation of green building practices."
The program is not rigidly structured; not every project must meet identical requirements to qualify.

Three LEED products are currently available:

- LEED-NC v2.1 for new commercial construction and major renovation projects
- LEED-EB v1.0 for existing building operations
- LEED-CI v1.0 for commercial interiors projects

Five Ways Concrete Helps Build Green

1. Concrete creates sustainable sites.
2. Concrete enhances energy performance.
3. Concrete contains recycled materials.
4. Concrete is manufactured locally.
5. Concrete builds durable structures.

The LEED rating system has five main credit categories:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality

Photo by Jim Schafer Location Photography, Inc.

Clearview Elementry School, Hanover, PA, is the state's first LEED registered educational building.

Each category is divided into credits. Detailed information on the LEED program and project certification process is available on the USGBC Web site, www.usgbc.org. The program outlines the intent, requirements, technologies, and strategies for meeting each credit. Credits are broken down into individual points. Additional points can be earned for innovation, exceptional environmental performance, and the use of a LEED accredited professional on the project team.

Concrete and LEED

Using concrete can increase the number of points awarded to a building in the LEED system. The following are suggestions for earning LEED-NC v2.1 points through the use of cement and concrete products. The paragraph headings correspond to the credit categories and the credit numbers in the LEED rating system. Points must be documented according to LEED procedures in order to be earned. The USGBC Web site, www.usgbc.org, contains a downloadable "letter template" that greatly simplifies the documentation requirements for LEED v2.1. The potential available points that can be earned by using concrete range from 11 to 21.

Points for Certification for LEED-NC v2.1

At least 26 points are required for LEED certification. Silver, gold, and platinum levels are also available.

Credit Category	Points Available
Sustainable Sites	14
Water Efficiency	5
Energy and Atmosphere	17
Materials and Resources	13
Indoor Environmental Quality	15
Total Core Points	**64**
Innovation and Design Process	5

LEED Certification Levels	
Certified	26 - 32 Points
Silver	33 - 38 Points
Gold	39 - 51 Points
Platinum	52 - 69 Points

Sustainable Sites Credit 5.1. Concrete parking garages.

Brownfield Redevelopment (Sustainable Sites Credit 3). Cement can be used to solidify and stabilize contaminated soils and reduce leachate concentrations to below regulatory levels. Documentation is required indicating that the site was contaminated and the remediation performed. This credit is worth 1 point.

Reduced Site Disturbance: Protect or Restore Open Space (Sustainable Sites Credit 5.1). Concrete parking garages within buildings can be used to limit site disturbance, such as earthwork and clearing vegetation. For example, one LEED criterion is to limit site disturbance to 12m (40 ft) beyond the building perimeter. Parking garages within buildings help maintain existing natural areas that would otherwise be consumed by paved parking. This credit is worth 1 point.

Sustainable Sites Credit 6.1. Water flows freely through a section of pervious concrete pavement.

Reduced Site Disturbance: Development Footprint (Sustainable Sites Credit 5.2). Concrete parking garages on the lower floors of a building can be used to help reduce the footprint of the development. In this context the building footprint includes the building, access roads, and parking. Garages within buildings reduce the building footprint by minimizing paved parking areas. This requirement can be met by exceeding the local zoning's open space requirement for the site by 25%. This credit is worth 1 point.

Stormwater Management: Rate and Quantity (Sustainable Sites Credit 6.1). The intent of this credit is to limit disruption and pollution of natural water flows by managing stormwater runoff. Using pervious concrete pavements will reduce the rate and quantity of stormwater runoff because they increase infiltration of stormwater. Pervious concrete contains coarse aggregate, little or no fine aggregate, and insufficient cement paste to fill the voids between the coarse aggregate. It results in concrete with a high volume of voids (20% to 35%) and a high permeability that allows water to flow through easily. Similar results can be achieved by using concrete grid pavers that have large voids where vegetation can grow. On building sites where the existing imperviousness is greater then 50%, this credit requires reducing the rate and quantity of stormwater runoff by 25%. On building sites where the existing imperviousness is less than 50%, the requirement specifies that the post-development discharge rate and quantity from the site shall not exceed the pre-development rate and quantity. This credit is worth 1 point.

Landscape and Exterior Design to Reduce Heat Islands (Sustainable Sites Credit 7.1). This credit requires high albedo materials (reflectance of at least 0.3) and/or open-grid pavement for at least 30% of the site's non-roof impervious surfaces such as sidewalks, parking lots, drives, and access roads. It can be met by using concrete, light colored pavers, or open-grid pavers rather than asphalt for 30% of the impervious surfaces. Two other options include placing a minimum of 50% of parking spaces underground or covered by structured parking; or using an open-grid pavement system (less than 50% imperviousness) for a minimum of 50% of the parking lot area. Albedo, which in this context is synonymous with solar reflectance, is the ratio of the amount of solar radiation reflected from a material to

Project Checklist: LEED– New Construction (NC) v2.

How Concrete Can Contribute to Points.

Credit Categories		Possible Points
Sustainable Sites		
Credit 3	Brownfield Redevelopment	1
Credit 5.1	Reduced Site Disturbance, Protect Open Space	1
Credit 5.2	Reduced Site Disturbance, Development Footprint	1
Credit 6.1	Stormwater Management, Rate & Quantity	1
Credit 7.1	Heat Island Effect, Non-Roof	1
Energy and Atmosphere		
Prerequisite 2	Minimum Energy Performance	required
Credit 1	Optimize Energy Performance	1-10
Materials and Resources		
Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	1
Credit 1.2	Building Reuse, Maintain 100% of Existing Shell	1
Credit 2.1	Construction Waste Management, Divert 50%	1
Credit 2.2	Construction Waste Management, Divert 75%	1
Credit 4.1	Recycled Content, Use 5% (post-consumer plus 1/2 post-industrial)	1
Credit 4.2	Recycled Content, Use 10% (post-consumer plus 1/2 post-industrial)	1
Credit 5.1	Regional Materials, 20% Manufactured Regionally	1
Credit 5.2	Regional Materials, 50% Extracted Regionally	1
Innovation and Design Process		
Credit 1.1	Innovation in Design, Reduce Cement Content	1
Credits 1.2-1.4	Apply for other credits demonstrating exception performance	3*
Credit 2	LEED Accredited Professional	1
Project Totals		**25**

*Up to 3 additional points can be earned, must be submitted and approved (not included in total)

Sustainable Sites Credit 6.1. Light colored concrete panels

the amount that shines on the material. Solar radiation includes the ultraviolet as well as the visible spectrum. Generally, light-colored surfaces have a high albedo, but this is not always the case. Surfaces with lower albedos absorb more solar radiation. The absorbed radiation is converted into heat and the surface gets hotter. Where paved surfaces are required, using materials with higher albedos will reduce the heat island effect—consequently saving energy by reducing the demand for air conditioning—and improve air quality. As the temperature of urban areas increases, so does the probability of smog and pollution. Smog episodes rarely occur when the temperature is below 21°C (70°F).

Concrete constructed using ordinary portland cement generally has a reflectance of approximately 0.35, although it can vary. Measured values are reported in the range of 0.35 to 0.5. For concrete made with "white" portland cement, values are reported in the range of 0.7 to 0.8. New asphalt generally has a reflectance of approximately 0.05, and asphalt five or more years old has a reflectance of approximately 0.10 to 0.15. This credit is worth 1 point.

Minimum Energy Performance (Energy and Atmosphere Prerequisite 2). All buildings must "meet building energy efficiency and performance as required by ASHRAE Standard 90.1-1999 or the local energy code, whichever is the more stringent." The ASHRAE standard is usually more stringent and applies in most states. The requirements of the ASHRAE standard are cost-effective and not particularly stringent for concrete. Insulating to meet or exceed the standard requirements is generally a wise business choice. Determining compliance for the envelope components is relatively straightforward using the tables in Appendix B of the ASHRAE standard. Minimum requirements are provided for mass and non-mass components such as walls and floors. Components constructed of concrete generally are considered "mass." This means they have enough heat-storage capacity to moderate daily temperature swings. Buildings constructed of cast-in-place,

Solaire, Battery Park City, NY. The nation's first green residential high-rise building.

tilt-up, precast concrete, insulating concrete forms (ICF), or masonry possess thermal mass that helps moderate indoor temperature extremes and reduces peak heating and cooling loads. In many climates, these buildings have lower energy consumption than non-massive buildings with walls of similar thermal resistance. When buildings are properly designed and optimized, incorporating thermal mass can lead to a reduction in heating, ventilating, and air-conditioning equipment capacity. Reduced equipment capacity can represent energy and construction cost savings. This item is required and is not worth any points.

Optimize Energy Performance (Energy and Atmosphere Credit 1). This credit is awarded if energy cost savings can be shown compared to a base building that meets the requirements of ASHRAE 90.1-1999. The method of determining energy cost savings must meet the requirements of Section 11 of the standard. Many engineering consulting firms have the capability to perform whole building energy simulations to determine energy savings as required using a computer based program such as DOE-2 or EnergyPlus. When concrete is considered, it is important to use a program like

Concrete framed buildings provide thermal mass and have lower energy consumption than non-mass buildings.

these that calculate yearly energy use on an hourly basis. Such programs are needed to capture the beneficial thermal mass effects of concrete. Insulated concrete systems, used in conjunction with other energy-savings measures, will most likely be eligible for points. The number of points awarded will depend on the building, climate, fuel costs, and minimum requirements of the standard. From 1 to 10 points are awarded for energy cost savings of 15% to 60% for new buildings and 5% to 50% for existing buildings. Studies show that using concrete walls that are insulated to exceed minimum code requirements by a modest amount (about the same as minimum

Materials and Resources Credit 2. The picture shows machinery taking portions of concrete walls, columns, and floors and crushing them to be used as fill material.

requirements for frame walls) can contribute to earning 1 to 3 points, depending on the building type, orientation, and climate.

Building Reuse (Materials and Resources Credit 1). The purpose of this credit is to leave the main portion of the building structure and shell in place when renovating. The building shell includes the exterior walls, roof, and framing but excludes window assemblies, interior walls, floor coverings, non-structural roofing material, and ceiling systems. This credit should be obtainable when renovating buildings with concrete walls, since concrete in buildings generally has a long life. This is worth 1 point if 75% of the existing building structure/shell is left in place and 2 points if 100% is left in place.

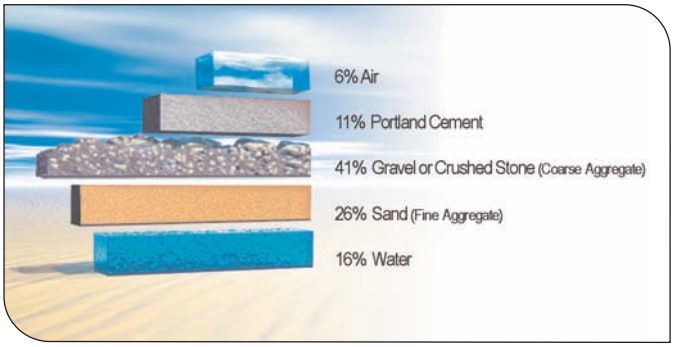
Construction Waste Management (Materials and Resources Credit 2). This credit is received for diverting construction, demolition, and land clearing waste from landfill disposal. It is awarded based on diverting at least 50% by weight of the above listed materials. Because concrete is a relatively heavy construction material and is frequently crushed and recycled into aggregate for road bases or construction fill, this credit should be obtainable when concrete buildings are demolished. This credit is worth 1 point if 50% of the construction, demolition, and land clearing waste is recycled or salvaged and 2 points for 75%.

Recycled Content (Materials and Resources Credit 4). The requirements of this credit are for using materials with recycled content. One point is awarded if the sum of the post-consumer recycled content plus one-half of the post-industrial recycled content constitutes at least 5% of the total value of the materials in the project. The value of the recycled content of a material is the weight of the recycled content in the item divided by the weight of all materials in that item, and then multiplied by the total cost of the item. Supplementary cementitious materials, such as fly ash, silica fume, and slag cement are considered post-industrial. Furthermore, using recycled concrete or slag instead of extracted

Materials and resources Credit 4. Supplementary cementitious materials are easily and widely used in concrete.

aggregates would qualify as post-consumer. Although most reinforcing bars are manufactured from recycled steel, in LEED, reinforcing is not considered part of concrete. Reinforcing material should be considered as a separate item. This credit is worth 1 point for the quantities quoted above and 2 points if the quantities are doubled to 10% combined post-consumer plus one-half post-industrial recycled content.

Regional Materials (Materials and Resources Credit 5). This credit supports the use of local materials and reduced transportation distances. The requirements state:



"Use a minimum of 20% of building materials that are manufactured regionally within a radius of 800 km (500 miles)." Concrete will usually qualify since ready-mix and precast plants are generally within 80 km (50 miles) of a job site. The percentage of materials is calculated on a cost basis. This credit is worth 1 point.

An additional point is earned if 50% of the regionally manufactured materials are extracted, harvested, or recovered within 800 km (500 miles). Ready-mix and precast plants generally use aggregates that are extracted within 80 km (50 miles) of the plant. Cement and supplementary cementitious materials used for buildings are also often manufactured within 800 km (500 miles) of a job site. Reinforcing steel is usually manufactured within 800 km (500 miles) of a job site, and is typically made from recycled materials from the same region.

Others Points

Concrete can also be used to obtain points indirectly. For example, the Pennsylvania Department of Environmental Protection building in Harrisburg, is LEED Bronze certified and features a concrete floor with low-VOC sealant. This allowed the building to obtain the Low-Emitting Materials Credit (Indoor Environmental Quality Credit 4.2). All other paints and coatings in the building must also meet certain criteria to obtain this point.

In addition to the points discussed above, 4 points are available through Innovation Credits. These points can be applied for if an innovative green design strategy is used that does not fit into the point structure of the five LEED categories or if it goes significantly beyond a credit requirement and demonstrates exceptional environmental performance. For example, the USGBC has issued a credit interpretation

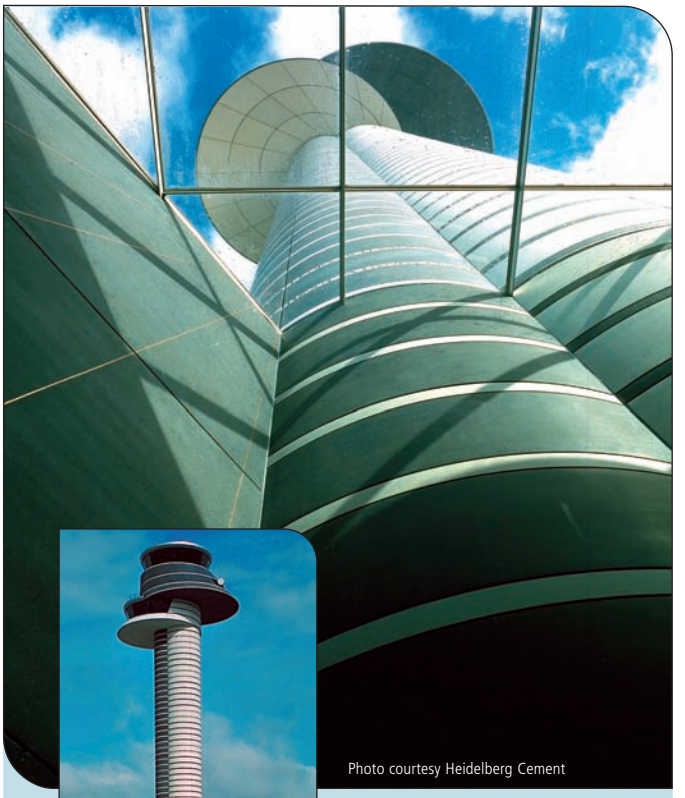
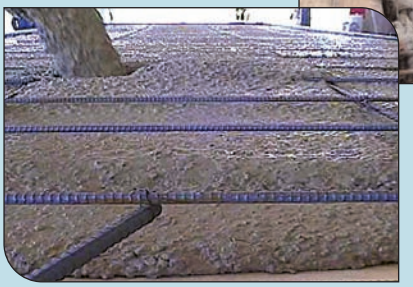


Photo courtesy Heidelberg Cement

Slim and accurate construction is much easier to realize with self-consolidating concrete. This 83-m high Stockholm Airport tower is decorated with excerpts from the work of Antoine de Saint-Exupéry. Reduced noise levels made construction during nighttime hours possible.



that allows for an innovation credit if 40% less cement is used than in typical construction, or if 40% of the cement in concrete is replaced with slag cement, fly ash, or both. Slag cement is commonly used at replacement levels up to 60%. However, using fly ash replacement levels for portland cement greater than 25% are not routine. Actual limits should be based on compatibility of fly ash with cement, experience, and concrete performance in the field or laboratory. Contact your local ready-mix concrete supplier to determine what fly ash or supplementary cementitious material is available
and to verify its performance in quality concrete.

In addition, one point is provided if a principal participant of the project team is a LEED Accredited Professional. The concrete industry has LEED-experienced professionals available to help maximize the points for concrete.

Benefits of LEED Certification

LEED is a voluntary program; however, obtaining a LEED certification projects a positive environmental image to the community. Additionally, meeting many of the green building practices can result in energy and cost savings over the life of the structure. Other advantages include better indoor air quality and increased amounts of daylight.

Walmart's experimental green store in McKinney, Texas features the latest in environmental, sustainable design including concrete parking lots and pervious paving.

Studies have shown that workers in these environments have increased labor productivity, job retention, and days worked. These benefits contribute directly to a company's profits because salaries are the largest expense for most companies occupying office space—about ten times higher than rent, utilities, and maintenance combined. In addition, students in these environments have higher test scores and lower absenteeism. Retail sales are higher in day-lit buildings.

Support for green buildings has increased rapidly each year during the last five years. Many cities and states either provide tax credits or grants for green buildings, or require green building certification for public buildings. The U.S. government is adopting green building programs similar to LEED through the General Services Administration (which owns or leases more than 8300 buildings), the U.S. Army, the Department of State, the Department of Energy, and the Environmental Protection Agency. Eight states including California, New York, Oregon, and Washington have adopted its use for public buildings. Many agencies are requiring LEED silver certification as a minimum. Thirteen countries have expressed interest in LEED including China and India; these countries have exceptionally high new building construction. Conditions vary and the list is growing, so please contact local jurisdictions or USGBC for details.

The LEED Green Building Rating System for New Construction, Version 2.1, promotes environmentally sustainable buildings for the improvement of outdoor and indoor building quality, the conservation of resources, and the reduction of waste during the building process. Concrete can be used in conjunction with the LEED program to earn certification. **For technical support and resources go to www.cement.org/buildings.**

PCA

Portland Cement Association
5420 Old Orchard Road
Skokie, Illinois 60077-1083
847.966.6200 Fax 847.966.9781
www.cement.org

An organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.