Using Concrete to Maximize LEED™ Points

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The Leadership in Energy and Environmental Design (LEED) green building rating system recognizes buildings with lessened environmental impact using a point system. LEED is both a design guideline for sustainable construction and operation, and a standard for certification. LEED takes a whole-building approach that encourages and guides a collaborative, integrated design and construction process. As a standard, it is predominantly performance-based. The LEED green building rating system, Version 2.0, is consensus-based and administered by the U.S. Green Building Council. It is intended for commercial, institutional, and high-rise residential new construction and major renovations.

Points are awarded when a specific intent is met, and a building is LEED certified if it obtains at least 26 points. Silver, gold, and platinum levels are awarded for at least 33, 39, and 52 points, respectively. There are five categories from which one can earn points: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. Using concrete can help architects and owners earn up to 18 points (out of 26 required) towards a LEED-certified building.

Sustainability is generally defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. We are a society of people who are concerned about environmental impacts, but few of us are willing to pay more for a building or product that reduces these impacts. LEED balances sustainable design with cost-effectiveness.

A sustainable design, the result of an integrated design process, can reduce project and operating costs. Energy- and water-efficient buildings have lower operating costs than conventional buildings ($0.60 to $1.50 versus $1.80/ft^2 [$6 to $16 versus $19/m^2]). Low energy costs mean smaller sizes and lower first costs for mechanical heating and cooling equipment. The effective use of daylighting and passive solar techniques can further reduce heating and cooling costs.

Reusing materials, such as demolished concrete for base or fill material, can reduce hauling and landfill costs. Labor productivity, worker retention, and days worked are all higher in buildings with daylighting and good air quality. These add to a company's profits because salaries are the largest expense for most companies occupying offices, and they are about 10 times higher than rent, utilities, and maintenance combined. If sustainability is an objective at the outset of the design process, the cost of a sustainable building is competitive.[1]

Many U.S. government agencies require buildings to meet LEED requirements, although they do not require LEED certification. These include the General Services Administration (GSA), with over 8300 owned or leased buildings, and the U.S Army, which has adopted LEED into its Sustainable Project Rating Tool (*SpiRiT*). In addition, many municipalities and government agencies are considering requiring LEED certification for government buildings.

LEED POINT SYSTEM

Concrete has the potential to earn points under the following portions of LEED. For some criteria, specific auditing or record keeping requirements must be met.

Sustainable sites

Credit 6.1 (1 point), stormwater management: For building sites where the existing imperviousness is greater then 50%, pervious concrete pavements can be used to help reduce the rate and quantity of storm water runoff. The purpose of the requirement is to reduce the rate and quantity of storm water runoff by 25%. Pervious concrete contains coarse aggregate, little or no fine aggregate, and insufficient cement paste to fill voids between the coarse aggregate. This produces a concrete with a high volume of voids (20 to 35%) and a high permeability that allows water to flow through easily. Concrete pavers with large voids where vegetation can grow can also be used.

Credit 7.1 (1 point), landscape and exterior design to reduce heat islands: One option in this requirement is to "use light-colored/high-albedo materials (reflectance of at least 0.3) for 30% of the site's nonroof impervious surfaces." This requirement can be met by using portland cement concrete rather than asphalt concrete for 30% of all sidewalks, parking lots, drives, and other nonroof impervious surfaces. Figure 1 shows an effective way to reduce heat islands using concrete and trees.

Albedo is the ratio of the amount of solar radiation reflected from a material to the amount shone on the material. Solar radiation includes ultraviolet light as well as the visible spectrum. Generally, surfaces that look light colored have a high albedo, but this is not always the case. Surfaces with lower albedos absorb more solar radiation. This is then converted into heat and the surface gets hotter. Pavements with higher albedos absorb less energy and thus are cooler. Where paved surfaces are required, using materials with higher albedos will reduce the heat island effect—thereby saving energy by reducing the demand for air conditioning—and improve air quality.

Fig. 1: Concrete pavement and trees used to mitigate the urban heat island effect *(Photo courtesy of the Portland Cement Association)*

Traditional portland cement concrete generally has an albedo or solar reflectance of about 0.35, although values can vary. Measured values are reported in the range of 0.4 to 0.5. For "white" portland cement, values are reported in the range of 0.7 to 0.8.[2] New asphalt concrete generally has a reflectance of about 0.05 and asphalt concrete 5 or more years old has a reflectance of about 0.10 to 0.15. More information on urban heat islands is available from the Lawrence Berkeley National Laboratory.

Energy and atmosphere

Prerequisite 2, minimum energy performance: All buildings must "meet building energy efficiency and performance as required by ASHRAE/IESNA 90.1-1999[3] or the local energy code, which ever is the more stringent." The ASHRAE code is usually more stringent and applies for most states. However, requirements of the ASHRAE code are cost-effective and not particularly stringent for concrete. Insulating to meet or exceed the requirements of the code is generally a wise business choice.

Determining compliance for the envelope components is relatively straightforward using the tables in Appendix B of ASHRAE/IESNA 90.1-1999. Minimum requirements are provided for mass and nonmass components such as walls and floors. Building components constructed of concrete generally are considered "mass." This means the components have enough heat-storage capacity to moderate daily temperature swings. Buildings with thermal mass, for example, insulating concrete forms (ICF) or concrete block walls, moderate indoor temperature extremes and reduce peak heating and cooling loads. In many climates, they have overall lower energy consumption and need a smaller heating, ventilating, and air conditioning (HVAC) system capacity than nonmassive buildings with walls of similar thermal resistance.[4] This item is required for LEED certification and is not worth any LEED points.

Credit 1 (2 to 10 points), optimize energy performance: This credit is allowed if energy cost savings can be shown compared to a base building that meets the requirements of ASHRAE/IESNA 90.1-1999. The method of determining energy cost savings must meet the requirements of Section 11 of the ASHRAE standard. Section 11 requires modeling a building to determine energy savings as required using a computer-based program such as DOE 2.6.[5] When concrete is considered, it is important to use a program such as DOE 2.6 that calculates yearly energy consumption on an hourly basis. Such programs are needed to capture the beneficial thermal mass effects of concrete. Many analyses that are done gratuitously by HVAC manufacturers do not have this capability.

ICF systems in walls, used in conjunction with other energy savings measures, will most likely be eligible for points. Figure 2 shows a completed ICF structure before the exterior finish materials are applied. The points awarded will depend on the building, climate, fuel costs, and minimum requirements of ASHRAE/IESNA 90.1-1999. From 2 to 10, points are awarded for energy cost savings of 20 to 60% for new buildings and 10 to 50% for existing buildings.

Materials and resources

Credit 1 (1 to 2 points), building reuse: The purpose of this credit is to encourage leaving the main portion of the building structure and shell in place when renovating. The building shell includes the exterior skin and framing and excludes window assemblies, interior walls, floor coverings, and ceiling systems. This credit should be obtainable when renovating buildings with a concrete skin because concrete in buildings generally has a long life. Figure 3 shows a renovated building whose concrete shell was left in place. This credit is worth 1 point if 75% of the existing building structure and shell is left in place, and 2 points if 100% is left in place.

Credit 2 (1 to 2 points), construction waste management: This credit is extended for diverting construction, demolition, and land-clearing waste from landfill disposal. It is awarded based on diverting at least 50% (by weight) of the previously listed materials for a given project. Because concrete is a relatively heavy construction material, and is frequently recycled into aggregate for road bases or construction fill,[5,6] this credit should be obtainable when concrete buildings are demolished.

Figure 4 shows a machine[7] crushing the walls, floor, and columns of a concrete building into aggregate-size pieces that will be used as fill and road base. 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%. For concrete, either Credit 1 or 2 in materials and resources can be applied because either the concrete structure is reused or it is recycled into another use.

Credit 4 (1 to 2 points), recycled content: This credit states, "specify a minimum of 25% of building materials that contain in aggregate a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 40% post-industrial recycled content material." Building material percentages are determined on a cost basis. The sample calculations in the LEED Reference Guide[8] show how to easily calculate recycled content. Supplementary cementitious materials, such as fly ash, silica fume, and ground-granulated blast-furnace slag,[9] are considered post-industrial. Furthermore, using recycled aggregates instead of extracted aggregates would qualify as post-consumer.

Because concrete is an assembly, its recycled content should be calculated as a percentage of recycled material

Fig. 2: ICF building with concrete between forms before the exterior finish is applied *(Photo courtesy of Polysteel Southeast Distributors)*

Fig. 3: Renovating an existing building and leaving the concrete shell in place

Fig. 4: Crushing concrete for reuse as fill or road base

on a mass basis. Although most reinforcement is manufactured from recycled steel, and would probably qualify, it would not be considered part of the concrete. This credit is worth 1 point for the quantities quoted above and 2 points for an additional 25% of the building materials meeting this requirement.

Credit 5 (1 to 2 points), local/regional materials: This credit states, "specify a minimum of 20% of building materials that are manufactured regionally within a radius of 500 miles (800 km)." A ready-mix or precast plant within 500 mi (800 km) of the building would qualify. Concrete will usually qualify since ready-mix plants are generally within 50 mi (80 km) of most job sites.

The percentage of materials is calculated on a cost basis. This credit is worth 1 point. One additional point is earned if 50% of the regionally manufactured materials are extracted, harvested, or recovered within 500 mi (800 km). Ready-mix and precast plants generally use aggregates that are extracted within 50 mi (80 km) of the plant and most building projects will be within 50 mi (80 km) of a ready-mix plant.

Cement and supplementary cementitious materials used for buildings are also generally extracted and manufactured within 500 mi (800 km) of a job site. Imported cement, which would not qualify, is generally used for very large projects near ports. Reinforcing steel is also usually manufactured within 500 mi (800 km) of a job site and is usually made from recycled materials from the same region. The Kandalama Hotel in Dambulla, Sri Lanka, earned a LEED bronze certification and features a concrete frame with 73% of building materials coming from local sources.

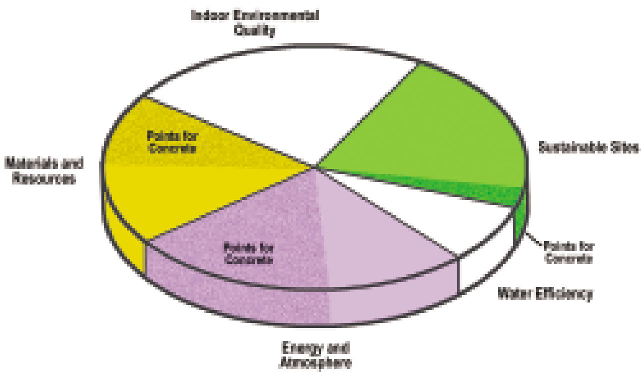

Fig. 5: Fraction of LEED points that are possible using concrete

TABLE 1:
SUMMARY OF POSSIBLE POINTS IN LEED FROM USING CONCRETE

Category	Number of points		
	Total possible	Using concrete	
		Number	% of total
Sustainable sites	14	2	14
Water efficiency	5	0	0
Energy and atmosphere	17	10	59
Materials and resources	13	6	46
Indoor environmental quality	15	0	0
Innovation credits	4	0*	0
LEED-accredited professional	1	0	0
Total	69	18	26

*More are possible: see text.

Other points

Concrete can also be used to get points indirectly. The Pennsylvania Department of Environmental Protection building in Harrisburg, PA, is LEED bronze certified and features a concrete floor with low-VOC sealant. This allows the building to obtain the Low Emitting Materials credit under Indoor Environmental Quality.

In addition to the points discussed previously, 4 points are available under 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.

SUMMARY

As many as 18 points can be earned using concrete on a green building project using the LEED system. The points are summarized in Table 1. Figure 5 shows the overall fraction of points that are possible using concrete.

The points awarded can help a building become LEED certified or obtain a higher level of certification. Concrete can be used as part of a sustainable design to lessen the impact a building has on its environment.

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Selected for reader interest by the editors.

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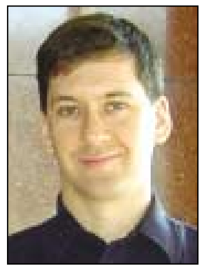

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