



CONCRETE SUSTAINABILITY REPORT

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Concrete's Contribution to LEED v4

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Since its inception, the LEED green building rating system has been used to reduce environmental impacts of the built environment. LEED has been a market transformation device affecting all sectors of the construction industry, including concrete production and construction. The system is credit-based, allowing projects to earn points for environmentally friendly strategies employed during the design and construction process.

With each new version, the US Green Building Council (USGBC), developers of LEED, has increased the targets and scope for reducing environmental impacts related to building design, construction and maintenance. LEED v4, released in November 2013, continues the momentum with a number of advancements that will likely change the way design professionals, contractors and product manufacturers do business. Many credits, such as Stormwater Management, Heat Island Reduction and Optimized Energy Performance, are refined but maintain the same intent. Others, such as Material and Resource (MR) credits, challenge product manufacturers to disclose their environmental, social and health impacts in third party validated reports.

LEED v4 has six main credit categories: Location & Transportation (LT), Sustainable Sites (SS), Water Efficiency (WE), Energy & Atmosphere (EA), Materials & Resources (MR), and Indoor Environmental Quality (EQ). Each credit category is divided into credits that outline the intent, requirements, technologies and strategies for meeting each credit. Credits are broken down into individual points. Additional points can be earned for Integrative Process (IP), Innovation (IN) and Regional Priority (RP) credits. Table 1 provides a summary of LEED v4 credit categories and points available in each category.

Credit Category	LEED v4 Points
IP – Integrative Process	1
LT – Location & Transportation	16
SS – Sustainable Sites	10
WE – Water Efficiency	11
EA – Energy & Atmosphere	33
MR – Materials & Resources	13
EQ – Indoor Environmental Quality	16
IN – Innovation	6
RP – Regional Priority	4
TOTAL	110

Table 1. LEED v4 credit categories and points available in each credit category.

Points for LEED Certification

A building must achieve at least 40 points for the basic certification level. Silver level requires 50 points, gold level requires 60 points and platinum level requires 80 points. There are a total of 110 points available. Table 2 outlines the certification levels in LEED v4.

LEED v4 Certification Levels	Points Required
Platinum Level	80+ points
Gold Level	60-79 points
Silver Level	50-59 points
Certified Level	40-49 points

Table 2. LEED certification levels and points required for each level.

Concrete and LEED v4

Because of concrete's versatility there are many applications where concrete can be used in a building project, from foundation and superstructure to sidewalks and parking lots. That means concrete can contribute to every credit category. The following are suggestions for earning LEED v4 points through the use of ready mixed concrete products. The paragraph headings below correspond to the credit in LEED v4 Building Design and Construction (BD+C): New Construction (NC). Other LEED v4 rating systems for Core and Shell, Health Care and Schools, among others, have similar credits available but may vary slightly in the points available for each credit.

Integrative Process (IP)

The integrative process involves the building owner, design team, contractors and product manufacturers during the pre-design phase and throughout the design phases to identify synergies across design disciplines for energy and water related systems. For energy related systems, the team performs a preliminary energy analysis that takes into account site shading, hardscape, building massing and orientation, insulation (and thermal mass), glazing, thermal comfort, plug and process loads. For water related systems, the design team works together to perform a preliminary water budget analysis to explore ways to reduce potable water loads in the building. Although concrete does not contribute to this credit directly, informed concrete producers can contribute by understanding concrete's contribution to energy efficiency and water efficiency and offer concrete solutions early in the design phase. This credit is worth 1 point.

Location & Transportation (LT)

LEED for Neighborhood Development Location

The intent of this credit is to avoid development on inappropriate sites, reduce vehicles miles traveled, enhance livability and improve human health by encouraging daily physical activity. To meet this credit, the project must be located within the boundary of a LEED certified Neighborhood Development (ND). Concrete contributes to many credits within LEED ND, including:

- Walkable Streets since sidewalks are generally made of concrete
- Compact Development since concrete excels for multi-story construction

- Transit Facilities since most public transportation systems use concrete
- Neighborhood Schools since most schools are concrete intensive
- Optimized Energy Performance since concrete building systems help improve energy efficiency
- Rainwater Management since pervious concrete can be used to minimize stormwater runoff and improve stormwater quality
- Heat Island Reduction since concrete pavements are highly reflective.

The total number of points awarded the building is based on the LEED ND certification level: Certified (8 points), Silver (10 points), Gold (12 points) and Platinum (16 points).

Projects not located in a LEED ND can earn points for individual LT Credits as follows:

High Priority Sites

The intent is to encourage project location in areas with development constraints with three available options. Option 1 is to locate the project on an infill location in a historic district (1 point). Option 2 is to locate the project on a government designated priority site (1 point). Option 3 is to locate on a brownfield with soil or groundwater contamination and perform remediation to the satisfaction of that appropriate authority (2 points). Cementitious materials can be used to solidify and stabilize contaminated soils and reduce leaching concentrations to below regulatory levels. Although not typical, ready mixed concrete trucks and plants have been used to mix and deliver cementitious slurries for solidification and stabilization projects. This credit is worth up to 2 points.

Surrounding Density and Diverse Uses

This credit encourages development in areas with existing infrastructure in order to promote land conservation, farmland protection, walkability and transportation efficiency. There are two options to meeting the credit. Option 1, Surrounding Density, is to locate on a site with a minimum surrounding existing density (floor area to land area ratio) within a ¼-mile (400 m) radius of the project boundary. This option is worth 2-3 points. Option 2, Diverse Uses, requires the building's main entrance to be within a ½-mile (800 m) walking distance of the main entrance of four to seven (1 point) or eight or more (2 points) amenities such as grocery stores, retail stores, banks, places of worship, parks, medical facilities and restaurants, among others.

Concrete contributes to Option 1 of this credit since high density often means multi-story construction. Concrete's strength, economy and versatility make it ideal for multi-story residential and commercial construction in urban settings. Features such as long spans, low floor-to-floor heights and energy efficiency contribute to environmental performance.

Access to Quality Transit

The intent of this credit is to encourage development in locations with several public transportation options with the purpose of reducing greenhouse gas emissions, air pollution, and other environmental and public health harms associated with automobile use. There are several specific requirements for locating the project near rideshare locations, bus stops and train stations. The public transportation options can be existing or built within 24 months of project completion. Since most public transportation facilities, including bus stops and train stations, are concrete intensive, concrete can contribute to this credit, which is worth up to 5 points depending on the frequency of scheduled public transportation stops.

Sustainable Sites (SS)

Site Development—Protect or Restore Habitat

The intent of this credit is to conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity. This credit is achieved by limiting the amount of developed space on a site to specified minimums. Projects that achieve a density of 1.5 floor area to land area ratio (generally multi-story construction) may include vegetated roof surfaces in this calculation. Concrete can contribute to this credit since concrete excels in multi-story applications and vegetated roofs are generally supported by concrete structures. Another potential strategy for increasing density is to locate parking areas within the building footprint to limit site disturbance. A parking garage, typically built with concrete, located within a building helps maintain existing natural areas that would otherwise be consumed by surface parking. Using a pervious concrete parking area to store and treat rainwater, thereby eliminating or minimizing land required for detention ponds, helps protect and restore habitat. This credit is worth 2 points.

Open Space

For this credit, the project must have a specific amount of exterior open space accessible to building occupants. The concept is to encourage interactions with the environment, social interactions and physical activities. For projects with a density of 1.5

floor-area to land area ratio, vegetated roofs which are often supported on concrete structures, can be used toward the minimum vegetation requirement. Parking garages, typically built using concrete, on the lower floors of a building can be used to help reduce the developed footprint on a site. Pervious concrete parking areas can eliminate or reduce land required for detention ponds and can help maximize open space. This credit is worth 1 point.

Rainwater Management

The intent of this credit is to reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site using low-impact development. The number of points available is dependent on the site density and percentage of rainfall managed on site. Using pervious concrete pavements can improve the rate, quantity and quality of stormwater runoff because it increases infiltration. Vegetated roofs are another strategy to achieve this credit. Reinforced concrete is often used as the structural system to support the heavy loads of vegetated roofs, which can reduce stormwater runoff. This credit is worth up to 3 points.

Heat Island Reduction

This credit's intent is to minimize effects on microclimates and human and wildlife habitats by reducing heat islands. The requirements include 2 options. Option 1 encourages the use of site shading and reflective pavements and roofing materials or vegetative roofs. Option 2 encourages underground or shaded parking areas. For reflective pavements, the requirement is to use paving materials with a three-year aged solar reflectance (SR) value of at least 0.28, or an initial SR of at least 0.33. The requirement for SR can usually be met by using concrete rather than asphalt for hardscape areas, including sidewalks, parking lots, drives and other impervious surfaces. Solar reflectance is the ratio of the amount of solar radiation reflected from a material to the amount that shines on the material. Generally, light-colored surfaces have a high SR. Conventional grey concrete generally has an initial SR of greater than 0.35. Concretes made with white cements can have SR greater than 0.70. As a comparison, new asphalt generally has an SR of approximately 0.05. Solar reflectance is measured using ASTM Standards E903 or E892. This option of the credit is worth 2 points.

Option 2 is achieved by placing a minimum of 75% of parking spaces under cover. Any roof used to shade or cover parking must (1) have a three-year aged Solar Reflectance Index (SRI)

of at least 32 or initial SRI of at least 39, (2) be a vegetated roof, or (3) be covered by energy generation systems, such as solar thermal collectors, photovoltaics and wind turbines. Concrete can generally contribute to this option since the material of choice for parking structures is concrete. This option is worth 1 point.

Water Efficiency (WE)

Outdoor Water Use Reduction

This credit requires the reduction of outdoor water consumption through the use of landscape that does not require permanent irrigation or through the use of alternative water sources. Option 1 offers 2 points if the landscape does not require a permanent irrigation system beyond a maximum two-year landscape establishment period. Option 2 offers 1 point for 50% reduction from peak watering months and 2 points for 100% reduction from peak watering months. Up to 30% of the reductions can be achieved using any combination of efficiency, alternative water sources and smart scheduling technologies. Alternative water sources include reclaimed wastewater, graywater, captured rainwater and stormwater, among other sources. Cisterns for capturing and storing alternative water are often built using concrete. Pervious concrete systems and other concrete stormwater management systems, such as culverts and pipes, can be used to capture stormwater for collection into cisterns for irrigation purposes.

WE Credit: Indoor Water Use Reduction

For this credit, the intent is to reduce indoor water use by using low flow fixtures and using alternative water sources. One to 6 points are awarded for 25% to 50% reduction below specified baselines. Concrete cisterns could be used to collect and treat alternative water sources such as reclaimed wastewater, graywater, captured rainwater and stormwater.

Energy and Atmosphere (EA)

Minimum Energy Performance

For a project to be LEED v4 certified it must reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency. There are several options for achieving this credit, but the most frequently used option is to demonstrate 5% improvement over a baseline building using the ANSI/ASHRAE/IESNA Standard 90.1. Energy performance must be measured by a whole building simulation using the Building Performance Rating Method in Appendix G

of the standard. Many consulting firms have the capability of modeling a building to determine energy savings using a computer-based program such as DOE2. When concrete is considered, it is important to use a program like DOE2 that calculates annual energy use on an hourly basis since building components constructed of concrete generally exhibit a property known as thermal mass which can only be accounted for in sophisticated energy analysis software.

Buildings constructed of cast-in-place concrete frame, tilt-up concrete or insulating concrete forms (ICF) possess thermal mass which helps moderate indoor temperature extremes and reduce peak heating and cooling loads. In many climates, these buildings have lower energy consumption than non-massive buildings with walls of similar insulation. In addition, heating, ventilating and air-conditioning needs can be met with smaller capacity equipment.

Optimize Energy Performance

This credit is awarded if energy cost savings beyond the prerequisite can be demonstrated compared to a baseline building that meets the requirements of ANSI/ASHRAE/IESNA Standard 90.1. Concrete building systems, used in conjunction with other energy savings measures, will most likely help improve energy performance and thus contribute to points under this credit. The number of points awarded depends on the demonstrated energy savings for the building. One to 18 points are awarded for 6% to 50% energy cost savings.

Material and Resources (MR)

In the past versions of LEED, the focus of material impacts has been on single attributes such as recycled content, rapid renewability or regional materials. While these attributes are important, they only tell part of the story. A product could perform well in one attribute but poorly in another. The new LEED v4 MR credits attempt to take a holistic look at materials by adopting life cycle assessment (LCA) and product disclosure and optimization.

Life cycle assessment, or LCA, is the investigation and evaluation of the environmental impacts of a product, process or service. LCA evaluates all stages of a product's life to determine its environmental life cycle impacts. LCA is the most comprehensive approach to determining environmental impacts of a building. There is one credit in LEED v4 called Building Life-Cycle Impact Reduction that rewards points if the building has lower life cycle impacts than a baseline building.

Product disclosure means reporting environmental, social and health impacts through third party verified reports, including Environmental Product Declarations (EPDs), Corporate Sustainability Reports (CSRs) and Health Product Declarations (HPDs), among others. There are three Building Product Disclosure and Optimization credits and each offers two points.

The first point (Option 1), Disclosure, requires the project use 20 permanently installed products that disclose impacts using EPDs, CSRs and/or HPDs. In LEED v4, a “product” is defined by the distinct function it serves. That means concrete has the advantage of contributing significantly because of concrete’s wide range of applications or functions. For example, footings, foundations walls, shear walls, bearing walls, columns, beams, slabs, sidewalks and parking areas, each with a unique mix design, would all be considered different products in LEED v4 and therefore contribute significantly to the 20 required products.

The second point (Option 2), Optimization, requires a certain minimum value of building products to demonstrate they are performing better than industry baselines for environmental, social and health impacts. The second option limits the contribution of structure and enclosure to 30% of the qualifying products on a cost basis. However, the value of products manufactured and extracted within 100 miles (160 km) of the project site is doubled, meaning concrete can contribute significantly to this option since concrete is almost always manufactured and extracted locally.

Construction and Demolition Waste Management Planning

This prerequisite requires the project teams to develop a plan for the reduction of material disposed of in landfills and incineration facilities. Since concrete is a relatively heavy construction material and is frequently crushed and recycled into aggregate for road bases, construction fill or new concrete, the waste management plan should certainly consider waste diversion goals for concrete.

Building Life-Cycle Impact Reduction

This credit offers several options for reducing the impact of buildings, mostly centered around existing building adaptation and reuse. However, for new buildings, Option 4 of the credit encourages the use of LCA to demonstrate lower environmental impacts of the proposed building over a baseline building. The project is awarded 3 points for conducting a whole-building life-cycle assessment of the project’s struc-

ture and enclosure that demonstrates a minimum of 10% reduction, compared with a reference building, in at least three of following six impact categories:

- Global Warming Potential (Required)
- Reduce Ozone Depletion
- Land /Water Acidification
- Eutrophication
- Tropospheric Ozone
- Non Renewable Energy

No impact category assessed as part of the life-cycle assessment may increase by more than 5% compared with the reference building. Concrete structures have always been known for durability and long service life and therefore decrease the environmental impacts associated with reconstruction, repair and maintenance and can often demonstrate the lowest life-cycle impacts.

Building Product Disclosure and Optimization – Environmental Product Declarations

Environmental Product Declarations (EPDs) are reports published by product manufacturers that provide third party verified information regarding environmental performance of their product. Option 1 (Disclosure) awards 1 point for using 20 permanently installed products in the building that have published EPDs. Under this credit, a plant specific EPD is more desirable (worth full product) but industry average EPDs (worth half product) can be used if site specific EPDs are not available. There are no requirements for reducing environmental impacts; simply disclosing the product’s environmental impacts will support this credit. Concrete producers with EPDs will be able to contribute significantly to this credit because of the wide range of concrete products on most projects.

Option 2 (Optimization) awards 1 point if 50%, by cost, of all products in the building can demonstrate that their products perform better than the industry average or baseline environmental impacts. Many industries are developing their industry averages, including concrete, which means concrete producers will be able to compare their impacts to these baselines and formulate products that have lower environmental impacts than average.

Building Product Disclosure and Optimization – Sourcing of Raw Materials

Option 1 (Disclosure) rewards 1 point for selecting 20 products verified to have been extracted or sourced in a responsi-

ble manner. Responsible sourcing strategies include commitments to long-term ecologically responsible land use, reducing environmental harms from extraction and/or manufacturing processes, and meeting applicable standards or programs voluntarily that address responsible sourcing criteria. The credit requires Corporate Sustainability Reports (CSRs) from 20 different products which means concrete producers with a CSR can contribute a significant number of products to this option.

Option 2 (Optimization) awards 1 point if 25%, by cost, of all products in the building have demonstrated leadership in the sourcing of raw materials. Several pathways are provided for meeting this option, including responsible forestry, material reuse and recycling, among others. Concrete products can contribute to the Recycled Content pathway since most concrete contains recycled materials such as fly ash and slag and in some cases recycled aggregate.

Building Product Disclosure and Optimization – Material Ingredients

Option 1 (Disclosure) of this credit provides 1 point if 20 products in the building disclose chemical ingredients in their products using an accepted methodology. Option 1 requires reporting of chemical ingredients of products to at least 1% (or 1000ppm) in a Health Product Declaration (HPD) or under another approved program such as *GreenScreen* or *Cradle to Cradle*. HPDs are reports that allow manufacturers to present building product ingredients in a format that is consistent and includes information on product ingredients, product testing, regulatory compliance, health hazards and risks. Concrete producers with HPDs can contribute many products to this option.

Option 2 (Optimization) provides 1 point if 25%, by cost, of all products in the building are verified to have improved life-cycle impacts by optimizing their material ingredient chemistry. Concrete is typically an inert material and has one of the lowest levels of volatile organic compounds (VOCs) and off-gassing when compared to other commonly used building materials and can likely meet the credit requirement.

Construction Waste Management

This credit is provided for diverting construction, demolition and land clearing waste from landfill and incinerator disposal. Since concrete is a relatively heavy construction material and is frequently crushed and recycled into aggregate for road bases, construction fill and new concrete, this credit should be obtainable when concrete buildings are demolished on an existing

site. In addition, returned concrete that is diverted from landfills by making landscaping blocks or recycling into new concrete can contribute. Option 1 of this credit is worth 1 point if 50% of the construction, demolition and land clearing waste are recycled or salvaged, 2 points if 75% is diverted. Option 2 is worth 2 points if the project does not generate more than 2.5 pounds of construction waste per square foot (12.2 kilograms of waste per square meter) of the building's floor area.

Indoor Environmental Quality (EQ)

Low-Emitting Materials

The intent of this credit is to reduce concentrations of chemical contaminants that can damage air quality, human health, productivity and the environment. The focus is on removing volatile organic compounds (VOCs) emissions into indoor air and the VOC content of materials in ceilings, walls and floors where many of the interior finishes, such as paints, coatings, adhesives and sealants have significant emissions. In many applications, exposed concrete is both an excellent structure and finish material, eliminating the need for additional material to be applied on the interior. Concrete is defined as an “*inherently nonemitting source*” of VOCs in LEED v4 and therefore can demonstrate compliance to this credit without any VOC emissions testing if it does not include integral organic-based surface coatings, binders or sealants. This credit is worth 3 points.

Daylight and Quality Views

The intent of these credits is to provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building. Up to 3 points can be achieved for Daylight through simulation, calculation or measurement. For Quality Views, up to 2 points can be achieved with a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area. The strategy is to design the building to maximize interior daylighting and views to the outdoors through building orientation, shallow floor plates and increased building perimeter. Concrete floor systems can span large distances with shallow floor plates and column free spaces to help achieve these credits. Concrete can also be exposed on ceilings to reflect light deep into interior spaces.

Acoustic Performance

Unwanted noise can be a major distraction, whether in a school, work or healthcare environment. The intent of this

credit is to provide spaces that promote occupants' well-being, productivity and communications through effective acoustic design. Project teams must meet the composite sound transmission class (STCC) ratings referenced or local building code (whichever is more stringent) and meet the reverberation time requirements referenced. Concrete offers excellent noise control in two ways. First, concrete floors and walls effectively block airborne sound transmission over a wide range of frequencies. Second, concrete effectively absorbs noise, thereby diminishing noise intensity. This means that concrete can demonstrate compliance to this credit either through calculation or measurement. This credit is worth 1 point.

Innovation

Up to 5 points can be applied to the project for innovative green design strategies used that do not fit into the point structure of the six major credit categories or if a credit achievement goes significantly beyond the requirement in one of the existing credit categories, thus demonstrating exemplary performance. One strategy that has been used to obtain a LEED point in the Innovation credit category is to reduce CO₂ embodied in concrete by 40%. One way to accomplish this is by using high volumes of fly ash, slag or silica fume in concrete such that the result is a decrease in embodied CO₂ by 40% over typical mixes. Another potential innovation is to use exposed concrete for walls, floors and ceilings. This strategy would eliminate a significant quantity of wall and floor coverings along with ceiling materials, all of which are common sources of VOCs that can degrade indoor air. This strategy could significantly improve indoor air quality. Another Option in this credit is for the project team to adopt a Pilot Credit from the USGBC's Pilot Credit Library.

LEED Accredited Professional

The intention of this credit is to encourage the design integration required by a LEED project and to streamline the application and certification process. To achieve this credit, at least one principal participant of the project team must be a LEED Accredited Professional (AP) with a specialty appropriate for the project. Most LEED projects will have a LEED AP as a member of the design team. In addition, the concrete industry has many LEED Accredited Professionals available to help maximize points using concrete. This credit is worth 1 point.

Regional Priority

Regional priority credits are identified by USGBC Chapters and Regional Councils for each "environmental zone" and a maximum of four points is available for project teams to pursue in this credit category. Each USGBC region has the authority to create 6 potential regional priority credits, of which one may pursue a maximum of 4. This allows for the "regional authority" to designate target credits that are of particular importance for a region and potentially give additional credits for projects that meet criteria in existing credit categories.

For example, in a region where urban heat island reduction is identified as an important goal, the USGBC Chapter could increase the points available for Sustainable Sites: Heat Island Reduction creating greater incentive for design teams to employ heat island reduction strategies. Since concrete contributes to most credit categories it will play a significant role in achieving Regional Priority credits.

Summary

Using concrete can influence 25 of 55 LEED v4 credits and prerequisites and potentially contribute to as many as 74 of the 110 points available. Table 3 provides a list of LEED v4 credits influenced by concrete. Of course, using concrete does not directly achieve credits, but concrete's environmental attributes can help project designers achieve LEED certification.

Obtaining a LEED certification demonstrates a positive environmental image to the community. Additionally, implementing green building practices can result in energy and cost savings over the life of the structure. Other advantages include better indoor air quality and plenty of daylight. Studies have shown that workers in these environments have increased labor productivity, job retention and days worked. These benefits contribute directly to a company's profits because salaries—which are about 10 times higher than rent, utilities and maintenance combined—are the largest expense for most companies occupying building space. Students in these environments often have higher test scores and lower absenteeism.

Detailed information on the LEED v4 and project certification process is available on the USGBC Web site, www.usgbc.org. More information about the environmental benefits of concrete can be found at www.nrmca.org/sustainability.

LEED Credit categories in Which Concrete Can Contribute	Points Potentially Influenced by Concrete
Integrative Process	1
Location & Transportation (16 Points Available)	
Neighborhood Development Location	16, or
High Priority Sites	2
Surrounding Density and Diverse Uses	3
Access to Quality Transit	5
Sustainable Sites (10 Points Available)	
Site Development — Protect or Restore Habitat	2
Open Space	1
Rainwater Management	3
Heat Island Reduction	2
Water Efficiency (11 Points Available)	
Outdoor Water Use Reduction	2
Indoor Water Use Reduction	6
Energy & Atmosphere (33 Points Available)	
Minimum Energy Performance	Required
Optimize Energy Performance	18
Material and Resources (13 Points Available)	
Construction and Demolition Waste Management Planning	Required
Building Life-Cycle Impact Reduction	3
Building Product Disclosure and Optimization – Environmental Product Declarations	2
Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
Building Product Disclosure and Optimization – Material Ingredients	2
Construction and Demolition Waste Management	2
Indoor Environmental Quality (16 Points Available)	
Low-Emitting Materials	3
Daylight	3
Quality Views	1
Acoustic Performance	1
Innovation (6 Points Available)	
Innovation	5
LEED AP +	1
Regional Priority (4 Points Available)	
TOTAL	74

Table 3. Concrete’s Potential Contribution to LEED v4 BD+C New Construction



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