CONCRETE CONTRIBUTIONS TO GREENROADS™ RATING SYSTEM v1.5

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Sustainable practices have been integrated into a wide range of construction markets during the past decade. The Greenroads™ Rating System[1] was developed to provide sustainability metrics for roadway projects. Loosely modeled after the USGBC's LEED® Rating System, this third-party program identifies strategies and best practices for improving the sustainability of roadway projects, and offers a performance ranking based on achieving specific credits.

Building Greenroads - The Rating System.

Greenroads Rating System came about as an academic research project at the University of Washington in 2007. The project evolved with the establishment of the Greenroads Foundation in 2010, and the formal launch of their Greenroads Manual.[2] Within the Manual, the user will find various strategies to improve the sustainability of a project. By achieving these strategies, users are awarded points toward a total for the project which can be used as an indicator of sustainability. The Manual outlines the goal, requirements, applications and documentation necessary for evaluation of the project.

Credits in the Greenroads Rating System are organized into seven categories, each of which address a specific application for sustainable performance. The Project Requirements category contains 11 mandatory credits that must be met by all projects. Six categories contain 37 Voluntary Credits that are each worth from 1 to 5 points, for a total of 118 possible points. Credits offer optional achievement paths which are selected based on the scope and scale of the project. It is unlikely that a project will be able to achieve all the credits. The intent is to offer alternatives so that any roadway project of any scale could receive enough relevant credits to obtain at least a minimum certification level. In the Custom Credit category, users can propose a new strategy that offers measurable improvement not currently part of the existing criteria, and to use approved new strategies proposed by other teams.

Greenroads Credit Categories	Points
Project Requirements (PR)	0
Environment and Water (EW)	21
Access and Equity (AE)	30
Construction Activities (CA)	14
Materials and Resources (MR)	23
Pavement Technologies (PT)	20
Custom Credits (CC)	10
Total	**118**

The Project Team, led by a Project Manager, submits documentation supporting the performance of those Project Requirement and Voluntary Credits they are pursuing. This documentation is verified by an independent reviewer team and the project is assigned a Greenroads score.

Certification Levels

All Project Requirement Credits must be met plus:

- Certified: 32-42 Voluntary Credit points
- Silver: 43-53 Voluntary Credit points
- Gold: 54-63 Voluntary Credit points
- Evergreen: 64+ Voluntary Credit points

Obtaining these levels is an official acknowledgement by Greenroads that a project has met all Project Requirements and achieved enough of the 118 possible Voluntary Credit points to meet or exceed the predetermined certification level. A Certified roadway project can be considered a Greenroad.

Concrete Contributes to a More Sustainable Infrastructure

Concrete and concrete products provide solutions that can contribute to Greenroad credits through a variety of environmental benefits. This resource outlines the Required Credit category and four of the Voluntary Credit categories of the Greenroads Rating System, and highlights the specific credits where concrete can contribute, along with a brief description of the credit goal and strategies for implementation.

Required Credits

Project Requirements Category

The credits within the Project Requirement Category typically address the evaluation and planning process for a particular project. This ensures that, prior to design and construction, consideration of sustainable practices are included. Credits within this section specifically address the main environmental impacts, including lifetime cost, energy consumption, greenhouse gas production, waste, stormwater, noise and long term maintenance as well as an educational component designed to increase awareness and inform the general public about the sustainable practices utilized.

Since this section is focused on the planning aspects for a project, specific material attributes do not directly contribute to these credits. However, engagement by local concrete contractors and suppliers can be instrumental in achieving the goals of the Required

[1] www.greenroads.us

[2] Muench, S.T., Anderson, J.L., Hatfield, J.P., Koester, J.R., & Söderlund, M. et al. (2011). Greenroads Manual v1.5. (J.L. Anderson, C.D. Weiland, and S.T. Muench, Eds.). Seattle, WA: University of Washington.

Credits and setting the stage for achieving points in the Voluntary Credits.

The relevant sections for concrete industry engagement include:

- PR-4 Quality Control Plan
- PR-5 Noise Mitigation Plan
- PR-6 Waste Management Plan
- PR-7 Pollution Prevention Plan
- PR-8 Low Impact Development Plan

Environment and Water

EW-2 Runoff Flow Control

Goal: Mimic predevelopment hydrological conditions in the right of way (ROW) and minimize offsite stormwater controls.

Simply put, this credit promotes strategies to construct the project so that stormwater patterns and quantities are not altered from those prior to construction.

In a typical urban environment, 25% to 40% of the land area is covered with buildings, roads, parking lots and other infrastructure. Covering large areas with impervious surfaces has traditionally resulted in dramatic changes to the natural watershed systems in our communities. Traditional practices collected stormwater and piped it directly to a nearby stream or river, or to a local treatment plant before discharge. Run-off rates on impervious surfaces are generally much higher than those on natural surfaces, and this rapid change in flow causes deterioration to natural waterway habitats. Additionally, the redirection of rainwater via a stormwater sewer system reduces the possibility for recharging natural groundwater aquifers.

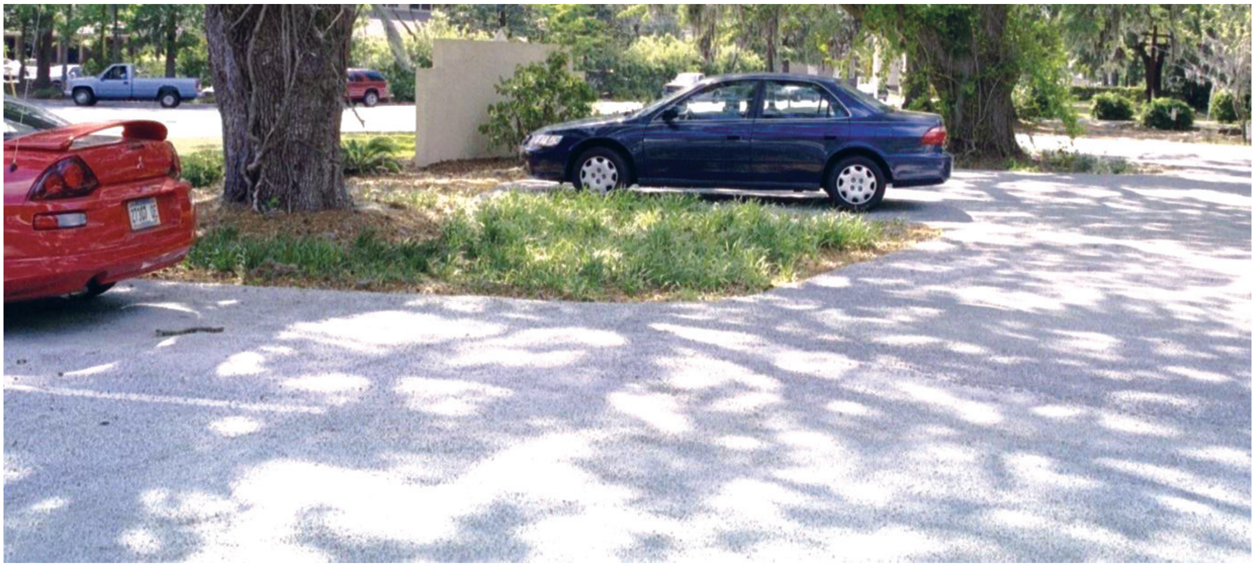
Low-impact development (LID) strategies attempt to mimic predevelopment hydrologic conditions by emphasizing groundwater infiltration, evaporation and transpiration of stormwater, storage for controlled long-term flow control and possible reuse. Beneficial technologies also include preserving native vegetation and protecting soils with high infiltration capacity.

Concrete Contributions - The U.S. EPA recognizes pervious concrete and permeable paver systems as a Best Management Practice (BMP) offering design teams several options to manage stormwater quantity and quality. Pervious concrete and permeable paver systems along with natural options such as vegetation, grading and soil modification techniques can be used for a system-wide solution on a project.

Pervious and permeable pavements allow rainwater to migrate into a storage bed under the driving surface, where it can percolate into the ground, or be released at a lower controlled rate into natural watersheds. Engineers are able to design the capacity of the storage bed to address the majority of storm events. Research has shown that infiltration rates through these concrete structures can be as high as 300 to 400 inches per hour, exceeding the rates of even the most torrential storm. Design of these structures can include acceptance of water from other impervious surfaces (run-on).

The benefits include:

- A pervious paving surface becomes a detention or retention pond that you can drive or park on, saving land for other applications such as open space.
- Recharging local groundwater.
- Reducing damaging stormwater flow rates into local waterways.



Pervious paving surface, such as this parking lot, acts as a retention pond that you can drive on, saving land for other applications.

- Reducing or eliminating the cost for on-site stormwater control systems (catch basins, piping, etc)
- Reducing additional stormwater treatment capacity of municipal facilities.

Greenroads users must perform and document flow rate and stormwater volume calculations from pre- and post-project conditions. Points are awarded for new construction if the flow rate or volume of water is lower than pre-development conditions. Up to three points can be earned for increasing levels of performance.

Information about the design and installation about pervious concrete and permeable pavers can be found at the following sources:

Pervious Concrete Paving - *http://www.pervious.info/*

Permeable Paver Systems –*http://www.icpi.org/node/553*

EW-3 Runoff Quality

Goal: Improve water quality of stormwater runoff leaving the roadway Right-of-Way (ROW)

In a process known as "first flush," rain can wash the accumulated pollutants from vehicles, abraded or oxidized coal tar seal-coating, metal leachate and air pollution from an impervious paving surface in a concentrated discharge into local waterways. In many metropolitan areas, this level is high enough that stormwater is required to be treated to reduce the levels of pollution before releasing them into streams, rivers and lakes. Rainwater can also be heated by large impervious surfaces, creating a thermal shock to aquatic life when discharged into these same waterways[1]. Best management practices sited by Greenroads include pervious pavements, constructed wetlands, vegetated buffer strips, and bio-filtration beds.

Concrete Contributions - Capturing run-off through pervious concrete and permeable paver systems significantly reduces the volume of run-off and correspondingly, the amount of surface contamination into local waterways. Biological decomposition of hydrocarbons will generally occur with the establishment of natural bacterial action within the aggregate matrix, while particulate matter will be filtered by the sub-soil of the storage bed[2]. Initial results from recent research suggests that significant amounts of dissolved zinc and copper from roofing, fencing, guardrails, and metallic products is absorbed and chemically bound into the concrete matrix of pervious concrete driving surface or storage bed material if crushed concrete is used.

Similar to Credit EW-2, pervious concrete and permeable paver systems along with other options such as bio-retention, filtration, pond, wetland and vegetative techniques can be used for a system-wide solution on a project. Greenroads users must perform pre- and post-construction calculations to determine reductions in total suspended solids (TSS), heavy metals, hydrocarbons, pathogens and water temperature. Again, up to 3 points are awarded for increasing treatment levels and volumes treated.

EW-7 Ecological Connectivity

Goal: Provide or improve wildlife access and mobility across roadway facility boundaries and reduce vehicle-wildlife collisions and related accidents.

The linear nature of road and highways can often separate animals from natural migration patterns resulting in a degradation of the ecosystem and a safety issue for wildlife and motorists alike. An ecological connection is a designed element providing a transit path of wildlife across, under, above, or through a roadway project footprint without impacting the safety of human users. This may include the use of bridges, underpasses, culverts, fencing and similar structures.

Concrete Contributions - The use of concrete as a structural element for underpasses, bridges, and culverts is well documented as a durable, safe and cost effective solution in transportation infrastructure. Additionally, the relatively inert nature of concrete minimizes aquatic environmental degradation where exposure to water can leach metal and phalates from other products.

Greenroads users are first required to complete a site-specific wildlife assessment for the roadway project. Then, they must pursue one of the following options:

Option A - Replace, retrofit, or upgrade any and all existing crossing structures and wildlife fencing deemed deficient or otherwise inadequate. (1 point)

Option B - Install new wildlife crossing structures and protective fencing as recommended by the wildlife assessment. In addition, existing structures must also evaluated and addressed as noted in Option 1 (3 points).

Materials and Resources

MR-2 Pavement Reuse

Goal: Reuse existing pavement and structural materials.

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1 http://www.bae.ncsu.edu/topic/bmp-temperature/
http://www.epa.gov/heatisland/mitigation/pavements.htm

2 Pratt, C.J., A.P. Newman, and P.C. Bond, Mineral Oil Bio-Degradation Within a Permeable Pavement: Long Term Observations. Water Science and Technology 39.2:103-109, 1999.

The reuse of existing on-site materials, such as full-depth reclamation, saves energy and natural resources while often reducing project costs.

The reuse of existing on-site materials often contributes savings to the environment, the community and to the financial cost of the project. Environmentally, both virgin material use and waste are reduced as well as the transportation impacts (fuel consumption and emissions) for relocation of these materials. Correspondingly, there are potentially reduced financial costs for transportation, materials and waste. On-site material reuse eliminates much of the construction truck traffic through the adjacent community.

For this credit, Greenroads makes a clear distinction between reuse and recycle.

> *"Reuse" is defined as a continued use or repurposing of existing materials within the project limits with minimal processing. These methods employ strategies to extend the life of the existing pavement or structure in place.*

"Recycle" is defined as recovering a portion of a used product or material from the waste stream for reprocessing and/or repurposing.

Concrete contributions - A variety of applications supported by cement or concrete are available:

- Full depth reclamation
- Diamond grinding of a road surface to improve ride quality.
- Portland cement concrete (PCC) overlays
- Portland cement concrete (PCC) Crack and Seat Technique
- Reuse and repairs of structural foundations
- Bridge and retaining wall retrofits

The Greenroads user is directed to determine the percentage of reused materials compared to the project total, and provide a brief narrative. Points are awarded on a sliding scale (1 point for 50% reuse to 5 points for 90% reuse)

For more information, visit:

http://www.cement.org/pavements/pv_sc_fdr.asp

http://www.igga.net/technical-information/technical-information.cfm?mode=display&article=3

MR-4 Recycled Materials

Goal: Reduce lifecycle impacts from extraction and production of virgin materials.

Utilizing recycled content is a fundamental strategy in sustainability projects. It reduces impacts associated with virgin material acquisition and production, reduces waste and can be less costly in some applications. Recycled materials can be derived from processing on-site materials, or off-site from other sources and waste streams. Noted in MR-2, materials that are minimally processed in place as in the case of PCC crack and seat techniques are considered "reused".

Concrete Contributions - Concrete paving is readily recycled, often on-site or in-situ. The Construction and Demolition Recycling Association estimates that approximately 140 million tons of concrete is recycled annually. Frequently, end of life concrete is removed, crushed and processed into aggregates for base material and occasionally for new concrete. Recycling is not limited to crushed concrete from on-site. Reclaimed concrete from off-site, cement kiln dust, and supplementary cementitious materials (SCMs) such as fly ash and slag are also supportive of this credit.

The Greenroads users is directed to perform calculations on the percentage of recycled materials

Using recycled content, such as crushed concrete, is a fundamental strategy for sustainable construction projects.

incorporated into the project. Similar to previous credits, up to 5 points are awarded on a sliding scale for the percentage of recycled content utilized.

MR-5 Regional Materials

Goal: Promote use of locally sourced materials to reduce impacts from transportation emissions, reduce fuel costs, and support local economies.

Due to the weight of paving material, utilization of local materials is a traditional solution in pavement construction. According to research noted in Greenroads, shipping accounts for between 7% and 38% of the embodied energy for a paving project. By reducing transportation distances, less fuel is consumed and fewer emissions are generated.

Concrete Contribution - The sources of the main ingredients of concrete (coarse and fine aggregates, cement, and water) are found widely dispersed throughout the nation. Although cement production occurs within a 500 mile radius for most of the U.S., the mix design specifications defining the cement type, supplementary cementitious materials and the quality of available aggregates will influence the actual haul distances.

A study by the National Ready Mixed Concrete Association found that the average haul distance for all ready mixed concrete was just under 15 miles.

The user has two options for documenting this credit:

> **Option 1** - Cost Basis - Compute the percentage of costs for materials obtained within a 50 mile radius of the project site. Credit is on a sliding scale with 1 point achieved for 60%, up to 5 points for 95%.
>
> **Option 2** - Weight and Haul Distance – Calculate the haul distances and weight for each material delivered to the project site. 1 point is awarded if 95% of the total materials are shipped less than 500 miles, up to 5 points if they are shipped less than 100 miles.

Pavement Technologies

PT-1 Long Life Pavement

Goal: Minimize life cycle costs by promoting long lasting design of structures.

This credit recognizes the value that long life contributes to any structure. Beyond the additional cost, long life reduces the materials, energy, emissions and waste needed to remove and replace a pavement. Additionally, traffic congestion and its associated emissions add to the social impacts from construction.

The credit is offered for new pavements where the design life is 40 years or greater, as specified in commonly available design procedures found in the 1993 AASHTO Method and AASHTO MEPDG-1. Existing pavements that remain in place can contribute to this credit as well, including diamond grinding and overlays as appropriate technology to extend the life of the original structure. This credit is not appropriate for gravel, dirt or pervious pavements and roads sealed with bituminous surface treatments.

Bridges and other major structures may meet the intent of this credit using a 100-year design life as a minimum threshold based on AASHTO LRFD Bridge Design Specifications or other agency- recognized and documented design standard. The entire structure must be shown meet this design requirement, including foundations.

The Greenroads user is to prepare calculations and a drawing indicating the ratio of long-life lane miles against the total of all lane miles for the project. A total of 5 points are awarded for projects that meet or exceed 75% of the lane miles with long life pavement.

PT-2 Permeable Pavement

Goal: Improve flow control and quality of stormwater runoff through use of permeable pavement technologies.

Stormwater runoff from impervious surfaces can contribute to erosion, change riparian habitats and carry pollutants (such as oil, antifreeze, metal leachate, excess fertilizer and sediment) into natural waterways. The term permeable, pervious and porous are often used interchangeably in this context. Pervious pavements enable stormwater to pass through the structural surface into a storage layer of coarse aggregate, where it infiltrates the subsoil to recharge groundwater and filter

The average haul distance for ready mixed concrete is less than 15 miles, greatly reducing the impacts of transportation.

contaminants. In instances where infiltration rates of the subsoil are low, the capacity of the storage layer is designed to store rainwater where it can be released at a controlled rate into the natural watershed. Municipalities and building owners are recognizing that limiting site run-off also reduces the need for stormwater treatment capacity and the land required for detention or retention pond structures.

Concrete Contributions - Pervious concrete and permeable concrete pavers provide durable surfaces for vehicular and pedestrian traffic. Research revealed that flow rates through pervious concrete can be as high as 8 gallons per minute per square foot, the equivalent of 300 inches of rain in an hour! However, practical design considerations use ½ gallon per minute per square foot.

Additional information on pervious concrete pavement, including contractor certification can be found at *http://www.perviouspavement.org/*

For information on permeable interlocking concrete pavers, visit: *http://www.icpi.org/permeable*

The Greenroads user must provide calculations and plans reflecting a reduction of impervious surface for roadways areas. Additionally, a pavement maintenance plan, site photos and mix design specifications are required to be provided. Up to 3 points can be achieved with a 15% or greater reduction of impervious paving surface.

PT-3 Warm Mix Asphalt

Goal: Reduce fossil fuel use at the hot mix asphalt plant, decrease emissions at the plant, and decrease worker exposure to emissions during placement.

Several technologies now exist that reduce the amount of energy required to process or prepare the binder medium for the paving material.

Concrete Contributions - The intent of this credit is to encourage alternative technologies for lower embodied energy in the pavement binder material. Although the credit was originally titled Warm Mix Asphalt, concrete utilizing cement from an Energy Star certified plant can also receive credit (see Errata, 10/07/2013). To be ENERGY STAR® certified, the plant must score in the top 25 percent based on the EPA National Energy Performance Energy Rating System.

Additionally, a plant that can document a 25% reduction of traditional fossil fuel consumption through recycled, waste or renewable fuels may also achieve this credit.

The user must provide documentation on the mix design, and calculations indicating that at least 50% of the project utilized Energy Star or lower embodied energy cement to receive 3 points.

PT-4 Cool Pavements

Goal: Reduce contribution to localized increased air temperatures due to pavement reflectance and minimize stormwater runoff temperatures.

Research has shown that cities are warmer that the surrounding undeveloped areas, due to a lack of vegetation and an increase in dark surfaces (roofs and paving). This effect is known as Urban Heat Island (UHI). Studies indicated that paved surfaces constitute 29-45% of the urban land coverage. This credit employs two strategies for heat island mitigation:

1) Install paving surfaces which have an albedo (solar reflectivity) of 0.3 or greater which reduces the absorption of solar energy

2) Install pervious pavements where the void structure enables convective and evaporative cooling.

Higher urban temperatures in the summer require additional electrical capacity and generation, which has capital and operational costs, as well as more emissions. NASA research estimated the 8°F increase by UHI effect in Atlanta, Ga. increased power consumption for cooling by 18%. Air temperatures above 78°F increase the formation of smog (ground level ozone), causing health concerns for children, elderly and those with asthma.

Concrete Contributions - New concrete has an average albedo (or solar reflectance) of approximately 0.34, meaning that it reflects about a third of the solar energy it receives, whereas new asphalt has an albedo of about 0.05. While concrete can become darker due to dirt, tire wear, and asphalt tracking from adjacent surfaces, the reflectivity can be usually be restored with pressure washing. Concrete surfaces (site-cast, pavers or pre-cast) that use integral stain, dye or colorant should be tested to ensure the reflectivity is appropriate for this credit.

The Greenroads user is asked to use a paving surface with an albedo of 0.3 or greater and/or pervious concrete or permeable pavers for at least 50% of the total hardscaped surfaces to achieve 5 points.

Custom Credits - Custom credits are for more sustainable design and construction practices that are not currently included in Greenroads. For details on submitting a Custom Credit, refer to the *Greenroads Manual*, v1.5, p. 471. To date, nine Custom Credits have been accepted by the Greenroads Foundation.

CC-9 VOC Reduction

Goal: Reduce exposure to hazardous air compounds.

Volatile organic compounds (VOCs) are organic chemicals that evaporate or sublimate at room temperature conditions. Many construction materials and coatings contain VOCs as a solvent, which can contribute to health problems and smog formation.

Concrete Contributions - Whether in a plastic or hardened state, concrete has very low VOC content, approximately 1% as what is found in typical acrylic latex paint. While concrete is relatively inert, curing compounds, sealers and waterproofing agents can contain VOC's. With an increased awareness of the health issues, most manufacturers provide a low or no VOC option in their product line. However, substitution of a low VOC product from construction specifications will likely require approval from the designer.

This credit awards 1 point for a 10% reduction and 2 points for a 20% reduction of total VOCs on a project, in lieu of traditional products specified for the application. All paints must comply with GS-11 Green Seal Environmental Standard for Paints and Coatings.

Greenroads Resources

The Greenroads Foundation offers a range of free, well written documents through their website at *www.greenroads.org.*

- ***Greenroads™ Manual* v1.5**. Comprehensive manual of all prerequisite and voluntary credits, strategies and submittal requirements.
- Industry professionals can become accredited through the Greenroads Sustainable Transportation Professional (STP) credentialing program. The STP candidate guide and webinar detail the information required for taking and passing the exam.
- A directory of projects and case studies highlight sustainable strategies on infrastructure projects.