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PCI AND SUSTAINIBILITY

1. What is PCI's position on sustainability?

Because of the inherent sustainable qualities of precast concrete, the [Precast/Prestressed Concrete Institute](#) (PCI) believes that precast manufacturers have a unique opportunity and obligation to participate in the sustainability movement by supporting green building practices. PCI's sustainability mission is:

[ENTER MISSION STATEMENT]

2. How does PCI actively encourage green building practices?

As the voice of the precast concrete industry, PCI has established a sustainability committee to provide leadership through education and sharing of green building practices using precast technology. PCI operates voluntary certification processes that standardize practices among precast plants and erectors. A key initiative is the development of similar guidelines for sustainable practices, including water recycling water, dust and emissions control, and energy reduction.

SUSTAINABILITY AND PRECAST CONCRETE

1. Is precast concrete a “green” building material?

Precast concrete contributes to green building practices in significant ways. Its low water-cement ratio – 0.36 to 0.38 – means precast concrete is extremely durable. Its mass shifts heating and cooling loads to help reduce mechanical system requirements. Because it's factory-made, precast concrete reduces construction waste on site, and does not add to construction IAQ concerns. The load capacity and long spans of precast members help eliminate redundant structures, and precast readily accommodates recycled content.

2. What makes precast concrete so durable?

The primary ingredients of concrete – sand, gravel and cement – are mineral based. When mixed with water, the cement molecules chemically combine with the water to create a crystalline matrix of high compressive strength. This matrix

binds the sand and gravel together, creating what is sometimes called “liquid stone.” Unlike other construction materials, which rust, rot or otherwise degrade when in the presence of moisture, concrete actually gets stronger.

3. Is precast concrete different from other types of concrete?

Precast concrete is different because it is made in a factory by highly experienced personnel who apply stringent quality control. In the factory environment, precasters are able to achieve consistency in temperature and moisture and low water to cement ratios that are not possible in field fabricated concrete. Precast strength easily achieves 5,000 to 7,000 psi or more, with densities that minimize permeation.

By contrast, the strength of field-applied concrete is typically in the range of 3,000 to 4,000 psi, and it is easily permeated by chloride-laden water that may cause corrosion of concrete reinforcing. Also more susceptible to mechanical damage, field-applied concrete’s generally lower strength is often due to changing personnel, water added to mix during travel and conditions at the site.

4. Is precast concrete energy efficient?

The thermal mass of precast concrete absorbs and releases heat slowly, shifting air conditioning and heating loads to allow smaller, more efficient heating, ventilating and air conditioning (hvac) systems. Insulation is often used in architectural panels and wall panels to increase thermal efficiency, and may achieve continuous insulation (“ci”) in walls. The resulting savings are significant – up to 25 percent on heating and cooling costs.

5. Does precast concrete contain recycled materials?

Precast concrete performance improves when several common industrial byproducts are added. Fly ash, slag and silica fume that would otherwise go to landfills can be incorporated into concrete mixes as supplementary cementitious materials (SCMs). These byproducts can reduce the amount of cement used in concrete.

Reinforcing is typically made from recycled steel. (Steel is one of the most recycled building materials, and can be reused again and again.) Insulation and connections within the precast concrete also contain recycled content.

6. Can precast concrete members be reused?

Precast concrete members are unique in that they are individually engineered products that can be disassembled. Designers can easily plan future additions to buildings, because the precast “kit of parts” can be rearranged. Once removed, precast members may be reused in other applications.

Precast is also friendly to downcycling, in which building materials are broken down, because it comes apart with a minimum amount of energy and retains its original qualities. An example of downcycling would be the use of crushed precast concrete as aggregate in new concrete or as base materials for roads, sidewalks and concrete slabs.

MATERIALS

1. What is the difference between concrete and cement?

While the terms are sometimes used interchangeably, concrete and cement are not the same. Concrete is a building material, a composite of aggregates including sand and gravel plus other ingredients. Cement is a key ingredient of the concrete mix, typically comprising 10 to 12 percent of the volume.

2. What does cement do to concrete?

Cement does what its name implies – it “cements” the aggregates and other ingredients together. A fine powder usually gray or white in color, cement is “hydraulic,” meaning it is activated by water. As the concrete mix is agitated, cement helps to turn it into a flowable, formable emulsion, finally curing it into the rock-like substance used for everything from simple sidewalks to sophisticated skyscrapers.

3. What is “Portland” cement?

Portland cement is a typical ingredient of concrete. It was invented in the early nineteenth century and named for the fine building stones that were quarried in Portland, England. The innovation marked a milestone in the construction history, as Portland cement created a far stronger bond than the plain crushed limestone of the day. Today it remains the best-performing and most economical binder for concrete mixes.

4. What are Supplementary Cementitious Materials (SCMs)?

SCMs are typical concrete ingredients that are byproducts of other industrial processes. Examples include fly ash, which is left over from coal burning power plants, and slag, which is produced during the production of steel. Other examples include silica fume and calcined clays.

As industrial byproducts, some SCMs may not be part of an ideal future. As sustainable development extends to other industries, less and less of these materials may be available to be recycled into concrete. In the meantime, SCMs offer an opportunity to improve concrete performance with a recycled material that would otherwise clog landfills.

5. What do SCMs do to concrete?

SCMs work with cement to bind the aggregates and other concrete ingredients, and can improve its strength and durability. Light colored SCMs such as white silica fume or metakaolin are used for architectural face mixes. Certain SCMs such as fly ash may slow the time of set, which may be offset by chemical accelerating admixtures. SCMs work through either hydraulic or pozzolanic reactions.

6. What are hydraulic and pozzolanic reactions?

These terms describe how concrete mixtures set and then harden. Hydraulic reactions occur when a reactive ingredient is mixed with water. Cement is hydraulic, and so are Class C Fly Ash and certain types of ground granulated blast furnace slag. Pozzolanic reactions occur in the presence of calcium hydroxide ($\text{Ca}(\text{OH})_2$), which is a byproduct of the hydration of cement. Class F Fly Ash, silica fume, calcined clays, and most slags are pozzolanic.

Both hydraulic and pozzolanic reactions increase the strength and durability of finished concrete.

MANUFACTURING

1. How is precast concrete made?

Precast concrete is made in a factory setting, where a dedicated batch plant produces a specially designed concrete mix for precast products such as structural beams, columns and double tees, architectural cladding, and wall systems. Sand and aggregates usually come from nearby quarries, while cement and other ingredients are supplied.

The mixed concrete is poured into a form around reinforcement and, often, prestressing strands that provide load-resisting camber to the finished precast member. After it is cured, the precast product is stripped from the form and moved to the precaster's yard for finishing and storage prior to shipping to the job site.

2. What steps are precast operations taking toward sustainability?

Precast manufacturing members of PCI meet local and state ordinances and emissions requirements. Initiatives within the industry include:

- Use of local materials in all mixes; local aggregate resources
- Water reclamation and recycling
- Reducing cement requirements by lowering water-cement ratios
- Admixtures such as hardening accelerators to eliminate applied heat in curing
- Use of self-consolidating concrete (SCC) for quicker placement, no vibration, and reduced surface defects
- Use of environmentally friendly thin brick in place of conventional brick in precast systems
- Carbon fiber reinforcement that allows lighter and larger concrete sections with less embedded energy, and no corrosion
- Use of supplemental cementitious materials (SCMs) to reduce cement consumption; participation in [Cool Climate Concrete](#)
- Enclosed sand blasting facilities with 100% process waste control
- Standardizing wood form parts for multiple reuse; recycling discarded forms into mulch or fuel
- Recycling all scrap steel and rebar
- Beginning initiative to reduce and reuse product packaging received into our facilities

3. How much cement is in precast concrete?

Typical concrete mixes contain approximately 10-12 percent cement. The cement is activated by water to bind together the sand, aggregates and other ingredients of the concrete mix. According to the [DOE](#), cement production contributes between 1 and 2 percent of global carbon dioxide emissions through the burning of fossil fuels and process-related emissions.

The amount of cement used in precast concrete may be reduced by up to 60 percent through substitution by Supplementary Cementitious Materials (SCMs), which further strengthen concrete. Cement substitution is subject to mix design requirements, and to the products and processes of individual precast manufacturers and plants.

4. What is being done about CO₂ emissions during the cement manufacturing process?

Since 1975 the [cement industry](#) has reduced CO₂ emissions by 33 percent. Today cement production accounts for less than 1.5 percent of U.S. carbon dioxide emissions, well below other sources such as electric generation plants for heating and cooling the homes and buildings we live in (33 percent) and transportation (27 percent).

In 2000, the cement industry created a new way to measure CO₂ emissions. Recently introduced guidelines will allow for greater use of limestone as a raw material of cement, ultimately reducing CO₂ by more than 2.5 million tons per year. By the year 2020, plans call for further reduction of CO₂ emissions to 10 percent below the 1990 baseline through investments in equipment, improvements in formulations, and development of new applications for cements and concretes that improve energy efficiency and durability.

PRECAST CONTRIBUTIONS TO LEED CERTIFICATION

1. What is LEED?

The US Green Building Council (USGBC) developed LEED Green Building Rating systems to assist with market transformation to a more stable, efficient and environmentally sound approach to design and construction. LEED stands for “Leadership in Energy and Environmental Design.” The programs are voluntary, consensus based systems used as standards for certification and design guides for sustainable construction and operation.

LEED includes a growing portfolio of rating systems serving specific market sectors:

- New Construction (LEED-NC)
- Existing Buildings (LEED-EB)
- Commercial Interiors (LEED-CI)
- Core & Shell (LEED-CS)
- Homes (LEED-H)
- Neighborhood Development (LEED-NH)

Note: With its rigorous metrics, LEED rating systems are emerging as a key means to measure sustainable design practice. Other paths include Green Globes and Energy Star.

2. How does LEED-NC work?

The LEED-NC rating system assigns points to aspects of sustainable performance in six categories:

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Innovation and Design

To achieve LEED certification, project teams must satisfactorily document achievement of all the LEED prerequisites and a minimum number of points.

Project teams submit design concepts and plans to the USGBC, often through the efforts of a LEED Accredited Professional (LEED AP). USGBC assigns an expected rating to the project, and gives a formal rating after the team completes a construction submittal.

3. How many points are required for a project to be LEED-NC Certified?

LEED-NC certifies buildings to four levels of increasing sustainable performance:

Certified	26–32 points
Silver	33–38 points
Gold	39–51 points
Platinum	52–69 points

4. How does precast concrete contribute to LEED-NC rating points?

Precast concrete:

- Reduces site disruption (area and time)
- Reduces damage to drainage paths and natural habitats
- Can increase open area with multi-level precast garages are used
- Reduce the heat-island effect with light colors
- Improve energy efficiency and thermal comfort
- Reuses and recycles precast forms, keeping materials out of the landfill
- Uses recyclable concrete and steel
- Can be reused or recycled
- Can use waste materials such as pozzolans (slag, fly ash, silica fume)
- Is generally made from materials that are extracted and manufactured regionally
- Does not off-gas, and does not need to be sealed or painted

5. What LEED-NC points does precast concrete contribute toward?

Precast concrete and other materials contribute to LEED points by providing performance and properties that are measured by the LEED program. At this time, PCI endorses potential precast contributions for up to 20 LEED points (see LEED Project Checklist) and possibly more, depending on the project.

Sustainability FAQ

Frequently Asked Questions

Table 5.4.3 – LEED® Project Checklist: Precast Concrete Potential Points.

LEED CATEGORY	CREDIT OR PREREQUISITE	POINTS AVAILABLE
Sustainable Sites	Credit 5.1: Site Development: Protect or Restore Habitat	1
Sustainable Sites	Credit 7.1: Heat Island Effect: Non-Roof	1
Energy and Atmosphere	Prerequisite 2: Minimum Energy Performance	—
Energy and Atmosphere	Credit 1: Optimize Energy Performance	1-10
Materials and Resources	Credit 2.1: Construction Waste Management: Divert 50% From Disposal	1
Materials and Resources	Credit 2.2: Construction Waste Management: Divert 75% From Disposal	1
Materials and Resources	Credit 4.1: Recycled Content: 10% (post-consumer + ½ pre-consumer)	1
Materials and Resources	Credit 4.2: Recycled Content: 20% (post-consumer + ½ pre-consumer)	1
Materials and Resources	Credit 5.1: Regional Materials: 10% Extracted, Processed, & Manufactured Regionally	1
Materials and Resources	Credit 5.2: Regional Materials: 20% Extracted, Processed, & Manufactured Regionally	1
Indoor Environmental Quality	Credit 3.1: Construction Indoor Air Quality Management Plan: During Construction	1
Innovation and Design	Credit 1.1: Apply for other credits demonstrating exceptional performance	1†
Innovation and Design	Credits 1.2: Apply for other credits demonstrating exceptional performance	1†
Innovation and Design	Credits 1.3: Apply for other credits demonstrating exceptional performance	1†
Innovation and Design	Credits 1.4: Apply for other credits demonstrating exceptional performance	1†
Innovation and Design	Credit 2: LEED Accredited Professional	1
PROJECT TOTALS		20

*LEED: Leadership in Energy and Environmental Design.

† Up to 4 additional points can be earned, must be submitted and approved (not included in total).

Note: Scoring System: Certified, 26-32 points; Silver, 33-38 points; Gold, 39-51 points; and Platinum, 52-69 points.

For a detailed discussion of precast concrete's contributions to green building practices, including LEED points, please refer to "[Achieving Sustainability with Precast Concrete](#)," Martha VanGeem, CTL Group, *PCI Journal*, January-February 2006.

6. How can precast concrete reduce the heat island effect described in the Sustainable Sites section (SS 7.1)?

Sustainable Sites Credit 7.1 is intended to reduce heat islands, meaning the thermal gradient difference between developed and undeveloped areas. Partially attributed to the dark surfaces of roofing and paving, the additional heat increases hvac loads and contributes to the creation of smog. Reducing heat islands minimizes impact on microclimate and human and wild life habitat.

Precast concrete parking decks that place at least 50% of the spaces under cover (e.g. underground, under a building, under a deck or roof) can reduce this effect. Any roof used to shade or cover parking must have a solar reflective index (SRI or albedo) of at least 29. In addition, high albedo vertical precast concrete wall surfaces reduce the heat island effect.

7. Do recycled materials in concrete (fly ash, etc) contribute to LEED points?

Yes, under the recycled content Credit MR 4.1 and 4.2.

8. Is the 500-mile radius requirement for local material content limited to the finished precast product, or does it also apply to the raw materials?

Credit MR 5.1-5.2 applies to all materials which are extracted, processed and manufactured within a 500-mile radius of the project site.

9. How can precast concrete contribute to Innovation and Design in LEED?

Projects earn Innovation and Design credits when they demonstrate exemplary performance in a recognized LEED credit area, or bring new approaches and technologies such as carbon fiber reinforcing that reduce weight and embedded energy and advance sustainable design. Because of its significant contributions to LEED, and its inherently green characteristics, precast concrete offers an excellent platform on which creative project teams can base their sustainable design plans.

10. How does precast contribute to the underlying sustainability concept of "Reduce, Reuse, Recycle"?

By Reducing the amount of materials and the toxicity of waste materials ...

Sustainability FAQ

Frequently Asked Questions

- Precast concrete can be designed to optimize (lessen) the amount of concrete
- Use of carbon fiber reinforcement can reduce:
 - Amount of concrete needed in a precast panel
 - Weight of a precast panel
 - Transportation cost of precast panel
 - Amount of energy used to erect a precast panel
- Precast concrete generates low amounts of waste with low toxicity
 - 2% of the concrete at a precast plant is waste
 - 95% of the waste is used to manufacture new panels

By Reusing products and containers and repair what can be reused ...

- Precast concrete panels can be reused when buildings are expanded
- Concrete pieces from demolished structures can be reused to protect shorelines
- Wood or fiberglass formwork used to make precast are reused generally 40 or more times
- Concrete and steel have practically unlimited service lives

By Recycling as much as possible, including buying products with recycled content ...

- Industrial wastes (fly ash, slag cement and silica fume) can be used as partial replacements for cement
- Wood and steel forms are recycled when they become worn or obsolete
- Virtually all reinforcing steel is made from recycled steel
- Insulation contains partially recycled material
- Concrete in most urban areas is recycled as fill or road base

SUSTAINABILITY

1. What is sustainability and why is it important?

The United Nations [Brundtland Commission Report](#) (1987) defined sustainable development and urged the world to take note: “Sustainable development is that which meets the needs of the present without compromising the ability of future generations to meet their own needs.”

A growing global population is straining the finite resources available on the planet. Sustainability seeks to balance the economic, social and environmental impacts, recognizing that population growth will continue. Sustainable development brings this evaluation to the design and construction industries, which have significant potential to reduce the negative impact of human activities on the environment.

2. Why is there demand for sustainable development?

According to the U.S. Green Building Council (USGBC), buildings in the United States consume nearly 10% of the world's energy, and over 30% of the total energy and more than 60% of the electricity in the U.S. The [DOE reports](#) that 51% of electricity comes primarily from the burning of coal, a fossil fuel that produces significant greenhouse gases during combustion.

With energy costs increasing, and concerns about environmental impact growing, the U.S government is adopting green building programs. In addition, increasing number of states are offering tax benefits for green public buildings, and large corporations are moving toward sustainable design for their facilities.

3. What is a green building?

The U.S. Office of the Federal Environmental Executive (OFEE) [defines](#) green buildings as those that:

- demonstrate the efficient use of energy, water and materials
- limit impact on the outdoor environment
- provide a healthier indoor environment

Studies show that green buildings offer improved air quality and more access to daylight in addition to energy and cost savings. The USGBC estimates that green buildings cost 8-9% less to operate, and have a 7.5% greater building value.

4. What is the cost premium for a green building?

The [USGBC cites](#) an initial cost premium of anywhere from 0% to 2% for green buildings in the US. As project teams become more experienced with building green, these costs should decrease. Generally, a 2% increase in construction costs will deliver a savings of (ten) 10x the initial investment in operating costs for utilities (energy, water, and waste) in the first 20 years of the building's life.

5. What is the payback for a sustainable building project?

The financial payback of green building practice is measured in operating savings over time offsetting initial costs of sustainable features. The payback varies from project to project along with sustainable features and other factors such as availability of materials and expertise of the design team. However, experienced design professionals maintain that green buildings do not have to cost more than non-green buildings.*

*[HOK Guidebook to Sustainable Design](#)

6. How can I measure the costs and benefits of sustainable design?

Most project teams perform a comprehensive life cycle assessment (LCA) prior to defining their sustainable goals for the project. The LCA predicts how long it will take to recoup additional first cost.

7. Do government projects require LEED certification?

More and more local, regional and national government agencies require sustainable building practices or LEED certification. The Wall Street Journal reported that Michigan, Washington and Arizona adopted guidelines to produce buildings that are more energy efficient and environmentally sensitive. The [General Services Administration](#) (GSA), [U.S. Army](#), Department of State, [Department of Energy](#) (DOE), and Environmental Protection Agency (EPA) are adopting LEED or similar green building standards. Eight states including California, New York, Washington and Oregon have adopted LEED, as have many U.S. cities including [Chicago, Boston and San Francisco](#).

GREENHOUSE GASES

1. What are greenhouse gases?

Gases that trap solar heat in the Earth's atmosphere and contribute to global mean temperature are considered greenhouse gases. They take their name from the "greenhouse effect," the term that compares the heat-trapping gases to the glass panes of a greenhouse for the way they warm the atmosphere. [According to the National Energy Information Center](#), "Many gases exhibit these "greenhouse" properties. Some of them occur in nature (water vapor, carbon

dioxide, methane, and nitrous oxide), while others are exclusively human-made (like gases used for aerosols).

2. Carbon dioxide occurs naturally in the atmosphere, so why are CO₂ emissions a concern?

Studies show that human activities are rapidly increasing the amount of CO₂ in the atmosphere, which in turn is increasing global mean temperature. The Intergovernmental Panel on Climate Change (IPCC) [cites climate models](#) predicting the effects of higher temperatures, including rising sea levels and greater frequency of heat waves and floods. [These events](#) could have severe impact on the biosphere, human health, political stability and economic development.

3. What is a “carbon footprint”?

A [carbon footprint](#) is the quantification of energy-related emissions from human activity expressed in units of carbon dioxide (CO₂). It includes all the heat, light, power, refrigeration, and transportation emissions associated with the harvesting, manufacturing, use and disposal of a particular material, product or service.

Carbon footprints are most closely linked to the burning of fossil fuels. The USGBC estimates that in the next 25 years, CO₂ emissions from buildings are predicted to grow faster than any other sector of the economy, with commercial building emissions forecast to increase 1.8 percent through 2030. New commercial buildings will add an estimated 12 million metric tons of CO₂ per year.