Total-precast structure aids office design by offering 'green' qualities, including close proximity, energy efficiency, reliability and minimal construction waste.

Precast Concrete Achieves Sustainability Goals

CH2M Hill World Headquarters, Englewood, Colo., Architect: Barber Architecture, Denver.

Sustainability has become a watchword for owners and architects when designing new buildings, intermingled with terms such as "environmental friendliness" and "green building."

Today's green-building approaches extend beyond the ability to renew or recycle resources and examine the embodied energy required to make use of that material. This accounting practice encompasses all the energy necessary to manufacture, deliver and install the product. This includes the fuel to extract materials, finish them and transport them to the site.

While other building materials may have to alter their configurations or properties to be applicable to sustainable structures, precast concrete's inherent composition provides natural advantages for sustainability. It contributes by incorporating integrated design, efficient use of materials, and the reduction of construction waste, site disturbance and noise.

Precast concrete components can maximize benefits from integrated-design strategies, which focus on all of the building's materials and systems, as well as how they interact. An integrated-design strategy embracing sustainable concepts encompasses three ways to minimize material use:

1. Reduce the amount of material used and the toxicity of waste materials. Precast concrete can be designed to optimize or lessen the amount of concrete used. Industrial wastes such as slag cement and silica fume can be incorporated into the mix, reducing the amount of cement, which in turn reduces CO_2 emissions. As a manufactured product created under controlled conditions in the plant, precast concrete generates low amounts of waste, and the waste generated has low toxicity.

2. Reuse and repair products. Precast concrete panels can be reused when buildings are expanded. Concrete pieces from demolished structures also can be reused in other applications. Because the precast process is self-contained, formwork and finishing materials are reused. Wood or fiberglass forms can generally be used 40 to 50 times without major maintenance, while concrete and steel forms have practically unlimited service lives.

3. Recycle and use products with recycled content. Concrete can be recycled as fill or road base. Wood and steel forms are recycled when they become worn or obsolete. Virtually all reinforcing steel is made from recycled steel. Many cement plants burn waste-derived fuels such as spent solvents, used oils and tires.

Precast concrete can help buildings in a variety of ways to achieve the standards created by the Leadership in Energy & Environmental Design (LEED) building-rating system. The LEED system's points create a framework for assessing building performance and meeting sustainability goals.

Appropriate use of precast concrete components can help a building earn up to 27 LEED points, one more than is required for LEED certification (a chart that oulines these points is available at *www.pci.org/ascent*). The attributes and capabilities of precast concrete that help meet LEED certification vary by the intent of each category. The key applications center on these attributes:

Durability

Precast concrete panels provide a long service life due to their durable and low-maintenance concrete surfaces. A precast concrete shell can be left in place when the building interior is renovated. Yearly maintenance should include inspection and, if necessary, repair of joint material.

Modular and sandwich-panel construction with precast concrete exterior and interior walls provides long-term durability inside and out. Precast concrete construction creates the opportunity to refurbish the building if its use or function changes rather than tearing it down to start anew.

Precast concrete's inherent composition allows it to naturally achieve sustainability.

These characteristics decrease the contribution of solid waste to landfills, and reduce the depletion of natural resources and production of air and water pollution caused by new construction.

Mitigating Urban Heat Islands

Cities and urban areas are 3 °F to 8 °F warmer than surrounding areas due to buildings and pavements taking the place of vegetation. The ability of a material to reflect solar heat is called albedo, and the higher the material's albedo, the better it reflects.

Concrete has a relatively high albedo. Traditional portland-cement concrete generally has an albedo or solar reflectance of approximately 0.4 to 0.5.

Precast Concrete Production

The production of precast concrete has many environmental benefits, including:

- Less material is required because precise mixture proportions and tighter tolerances are achieved.
- Optimal insulation levels can be incorporated into sandwich wall panels.
- Waste materials are more likely to be recycled.
- Gray water can be recycled into future mixtures.
- Hardened concrete is recycled (about 5% to 20% of aggregate in precast concrete can be recycled concrete).
- Sand used for finishing surfaces is reused.
- Steel forms and other materials are reused.
- Less dust and waste are created at the construction site because only needed precast concrete elements are delivered.
- There is no debris from formwork and associated fasteners.
- Fewer trucks and less time are required for construction because concrete is made off-site.
- Precast concrete units are normally large components, so greater portions of the building are completed with each activity.
- Less noise occurs at the construction site because concrete is made off-site.
- Less concrete generally is used in precast buildings compared to other concrete buildings because of the optimization of materials. A properly designed precast concrete system will result in smaller structural members, longer spans and less material used on-site. This creates economic and environmental savings.

Constituent Materials

Concrete contributes to a sustainable environment because it does not use scarce resources. It consists of only a few ingredients, primarily cement, water, large and small aggregates, and admixtures, all of which are abundant locally. Although portland cement, a key ingredient, is energy intensive, the U.S. cement industry has reduced energy usage per ton of cement by 35% since 1972. Fly ash, slag cement and silica fume can be used to replace portland cement content.

Aggregates, which make up about 85% of concrete, generally consist of materials that require low levels of energy to produce, comprising local, naturally occurring sand and stone. Their benefits can be further improved by using blast-furnace slag or recycled concrete as aggregates.

Local Ingredients

The use of local materials reduces the transportation needs for heavy building materials, along with the associated energy and emissions. Most precast concrete plants are within 200 miles of a building site. The cement, aggregates and reinforcing steel used to fabricate precast concrete components, along with the raw materials used to manufacture cement, are usually obtained or extracted from sources within 200 miles of the precast concrete plant.

Energy Conservation

Energy conservation is a key tenet of sustainability. About 90% of the energy used during a building's life is attributed to heating, cooling and other utilities. The remaining 10% is attributed to manufacturing materials,construction, maintenance, replacement of components and demolition.

Precast concrete's inherent capabilities to provide energy efficiency rely on the high thermal mass of the material, which benefits exterior wall applications. Mass works well on the inside surfaces by absorbing the heat gains generated by people and equipment indoors. Light-colored precast concrete will reduce energy costs associated with indoor and outdoor lighting. The more reflective surfaces will reduce the amount of fixtures and lighting required.

Indoor Air Quality

Concrete contains low to negligible Volatile Organic Compounds (VOCs). These compounds degrade indoor air quality when they off-gas from new products such as interior finishings, carpet and furniture. Manufactured wood products such as laminate, particleboard, hardboard siding and treated wood can also lead to off-gassing. In addition, VOCs combine with other chemicals in the air to form ground-level ozone.

Polished concrete floors do not require carpeting. Exposed concrete walls do not require finishing materials. The VOCs in concrete construction can be minimized further by using low-VOC materials for form-release agents, curing compounds, damp-proofing materials, wall and floor coatings and primers, membranes, sealers and water repellants.

Concrete is not damaged by moisture and does not provide nutrients for mold growth.

The concrete industry has LEED-experienced professionals available to assist teams with concrete applications and help maximize points for concrete. An additional point is available if a principal participant of the project team is a LEED-Accredited Professional. ■

Energy efficiency, manufacturing processes and other attributes make precast concrete a strong choice when trying to achieve sustainable design

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 5.2: Site Development, Maximize Open Space	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 1.1: Building Reuse, Maintain 75% of Existing Shell	1
Materials and Resources	Credit 1.2: Building Reuse, Maintain 95% of Existing Shell	1
Materials and Resources	Credit 2.1: Construction Waste Management, divert 50% by weight or volume	1
Materials and Resources	Credit 2.2: Construction Waste Management, divert 75% by weight or volume	1
Materials and Resources	Credit 4.1: Recycled Content, the post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% (based on cost) of the total value of the materials in the project	1
Materials and Resources	Credit 4.2: Recycled Content, the post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 20% (based on cost) of the total value of the materials in the project	1
Materials and Resources	Credit 5.1: Local/Regional Materials, Use a minimum of 10% (based on cost) of the total materials value	1
Materials and Resources	Credit 5.2: Local/Regional Materials, Use a minimum of 20% (based on cost) of the total materials value	1
Indoor Environmental Quality	Credit 3.1: Construction Indoor Air Quality Management Plan, During Construction	1
Innovation and Design Process	Credit 1.1: Use of high volume supplementary cementitious materials. Apply for other credits demonstrating exceptional performance	1†
Innovation and Design Process	Credits 1.2: Apply for other credits demonstrating exceptional performance	1†
Innovation and Design Process	Credits 1.3: Apply for other credits demonstrating exceptional performance	1†
Innovation and Design Process	Credits 1.4: Apply for other credits demonstrating exceptional performance	1†
Innovation and Design Process	Credit 2.I: LEED Accredited Professional	1
	PROJECT TOTALS	**23**

*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.

Flannery Constrcution Headquarters, St. Paul, Minn.

Photo: Hansen Structural Precast Midwest, Inc.

Typical Albedos for Selected Building Products

Material	Albedo range
Alphalt	5-20%
Roofing tile	10-35%
Stone	20-35%
New concrete	35-40%
Colored metal roofs	55-66%
Cool roofs (with reflective membrane)	85%
Snow	75-95%

Source: U.S. Environmental Protection Agency (www.epa.gov) and ESPERE-ENC (Environmental Science Published for Everybody Round the Earth-Educational Network on Climate)

Precast concrete's high thermal mass creates inherent energy efficiency.