ABSTRACT:
Sustainability has become a watchword for owners and architects when designing new buildings, intermingled with terms such as “environmental friendliness” and “green building.” Few industries are moving sustainability forward at a faster rate than the Precast/Prestressed Concrete Institute (PCI). Because of its history as the technical and standard-setting institute, and the body of knowledge for the precast/prestressed concrete industry, PCI’s approach to sustainability is to provide information that is based on research and technical knowledge.

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.

Sustainable Attributes
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]

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 CO2 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 deconstruction. 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.

While products do not earn points, appropriate use of precast concrete components can help a building earn
LEED points in several categories, and achieve LEED certification. 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:

![Figure 1](image1.png)

**Figure 1.** All three total precast buildings are LEED certified. CH2M Hill World Headquarters, Englewood, CO. Architect: Barber Architecture (Courtesy: Barber Architecture)

**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. Periodic 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.

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.

![Figure 2](image2.png)

**Figure 2.** The buildings in the corporate campus for CH2M Hill in Englewood, Colo., are framed with a total precast concrete system; including precast concrete shear walls, double-tees, inverted-tee beams, and load-bearing exterior walls. The buildings are some of the first LEED-certified total precast concrete office buildings.

**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, continuous 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 continually reused.
- Less dust and waste are created at the construction site since only needed precast concrete elements are delivered. Little to no lay down area is required, allowing less site disturbance.
- 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 offsite.
- 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.

- And, the prefabrication of precast components leads to accelerated construction, allowing other trades earlier access and safer, enclosed working conditions.

**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 interior wall applications. Mass works well on the inside surfaces by absorbing the heat gains generated by people and equipment indoors. Often, HVAC equipment can be down sized, and energy can be consumed during non-peak times. 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 finishes, 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.

CASE STUDY – THE PROXIMITY HOTEL [2]

Designed to resemble an old cut-and-sew textile factory, and named after the Proximity Cotton Mill that operated nearby in the early 1900s, the Proximity Hotel is the first hotel in the nation to achieve LEED Platinum certification. The structure, in fact, boasts over 70 energy and health-related enhancements and earned 55 out of a possible 69 credits for LEED – New Construction.

The seven-story project showcases the fact that sustainable construction, even at the level of a LEED Platinum design, can be cost effective when based on a life-cycle analysis. Dennis Quaintance of Quaintance-Weaver, owners of the hotel, estimates that environmental goals added between $1.5 and $2 million to the budget, but that the green strategies will pay for themselves in less than 4 years. The
water savings alone saved the company $13,000 in the first year of operations. Overall, Quaintance expects to save $140,000 a year in utility costs.

With 147 rooms, the hotel contains 102,000 square feet of space, including 7,000 square feet of conference and event space and a full-service restaurant. “The owners wanted a unique character for this luxury, boutique hotel,” says Tom Murphy, principal architect, Centrepoint Architecture. “The intent was to make the building look like an industrial factory. The idea was to have everything be itself. There isn’t a lot of trim or cover details. All the conduit and ductwork is exposed. The light fixtures are fairly basic. So, we had to pay close attention to all the details and how they fit together. The precast concrete insulated panels were a major factor because they were finished inside and out and did not need additional finishings.”

**Precast Concrete’s contribution to Sustainable Construction Practices**

The high-performance, structurally composite precast concrete wall panels are durable, impervious and thermally efficient. The mass wall system includes 3.5 in. of continuous foam insulation at the core that exceeds ASHRAE energy standards, surrounded by exterior and interior precast concrete layers totaling 6.5 in. of concrete. Use of carbon grid wythe connectors greatly reduced thermal bridging. Total R-value of the wall panels is 15.5.

Precast panels arrived on site with a finished exterior, complete with integral color, reveals and sandblasting. The ready-to-paint interior does not emit volatile organic compounds and limits the need for field labor and finishing materials.

Precast concrete contributed to project sustainability by reducing the use of harvested materials and by reducing site noise, disturbance, and dust. The precast concrete has near zero construction site waste and nearly all cement, sand, aggregates, reinforcement, and insulation was sourced within 500 miles. The concrete mix utilized 20% fly ash. Reinforcing steel contains a high degree (80 to 90%) of post-consumer content. Steel, insulation and cement used also contains pre-consumer content.

**REFERENCES**
