

WHAT ARE HIGH PERFORMANCE AND HIGH PERFORMANCE PRECAST CONCRETE?

What is a High Performance Structure?

The United States Government defines a high performance structure as one that

“...integrates and optimizes on a lifecycle basis all major high performance attributes including energy and water conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.”

- Energy Independence and Security Act of 2007 - 401 PL 110-140

At the heart of this definition is a fundamental shift in perspective from sustainable design and construction to sustainability **and** performance on a lifecycle basis. The concept of ‘high-performance’ encompasses the concepts and practices of sustainability. However it goes beyond a ‘this-or-that’ approach by requiring optimization of **all** relevant attributes for a project. Hence, characteristics such as energy and water conservation, safety, security, and durability, are no longer just options, but requirements that must be integrated into a structure’s overall design, construction, and performance.

High performance structures are essential to meet a variety of demands, from economic to environmental. As a result, more codes, funding entities, and owners are requiring high performance structures. Examples include the new International Green Construction Code, the next version of LEED (v.4) and the mandate by the U.S. Federal Government Executive Order 13514 which requires government buildings to achieve net zero by 2030.

High performance structures require high performance materials and systems. These consist of integrated systems that allow for design versatility and are efficient, resilient and can be optimized to meet the multi-hazard requirements and long-term demands of high performance structures. Precast concrete is used more and more to help projects meet and exceed their high performance goals during design, construction, and operation.

High Performance Precast Concrete

Precast concrete is a high performance material that integrates easily with other systems and inherently provides the versatility, efficiency, and resiliency needed to meet the multi-hazard requirements and long-term demands of high performance structures.

Precast Concrete is Versatile

Precast concrete has excellent *aesthetic versatility*, providing an almost endless array of colors and textures and allowing for subtle variations through different techniques. These are achieved by using a variety of aggregates, finishing techniques, and pigments. Precast concrete can also be embedded or veneered with many natural materials such as clay thin-brick and natural stone. This offers the natural beauty of these materials with the high performance benefits of precast concrete.

Precast concrete allows the designer to create a variety of shapes, patterns, and details, which are difficult — if not impossible — to achieve with other materials.

Multiple finishes can be combined in one panel, which reduces detailing, joints, flashing and maintenance costs, as well as the associated liability risks that are a frequent by-product of facades created from multiple materials.

Precast concrete can serve as both the structural and cladding/envelope systems simultaneously, minimizing material use and accelerating construction. In today's financial environment, reduction in the overall construction schedule results in quicker return on investment, making precast concrete the optimal solution.

Because precast concrete is essentially custom designed and manufactured, it has the flexibility for unique applications, lending it to project optimization. Precast/prestressed concrete also provides for *longer open spans with fewer columns and obstructions*, as well as smaller cross sections through the use of high-strength concrete and prestressing. This allows floor plans to be more easily adapted as a building's function changes throughout its service life.

Its versatility also allows for *scalable performance*. New energy codes and ASHRAE requirements demand increasing thicknesses of continuous insulation. Precast concrete insulation can be tailored to meet these requirements while avoiding many of the detailing difficulties of cavity wall construction.

Precast Concrete is Efficient

High performance materials and systems must be efficient in their initial use of resources while minimizing a structure's life-cycle costs. Precast concrete is manufactured offsite in a controlled environment. This *helps minimize negative effects on a construction site* while maximizing quality. Precast concrete does not require onsite storage or staging; it is delivered to the site as needed. It is typically erected with a crane and a relatively small crew, which allows for construction within a small footprint and minimizes disruption to the surrounding area.

Precast concrete arrives at the site ready for installation and does not require protection from rain, sun, snow, wind, or extreme temperatures. This saves time and money and reduces the potential for change orders due to winter conditions. *Precast concrete is one of the fastest building systems available* taking as much as 40% less time than steel construction.

Precast concrete helps *reduce a project's life-cycle costs*, particularly with regard to energy use. Precast concrete has thermal mass, which can be used to reduce the total energy needed to heat and cool a building. Concrete has a high heat capacity, which means it stores heat and then slowly releases it when the temperature differential shifts. This moderates the demand for heating and cooling and shifts peak demands to times when utility rates are lower. Thermal mass provides for a greater effective R-value, allowing smaller HVAC systems to do the same job. This all translates to less energy needed to maintain a comfortable and more uniform indoor temperature.

Precast concrete sandwich wall panels combine thermal mass with a layer of continuous, edge-to-edge insulation meeting the new continuous insulation (ci) requirements. Composite connectors between the wythes *eliminate thermal bridges or cold spots*. This is verified through thermal imaging.

Because energy efficiency is one of the greatest factors contributing to total life cycle costs and environmental impact, this is a vital area to optimize. Precast concrete sandwich wall panels can greatly contribute to the optimization of a building's envelope and often *help reduce total energy consumption of a building* by as much as 30%.

Precast concrete can have over *100 years of service life*. It does not rot, rust, or degrade in the presence of moisture or when exposed to sunlight. Precast structures typically have fewer joints relative to other cladding systems and do not require painting. All of these attributes contribute to *reduced maintenance costs*.

Precast Concrete is Resilient

High performance systems must be able to resist natural and manmade forces. Resiliency encompasses durability and sustainability as well as a structure's ability to be restored to its full function with minimal effort and resources following a major disaster such as an earthquake or hurricane. This also helps minimize negative effects on the environment after such an event, as resilient structures do not need to be completely rebuilt.

Precast concrete provides *resilience against earthquakes*. PCI has conducted extensive research on seismic design and the performance of precast concrete structures in earthquakes. This research has resulted in innovative design methodologies including the Precast Seismic Structural Systems (PRESSSS). Precast concrete systems can be designed to withstand high seismic forces and allow a building to “self-right” after an earthquake.

Several of these concepts have been adopted into building codes such as ACI-318, which is referenced by the International Building Code. These systems now are used by developers across the country, including in high-seismic zones such as California.

Precast concrete also offers *protection from high winds and flying debris*. Impact studies highlight the protection that precast concrete construction provides. Three different wall systems were tested by launching 2 x 4 projectiles at 100 mph at each test panel. Projectiles easily penetrated through both stud and cavity wall system test panels, which had ¾ in. OSB sheathing over a 2 x 4 stud frame. One was then finished with vinyl siding, and the other with a 4 in. brick veneer. However, the projectile did not penetrate or crack the precast concrete sandwich wall panel system. In fact, after multiple tests, the precast panel suffered only minor blemishes.

Precast concrete also provides *resilience against blasts*. Recent tests conducted by the Air Force Research Laboratory demonstrate the ability of precast concrete to withstand blast forces. This research examined the blast resistance of insulated precast concrete sandwich wall-panel construction under full-scale blast conditions in a multi-story structure.

These results enable designers to use precast concrete to protect against threats in the design of structures. Results also show that due to the strength and resilience of precast concrete, the required stand-off distance can be reduced when using precast concrete compared to traditional design requirements.



Precast Concrete Provides a Safe Environment

By designing and building with high performance precast concrete, we help ensure that the occupants remain safe. Precast concrete is resilient against disasters such as earthquakes and hurricanes and is also fire resistant. Concrete does not combust, so it provides passive fire protection. This protection does not rely on other systems such as mechanical or water pipes that sometimes fail to operate. Precast concrete can also easily meet fire ratings required by building codes.

Precast concrete is an inert material and does not contribute to poor indoor air quality through Volatile Organic Compounds (VOCs) offgassing, or mold growth. Because precast concrete can be erected quickly, buildings are enclosed quickly, protecting the interior from external contaminants and moisture while shaving months off of a project's schedule. Precast concrete's high Sound Transmission Class (STC) ratings provide effective acoustic separation of occupiable spaces from exterior and interior noises. In many cases, precast concrete can be left exposed on the interior of a building, eliminating the need for drywall, reducing waste, and increasing the overall durability of the interior finish. Overall, precast concrete provides a safe and pleasant indoor environment.

Precast concrete is a versatile, efficient, and resilient high performance system that allows designers and owners to integrate and optimize important attributes for their projects.