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DESIGNING WITH PRECAST CONCRETE

DIGITAL EDITION

FALL 2024

HOW PRECAST BUILDS

Did you know precast concrete is the ideal solution for many projects?

Did You Know?

Precast concrete is the ideal construction material for the data center you are planning

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Data centers and the digital infrastructure they support are the lifeblood of our economy, powering everything from search engines to e-commerce to artificial intelligence. We asked three industry experts to provide insights regarding precast concrete and the rapidly expanding data center market

Precast concrete plays a significant role in meeting the needs of data centers. No other market so readily embraces the inherent qualities and benefits of the material. Precast concrete is well-suited to withstand natural or man-made disasters, and to protect the valuable equipment and data inside that are now an essential part of our infrastructure.

Although precast concrete is not new to the data center market, readers are curious about the rapid changes to the industry. According to a McKinsey & Company Report, the U.S. demand for data centers is predicted to grow by 10% per year until 2030, while others think those numbers are very conservative. The experts agree that technological innovation is driving record demand for data storage and computing power. Digital transformation will accelerate the need for processing power, storage, and cloud services in colocation and hyperscale data centers.

Ascent talked to the experts about the engineering behind these mission-critical structures; their approaches to project delivery; the expansion and evolution of the market; and the risks, rewards, and challenges in the marketplace. Their responses were edited for clarity and brevity. All the experts agree that data centers will be filling up their pipeline of work in the years to come.

DC Blox in Birmingham, Ala., won a 2021 PCI Design Award for best data center. GATE Precast supplied the precast concrete. ***Photo:*** *DC Blox.*

This confidential data center in Manassas, Va., used precast, prestressed concrete to frame the 354,000-ft² facility. ***Photo:*** *Clune Construction.*

The data center market is exploding; how are you managing the demand?

ROXY TAGHIZADEH RTG: AG&E serves as the engineer of record (EOR) for 50 to 80 data centers a year and things are not slowing down. There is huge demand for us to churn these out as quickly as possible to meet the expedited construction schedules. We possess the capabilities to perform all functions in-house, from EOR to precast concrete and steel detailing, which enables us to offer a variety of services to the owner. Streamlining the coordination process and having all parties under one roof is one way we are handling the level of work that's out there.

COREY GREIKA CG: Many precasters have installed new production lines to increase their capacity and speed to produce precast concrete components for data center projects. Precasters can also use multiple manufacturing facilities to help meet schedules. Most data center owners procure their precast concrete well in advance, which helps keep a project on schedule and avoids construction delays.

MICHAEL LYONS ML: Over the past five years, the market has exploded, especially with hyperscale and colocation facilities. For instance, in 2020, the Phoenix area had an estimated 72 MW of critical capacity under construction, with projections of 500 to 600 MW to be built over the following five years. We have far exceeded those projections, with several data center campuses now under construction around the city that surpass the capacities of 2020 and early predictions. Additionally, this year there has been a shift toward higher density with liquid cooling, and we have yet to fully see its impact on the market. The only factor currently slowing the market is access to power.

How is precast concrete construction being leveraged for data center infrastructure?

ML: Precast concrete is ideally suited for the data center industry, particularly when clients engage with precasters early in the project. This early collaboration allows us to integrate precast solutions seamlessly during the design phase, enabling the fabrication of precast concrete panels concurrently with site preparation. One significant advantage of precast is the reduction of on-site trades—streamlining construction and minimizing potential delays. Most data centers require a hardened exterior shell for security purposes, and precast concrete inherently provides this robustness. Uptime is critical in these facilities, where even a minute of downtime can be costly. Precast concrete supports this need by offering a durable, secure exterior that enhances operational reliability in mission-critical environments.

CG: Data centers are designed as resilient structures to resist wind and seismic loads. Owners require continuous operations and precast concrete excels at resisting these kinds of loads. Second, owners of data centers put an importance on schedule. The structure must be in place and dried-in prior to the mechanical and electrical equipment arriving on-site. Since precast concrete components are manufactured off-site, they can be procured and fabricated prior to the site being disturbed, and the precast can be scheduled to be erected at a specific time once the foundations are in place. Once precast concrete erection begins it is an extremely fast process, especially when you consider that insulated precast concrete wall panels have all the elements of a finished wall system (finished surface, air, and vapor barrier) built in. This predictability and speed are critical to the success of the project from the owners' perspective.

RT: The data centers we design vary between steel buildings with precast wall panels or total–precast concrete structures. The current trend is an increase from one- to two- and three-story buildings. That is driven by the evolution from typical data centers to a layout that can handle the computing power needed by artificial intelligence (AI), which changes the building significantly.

What is the pace of project delivery and who is driving it?

RT: While architects take the lead in most cases, these projects are very engineering intensive. Most are driven by MEP [mechanical, electrical, and plumbing] programming. One critical aspect of these data centers is getting involved early in that design phase. For precast design and detailing to begin, an important factor is precaster selection. Getting precasters involved early on the project helps us design and detail the structure with minimal changes later. To achieve that, we recommend that owners find and hire precasters as early as possible. This leads to the owners buying precast and reserving production schedule time directly with each producer. Equipment like generators, chillers, and transformers all have long lead times and are also being purchased well in advance. There are many different pieces and parts that make up a data center, and we try to incorporate repetition and modularization wherever we can to help expedite schedules.

ML: The pace is typically as fast as possible. To achieve this, coordination is particularly critical in the data center industry, given its focus on speed to market and the complexities of the equipment housed within these facilities. We prioritize early coordination with precasters to expedite the construction schedule. Prefabricating coordinated openings between all trades significantly saves time. It is typical to see multiple cranes on-site working 24/7 to get the building dried-in as quickly as possible—getting dried-in is a major milestone that allows for equipment installation to begin. The biggest challenge recently has been the permitting process. A few years ago, a data center could be approved with minimal comments, but now there is increased scrutiny from all stakeholders. Building codes have not yet adapted to the unique needs of data centers, resulting in varying requirements across jurisdictions and leading to inconsistencies in the permitting process.

Energy efficiency is closely tied to a wall system's thermal performance—the better the insulation, the less energy it consumes. Do precast concrete building systems make a difference?

CG: Insulated precast concrete panels outperform other wall systems due to their inherent thermal mass effect. Sandwiching continuous insulation between two layers of concrete allows the structure to take advantage of using the interior wythe of concrete as a heat sink. The interior concrete wythe will attain the ambient temperature of the indoor space over time. This increases the effective *R*-value of the wall system by 50% to 80% over the material *R*-value. The effective *R*-value can be used to reduce the required size of the HVAC [heating, ventilation, and air-conditioning] equipment for the structure.

RT: To meet the changing ASHRAE [American Society of Heating, Refrigerating and Air-Conditioning Engineers] requirements in *R*-values across regions, we utilize continuous insulation in precast sandwich panels. Depending on the project requirements, if three inches of continuous insulation is needed, we recommend four inches to accommodate solid zones near the top and bottom of panels, as well as reduced insulation at embeds and lifting devices. This allows for tolerance and an average *R*-value to be achieved. There has been increased investment in advanced cooling systems like liquid cooling. Innovation in data center cooling technology will ramp up past the capabilities of air cooling. Liquid cooling, in all its many forms, will become commonplace in data centers.

PCI Forms Data Center Task Group

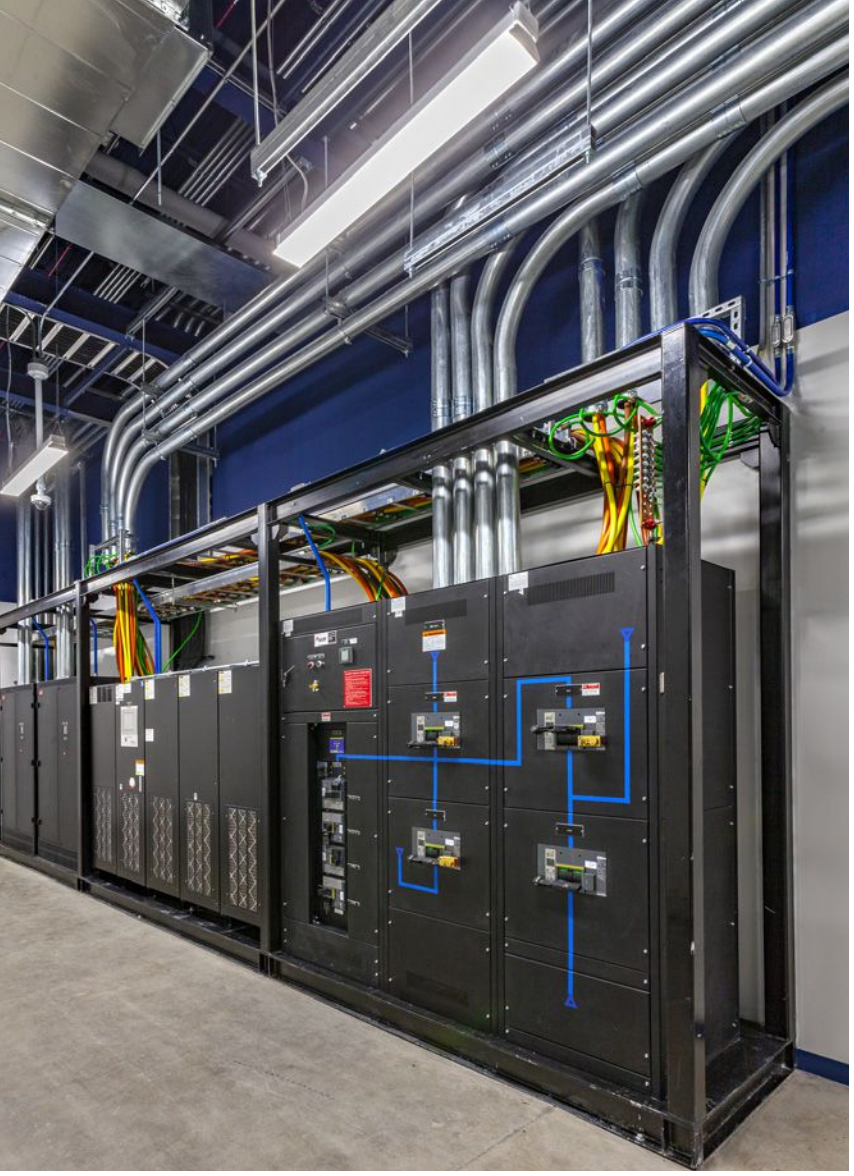
For decades, parking structures have been the focal structure type for the precast concrete industry. However, recent trends indicate a significant interest and expansion of data centers constructed using precast concrete.

Precast concrete structural and envelope systems meet the high-performance demands of data centers by providing cost-effective open spans, passive fire resistance, and durable, high-efficiency, low-maintenance building envelopes. This is very important to mission-critical facilities—which data centers often are. 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 multihazard requirements and long-term demands of high-performance structures.

To support this growing market, the PCI Technical Activities Council has formed a Data Center task group. The task group's mission is to develop recommended practices for using precast concrete in data centers, organize the Body of Knowledge for total–precast concrete and precast concrete–clad data centers, and provide recommendations for integrating precast concrete with other trade requirements.

The Data Center task group is currently developing a new PCI document titled "Precast Concrete Data Centers: Recommended Practice for Design and Construction." This document will guide designers on addressing the unique challenges of data center design and demonstrate the benefits of using precast concrete for data center construction to developers and architects.

– Tim Cullen, PCI director, Technical Activities



With artificial intelligence, data centers will require larger racks, which in turn requires larger floor-to-floor heights.
Photo: *HKS/Kevin Perrenoud Photography.*

ML: Since data centers inherently generate substantial heat, the strategy around insulation is nuanced. Instead of simply retaining heat, our approach involves a careful balance using energy modeling and condensation risk analysis to determine the optimal use of insulated versus solid precast panels. This ensures we meet both prescriptive code requirements and pursue envelope optimizations that reduce operational costs, particularly in conjunction with efficient mechanical and lighting systems. The specificity of each client's needs and regional variations lead us to a performance-based compliance with energy codes more frequently. Given the high internal heat generation, some climates benefit from allowing heat dissipation through the thermal mass of precast concrete. Also, reducing insulation not only lowers initial construction costs but also yields long-term operational savings. It also reduces the embodied carbon associated with the use of fossil fuel–based rigid insulation. This aspect is increasingly vital for clients committed to offsetting the embodied carbon in their products, aligning with broader environmental goals.

Precast concrete is strong and durable for heavy equipment inside. Are typical precast components sufficient to meet structural requirements?

CG: Typical precast concrete components are used for data center designs, but deeper double-tee and beam sections have also been utilized to accommodate the heavier design loads while providing longer clear spans.

RT: The benefit of utilizing precast concrete is its inherent strength and durability to withstand the loads from heavy equipment. The hardened shell with its typically windowless exterior walls are ready-made to withstand all manner of weather and fire events. Rising customer demand for higher density is propelling innovation in both data center design and technology. Spurred by growing computing power, clients are looking to pack more into a smaller space. So, not every data center is created equal. The introduction of AI computing is altering the design requirements. The trend is moving from one-story to two- and three-story structures.

What about aesthetics on the exterior of precast concrete data centers?

RT: While owners consider the exterior of the precast concrete wall panels, their priority is speed to completion. We have seen basic reveals in the precast concrete, but frequently see basic gray concrete with a painted exterior. On the administrative side of the building there is more glazing and precast panels with architectural features like formliners and more reveals.

CG: Owners do care about aesthetics, or at least the neighborhoods and local government officials do. Most municipalities require the buildings to not look like big gray storage boxes, they want the façades to be broken up by reveal patterns and warmer color tones. Some owners meet the requirements with an architectural precast mix and finish on the exterior to provide the low-maintenance façade. This helps the schedule because it eliminates a future trade.

ML: Aesthetics are strategically employed, particularly in the core administrative areas where we use glass to allow natural light and create a lively atmosphere. This approach is vital, considering that the number one cause of downtime in data centers is human error. For the data center portion, while the design prioritizes functionality and security, it still embraces a thoughtful aesthetic approach. We are moving beyond the traditional utilitarian model. Although the layout may not vary significantly due to operational requirements, the industry's increased visibility has heightened the importance of aesthetic considerations. Precast concrete offers aesthetic flexibility: it can be used not only for its finished texture, but also to incorporate other decorative elements that elevate the overall design. Given the large footprint of these facilities, it is important to visually segment the structure to enhance its appeal. The entire building incorporates design aesthetics, though the approach varies between the people-centric spaces and the data hall zones.

Can precast concrete adapt to custom layouts in order to maximize the usable area vital to data centers?

MLS The evolving needs of data centers call for adaptable construction solutions, and precast concrete excels in this regard. It is renowned for its ability to accommodate long clear spans, which are essential for arranging various rack layouts with minimal impact. As floor-to-floor heights increase to around 30 feet to support more electrical and low-voltage connections throughout the structure, precast concrete stands out. It enables the use of long-spanning double tees, optimizing floor plans and improving column spacing. This configuration not only allows for more efficient rack placement but also bolsters the structural integrity needed to handle increasing loads. Beyond functionality, precast concrete offers load-bearing capabilities that reduce construction time and minimize on-site concrete work, perfectly aligning with the rapid pace of data center development.

CGH Long clear spans are important to owners, and some of precast concrete's advantages are its inherent fire protection, the ability to make the exterior façade load bearing for the floor and roof members (which saves construction time and minimizes construction joints), and the reduction of cast-in-place concrete on-site (steel systems typically have to be topped with a thicker CIP topping slab as compared to precast concrete systems).

RTH If the future is AI, then data centers will require larger racks, which in turn requires larger floor-to-floor heights—increasing from 24 to 30 feet. The racks are taller, and the cooling system is different, and the floor loads are heavier. For data centers, we're going from a typical 250 psf rack load to 400 psf. The industry needs more data to support these heavy loads. Currently, owners like precast as a solution for its ability to span 60 feet with double tees. That enables a larger floor plan with better column spacing. The current layout in a total–precast concrete data center allows for more room for racks with fewer columns.

ONLINE EXCLUSIVE

Rather than location driving the decision where to build, power availability is a big influence. Is the precast concrete industry able to meet demands across the country?

MLS The availability and capacity of power are paramount in determining the location for data centers, with significant variations across the country. We recommend proactive engagement with local jurisdictions early in the project lifecycle to ensure smoother project progression. Additionally, data center companies should establish early connections with precast suppliers in the project region. This proactive strategy not only ensures efficient adaptation and delivery across diverse regions, but also aligns with local power infrastructures and regulatory conditions. Given that some regions may experience backlogs, early engagement is crucial to prevent potential delays and facilitate timely project execution.

CGH Any precast producer can enter the data center market. Even the specialized and smaller precast producers who only produce certain product lines, like hollow-core plank, architectural precast panels, or underground precast structures like data duct banks or utility trenches. Currently the precast concrete industry has excess capacity in the Midwest (and surrounding regions), which the data center market can use to its advantage. It is important for data center owners and construction managers to have relationships with precast producers in the regions in which they are building so that they have current information on product availability and backlog.

RTH Power availability continues to influence data center operators' location decisions more than geography. The location is often irrelevant because it is not about convenience or access to the site, but reliable power to the servers. Some regions are attracting data centers with incentives and ready supplies of power. We worked on a project where the owner's negotiations with the power company stalled, construction was halted, and the data center was relocated to a different region of the country. The demands that AI places on the power grid is one of the biggest challenges. Demand for data centers is not slowing down and we are beyond the point of no return when it comes to AI and our need for data. In my opinion that demand is only going to increase and so is the need to build data centers.

> The location is often irrelevant because it is not about convenience or access to the site, but reliable power to the servers.

Modular and prefabrication are a good fit for these scalable data centers. How does precast concrete adapt to other prefabricated assemblies like electrical and mechanical?

CGH Precast concrete components can include multiple trades cast into them—insulation, electrical conduits and boxes, inserts for racking equipment, block-outs for mechanical equipment, inserts for glazing, etc. Through the use of BIM [building information modeling], the precast manufacturer can communicate effectively with these other trades to ensure that material and location information are provided in a timely manner to meet the requirements of the precast concrete fabricator's production schedule.

MLS Precast concrete excels in scalable data center projects, particularly through its seamless integration with modular and prefabricated components, including electrical and mechanical systems. Our process usually begins with a prototype-based building design, which we adapt for various sites. Despite rapid market changes that require ongoing coordination, precast concrete efficiently supports these adaptations. We engineer precast concrete to include built-in service runs, aligning perfectly with equipment installations and enhancing construction efficiency and precision. We also design specific zones for future penetration flexibility. Furthermore, we pre-mold openings to connect yard and rooftop equipment directly with the building's interior, ensuring a precise fit and minimizing the need for on-site adjustments. This approach not only streamlines construction but also ensures the building's structural integrity and adaptability, accommodating any changes in size and shape driven by system upgrades.

What does the future hold for precast concrete data centers?

RTH The precast concrete industry needs more data to support the heavier loads prevalent in new data centers. With the push toward fewer columns and more room for racks, there could be changes to bay spacing and the heavier loads would require deeper cross sections. I think that trend will continue to increase, so it is a matter of determining those requirements and figuring out the next size double tee or the optimum column spacing. The precast industry needs to get ahead of this trend and determine the next steps so we can accommodate these new requirements. PCI recently formed a new task group to write a technical document that will provide designers and engineers guidelines for precast, prestressed concrete data centers. The industry will benefit from this document and show that PCI and its members are committed to contributing to the needs of the data center industry. ●