Record-Breaking Courthouse

Dramatic precast concrete façade design not only creates distinctive appearance and provides high blast and energy performance, but sets record for fastest ever delivery

— Craig A. Shutt

With design and construction completed in only 27 months, the James F. Battin United States Courthouse in Billings, Mont., set the record for the fastest delivery of a federal courthouse in modern history. Architectural precast concrete panels were used to help express a dramatic visual appearance while also achieving strict standards for Anti-Terrorist/Force Protection (AT/FP) needs and energy efficiency. More impressive still: the construction processes used on the Battin Courthouse also can be replicated for future projects to reduce costs and improve performance.

"Precast concrete provided attributes that were important to meeting the security and blast requirements that we needed," says Marvin Doster, project director at M.A. Mortenson Co., the design-builder. "Once we began examining it, we realized it also could provide a dramatic aesthetic design and help achieve our energy-performance goals as well."

The facility is located in downtown Billings and houses three courtrooms, four judges' chambers, the U.S. Marshal Service, and other court-related federal officers. The building features four distinct architectural elements that delineate each of the building's functions.

The first design concept was to make "Justice Visible." To achieve this, courtrooms were placed on an upper level with large expanses of glass and smooth precast concrete cladding. "Federalism" was represented by a precast concrete colonnade and classical portico, which bisects the main structure and stands over it.

"High Performance" was attained via the colonnade, the architectural precast concrete panels, and

The James F. Battin United States Courthouse in Billings, Mont., features four distinct architectural elements: "visible" courtrooms with soaring windows on top, a precast concrete colonnade and portico, a base clad with architectural precast concrete panels textured to represent a solid, stone foundation, and the use of local materials throughout. All photos: Sean Airyart.

other energy-efficient applications. "Regionalism" was embodied in the rusticated precast concrete base, directly recalling the geology of the surrounding Yellowstone rimrocks. The three-story base contains offices that visually and symbolically support the smooth precast and glass courtroom floors above.

"These concepts were not considered in isolation," says Steve McConnell, managing partner at NBBJ, the architectural firm. "Rather, they are woven into one integrated, contemporary design with key features simultaneously addressing all four concepts."

Blast Resistance Required

As a federal courthouse, the building had to meet a Federal Threat Level 4 design standard. "This threat level proscribed specific engineering-performance requirements for the exterior systems," Doster explains. "We also had a variety of other factors to consider that had to work with that requirement. The precaster's engineering staff was able to create a mix design, thickness, reinforcing pattern, and connection design for the panels that met all of the performance needs in an economical manner."

The balance of attributes required to meet AT/FP restrictions can create challenges for structural engineers and precasters. For most projects, wind loads are the controlling factor, which typically require panels to be stiffer, with more reinforcement to increase the load capabilities. Blast protection requires panels that are stiff enough to be durable but ductile enough to absorb a blast force. Blast protection also requires connections that hold the panels securely while providing a systematic path for progressive collapse.

The blast engineer and precaster created the ideal blend of characteristics using 3D modeling and engineering programs in a give-and-take relationship. "Blast-protection designs are more complicated from engineering and reinforcing standpoints," explains Chuck Smith, vice president of operations at Gage Brothers Concrete Products, the precaster for the project. "Finding

The stone texture on the courthouse's base was created by using 12 formliners combined in different ways, including flipping them 180 degrees, to create larger panels. The panels were erected in a particular sequence to avoid repetition. Each liner had a different skew, creating as much as 4 inches of offset between any two panels.

PROJECT SPOTLIGHT

James F. Battin United States Federal Courthouse

Location: Billings, Mont.

Project Type: Courthouse

Size: 147,000 square feet

Cost: $59 million

Designer: NBBJ, Seattle, Wash.

Owner: General Services Administration, Rocky Mountain Region, Denver, Colo.

Structural Engineer: Magnusson Klemencic Associates, Seattle, Wash.

Blast Engineer: Weidlinger Associates, New York, N.Y.

Design-Build Contractor: M.A. Mortenson Construction Co., Bellevue, Wash.

PCI-Certified Precaster: Gage Brothers Concrete Products, Sioux Falls, S.D.

Precast Speciality Engineer: Gage Bros and Infrastructure LLC, Omaha, Neb.

Precast Blast Consultant: Protection Engineering Consultants, San Antonio, Tex.

Precast Components: 349 architectural panels and column covers the correct amount of reinforcing to balance all of the needs was the key."

The panels needed to be ductile enough to bend but not break when hit by large forces, adds Collin Moriarty, engineering manager at Gage. "Instincts say to add more reinforcement for protection, but that makes the panels stiffer, which attracts more load from the blast back to the building. The goal is to spread the blast force over the panels and direct into the connections, then allow them to fail at points designed to contain the force. That ensures the energy dissipation is controlled."

For the courthouse, this design required a number of large plates and oversized bolts. To achieve the right combination of stiffness and ductility, Moriarty created panel designs with specific combinations of reinforcement and connection locations and sent them to Gage's blast consultant, Protection Engineering Consultants, who responded with dynamic load calculations.

'We had to determine the best balance of reinforcement and connections.'

"We had to determine the best balance of reinforcement and connections," Moriarty says. "They would send back the calculations, and I would adjust the design to bring the loads into alignment with what we needed, then send those back to see how they worked."

Each location had specific needs. The upper level courthouse walls, for instance, had to interface with large expanses of glass. Seven inches thick and eccentrically hung, with 18-inch returns, they presented stiff sections that produced serviceability concerns along with blast needs.

"The stiffness of these corners produced ridiculously large loads in the dynamic analysis," he says. Dynamic blast analysis produced a middle tieback load that was "off the charts." After discussions with the blast engineer, the panels were tied back and designed for blast at the top and bottom, while the center connection was designed for a wind load. "That arrangement made it more flexible so it met all of our requirements."

Energy Performance Enhanced

The panels also were designed to meet high energy-performance requirements, keeping the building on track to be certified LEED Gold. The courthouse was designed to be at least 30% more energy efficient than the industry standard, with initial energy savings reaching more than 40%, McConnell says. High-performance strategies were incorporated through the design, including active beams for heating, cooling, ventilating, and water-saving techniques. Recycled materials, local manufacturing, and minimal construction waste also were emphasized, and the precast concrete materials aided each of these goals.

The precast concrete panels also were a key part of the super-insulated exterior wall system, which also includes triple-glazed windows and shading from the colonnade for the west lobbies. "We used the high thermal mass of the precast concrete to help our energy performance

To create the elaborate textured appearance for the lower levels, designers added a 2-inch face to the front of the panels that served as the aesthetic design, giving them depth to replicate the stone patterns they desired.

In some areas on the first level, recessed façades required the precast concrete panels to be set first so steel could be erected over them. Close cooperation on such issues allowed the project to be completed in a record-setting 27 months.

and added insulation to the interior side," Doster explains. That face was textured to allow a spray-foam insulation to adhere readily. Structural support and framing members were designed and set at intervals that allowed access to the complete precast concrete panel to ensure consistent insulation coverage.

Unique Aesthetic Design

Along with meeting these strict functional needs, aesthetically expres-sing the four key design concepts was a key goal. The courthouse's programmatic layout lent itself to emphasizing each section in a distinct way. This was most apparent with the lower floors, where formliners were used to create a varied and textured appearance in the precast concrete panels.

"The solid-appearing lower three floors, housing offices that programmatically support the justice system, form the rimrock base for the 'visible justice' of the courtrooms above," explains McConnell. "The concrete patterning of the lower three floors is therefore designed to appear somewhat random, with carved angular planes for the strong local sunshine to play upon."

Achieving this apparent randomness took considerable planning. "We looked at several concepts, but we ultimately simplified the concept by essentially adding 2 inches onto the face of the panels to use for our aesthetic design," explains Doster. "We were able to accomplish everything we wanted to achieve with the precast concrete, which was important. We could focus the façade with one supplier, which really helped the budget."

The architect created the design plan for the textures, which the precaster calculated would require 18 formliner designs. The two teams then used BIM technologies to tweak the design to reduce that total to a dozen basic patterns that were combined in various permutations to produce eight large panels, which were then erected in a carefully orchestrated sequence. Each liner had a different skew, so between any two panels, up to 4 inches of offset could occur.

'We could focus the façade with one supplier, which really helped the budget.'

The precaster changed the liner position with each panel to vary the look and avoid repetition. "There is a pattern if you look really hard over a large enough area, but we don't think anyone can pick it out," says Smith. "We spent a lot of time with the architect finding the best solution that provided a strong aesthetic appearance that also was the most economical."

Two color variations were achieved by changing only the sand ratio in the mix, which provided a golden tone and a purer white. Both received an acid-etched finish. "The goal was to create a 'Yellowstone' color as well as a 'traditional government white' color to offer contrast," says Doster. "Combined with the various geometric shapes, it creates a variety of distinctive but complementary sections."

"The challenge of creating two contrasting but complementary colors and textures was creatively solved by the design-build team," says McConnell. "Mock-ups of several variations of sand, aggregate, and colorant mixes, with varied levels of finish, were produced and shipped to the site. There, we reviewed them in relation to each other, to the adjacent materials, and to the site."

BIM Aids Design

BIM design software was used extensively throughout the project, he notes. "This enabled the design team to see the finished façade in different lighting conditions prior to making a single piece of precast concrete. Using local knowledge, sands, aggregates, and colorants, we could ensure we produced panels that reinforced the relationship of the courthouse to its native surroundings."

Joints were kept consistent with the use of a blown-sand technique. While the caulk was still wet, a low-pressure hose blew in sand particles, which adhered to the caulk and helped minimize the appearance of the joint. "It improved aesthetics and created an organic appearance," McConnell notes.

A key to the courthouse's success was hiring the precaster on a design-assist basis early in the process, says Doster. "By selecting them early, they were able to provide practical solutions for design and

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construction challenges as they arose without any delays."

The precaster's early involvement also helped speed up construction, a primary goal for the government. Several areas posed particular challenges that required adapting the typical schedule to ensure fast construction. For instance, the first level's entry area features recessed façades behind the tall colonnades. These areas had to be erected first so steel could be erected above them. This sequencing requirement meant these first-level panels had to be cast first while minimizing change-overs.

To speed up the process, the design team, contractor, and precaster coordinated pre-welded connection platforms in a tight gap between the slab-closure plate and the back of the panels. The connections in this area also had to meet blast requirements, necessitating additional calculations for the connection forces. "The use of BIM as a planning and scheduling tool assured the entire erection was a very well-coordinated process," says Doster.

The large triple-pane glass inset into the blast-resistant precast concrete walls on the upper levels also required design coordination, although more due to placement challenges than connection needs, Smith notes. "The glass and concrete areas were designed simultaneously to ensure the loading requirements for the two materials together had been met."

Initially, contractors expected to lower the windows into place from the top, but the complicated framing and tall, narrow size of the massive windows made that difficult. Instead, the erectors slid the windows in from the open sides of the structure.

Panels were delivered to a staging area off-site and brought to the site and erected by one crane, which had to work around power lines located along one side of the property. The deliveries remained on track, despite flooding on some roads between the site and the precaster's plant in Sioux Falls, S.D., requiring trucks

Two color variations were created for the precast concrete panels by changing the sand ratio in the mix. That change created a golden "Yellowstone" color as well as an offsetting "traditional government white."

to navigate around road closures and through detours. Even with these difficulties, all pieces arrived as scheduled and were erected as planned.

Design Aids Future Projects

The coordinated efforts of the design and construction teams led to completion of the courthouse in only 27 months. Best of all, it was the second of three designed using a new process by the federal government intended to speed up construction on future projects. Funded by the American Recovery and Reinvestment Act, the projects are the first in the General Services Administration's (GSA) new Design/Build/Design Excellence process, which combines a fixed price with a design competition. The first courthouse, located in Bakersfield, Calif., was completed in 30 months.

"This approach to fast construction can be replicated," says Doster. "It requires GSA to have all funding for the project upfront so there are no delays moving from design to construction." Often, GSA's funding is paid out in increments, creating lags as funds are approved, causing the design process to slow and costs estimates to rise on materials.

It also requires that the project team use the design-build process, a delivery process that ensures

Despite the intricacy of the courthouse's design, the project's speed can be replicated in the future using the same procedures by GSA, which ensured no delays in funding as the project moved from design to construction.

each member of the design and construction team provides input early. "GSA is committing to the design-build process more often. For us, bringing in the precaster on a design-assist basis early made a big difference." Designers also must continue to take advantage of the growing array of high-tech design tools now available, including BIM and lean processes, he says.

McConnell agrees that the process works. "By ramping up our use of building-information modeling, working closely with subcontractors to align design intent with budget during the early concept phase, and increasing the collaboration between GSA, design, engineering, and construction partners, we've taken a significant step toward modernizing the nation's infrastructure."

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