

PROJECT SPOTLIGHT

Levi's Stadium sustainable, durable

On August 24, 2014, just three weeks after the new \$1.2 billion Levi's Stadium in Santa Clara, Calif., opened for its first game, California was hit by a 6.0 magnitude earthquake near Napa, 75 miles north of the stadium. It was the most powerful earthquake to hit the Bay Area since the Loma Prieta earthquake in 1989, but the stadium barely shuddered. Building engineers walked the entire facility that day, and after finding no signs of damage, allowed it to remain open for Sunday football.

The new stadium's resilience is due in part to the designers' use of precast concrete throughout the project. The Bay Area is a high seismic region, and seismic bracing was incorporated into the design and construction to meet California's seismic code requirements, says Tom Anderson, senior project manager with Clark Pacific, which provided the precast concrete.

Meeting seismic requirements was just one of many benefits that precast concrete brought to this project. It also helped the team achieve the extremely short project timeline, address environmental goals, and deliver a durable low-maintenance solution for the open-air design.

A typical NFL stadium takes four or more years to build, Anderson says, but the 49ers stadium had to be finished in just two years. "It was an incredibly tight schedule."

Using precast concrete immediately helped streamline construction because other trades could work on the site while the precast concrete elements were fabricated. That was a big deal, considering that the stadium used more than 40 million lb (178,000 kN) of precast concrete among 2000 elements. The precast concrete panels range in size from 20 to 40 ft (6 to 12 m) and weigh up to 35,000 lb (156 kN) each, and roughly 18 sections were produced per day using 100 yd³ (76 m³) of concrete to meet the schedule.

During construction of the stadium, the team further streamlined the process by using nonexposed grouted connections in lieu of welding connections from underneath or using exposed grout pockets.

"It helped us stay on schedule and was a more durable solution from a weathering standpoint," Anderson said.

The precast concrete was erected at night using two crews and cranes while the steel subcontractor used those same cranes with its crews during the day for steel erection. The Clark Pacific workers installed 36 panels per night on average.



The completed Levi's Stadium in Santa Clara, Calif., meets seismic requirements with precast concrete. Courtesy of © Todd Quam.



Workers erect a panel for Levi's Stadium in Santa Clara, Calif. Courtesy of © Todd Quam.

"The cranes basically never stood idle," says Thomas Ketron, director of marketing. As a result, the project managed to reach its scheduled opening for the 2014 football season.

To meet the project's environmental goals, Clark Pacific used fly ash for 15% cement replacement, effectively lowering the stadium's carbon footprint by over 500 tons of carbon dioxide.

"Producing the precast locally and using the special mix contributes to the 49ers' sustainability initiative for the project, which allowed it to achieve LEED gold status," Ketron says.

Because precast concrete is so durable, the open-air stadium will be able to withstand the weather conditions for decades with little required maintenance, Anderson says. "Maintenance was a big concern for the 49ers from the start of the project, and precast concrete was a great solution."

The 49ers love their new home, which is ready to host Super Bowl 50 in 2016, Anderson says. "Everyone is really pleased with how it turned out."

—Sarah Fister Gale

Broad Museum a work of art

The new Broad Museum in Los Angeles, Calif., is generating a lot of buzz, both for the art that it will soon house and the artistic design of the structure itself. The innovative building features a veil of curved precast glass-fiber-reinforced concrete (GFRC) panels that were designed and hung to emulate a honeycomb-like structure with hundreds of openings that will provide indirect lighting of the galleries inside.

The building structure is a cast-in-place concrete box that meets local seismic requirements. That structure is clad with the light-filtering veil, comprising more than 2500 precast GFRC panels. This design allows the skin of the building to incorporate the lightweight GFRC panels without requiring them to serve as structural support, says Mark Hildebrand, president and chief engineer of Willis Construction. On the east side of the building, the panels are mounted on the interior and exterior of a steel frame structure so that visitors will be able to view the honeycomb design from inside the galleries through a floor-to-ceiling window.

Creating this complex veiled look wasn't easy, Hildebrand says. To accommodate the vision of architect Diller Scofidio and Renfro, his team had three engineers working full time to analyze and fabricate more than 300 unique molds for the panels, some of which were used hundreds of times, while others were only used once.

The three-dimensional panels also posed considerable engineering challenges. "The panels were so curvy and twisted we had to develop new ways to analyze the GFRC skin stresses," Hildebrand says.

His team used structural analysis software to determine tensile stresses in the skin to be sure that the panels could meet wind and seismic requirements. The key, says Hildebrand, was making sure that the location of the connection points between the panels and the structure would minimize stress on the skin and still allow for safe movement of the panels. Using the software, they were able to adjust the anchor points until they found the ideal spots.

"It required a lot of back and forth between us and Seele [the designer of the supporting steel frame] to make it work," he says. This was especially challenging around the oculus, an eye-like depression in the facade where the panels curve in toward the gallery window.

"It all had to come together perfectly, with clearances that were as little as one-quarter of an inch in some places," he says. "It took a very high level of precision."

Despite these challenges, the facade came together beautifully and now stands out as a beacon of architectural artistry in the heart of the city.

"From engineering to quality control, from the mold shop to the weld shop to the spray crew, everyone in our company had to improve their skills to complete this project," Hildebrand says. "But now we know how to do it, and it is spurring a lot of interest."

—Sarah Fister Gale 



The oculus of the Broad Museum in Los Angeles, Calif., is formed by a depression in the glass-fiber-reinforced concrete panels that penetrates the interior glazing. Courtesy of Willis Construction Inc.



Forms for the glass-fiber-reinforced concrete panels were fabricated by precisely cutting styrofoam blocks into the desired shapes, resulting in these shapes.

Courtesy of Willis Construction Inc.