Pikes Peak Summit Visitor Center *(photo courtesy of City of Colorado Springs)*

A Peak Construction Challenge on America's Mountain

The highest total precast building in the world tops the Colorado Rockies

by Deborah R. Huso

Pikes Peak, fondly known as "America's Mountain," is situated on the spine of the Colorado Rockies near Cascade, CO, USA. Known for the awe-inspiring mountain views its summit offers on a clear day, the pinnacle has been revered by generations of explorers, poets, and shamans.

For generations, the Ute tribes have called the mountain Tava Kaavi ("Sun Mountain") because it is the first peak of the mountains to catch the morning light. In 1806, explorer Zebulon Pike (the mountain's current namesake) declared the peak insurmountable. In 1893, Katherine Lee Bates immortalized the mountain in her song "America, the Beautiful."

Since 1948, the nearby City of Colorado Springs has had a term special use permit with the U.S. Forest Service to operate the mountain's access highway and summit as a tourist attraction. But for decades, the summit's 1960s-era visitor center has been inadequate for the task of hosting the 600,000 people who now visit the mountain annually.

In 2015, the City of Colorado Springs started looking at designing and building a new visitor center. "We needed something sustainable," said Sandy Elliott, Tourism and Finance Manager for Colorado Springs Parks, Recreation, and Cultural Services. "The conditions on the summit are challenging. And we needed something that would speak to visitors."

The U.S. Forest Service had a minimum requirement of Leadership in Energy and Environmental Design (LEED) Silver for the building, and the City of Colorado Springs also wanted Living Building Challenge certification. The new structure went well beyond these aspirations. In fact, the recently completed 3567 m^2 (38,400 ft^2) Pikes Peak Summit Visitor Center gained status as the world's highest precast building when it was finished in 2022. At 4302 m (14,115 ft) above sea level, it is also the highest visitor center in the world.

Designing for Extreme Conditions

The original Pikes Peak visitor center, known as the Summit House, constructed in 1964, had been built on permafrost, causing its foundation to shift shortly after construction and nearly leading to its condemnation. RTA Architects of Colorado Springs, CO, and GWWO, Inc. of Baltimore, MD, USA, went through what RTA Associate Principal and Project Architect Michael Riggs called “a robust design process and community input process” to come up with a plan for the new building. After exploring four different locations and four different expressions of the building that would occupy the mountain summit, the design team settled on a structure that would nestle into the mountain’s southeast shoulder, most of it below grade with a walkout.

“We wanted to preserve as much natural experience on the mountain as possible,” Riggs explained, “and we also needed a structure that could handle the climatic conditions of the mountain.”

With outsized weather conditions, including temperatures that drop as low as −40°C (−40°F) and 370 km/h (230 mph) winds, Pikes Peak is a poor environment for both cast-in-place and stick-built construction.

“The main reason [we chose precast] was the prefabrication format and then additionally being able to design an insulated sandwich panel,” Tim Redfern, Field Operations Leader for Colorado Springs-based contractor GE Johnson, explained. “We had very stringent, very high R-value requirements for those wall panels.” Redfern said the design and construction teams considered structural steel but knew that framing would have to be done on site.

Precast concrete checked all the boxes. “We needed something that could be assembled quickly, and that would minimize hand labor on the mountain,” Riggs said, not to mention the challenges of transporting materials up a steep mountain road with 256 curves.

“Plus, we only have 3 months of weather [on the mountain] that isn’t wintery,” Elliott added. “The construction window is basically part of June through August.”

(photo courtesy of City of Colorado Springs)

Pikes Peak Summit Visitor Center under construction *(photos courtesy of Stresscon)*

"The fastest building material in the world for structures of this type is precast," said Don Palmer, Project Manager for Colorado Springs-based precast concrete manufacturer Stresscon. "Plus, the site and limitations of the working time up there—there was no other option."

According to Riggs, precast concrete construction offered structure, insulation, and a finished substrate, "so we didn't have to add a bunch of other materials to have [the building] enclosed quickly."

Delivering to the Summit

GE Johnson began excavating for the visitor center's foundation in 2018. The foundation is the only part of the building that was cast-in-place. Due to unanticipated delays, the precast portion of the project did not begin until July of the following year. "Timing was the main consideration," said Stresscon Project Manager John Hernandez. "Precast offered one season of construction."

The 432 precast components for the visitor center were manufactured at Stresscon's Colorado Springs plant and trucked to the mountaintop. Given the steep road to the mountaintop with its tight switchbacks, Stresscon and GE Johnson established strict load limits for the transport of the panels. Most tractor trailers could only accommodate one precast panel at a time.

The trailers could be no longer than 12 m (40 ft) and could carry only about half the usual load. Thus, piece dimensions were limited to 3 x 14 m (10 x 46 ft) and weights to 13,600 kg (30,000 lb). However, Stresscon did deliver a 22,680 kg (50,000 lb) inverted tee and two 3.5 m (11.5 ft) wide wall panels. The beam needed to be one continuous piece to avoid a need for a column in the dining area. The width of the two oversized wall panels was required to frame the elevator openings.

The roof panels had to be able to accommodate roof-clearing equipment because a visitor walkway rests on top of the building. According to Colorado Springs-based HCDA Engineering Principal Steve Horner, who served as structural engineer on the project, the building had to be able to carry a snow load of 125 lb/ft^2 (610 kg/m^2) and handle a wind speed of 435 km/h (270 mph), Exposure D.

"We would have loved to have made bigger panels," Riggs explained, "but because of switchbacks and the weight of transporting panels on trucks coming up 2377 m (7800 ft) from the base of the mountain, there was a limit to what could be brought up."

Because the summit remained open to visitors throughout construction, trucks carrying the precast panels had only a short window each day to make deliveries, as it was too dangerous to transport panels on the winding mountain road at night. All told, it took 351 truckloads to deliver the precast components for the visitor center's construction.

According to Palmer, of the 25 truck drivers that typically deliver precast panels for Stresscon, only seven were willing to navigate the steep, curving road to the summit of Pikes Peak.

Building Through Climate Challenges

The new visitor center was designed to be tucked into the southeast shoulder of the mountain. Unlike the previous structure, which was constructed on unstable permafrost and held up by jacks, the new building sits on solid bedrock. The construction team had to dig through 6 ft (1.8 m) of permafrost to access it.

"It's basically two levels deep with a walkout basement," Redfern said. "The only part of the building that bumps up is the grand stairway. The whole roof is an insulated plaza with railings for viewing."

But despite the challenges of the building site and the complexity of getting materials to it, Horner noted the Pikes Peak Summit Visitor Center's design "is a pretty conventional one for resisting loads." The building's cast-in-place concrete foundation consists of typical continuous footings bearing on bedrock with some crushed rock backfill beneath the footings. The lowest level floors are concrete slabs on cast-on insulation and site-crushed rock. "The thought was to heat up the concrete and the backfill, with both acting as thermal mass to hold heat [inside the building]," Horner explained.

Beginning construction in 2018, GE Johnson excavated about 26,000 m^3 (35,000 yd^3) of bedrock. According to Redfern, once one reaches 2 m (6 ft) below the surface soil, the temperature is a continuous −3°C (27°F). "There was a lot of ice in the fissures of the bedrock," he explained. "We had to get two crushing plants up to the summit because about 12,000 m^3 (15,700 yd^3) of that excavated bedrock needed to be used for backfill around the building."

The following season, in July 2019, work began in earnest on erecting the precast panels. Redfern said the construction team planned for at least 4 days of precast sitting on trailers on the summit so they would not have to run trucks every day, given the challenge of transport and construction while the mountain remained open to visitors. "We wanted enough precast on the summit to be able to set panels for 3 days without having to haul precast."

"It doesn't even get buildable up there till July," Redfern

Historic wall preserved from the 1800s with the new Visitor Center being constructed in the background *(photo courtesy of City of Colorado Springs)* noted, “and toward the end of September, we start getting freezing temperatures again.”

The one part of the building that is not precast is the steel-framed lobby. The main reason for this, according to Horner, was to allow for a thin profile for the visitor center’s roof, which tops a glass-enclosed viewing area with all-encompassing views of the Rockies.

While precast often offers construction efficiencies due to repetition in panel size and shape, there was very little repetition in the manufacture of precast components for the Pikes Peak Summit Visitor Center. “There were next to no repeats, not even on double tees,” Hernandez said. “We had two elevations with repeats, but the whole south face of the building was completely chopped up.”

Topped double tees were used to construct floors and the sloped roof to create a diaphragm for lateral resistance against soil and wind loads as well as to provide drainage from south to north. The roof also serves as the walk-on plaza from the parking lot. The deep and short-span double tees for the roof are designed to carry the load of the topping, 12 in. (300 mm) of insulation, landscaping, and people. The landscaping includes several large boulders as well as the visitor observation deck and walkway from the parking lot. “It’s a highly loaded roof plaza deck,” Horner said. The dead and live loads were 528 and 150 psf (25 and 7 kPa), respectively.

Meanwhile, the precast wall panels had to be able to retain over 7 m (25 ft) of rocks and earth as well as support the double-tee floor and double-tee roof systems.

A 250 tonne (276 ton) hydraulic crane, positioned right in the building footprint, was used to assemble the structure. Lightning strikes were a persistent danger at the project’s 4320 m (14,173 ft) elevation, so GE Johnson’s team drilled special lightning rods into the granite rock on top of the mountain and then attached them with heavy copper cables to the crane to protect both the machine and its crew. Further protection was provided by shutting down the work when lightning strikes were within a 32 km (20 miles) radius of the site.

High winds were also a consistent issue for construction crews. “The wind had to be below 48 km/h [30 mph], plus no lightning,” Palmer said, for crews to have the go-ahead to work. With the approach of fall, freezing temperatures also impacted construction, restricting the crane’s mechanisms.

“We established a target of [erecting] six pieces per day,” Palmer added. “There were days we had double that and days we had none.”

GE Johnson was diligent about monitoring the health and stamina of workers on site, requiring a “buddy system,” so that crew would watch for signs of altitude sickness in one another. All workers had to pass physical tests before being allowed to work on the summit, and most were working 6 to 7 days a week when the weather was good. Remarkably, according to Redfern, across 500 days of construction on the mountain, there was not a single recordable health or safety incident with the crew.

Over 3 years of building, the construction crew lost 125 complete days to bad weather and 90 half days due to lightning.

“Every day was different,” Horner said. “If you missed a day due to snow, [the next day] the snow would melt, and then you’d spend the rest of the week cleaning it up.”

Connections for installing the precast panels were anchored to the cast-in-place foundations using embedded plates and robust welds. “These connections were more robust than in typical buildings because of the wind loading,” Horner said.

“And the connections at the bottom of the walls were extremely heavy because of soil load,” Hernandez added. “Except for the south face, the [two-story building] is mostly underground.” According to Horner, the north basement wall was retaining 9 m (30 ft) of earth.

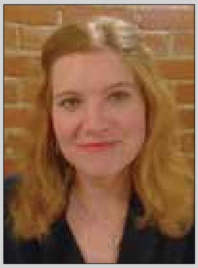
Considering the potential for weather delays and work stoppages, Stresscon predicted an erection rate of six panels per day or 72 days of precast construction total to enclose the visitor center. The erection process ultimately took 82 days at an average rate of just over five pieces erected each day. Precast panel erection occurred over 5 months from early July to December 2019.

Most of the wall panels were 476 mm (18.75 in.) thick, with a 200 mm (8 in.) structural concrete wythe, a 200 mm insulation layer, and a 76 mm (3 in.) exterior concrete wythe. The insulated structural precast panels provide a continuous insulation envelope, and the building also includes a highly efficient, in-floor radiant heating system. While the building’s structure is all precast, stone cladding for its façade was installed on site.

The Pikes Peak Summit Visitor Center, which opened to the public in June 2021, holds LEED Silver certification and is also the first building in Colorado designed and built to meet certification standards for the Living Building Challenge.

“There’s no other building quite like it,” Elliott said. “The location, the environment, the design, the sustainability—it’s at one of the most beautiful locations you can ever visit, and it’s 100% accessible.”

Selected for reader interest by the editors.



Deborah R. Huso is Creative Director and Founding Partner of WWM, Farmington, NM, USA. She has written for a variety of trade and consumer publications, such as *Ascent*, *U.S. News & World Report*, *Concrete Construction*, and *Construction Business Owner*. She has provided website development and content strategy for several building products companies, including Cultured Stone and Trex.