The Art of the Aspen

Colorado's signature tree was the inspiration to demonstrate the design versatility of GFRC

by Deborah R. Huso

The 265-room Populus hotel in Denver, CO, USA, puts a new spin on biophilic architecture. With a 13-story façade rendered in glass fiber-reinforced concrete (GFRC), the building's design was inspired by the knotted white bark of the native aspen tree (*Populus tremuloides*). The hotel's striking eye-shaped window openings mimic the scaling bark of the aspen, while the curving façade in which they are embedded stands like a series of stately aspen trunks rising from the city's sidewalks (Fig. 1).

Denver-based real estate developer Urban Villages claims Populus will be the first carbon-positive hotel in the United States, due in part to its energy-efficient design, which includes a rainscreen assembly with a panelized weather wall and thermal barrier. GFRC serves as cladding for the rainscreen assembly.

Architect Jeanne Gang of Chicago, IL, USA-headquartered Studio Gang, said she came up with the design for the 12,540 m^2 (135,000 ft^2) downtown Denver hotel after admiring the native aspen trees on a hike in the adjacent Rocky Mountains. "Forming an essential interface between inside and outside, the distinctive windows expand the hotel rooms to the city and Rocky Mountains beyond," Gang said. "Their shape is inspired by the growth pattern seen on the iconic aspen trees of Colorado, whose branches produce 'eyes' on the trunks' surface."

Achieving Unique Geometry with GFRC

"The materiality of GFRC was the preference of the design team," said Michael Koehler, Senior Project Manager with Dallas, TX, USA-headquartered contractor The Beck Group. Don Williams, President of Salt Lake City, UT, USA-based Unlimited Designs, the project's GFRC manufacturer, noted that while other materials were considered for the hotel's façade, they were quickly discarded in favor of GFRC. "This project definitely lends itself to GFRC with the unique geometry of the shapes," he said.

According to Chris O'Hara, Founding Principal with Denver-based structural engineering firm and façade consultant Studio NYL, GFRC was chosen due to "its ability to achieve the complex geometry and texture while providing large panels to limit jointing on the building."

Unlimited Designs' Director of Project Management

Fig. 1: Renderings of the Populus hotel *(images courtesy of Studio Gang)*

Dustin Williams stated that "GFRC added flexibility to the design of the façade by allowing for intricate shapes, curves, and thin sections that may be difficult or expensive to achieve with precast concrete."

Use of GFRC also allowed for an accelerated construction timeline because the building's weather wall could be installed prior to the GFRC panels. Thus, the GFRC outer skin of the building could be installed simultaneously with interior features, a distinct advantage with Denver's unpredictable weather. The construction team did not have to build floor by floor with both the weather wall and GFRC panel façade.

Koehler said a lot of work went into economizing the hotel's construction. "When originally drawn, it had 200-plus unique panel typologies," he explained. "But this is a hotel and has to be a revenue-generating project. We had to achieve a balance between design and cost." To meet budget requirements, The Beck Group, Studio Gang, Studio NYL, and Unlimited Designs economized shapes of the architectural GFRC panels to minimize the quantity of unique molds.

"The initial design already considered minimizing unique panels in the body of the building by using the same radius for the typical panels and seven modules of window types," O'Hara said. "Where the building met the ground and the corners is where other unique panels came about. The majority of the building surface area came from seven panel types" (Fig. 2).

With help from Studio Gang, Unlimited Designs was able to establish a lot of repetition in the manufacture of the GFRC panels. "The goal was not to *see* much repetition," Don Williams indicated, but by shifting the orientation of panels, one could achieve a completely different look for two different panels coming from the same mold. "We created pieces that plug and play," he added. "GFRC is great for that."

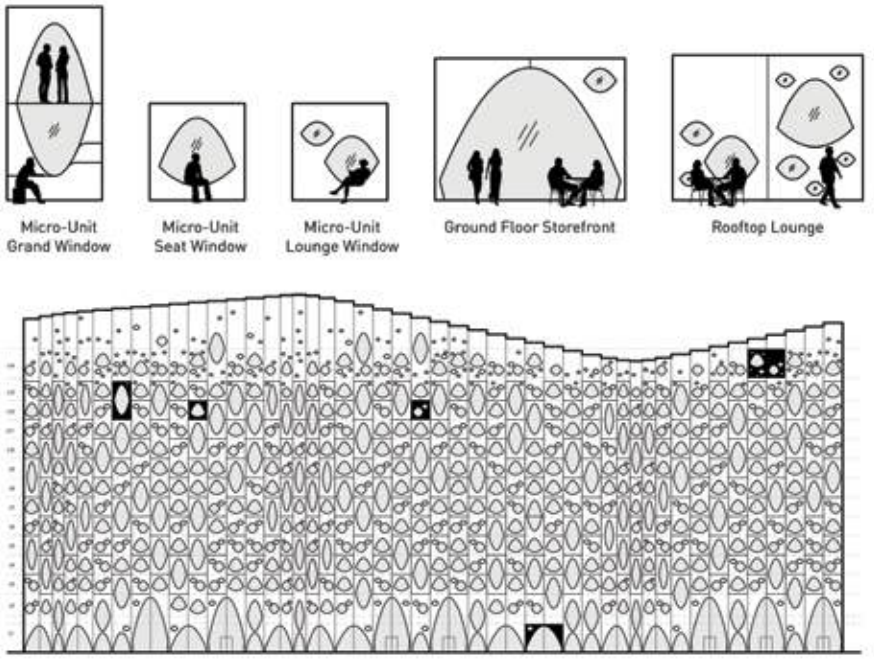

Fig. 2: A diagram showing five types of window openings *(drawing courtesy of Studio Gang)*

Manufacturing the "Scalloped" Panels

According to Dustin Williams, the main structure of the hotel consists of 374 GFRC panels, which required 64 unique molds: "We tried to have some repetition for mold building because that's the most expensive and time-consuming part of the project."

Unlimited Designs also built four different scallop types into the molds, each serving as the radius of a "tree trunk" and encasing the exterior wall of a single guest room. Meanwhile, the windows that dot the scalloped GFRC trunks mirror aspen "eyes," each with a window "lid" that extends outward both to shade the window and channel rainwater.

The scallops feature a radius of around 2 to 3 m (6 to 10 ft), and depending on which type of scallop was in the mold, one could achieve a very different look for panels that were otherwise the same.

Dustin Williams said his team used two different five-axis CNC machines to build the molds in medium-density foam (MDF), using a rib kit for the scallops (Fig. 3). "From the outer part of the 'eyebrow' to the return is almost as much as 4 ft [1.2 m] deep for some of the windows," he noted. "Those molds were made from high-density foam."

On the hotel's first floor, the windows are more like portals, extending 9 m (30 ft) in height to frame views into the building's lobby, restaurant, and other common spaces. The window openings on the upper floors all curve into parabolic window seats in the hotel's guest rooms, offering guests recumbent views of Civic Center Park to the southeast or the Rocky Mountains to the west (Fig. 4).

Apart from the unique "eye" holes and curving nature of Populus' architectural façade, the striking, bright white color of the building, not unlike the arresting alabaster of the aspen tree from which it takes its design inspiration, is its other standout feature. According to Dustin Williams, the color is naturally made of the crushed white aggregate from which the GFRC panels are constructed.

All 374 GFRC panels for the hotel's façade were transported 500-plus miles (800 km) from Salt Lake City to Denver on A-frames, with most trucks shipping two panels at a time (Fig. 5). The Beck Group had to employ a local storage yard to house the panels because there was no place to store them on the tight building site, which is bounded on three sides by streets, including the busy corner of Colfax Avenue and 14th Street across from Civic Center Park.

The entire building site was only 1115 m^2 (12,000 ft^2), 743 m^2 (8000 ft^2) of it making up the building itself. "We shipped enough panels to the jobsite for 2 to 3 days of use," Koehler said.

Fig. 3: Scalloped design features created in MDF *(photo courtesy of Unlimited Designs)*

Fig. 4: A guest room with a parabolic window seat *(image courtesy of Studio Gang)*

Fig. 5: Finished GFRC panels were transported on a truck from Salt Lake City, UT, to Denver, CO *(photo courtesy of Cannon Masonry)*

The hotel's façade features 374 large panels.

According to Koehler, the average panel measured about 3 m wide by 6 m (20 ft) tall. Each panel averaged about an 38 mm (1-1/2 in.) thickness, but that thickness varied because Unlimited Designs had to increase it around the windows, or "eyes" of the tree trunks.

Each GFRC panel has a barrel shape to create visual depth. Many have unique window openings with a huge return to the glass to create striking shadows and lighting both on the inside and outside of the building.

"We're extremely unique around the bottom of the building, then standardized in the middle, then unique again at the top," Koehler said.

Minimizing Panel Connections

Installation of the building's exterior façade began in late December 2023 and was completed in May 2024. The façade's weather wall comprises prefabricated metal stud panels attached to the hotel's reinforced concrete structure. The panels were fabricated with a water-resistive vapor-permeable air barrier membrane over continuous exterior insulation. The GFRC panels are attached to that weather wall (Fig. 6).

"All of the connections are based on stacking [the panels] on top of one another," Don Williams said. The connections are constructed of high-strength, galvanized steel. The connection system is quite simple. Panels hang from two connections on what the building team calls a towel bar with a receiver at the bottom that positions the panel. The GFRC installer, Salt Lake City-based Cannon Masonry, employed the same connection process all the way up the building.

"The design intended to minimize connections to the primary structure and permit the GFRC to work to its strengths," O'Hara explained. The team achieved this by minimizing the number of anchors using the towel bar and wind load pins. Thus, there were only about six anchors per

Fig. 6: The Populus hotel's façade during construction. The black areas are the weather wall's barrier membrane. The alternating metallic bands are high-strength galvanized steel "towel bars" for hanging the white GFRC panels *(photo courtesy of Cannon Masonry)*

10 m² (200 ft²) panel. "This minimized penetrations through the building envelope and also minimized the number of thermally broken connections needed," O'Hara added. "This greatly improved both the thermal and air performance of the enclosure."

According to Mark Cannon, owner and CEO of Cannon Masonry, each of the bottom panels was welded at the base of the building. About 180 pieces of the 374 GFRC panels were basically the same shape and size (3 x 6 m) but have different types of window openings.

To stack the panels up the building, the erectors welded a pin to the panel below, and the panel above sits on that base pin. "Then there's a mid-pin, which is bolted to the building, and then there's the towel bar that the panel hangs on at the top," Cannon explained, noting that the mid-pin is shorter than the bottom pin, so once the panel is on the bottom pin, the installers lean the panel into the weather wall. "It's basically a floating façade," he added.

The Beck Group laid out all the pins and brackets for attaching the GFRC panels. "All of these towel bars and mid-pins are attached around the whole building," Cannon said. "With most of the skin all put together, installation was fairly simple." However, he noted that sometimes his team had to take the mid-pin off the building and grind it to adjust it to make a panel fit.

Cannon said the tight building site was the most challenging aspect of panel installation. Typically, he said, his team would have used two forklifts to install the GFRC panels for a structure like Populus. But because of space constraints, they used a hoist system instead, employing one crane with two electric hoists to raise the panels into place.

"One day we'd set eight pieces, and then another day we'd set two," Cannon remarked. "Every single placement is different because if the mid-pins or towel bars aren't placed exactly right, you have to make fine adjustments. Alignment is huge."

On their best day, Cannon Masonry set 11 panels, according to Cannon, "but we averaged four to six panels per day." His crew placed all 374 panels that make up the main hotel, not including base pieces or the restaurant terrace, in less than 6 months.

"For something that's so repetitive, it was definitely a challenge," Cannon said, due in large part to the need for modifications during the installation process. "The [connections] on the building envelope are almost never exact, so we frequently made small modifications on either the GFRC or the frames. You've got to be able to think quickly on your feet."

"The biggest challenge [of Populus] was creating a building with a very unique geometry without blowing the budget with the molds," Don Williams said. "The genius is how [Studio Gang] helped us get the repetition without it looking like repetition."

"Even if you have the same panels, you can position them in a different way, so it isn't visible that there's repetition," Dustin Williams added.

"[The building's construction] is far more typical than it looks from the outside," Koehler said. It's basically a large-format prefabricated bypass wall panel system. "It's a practical approach. You can achieve these super complex shapes with a system that's familiar, tried, and true."

Populus opened for business in late summer 2024.

Selected for reader interest by the editors.

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