A Vertical Garden in Concrete

In one of the most biodiverse cities, a total-concrete residential building rises above the rooftops

by Deborah R. Huso

Bisected by the equator, Ecuador has a consistent, subtropical climate throughout the year, which accounts for its distinction of having more unique plant species per square meter than any other country on the planet. This flora-friendly environment was a significant inspiration for the designers of the IQON apartment building in Quito, one of the highest-elevation cities in the world.

Designed to look like a 130 m (427 ft) stacked flowerpot, the fully cast-in-place concrete residential structure is also the tallest building in the capital city and the third tallest in Ecuador (Fig. 1).

Completed in 2022, the IQON building features an eye-catching façade of stacked concrete "voxels" rotated around the structure's concrete core to provide private terraces replete with flowing greenery and views of the city below.

"Quito has amazing plant life, and we wanted to accentuate that connection to the outdoors," explained Lorenz Krisai, Associate at the New York, NY, USA office of Copenhagen, Denmark-based Bjarke Ingels Group (BIG), the building's primary architect. According to Natalia McLean, Design Director at Quito-based architectural planning, design, and construction company Uribe Schwarzkopf, a major goal of the IQON building's design was to make it an extension of the adjacent La Carolina Park with the same species of trees and plants climbing up the side of the structure, "like the branch of a tree."

Fig. 1: The IQON building in Quito, Ecuador *(photo courtesy of Uribe Schwarzkopf)*

Designing with Views and Seismic Movement in Mind

The building was designed as a gradually curving "L" so that every apartment would have a view, "like a series of rooms with staggered elements to capture views to the north and south," said Mario Lafontaine, Director of Seismic Technologies with Santiago, Chile-based René Lagos Engineers. As the building curves into this "L" shape, so do the rooms, always turning to optimize access to sunlight and the views over the rooftops of Quito. Each apartment also has a wall of windows facing mainly both north and south to allow for cross ventilation (Fig. 2).

Fig. 2: Each unit of the IQON building has a wall of windows *(photo courtesy of BIG)*

But that curving design, combined with the structure's height, created challenges of its own. "This building is the tallest in Quito, so we did a lot of dynamic analysis," Lafontaine noted, adding that engineers referred to building codes from the seismically active city of Los Angeles, CA, USA, as they designed the structure.

The relocation of Quito's airport away from the city center allowed the IQON building to be constructed at twice the height previously allowed. But its location in an area with active volcanoes, including Guagua Pichincha at the doorstep of the city, meant height came with risks.

"Seismic design is really important in this area," Krisai said. "You need a lot of mass and a very strong building."

According to Fernando Romo, Executive Vice President at Quito-based architectural and engineering consulting firm Fernando Romo Consultores, the geologic faults that establish Quito as a jurisdiction with high seismic risk account for concrete being a primary building material in the region: "Concrete provides rigidity and flexibility at the same time." In the case of the IQON building, concrete cores in each leg of the "L" work together to provide translational and torsional seismic resistance (Fig. 3).

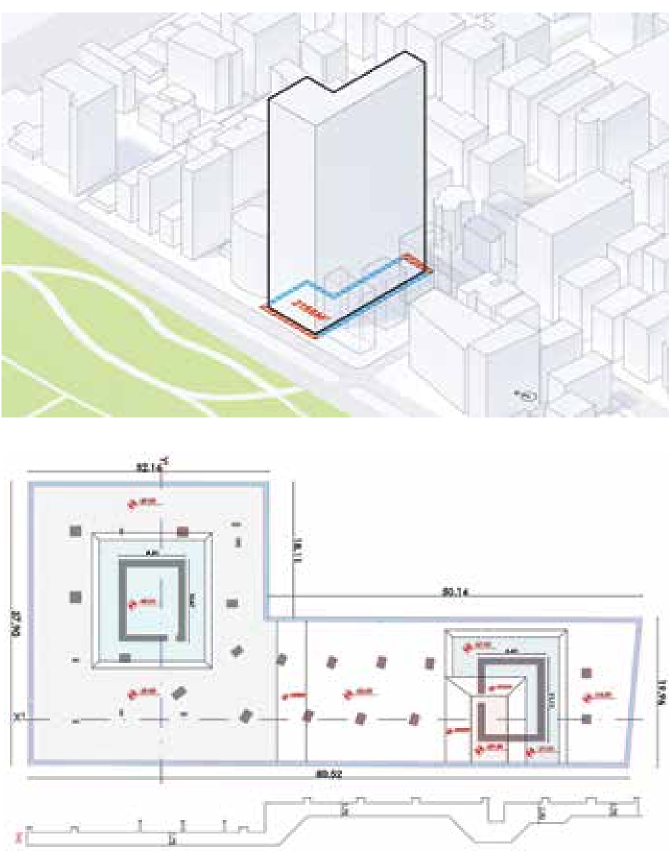

Fig. 3: The IQON building's mat foundation is stepped, varies in thickness from 2 to 5 m (6 to 16 ft), and has a footprint of 2200 m^2 (23,680 ft^2). Concrete cores in the two legs of the "L" provide seismic resistance for the tower above. Note: All dimensions are in meters *(figures courtesy of BIG and Fernando Romo Consultores)*

Concrete also achieves the necessary fire resistance for apartment buildings because, as Romo noted, "concrete is basically a man-made rock." Further, Ecuador is not a steel-producing country, so Romo said engineers and builders try to limit the amount of steel that must be imported. Lastly, as the go-to material for construction in Quito, concrete is familiar to local builders and tradespeople.

"This was our first project in Quito and South America in general," Krisai said, noting that the environment in the Andes offers an array of both opportunities and challenges. "Quito has a perfect climate year-round. The sun rises at 6 a.m. and sets at 6 p.m. every day, and you don't need to have insulation or air conditioning." That allowed for design and construction that was "more pure and minimal," Krisai added.

Concrete construction also allowed for the benefits of thermal mass in a structure without insulation or air conditioning. "It can get a little chilly at night and up to 28°C [82°F] during the day, so the building's concrete façade and structure help hold heat and cold," Krisai explained.

Further, concrete construction made it possible to create a building with greenery on its façade. Apartments feature terraces with planters containing one or more trees and plants like those found in adjacent La Carolina Park. "We wanted it to feel like you're walking into a garden when you step onto your balcony," Krisai explained. "The only way to do that without raised planters was to take up space in the apartment below, so we placed a structural wall underneath each terrace that essentially occupies space in the living room in the apartment below to give a hollow space for tree roots to grow (Fig. 4). The roots are hidden in the sculptural wall in your neighbor's living room," Krisai said, creating a unique architectural feature in concrete in the interior of every apartment.

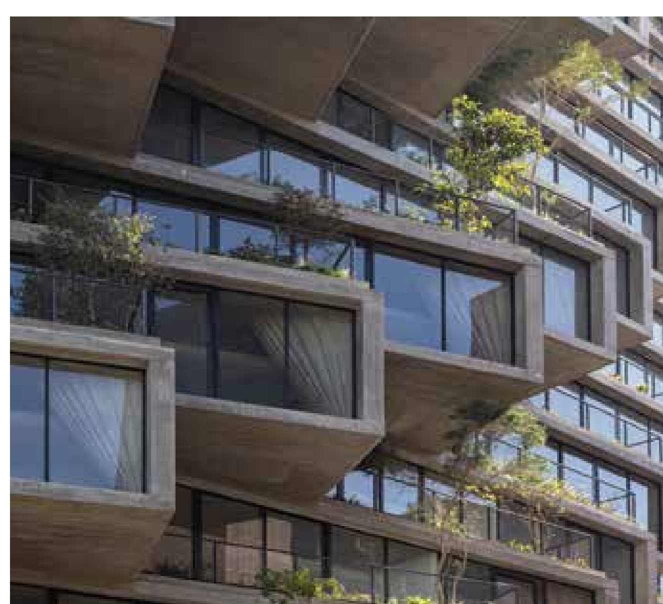

Fig. 4: Planters were created by forming sculptural walls in the apartment below *(photo courtesy of BIG)*

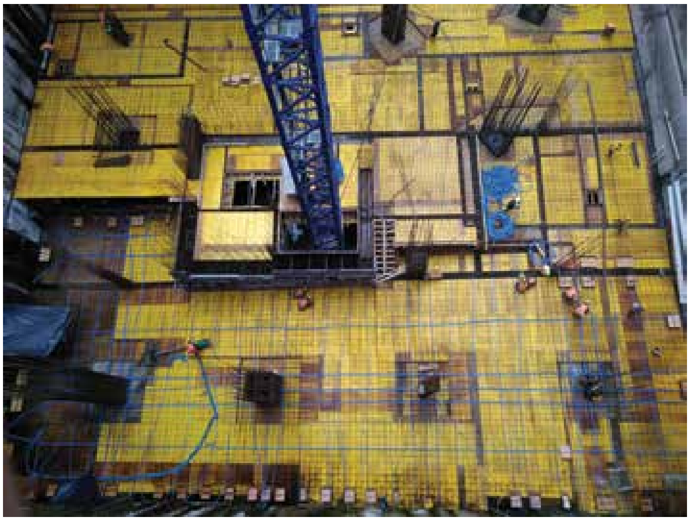

Fig. 5: Views of the mat foundation during construction *(photos courtesy of Fernando Romo Consultores)*

Deepest Foundation in Quito

The IQON building's distinctive concrete façade was an intentional design feature. "We wanted to be very honest about the material and use it for façade and structure," Krisai explained. "There's something very beautiful in the texture of the concrete. It picks up on the technique of the formwork, which is imprinted on the façade."

The striking 33-story apartment building also includes eight underground levels and is supported by a massive mat foundation placed nearly 30 m (98 ft) below grade (Fig. 3 and 5).

Romo said the IQON building has the deepest foundation for a residential building in the city, which created challenges for excavating deeper into Quito's water table, which is about 14 m (46 ft) below the soil surface. Builders had to abate the water level during excavation by installing wells on the jobsite.

Excavation was incremental. "We excavated [one level at a time] and then constructed perimeter walls," Romo explained. "Then we'd do the next level and so on." That process repeated all the way to the foundation.

From the foundation up, workers built the structure slab by slab. "As the building [went] up, the crane supported itself on the floors already built," Romo explained (Fig. 6). "The concrete mix design was modified gradually as the building was [going up] to maintain final properties but at the same time be viable for pumping at different heights."

"The floor slabs zigzag as they [orient] toward the park," Krisai explained. "There is some repetition with the pattern repeating every three floors." This allowed some of the formwork to be reused. "But it's not a very straightforward grid-like building," Krisai added. "Conceptually, it's one box sitting on another."

Each of the boxes has 300 mm (12 in.) walls and a 600 mm (24 in.) floor slab, although the slab thickness reduces to 300 mm at the terraces and where the soffit is exposed on the exterior of the building, as well as within the interior bay of the building.

Fig. 6: The construction crane was supported by recently completed floors *(photo courtesy of Uribe Schwarzkopf)*

Concrete Composition for High Elevation and Seismic Shift

The high altitude of Quito at 2850 m (9350 ft) above sea level presented some challenges for placing concrete. Because altitude can affect the curing process of concrete, different types of concrete were used throughout the building.

In most of the above-grade building, the concrete has a compressive strength of 45 MPa (6530 psi), according to Romo. In the case of reinforced columns located in areas of high congestion, the building team used self-consolidating concrete (SCC). The floors are post-tensioned slabs with a compressive strength of 45 MPa. Concrete had to achieve 20 to 25 MPa (2900 to 3625 psi) within 3 days of placing for post-tensioning to be applied. Thermal modeling was used to determine the curing process needed to avoid excessive core temperatures and thermal differentials in the foundation mat.

Fig. 7: Steel formwork was reused to build the terrace planters *(photo courtesy of Fernando Romo Consultores)*

The sculptural planters are also constructed with SCC. The design called for three sizes of planters, so the contractor used prefabricated and reusable steel formwork to build the required sculptural walls (Fig. 7). The building features 113 large planters, each with a large tree. "It was a challenge to make that work," Krisai said. "There's so much weight in those planters."

It took 4 years to complete construction of the IQON building, due in part to work stoppages as a result of the COVID-19 pandemic in 2020 and restrictions on the number of workers who could be on site at any given time. The top level of the structure was placed in January 2022, completing this vertical community and extension of La Carolina Park.

By the project's end, the building team had placed 4500 tonnes (4960 tons) of reinforcement and 39,000 m^3 (51,010 yd^3) of concrete. The total project cost came in at 45 million USD. The IQON building is also EDGE-certified, having met Green Business Certification Inc. (GBCI) requirements for resource-efficient construction in emerging markets.

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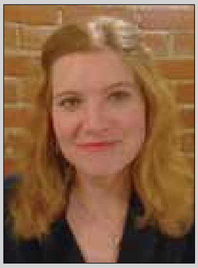

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