INTRODUCTION

Pier 27 Phase III is the tallest tower of a multi-building residential complex located on the waterfront in downtown Toronto. The 35-storey tower is characterized by 5m cantilevered balconies at each floor arranged in alternating sequence up the building.

Pier 27 and its cantilevered balconies rise above Lake Ontario as part of Toronto's waterfront community.

The very large cantilevered balconies are unique in current residential developments and helped our developer client, Cityzen, obtain the dramatic architecture they desired for this project, a feature much desired by purchasers. The balconies presented key design and construction challenges that gave Entuitive a real opportunity to be creative and innovative, the details of which are the subject of the next section.

CREATIVITY AND INNOVATION

The project presented three main challenges that Entuitive had to overcome during the design phase to aid in speedy and uninterrupted construction. Chief among these was the depth of the cantilevered balconies, which are of sizes rarely seen on residential projects and, as far as we know, unprecedented in the Toronto market. The other challenges included the development of a coupled lateral load-resisting system without coupling beams and building the south end of the podium over an existing (and operating) parkade that was part of an earlier phase of the development.

CANTILEVERED BALCONIES

One of Cityzen's goals for the 35-storey tower was to achieve the ambitious architectural vision for the building, characterized by cantilevered balconies, 5m (15 feet) deep at their maximum point, and which alternate in sequence up the building. Balconies of this depth are unprecedented in a residential development in Toronto.

To realize this vision, Entuitive used post-tensioned 225-mm thick concrete floor slabs. The slab thickness was minimized to ensure maximum floor-to-floor heights were achieved and to remain as close to the 200-mm slabs seen in typical condominium construction. Fully-grouted post-tensioning tendons were used to ensure long-term performance and to maximize safety during construction.

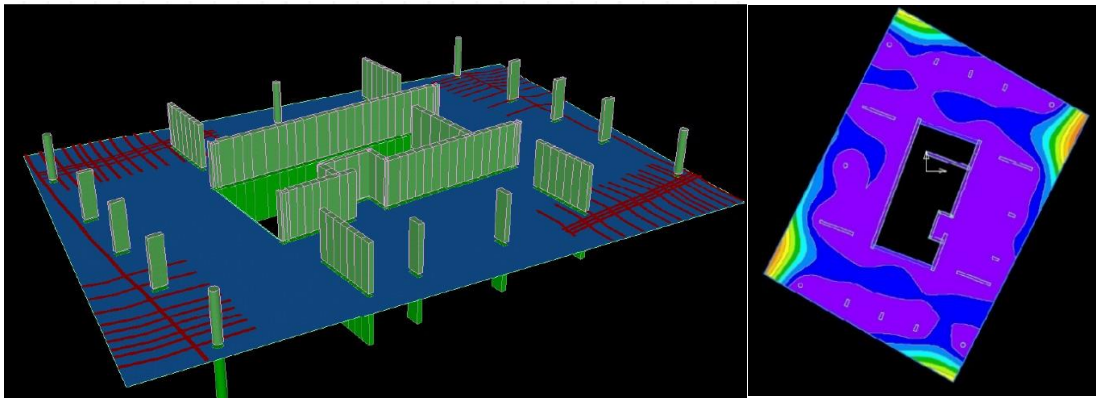
A close up view of the balconies under construction.

To ensure construction proceeded rapidly and to minimize cost, the post-tensioned zones of the slab were limited to the four corners of the floor plate, where the cantilevers were largest. This allowed the forming and post-tensioned trades to work sequentially without interference, while also keeping most of the slab conventional reinforced concrete. The combination of these features also made for relatively larger clear spans internally than is typically achieved. Although post-tensioned concrete is used somewhat commonly for specialized elements like individual transfer beams, to our knowledge, the project represents the most extensive use of post-tensioned slab construction on a condominium project in Toronto in many years.

The most complex problem on the project was to design the post-tensioned cantilevered balconies in a way that allowed them to be constructed quickly and simply. Localizing the post-tensioning to the corners of the plate, allowing the rebar and post-tensioning trades to follow each other around the plate in sequence, solved a key construction logistics issue. Early collaboration with the construction team and the forming, plumbing, railing and post-tensioning trades eliminated conflicts that could have affected the placement of post-tensioning tendons. This early collaboration not only addressed schedule concerns, but also the fear that after-the-fact coring might damage the tendons used in the post-tensioning. The use of fully-grouted tendons provided further safety and improved long-term performance.

An added benefit of the post-tensioned concrete was that somewhat larger column-free spans were possible in the corners of the building, maximizing sellable area, allowing more flexibility in the design of the suites and making the interior aesthetic of the suite more attractive to buyers.

The maintenance of the construction schedule required the stressing of the post-tensioned slabs within 24 hours of being poured. To do this, Entuitive collaborated with the concrete supplier to develop a high-early strength concrete mix. The mix design won an Ontario Concrete 2019 innovation award.

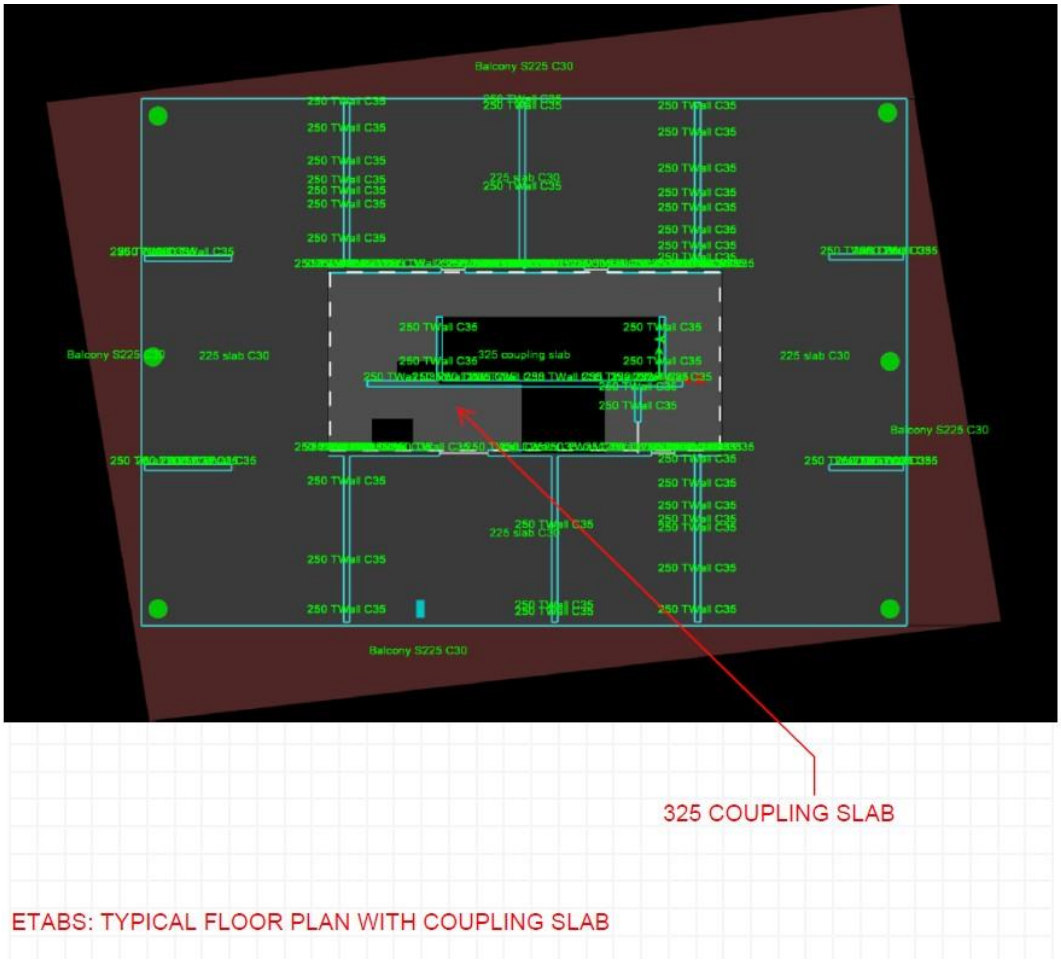


3D RAM concept model of post-tensioned slab showing tendons & long-term deflection plot.

COUPLING SLABS

300 thick coupling slabs were used within the core and corridor areas to tie (“couple”) the shear walls together to enhance their ability to resist lateral loads. The more conventional solution to this problem is to use coupling beams; however, those require more formwork. The minor reduction in headroom at the typical floor was not an issue for the interior design because it was confined to the common corridor areas. At mechanical plumbing transfer floors, the slabs could not be used without affecting headroom,

however on those floors, the use of coupling beams was still minimized through analysis. Overall, the use of the coupling slabs simplified forming and improved schedule even in areas of the floorplate that had to be stick-formed.

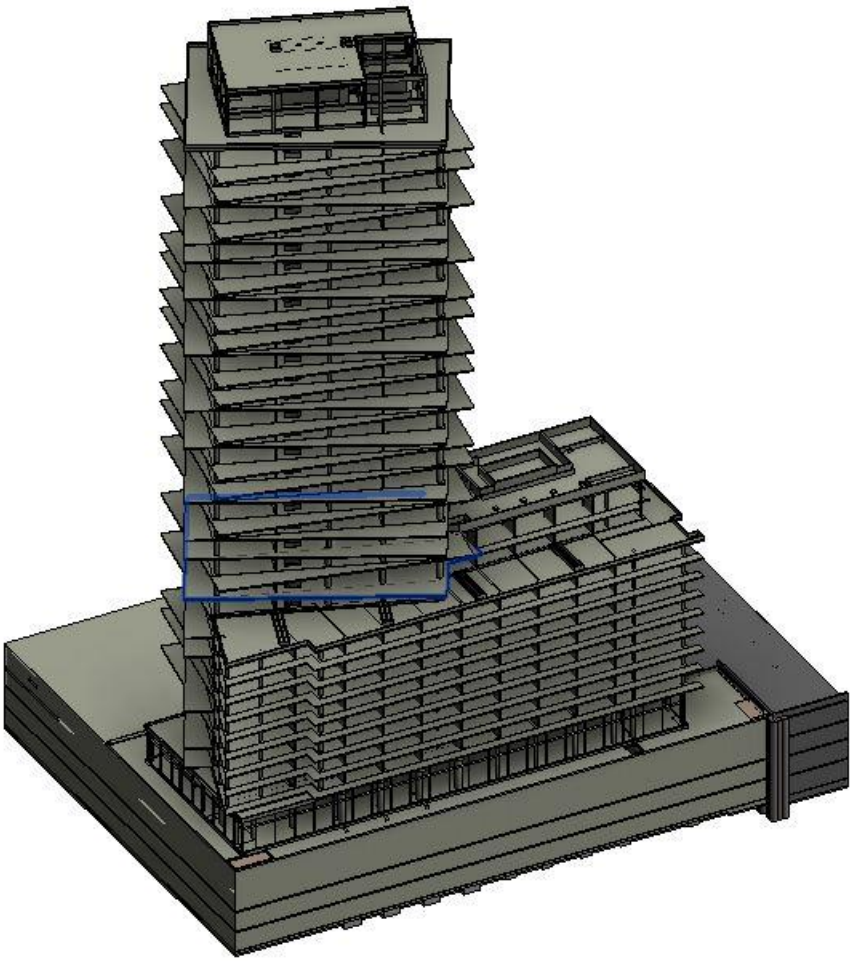


Analytical odel showing the extent of coupling slab at a typical floor.

PODIUM OVERBUILD

Having to construct the edge of the south podium on top of the parking garage of an earlier phase of the development presented a further challenge and opportunity to innovate. The existing columns had to be reinforced without disrupting the electrical/mechanical room through which they passed. This was done with shotcrete, as steel and CFRP jacketing methods were evaluated and rejected on cost and logistical grounds.

We knew the shotcrete could be applied in a fast, controlled way, while existing equipment was protected. The existing footings were enlarged for the new loads. A deep beam above the existing ground floor slab spread the loads from the new tower podium columns into the existing columns. Rigid insulation below the new ground floor slab above the existing garage roof further reduced loads.



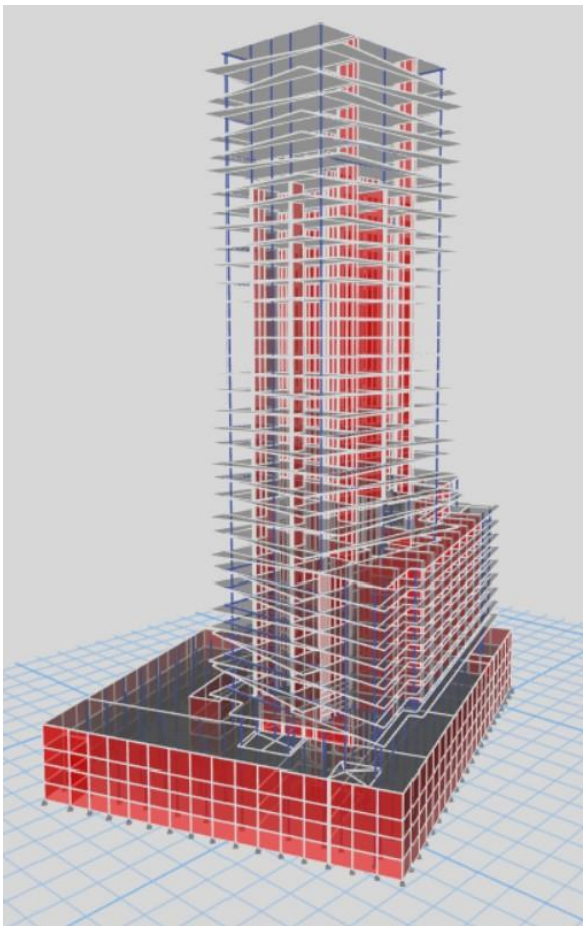
In this BIM image we can see the 35-storey tower rising over the existing parking garage.

ADDING CLIENT VALUE

Our client, Cityzen, had two main design/construction goals for this project, both related to, and essential for, making the project as commercially successful as possible.

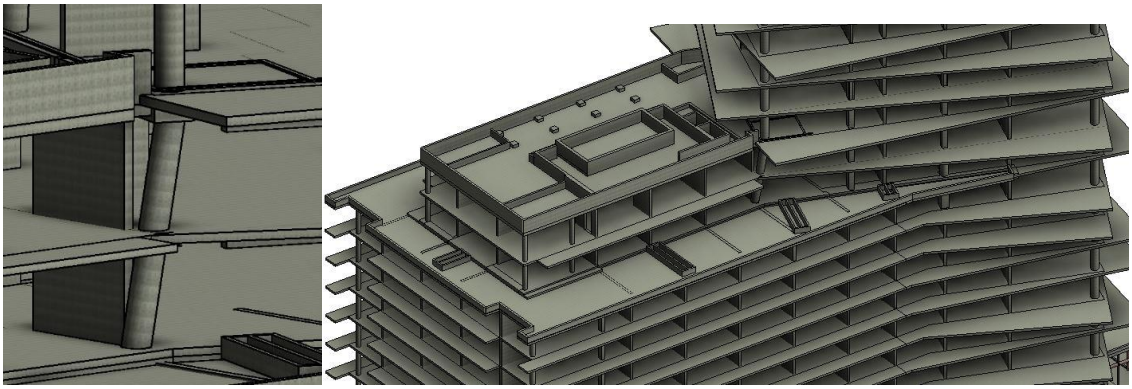
The first goal was for a design that could bring the bold architectural vision to life structurally. With the cantilevered balconies we achieved this, bringing a distinct impression to the growing waterfront community. The balconies provide a way to integrate the interior and exterior of the building while playing with the waterfront just beyond them. This made for spaces that were attractive to potential buyers and maximized the waterfront location.

A second goal was to keep construction on schedule and construction costs down, both of which were attained through cost-effective design. Careful use of the post-tensioning combined with thorough planning allowed construction to proceed efficiently and economically. Secondary innovations like the use of coupling slabs further simplified construction while reducing schedule and forming costs.



ETABS 3D model of the project, used for lateral analysis.

Entuitive generates all project documentation from a REVIT (BIM) model of the structure. We have developed in-house tools that allow our modeling and analytical programs to communicate easily. These tools enhance and complement any of the linkages built into the BIM and analysis software, maximizing their usefulness and productivity. This facilitates the exploration of design alternatives, reduces repetitive tasks, and improves accuracy. All of this is our natural way of working and provides value to the client at no additional cost.



The above two BIM models showcase the cantilevered balcony arrangement, sloped columns, and the complexities of the outdoor pool and landscaped areas in much finer detail.

Finally, the extensive collaboration and communication on the project ensured that all parties (owner, architect, construction manager, trades) were able to control risk by understanding all aspects of the design. This meant no major design changes were required throughout the project's construction and site issues were kept to a minimum.

CONTRIBUTING TO THE COMMUNITY

This rendering from Cityzen shows the level of greenspace and integration with the waterfront community that the development has provided.

The chief benefit of this project to the community is that it brings more life to the growing waterfront community of Toronto. The area south of the Gardiner Expressway has for a long time been forgotten and isolated from the rest of the city, making Toronto an outlier amongst cities with extensive waterfronts. This project represents a great step toward making a more developed life on the waterfront a reality for Toronto.

Through the addition of residents, new parks and landscaped green space and exterior art installations an integrated public realm at street level has been provided as well.

The provision to add retail to the ground level of the building also adds to the community, providing more shops and services while creating new jobs. The project also considered the environmental and operational requirements of the Redpath Sugar plant, a major employer on the waterfront.