"Necessity Is the Mother of Invention"

How challenges for The Artise turned into a willingness to create something new.

By Scott Erickson

The Artise, in Bellevue, Washington, is a 25-story, 1 million-square-foot, steel office building with six levels of below-grade parking for 900 parking stalls. Topped out in February 2023, The Artise utilized a one-of-a-kind structural system aimed to solve several design challenges at once and, consequently, resulted in at least 25% material savings compared to what's traditionally required for an office building of comparable size and materials. By using buckling restrained braces and fluid viscous dampers that skip floors, and a moment frame sub system in between brace points, the lateral resisting footprint was spread out and the pieces minimized. This reduced demands on the superstructure and the foundations. Further, by eliminating all lateral framing below grade, the design saved even more on cost.

Project Challenges

The design and construction teams faced several challenges, including:

- Contaminated seepage from the soil to the north side from across the street was not allowed to be diverted into the aquifer below the entire site. This meant that traditional shoring piles could not be used on half of the site and the base excavation was limited in depth. Traditionally, 900 parking stalls would have required seven levels. The site restraints on this project required the project team to fit that many stalls in six levels.
- During the design team discussions on arranging the brace points, the owner expressed a desire to clear span the entire west side retail experience at the ground floor, and transfer three lateral frame columns, to create a substantially more open entrance that would attract pedestrian traffic
- Due to the configuration of the building on the site, caused by setback requirements to the south and one-story deep street easements for the city on the north and west, a conventional 42-foot office span configuration in the tower, which would accommodate an 18-feet parking stall area and a 24-feet drive aisle, did not align well with an efficient parking layout below grade.
- Once the design was about 85% complete, just before structural steel was ordered, the building was changed to a category III building (from category II) to satisfy tenant needs. The performance based seismic design not only had to be redone in short order, but new ways of stabilizing the building were required due to the more stringent drift requirements.

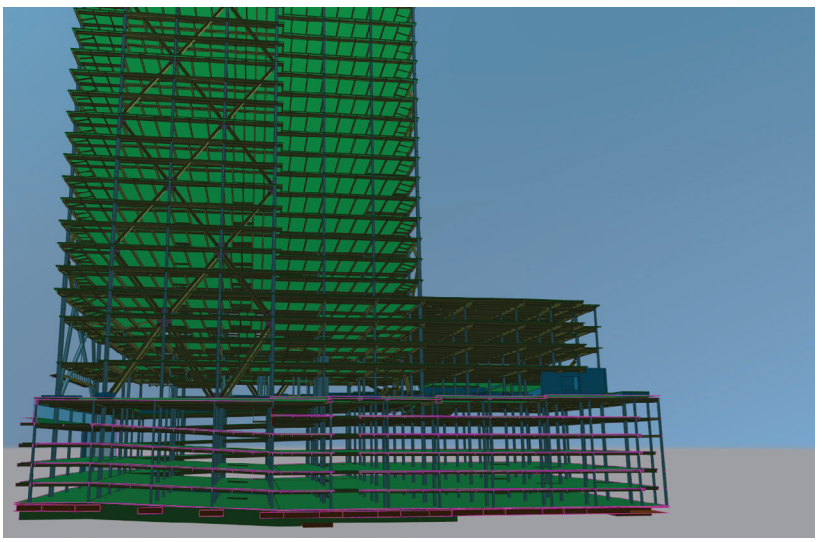
The Process

Many times, engineers revert to what they know, what has been done before, and what they are comfortable with. But for those who are willing to venture off the beaten path, and take risks with possible distractions and setbacks, the creation of something entirely new and rewarding is possible.

For The Artise, the engineering team threw out traditions and focused on the core goals of ownership, one of which was obtaining 900 parking stalls in six levels below grade. The project team decided to optimize the entire below-grade footprint for parking without any concern whatsoever for superstructure to test fit the idea of not using a lateral system below grade. The traditional concrete core was taken out of consideration, as was every lateral system horizontal brace or wall element from the space, to make room for the required available parking and maintain the structure above the aquifer.

What about the other 25 floors sitting on top of the below grade parking? The design team now needed to find a way to transfer the entire lateral system out at grade to maintain the parking count.

The star shaped pattern of braces and columns in The Artise allowed for an opened ground-floor retail area (photo by Scott Erickson).



A model of The Artise showing the below-grade areas without a lateral system.

Project Team

Owner: Schnitzer West, LLC
Structural Engineer of Record: DCI Engineers
Architect: NBBJ
General Contractor: Sellen

The super brace buckling restrained brace and damper system on The Artise (photo by Scott Erickson).

Internal sloping columns during construction (photo by Scott Erickson)

The Solution

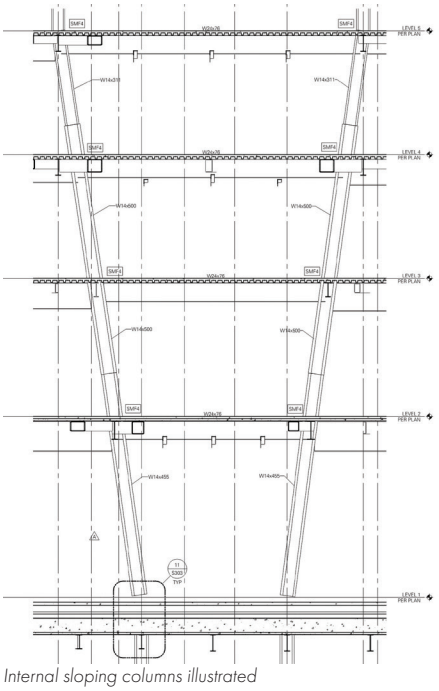
The baseline solution started with a short span steel parking configuration with a column grid of 30 feet or less below grade to minimize structure depth to W16 beams and W18 girders, which reduced excavation as a result. To support the steel-framed office tower above, the project team configured the extent of the office tower such that the perimeter columns extended straight down to the foundation without interrupting the parking drive aisles and without encroaching into the easements and setbacks. The interior columns from above landed in drive aisles and still needed a solution. But the perimeter column layout provided something to work with.

The decision was made to use a perimeter buckling restrained brace frame system. In the spirit of trying something new, the design team made it a super brace system—where braces extend over multiple floors and pass-through other floors on the way to their connection points. This more efficient system uses less braces and less connection material than a brace system that connects at each floor. Additionally, the longer length of the braces provides for more displacement, which also drives structural efficiency of each brace. At the floors where the braces passed through, small sections of moment frames were used only between the braced floors to transfer the diaphragm forces either up or down to the floors that were connected at brace points. Brace points on each side do not always align at a given floor. Some sides of the building have braces that skip one floor while others skip two.

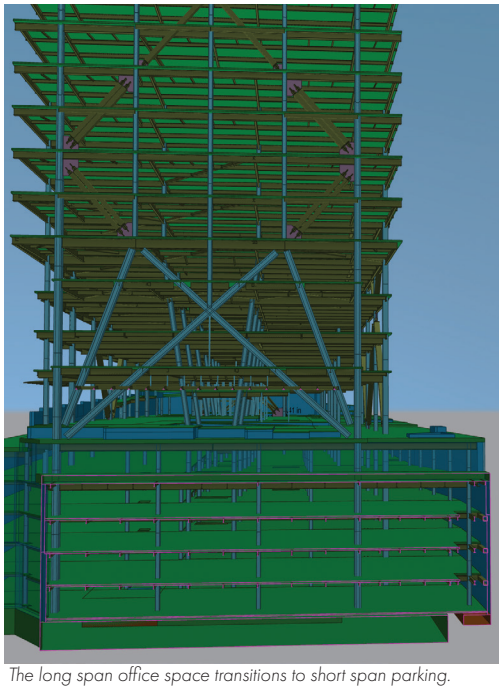
The superstructure interior gravity columns were sloped over five floors to match up with the column configuration below grade. The added kick from the sloped columns was fairly well balanced by sloping both sides, but even so, unbalanced loading was considered, which added a lateral gravity force to the super brace system.

To achieve the owner's goal of opening up the ground floor retail on the west side, three of the five west building face lateral frame columns near the base were transferred out to the corners. A star-shaped pattern of braces and columns was used to achieve this. The braces had to be elastic (not yield) for the transfer, which required a fine-tuned balancing act to navigate the non-linear analysis.

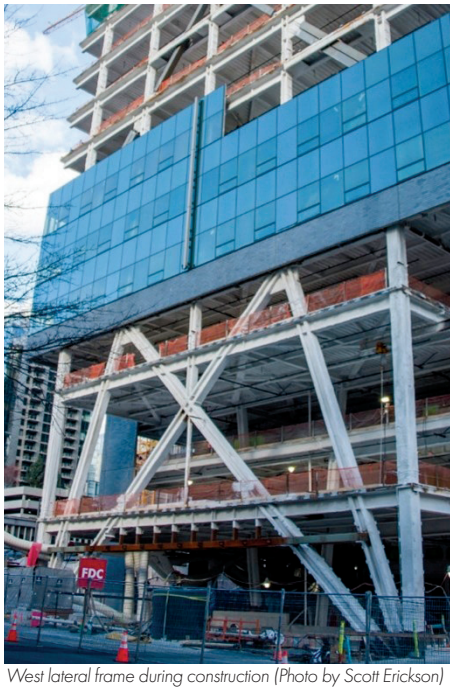
When the building was changed to a category III building (from a category II) with stricter drift requirements, a significant challenge was posed as braced frames are typically limited by drift. At this point in the design, the layout of the braces, their arrangement patterns, and



Internal sloping columns illustrated



The long span office space transitions to short span parking.



West lateral frame during construction (Photo by Scott Erickson)

their attachment points were configured to be aesthetically aligned with architectural goals of the tower. In addition, boxed out W14x873 columns were already used at the base (so columns could not be easily upsized), and the design had already doubled up on some of the larger producible BRBs with 40 inch-square cores and 24 inch-square casings. There were not many options left.

As a result, the project team decided to explore fluid viscous dampers. After trial and error, some of the BRBs were swapped out with dampers. Some dampers were placed within each frame, 24 in total. This solution controlled not only the drift, but the residual drift as well, and was especially important in helping balance the stiff star shaped brace on the west side with the east side frame.

At the end of the day, not only did 900 stalls fit into six levels (instead of seven) with a short span steel gravity system, but this unique structural lateral system configuration saved at least 25% of the cost of material than a traditional building would have required by eliminating a concrete core, reducing foundation reinforcing, eliminating a lateral system below grade, using a spread-out super brace lateral system, and reducing drift demand by using fluid viscous dampers.

Additional Hurdles

Typically, lateral systems are carried directly down to the foundation. Since The Artise only had perimeter columns extend to the foundation, the basement walls became the primary lateral system below grade. Wanting to save as much as possible on cost, a spread footing system and donut configured mat foundation below the lateral frame columns was used. As this didn't directly tie into the basement walls on all sides, soil structure interaction modeling, both vertically and horizontally, was required to determine the interaction of forces below grade. This alone would require many pages to elaborate on.

The super brace lateral system skips floors, requiring unique localized intermediate moment frames to deliver forces up and down to brace points. The interaction of these partial frames and how to model them properly in Perform 3D, along with the diaphragm design itself for the proper forces, became quite complicated.

Structural seismic lateral analysis requires that 90% of the mass participation be captured to ensure proper force distribution. Because the below grade structure was equal in mass to the superstructure and the basement wall lateral system was extremely stiff, scaling to 90% of the effective mass participation meant capturing a very large number of modes. This presented a unique challenge for properly scaling the conditional mean spectra.

The super brace lateral system is drift sensitive to both long period and short period ground motions, so optimization of the fluid viscous damper locations was key to controlling localized mean and residual drifts. This was especially true due to the elastic behavior of the transferred out west side frame, which created a stiffer frame than the east side.

An Elegant Cost Savings Solution

It would be easy to look at this process and see it as a never-ending cycle of compounded challenges and hours of problem solving. But, the best solutions do not usually come from the path of least resistance. The project team set out to determine the best way to optimize the structure, and in the end, the uniquely framed building not only met the project goals but saved considerable construction costs in the process. The ultimate goal in engineering is for solutions to transcend their immediate challenges and become universal in practice. For that alone, this project was a success, as the use of fluid viscous dampers in particular provides insight into how future projects can benefit from their use as well. ▪

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Damper and buckling restrained brace system on The Artise (photo by Scott Erickson).