Optimising the design of London's newest iconic skyscraper

DAVID HUIE

Considered one of London's most iconic building projects, One Blackfriars is a mixed-use development that features a 50-story residential tower as its centerpiece, an adjoining three-story podium housing a gym and retail facilities, and a boutique hotel with 161 rooms — all built over a three-story basement with a swimming pool, spa, and parking facilities.

Developed by St. George and designed by Simpson Haugh Architects, the project is situated on the south side of Blackfriars Bridge, overlooking the River Thames, offering views of St. Paul's Cathedral, Tower Bridge, Westminster's Big Ben and the houses of Parliament. WSP was appointed to provide structural modeling and engineering services. The project site varied in depth and had remaining elements of a previously demolished building, which could not be removed without collapsing the surrounding infrastructure.

After performing a 3D laser site survey, the team understood the site challenges and designed the new three-story basement down to 13 metres, fitting around the site's constraints. WSP also faced challenges designing temporary on-site client facilities, including developing structural solutions for the complex geometry of the 170-metre landmark building. WSP used MicroStation, RAM Concept, and RAM Structural as an integrated BIM solution to streamline workflows and carry out their work on the project.

3D design coordination

St. George sought a strong, on-site marketing and sales presence, so WSP designed a temporary three-story, steel-framed facility fitted with replica apartments to serve as the marketing suite. To support it at ground level, the team partially modeled the ground floor slab and supported the slab on plunge columns so that the three levels of the basement could be constructed around and underneath the marketing suite while in use. This piling configuration enabled temporary and permanent works to be combined and facilitated a top-down construction sequence. The interoperability of the BIM suite helped WSP to share the 3D design models with the main contractor for generating logistics plans and sequencing work packages. As the works reached the ground floor, the marketing suite was removed and the tower construction commenced.

To complicate matters, the tower's rooftop structure housed the main building maintenance unit (BMU), which contained a shaft extending down into the multi-level penthouse floors. WSP worked with its in-house façade access consultants, sharing 3D models to determine how to prevent the BMU from intruding on the penthouse space. Using the WSP model, contractors could fully understand the space and reduce the size of the BMU to a more compact unit.

In addition to coordinating with the contractors, WSP opted for a collaborative design process to analyse numerous options and determine innovative solutions to ensure structural integrity of the asymmetrically shaped tower. The design team used the architect's 3D model in MicroStation and developed a framing skeleton for the model. Floor plate layouts were then extracted and imported into RAM Concept, where multiple design iterations were analysed and automated drawing productions generated for client and design team coordination.

Post-tensioned design in practice

The geometry of the tower consists of a narrow base extending upward to a bulge, where the private viewing lounge offers panoramic views of London, and then slopes back in and continues rising upward. A multi-level penthouse accommodates the top five floors of the 50-story building. The tower includes 274 luxury apartments, all varying in layout with floor plates of different shapes and sizes and no repetition throughout the building. Not only did WSP need a structural solution for the varied floor plans, but it also needed to design support columns that offered unobstructed views without intruding on the apartment spaces.

Based on the architectural model, WSP determined that the optimal structural solution was a combination of fitting reinforced concrete blade columns between the party walls and circular feature columns. With the various sized apartments, the team needed to determine the location for the columns that best suited the individual layouts while still

ensuring structural integrity. The team optimised the column configuration and automatically generated arrangement drawings that were shared with the contractor for construction.

Finally, with RAM Concept, WSP designed the apartment floor slabs as thin as possible. The team modeled and designed 225-millimetre thick, post-tensioned concrete floor slabs, which proved the most cost-effective solution based on minimum structural zone. It reduced the self-weight of the floors, which allowed for maximum slab spans and floor-to-ceiling heights to increase apartment value. The post-tensioned slab design saved 10 percent in overall concrete volume for the floors alone, equivalent to five additional floor plates.

Interoperability ensures stability

WSP conducted finite element modeling to analyse the entire building, testing stability against wind and numerous forces. The team applied the software's meshing algorithm to accurately predict the floor slab concrete behavior and integrated it with other software, designing the stability system and producing an overall building model.

At the pinnacle of One Blackfriars Tower is the multi-level penthouse. Tasked with finding a structural framing solution for the most expensive part of the building, the design team used RAM software to develop structural support for the glass rooftop. At the conclusion of this process, WSP introduced a transfer slab to support the entire dead weight of the roof cap and restrained it with horizontal and vertical restraints.

The team conducted a detailed deflection cap analysis that included testing the structural robustness of the main BMU on various supporting transfer slabs.

Optimising structural solutions

Consistent with the elegant design of the tower, the architects were keen to have feature columns at the base of the building. The columns were narrow at the base and extended upward 10 meters in height, which forced the team to adopt high-strength concrete to ensure optimal axial stiffness and strength. However, the client also wanted a two-level mezzanine above the lobby without any of the columns interfering with the open lobby space. Using RAM Structural System, WSP designed a steel framework and hung the entire framing system from the first residential floor slab, while the design team enhanced the thickness of the first level slab to support the frame loads.

Project summary:

Organisation: WSP

Solution: Buildings and Campuses

Location: London, England, United Kingdom

Project Objectives:

- Provide structural solutions for site constraints and complex geometry of One Blackfriars Tower.
- Design cost-effective, efficient framing to fit 274 apartments within the 50-story skyscraper.
- Optimize collaboration with architects, client, and contractors to deliver elegant super-structure with spectacular views of London.

Products Used: MicroStation, RAM Concept, RAM Structural System

Fast Facts

- One Blackfriars is London's mixed-use development, accommodating 274 apartments and a multi-level penthouse.
- WSP used RAM Concept to design the floor slabs for this geometrically complex building.
- Using MicroStation, the design team shared 3D models and produced automated production drawings, facilitating collaboration.

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- RAM Concept optimised optioneering to achieve a costeffective structural solution within a short time period, saving the equivalent of five additional floor plates.
- Bentley's 3D technology coordinated modeling and streamlined workflows to save 50 percent in design time.
- Bentley applications' interoperability combined temporary and permanent works, increasing efficiency and reducing construction time.

WSP faced additional challenges in ensuring structural support for the post-tensioned floor slabs for the different apartment layouts. After conducting numerous design iterations, the team adopted a combined solution of walking columns, raking columns, and split reverse-Y columns. As the raking columns also generated horizontal forces, WSP used the floor plates to tie the column horizontal forces to the building.

Further up the tower structure are two smaller BMUs that required a variation in column design to avoid clashes as the columns rose from the floors below, the team deciding ultimately deciding to use reverse-Y transfer columns to allow space for the BMUs whilst still supporting the floors.

Finally, as with any high-rise building, lateral stability is a crucial issue. With residential buildings like One Blackfriars Tower, the building cores tend to be smaller compared to commercial buildings. To ensure lateral stability, WSP designed a staggered outrigger system that extended out and connected to the perimeter columns. This solution also provided the construction team complete access to each floor.

Pushing the limits of structural design

WSP explored and adopted many iterations and design changes from the initial design proposal stage through construction, while ensuring compliance with European design codes. Within a short period of time, they were able to achieve an efficient, cost-effective structural solution incorporating longer, thinner slabs and fewer columns.

Ultimately, WSP were able to design and deliver an iconic landmark for London. One Blackfriars will inspire the next generation of designers to think outside the box and promote London as the capital for world-class architecture and engineering.

David Huie is Senior Product Marketing Manager at Bentley Systems. ■