



Project Summary

Organization
WSP

Solution
Structural Engineering

Location
London, United Kingdom

Project Objectives

- To design a distinctive, detailed 50-story tower on a small footprint.
- To ensure that construction did not interfere with rail operations or damage masonry tunnels.

Project Playbook
PLAXIS®, RAM® Concept

Fast Facts

- Due to the small amount of space available, the GBP 200 million project could not proceed without a design that proved its viability.
- WSP had to protect a masonry rail tunnel while shielding the project's basement from railway vibrations.
- Top-down construction became necessary, as the ground floor slab would act as a protective horizontal prop.

ROI

- The detailed design and analysis proved that the tower design would work, even as piles were built 50 millimeters away from the tunnel.
- Optimized design reduced support materials by 60% and lowered the amount of temporary works needed during construction.
- With RAM Concept and PLAXIS, WSP created a more efficient design that reduced both material and labor costs.

WSP Overcomes a Small Footprint to Construct 50-story Principal Tower, Protecting Victorian-era Rail Tunnels

PLAXIS and RAM Concept's Proven Analysis Capabilities Enabled Project Team to Deliver Owner's Vision

Creating an Iconic Addition to London's Skyline

The newest addition to London's skyline is the 50-story, mixed-use Principal Tower, adjacent to the city's financial district. The building's unusual design consists of three shapes of varying heights arranged in a cruciform that measures less than 25 meters on each side. The amenities on the GBP 200 million project include floor-to-ceiling glazing, brass-colored louvres, balconies, a pool, spa, gym, movie theater, lounge, and a grand lobby that features a seven-ton staircase, which had to be assembled on site.

WSP, a global management and consultancy services company, was commissioned to design the project, provide a guide for construction, and deliver the owner's vision in the limited space available for construction.

The tower is a part of the wider Principal Place development, which includes smaller mixed-use buildings and Amazon's new London headquarters. The site is also adjacent to existing buildings, including the Liverpool Street train station, the third-busiest station in the country. In addition to squeezing the tower onto a small space, the design had to consider a six-track railway that connects to the station, including a protected corridor for the future development of two additional tracks. WSP's challenge was to ensure that they did not sacrifice aesthetics while making logistic concessions, per the project owner's specifications. With all the restrictions and details that they faced, WSP had to convince the project owners that they could fully realize their vision and build an economically viable tower within the available footprint.

Building around 24/7 Railway Operations

WSP knew that they needed to create a plan that would not adversely impact the railway's constant operations. Any design and construction guide would have to be approved by Network Rail, as their permission was required to proceed with the development of the tower. However, ensuring the tower's structural stability, which includes two basement levels, would prove a difficult task, as WSP would need to construct support piles as close as 50 millimeters from an underground masonry railway tunnel

constructed during the Victorian era. The design also had to account for frequent vibrations caused by the railway and keep soil displacement to a minimum.

Additionally, to tackle logistical challenges, project stakeholders decided to undertake top-down construction to accommodate the site constraints and allow sections of the building to open sooner, enabling the owners to reap a quicker return on investment. However, top-down construction requires careful planning and tight coordination to succeed. Because of the unusual design, the nearby railway, the construction method, and other complex details, traditional design software would not be able to deliver the project at the high level of quality required.



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“Much like fine craftwork relies on excellent tools, engineers rely on software to produce fine engineering solutions. Bentley’s applications have proven to be indispensable for providing the fine engineering solutions necessary for a highly complex project like Principal Tower.”

*– Nello Petrioli,
Associate Director and
Project Engineer, WSP*

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Deploying Innovative Applications to Minimize Soil Movement

WSP, a long-time user of Bentley applications, turned to RAM Concept and PLAXIS to successfully complete the design and analysis of the complex design elements. PLAXIS enabled them to analyze multiple potential designs and model soil movement during excavation, construction, and the building lifecycle. Their analysis, performed in 2D and 3D, indicated that constructing the ground floor slab first would create a horizontal prop and provide lateral support to protect the masonry tunnels during underground construction. Furthermore, the PLAXIS analysis predicted the lateral forces exuded by the tunnel arches, which helped optimize the slab design and construction. Their work within PLAXIS also helped them determine where to place temporary miniature piles and a temporary steel piling deck to protect the tunnels and ensure soil stability during construction.

Using RAM Concept, WSP incorporated the information gathered from the PLAXIS analysis into the design of the ground floor support slab. They used the application for all stages of foundation and basement design, from the early concepts to final detailing. RAM Concept’s ability to model elastomeric bearings in the supports as soft springs, rather than more rigid forms, provided a more accurate model of the foundation’s behavior and reaction to train vibrations. At the same time, RAM Concept helped WSP ensure that the design was acoustically isolated, eliminating noise from nearby trains. Additionally, they used the application

for other elements of the building’s structure, such as designing a hanging swimming pool that limited the width of any seams to meet waterproofing requirements.

Proving that the Visionary Project Could Proceed

The optimized and detailed design gave all stakeholders confidence in the project and that development of the tower could move forward. The detailed analysis of soil movement in PLAXIS and the design of the ground floor slab within RAM Concept clearly demonstrated to Network Rail that development would not harm the underground tunnels or affect operations. After having reviewed the analysis performed using Bentley software, the authorities granted permission for construction in the area.

By optimizing elements of the superstructure in RAM Concept, including 50 post-tensioned flat slabs for all the floors and the 3-meter raft that supports the tower, WSP complied with strict design codes while reducing the use of reinforcement materials by 60%, or 17 tons. The design also allowed contractors to lower the amount of temporary works needed during construction, such as back propping. With RAM Concept and PLAXIS, WSP created a more efficient design that reduced both material and labor costs. “Much like fine craftwork relies on excellent tools, engineers rely on software to produce fine engineering solutions,” explained Nello Petrioli, associate director and project engineer at WSP. “Bentley’s applications have proven to be indispensable for providing the fine engineering solutions necessary for a highly complex project like Principal Tower.”



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