TwentyTwo
Bishopsgate

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Currently the tallest construction site in the UK, TwentyTwo Bishopsgate will become the tallest building in the City of London and the second tallest in Western Europe, after The Shard. Its impressive glass façade is already almost reaching the top, making it disappear inside the cluster of buildings in London's financial district.

This magnificent tower is rising above its neighbours and it has already redefined London's skyline. But its merit goes beyond its shape or its glass walls; it lies within some of the most efficient structural engineering solutions in tall building design, and hidden below ground, one of the most challenging foundation re-use strategies in the UK.

What used to be an abandoned site; a daily reminder of the financial crisis; is rapidly becoming the most dynamic centre of growth in the City, and TwentyTwo is its biggest star.

Reusing "The Pinnacle" Foundations

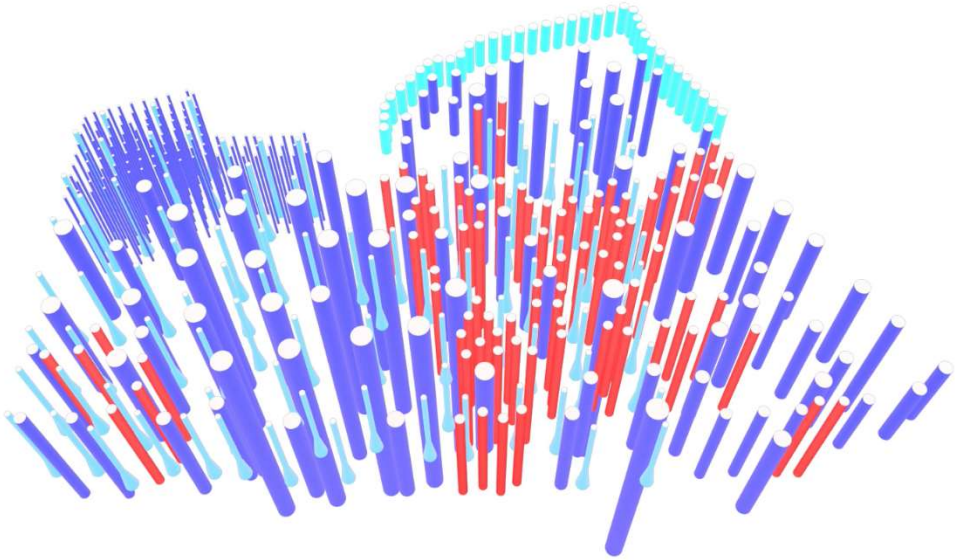
During the last recession, construction of *The Pinnacle* was halted. Three levels of basement and nine floors of the concrete core were left in the middle of the city, to be nicknamed *the Stump*. The main structural challenge faced was to reuse the existing foundations and basement, built for a completely different scheme, and provide 30 per cent more built area than its predecessor.

The Pinnacle's stability system consisted of a mega diagrid structure around its perimeter, leaving a small concrete core inside. Its foundations were designed for this condition. TwentyTwo Bishopsgate has a different shape and a different stability system, requiring foundation capacity in other areas. The new foundation scheme successfully incorporates 100% of those built in 2009 and those prior to it, integrating the original basement rafts and pile caps from the previous buildings which could be found on the site at different locations.

The Pinnacle foundations comprised a 5m deep reinforced concrete raft under its core, under-reamed piles constructed approximately 30 years ago which had incorporated into the basement, and mega piles under the core and superstructure columns. These piles were bored 50m deep into the Thanet Sands formation. The rest of the basement slab was 800mm thick and cast directly on top of the existing slab of previous buildings varying from 975mm to 2000m.

To provide extra capacity, 85 new piles were built. To minimise the amount of temporary works, the piling was carried out from within the lower basement level using a small Martello rig. Each with a capacity of 5MN, they were carefully located between the hundreds of existing piles in the ground, from the Pinnacle and the previous buildings. Under the core, a new 3m deep raft was built connected to the existing 5m deep raft, joining most of the new piles.

Re-use and recycle; this was the philosophy of sustainability adopted. All the capacity from the previous building's foundations was utilised, and most of the demolished concrete elements were recycled as aggregate for the new piles foundations.



The complex foundation scheme including under-reamed piles from previous buildings, Pinnacle piles and mega piles and 85 900mm Martello piles for the new scheme.

Hidden Giants

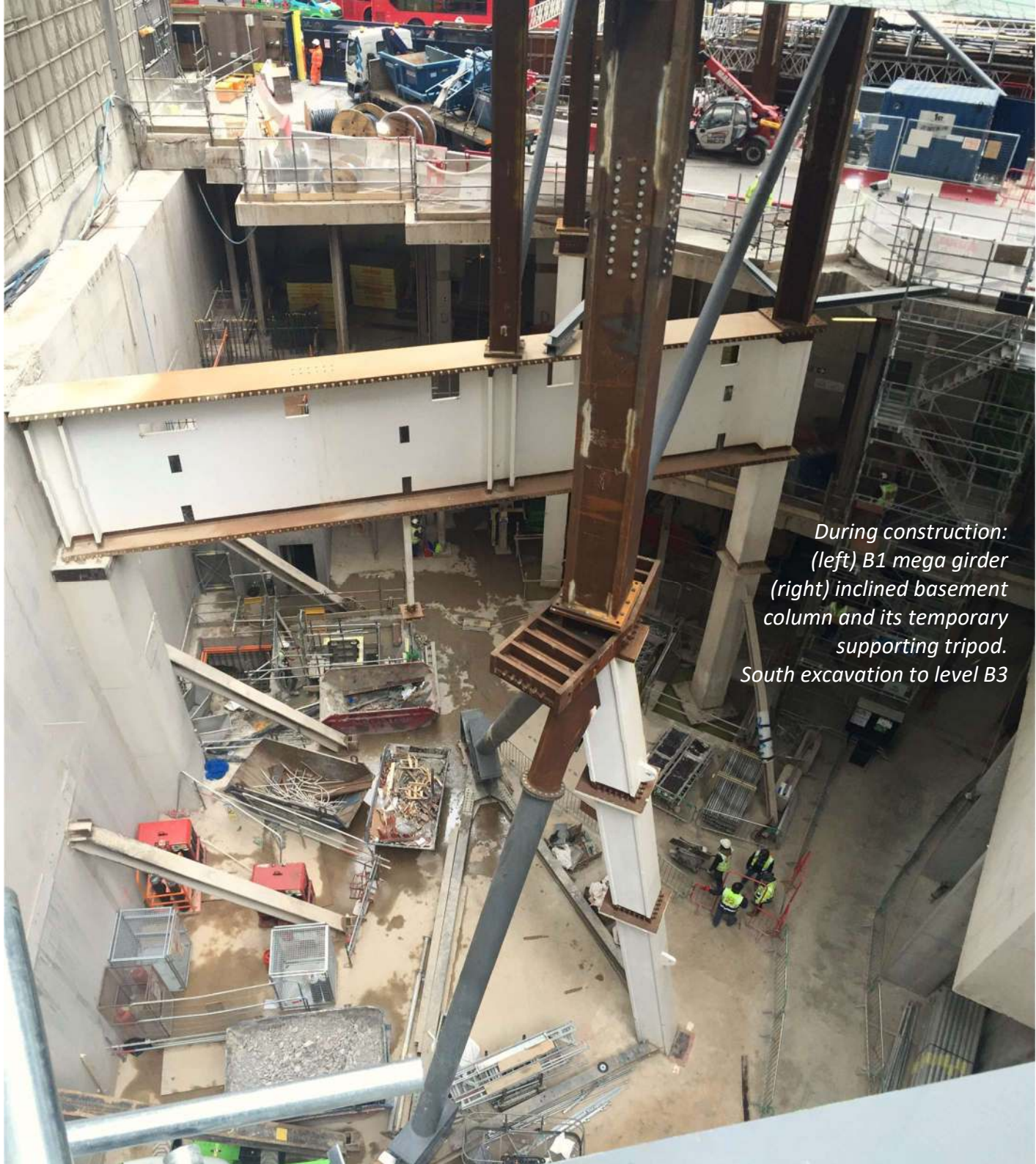
To solve the challenge of transferring the new building loads from the new column locations to where the existing foundation were, a series of mega transfer structures were built.

Along the perimeter, some basement walls were widened to act as deep transfer beams spanning between exiting pile caps. In the south of the building, two steel structures weighting each around 100ton were fabricated.

A solid still girder hidden within basement B1 and ground floor supports 62 storeys of load and transfers this to where the foundation capacity was present. The column it supports couldn't extend into the lowest basement due to the location of the vehicle turning table needed as part of a very precise waste management strategy. This beam is 15m long and 3.8m deep; pictured on the right.

At ground floor, one of the main perimeter columns inclines in towards the core over three basement levels to use one of the existing mega piles. In the permanent case, the column is restrained by the raft at the base and by the floor slabs at ground floor, transferring the horizontal reaction through the ground floor slab using post tensioned high strength cables embedded into the concrete slab. This creates a direct load path into the concrete core.

During construction, a temporary tripod was provided to support the inclined column to allow construction to progress to level 10 before the basement slabs had been completed.



During construction: (left) B1 mega girder (right) inclined basement column and its temporary supporting tripod. South excavation to level B3

Top-Down construction
20 levels of core; no foundations

The Rhino Truss

On the south east corner, three new columns located above the existing car lift into the basement had to be transferred. During construction, this lift was the main logistics route into the basement and could not be obstructed. The rhino-shaped truss brings together the out of plane loads from 62 storeys above and resolves this extraordinary system elegantly.

Squeezed between the existing concrete shafts, a future smoke exhaust duct and the set levels of the 2nd floor, careful coordination was required to ensure that the right geometry was achieved, considering particularly the inclination of the elements to match the external finishes and allow for internal doors and other openings within the space.

Floating Core

It is becoming the norm in the construction industry to build up at the same time as down. The benefits of Top-Down construction override its complexity and the challenges faces by engineers and designers. But the scale at which this was done at TwentyTwo is possibly unprecedented; 20 storeys of concrete core before completing the foundations .

To achieve this, a double storey concrete transfer was built in the basement, between ground floor and Basement B2, leaving Basement B3 free to carry-out the construction of the new piles. This transfer was built around the permanent core walls and extending beyond their footprint onto the existing columns from the previous building, which had foundations capable of carrying considereable loads. A very careful construction sequence assessment was prepared, considering the differen variables such as: existing piles capacity, existing pile cap capacity, and existing column capacity.

The core began construction before any of the new piles had been built. The existing B3 slabs were broken down and excated to create the new raft whilst the core was reaching level15. From level 15 to level 20, once the capacity of the existing columns supporting the core had been reached, a careful construction sequence was prepared. This included the especific order of constructions of walls between B2 and B3 and segments of the raft, to allow the core to continue to grow weekly and reach level 20 by the time the raft was completed. At this point, the final walls were built at B3 and the core could now continue up the next 42 levels.

Standing tall

Through mega transfer girders, inclined columns with high strength steel cable ties, partial demolition of the existing basement, and top-down construction of 20 levels of core, the solutions to the challenges faced at TwentyTwo Bishopsgate cut through complexity, delivering an efficient system for a sustainable and environmentally conscious building that re-uses 100% of the existing foundations.

Looking at the future and the increasing demand for infrastructure in the world, our goal us engineers must be to minimise the environmental impact of our designs, developing structural systems that use materials efficiently. From the reinforcement quantities in the walls, to the optimised flange thickness for each floor beam, TwentyTwo London is an example of the effort put into using materials sustainably.

Defiant and proud, TwentyTwo London has converted an abandoned site into a symbol of confidence and perseverance; a source of inspiration for a generation of professionals in the face of international uncertainty. This tower is changing more than our skyline; it is making us look up; it is changing the way we look at the future.

Project Team

Architect, **PLP**
Main Contractor, **Multiplex**
Concrete Frame, **Careys**
Steel Frame, **Severfield**
Multidisciplinary Engineering Services, **WSP**

Under construction, TwentyTwo London has already changed the character of the City of London