

# Large Diameter Bored Piling

## The Pinnacle Tower

City of London , U.K.



**Large Diameter, Long, Rotary, Base Grouted Piles, some bored under bentonite support, secant piled wall and restricted access mini-piles.**

### Introduction

The Pinnacle Tower is located in Bishopsgate in the heart of the City of London. When complete it will be 62 storeys in height and have three levels of basement, occupying a retail and commercial office space of about 1.4M sq ft. It will also be the tallest building in the UK. Brookfield Construction Limited is the Construction Manager for Arab Investments.

The plan area of site is approximately 140m by 70m and covers the footprint of three previous multi-storey buildings. The old foundations, built in the 1980's, incorporated up to 1.5m diameter bored piles, with under-ream bells of 4.5m diameter positioned 35m below ground level in the London Clay. In many instances the new foundations were installed by coring through the old piles.

At 65m deep, and founded in the Thanet Sand stratum, the piles were constructed under bentonite support fluid. The piles are believed to be the deepest ever constructed in the UK, and the largest diameter (up to 2400mm) ever to be base-grouted in the world.



**The Pinnacle Tower**



**Piling in the City of London**

CLIENT:	Arab Investments
CONSTRUCTION MANGER	Brookfield Construction
CONSULTING ENGINEER:	Arup
DURATION OF WORKS:	20 months

### Scope of Works

- 140m long 1180mm diameter secant wall to one boundary
- 54no. 1500-2400mm diameter, base grouted piles up to 65m deep

Foundation pile construction was undertaken predominantly from the existing ground floor slabs through three levels of propped, existing basement. Ground level was typically 14m above the existing 2-4m deep B3 slab. Holes were diamond cored/cut through the four existing slabs in advance and protected with removable covers to facilitate the piling



**Casing Extractor**

Much effort was put into the project in the early design stages to ensure a foundation solution that was simultaneously robust, efficient and buildable. The design team considered numerous foundation options to carry the 20MN to 45MN megaframe column loads, including groups of straight shafted bored piles founded in the London Clay, underream piles, hand dug caissons and deep piles founded in the Thanet Sand. Even a piled raft combining new and old piles over the whole site was considered in the early design stages, with piles founded in the London /Lambeth Clays.



**Piling through existing basement**

Of the many design risks to the project, ensuring reliable settlement performance of the tower's foundations was key. A preliminary test pile was completed on site, which incorporated a 52m de-bonded permanent liner, the longest ever installed in the U.K.



Being more than 3 times the height of the previous buildings on the site and of irregular shape, The Pinnacle did not lend itself easily to reuse of the existing foundations. However, through a value engineering exercise, the design team were able to identify a large number of piles that could be reused to support the more lightly loaded columns of the building, resulting in savings to the project in excess of £300,000 and substantial lorry movements.

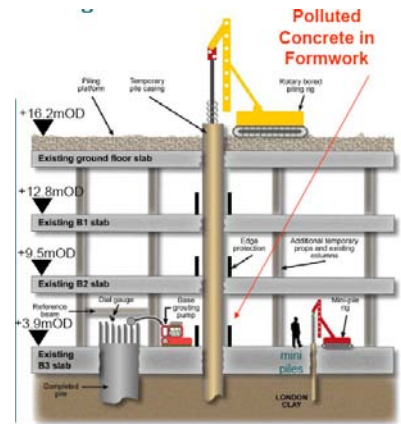


**Single & Double TAM circuits developed for base grouting**

There was no experience of base-grouted piles greater than 1800mm diameter prior to this project. At the Pinnacle, the extreme column loads and stringent settlement criteria meant that 1500mm, 1800mm, 2100mm and 2400mm piles all required base-grouting in the Thanet Sand Strata. Recognised techniques and the geometry of the Tube a Manchettes (TAMs) at the base of the pile, installed as part of the reinforcement cage, had to be reviewed and developed, to ensure uniform grout coverage over the entire base of the largest diameter piles.



Working together to understand the design requirements and constructability issues, the site team of Bachy Soletanche and Arup engineered an innovative new way of delivering grout to a series of inner and outer TAMs without the requirement for a costly double cage system.



**Piling through old basement**

The close working relationship between Arup and Bachy allowed piling construction problems to be quickly resolved minimising delays. As the works progressed Bachy Soletanche's site team developed a clear understanding of the Arup design requirements and Arup developed a high level of trust of Bachy Soletanche's workmanship.



**Sub-structure construction**

Throughout the piling operations in excess of 82,000 man hours were worked by the operatives and staff without any reportable accidents. In the 16 months on site there were only two minor injuries entered in the accident book. This is testament to the rigorous site inspection schedule that was supplemented by daily briefings and weekly toolbox talks.