

Further information

Cementation Skanska  
Maple Cross House  
Denham Way  
Maple Cross  
Rickmansworth  
Hertfordshire  
WD3 9SW  
United Kingdom  
Tel: +44 (0)1923 423100  
Fax: +44 (0)1923 423681

cementation@skanska.co.uk  
www.skanska.co.uk

Offices

Head Office +44 (0)1923 423100  
North +44 (0)1302 821100  
South West, Midlands & Wales  
+44 (0)1454 453200  
Scotland +44 (0)1698 735899  
Northern Ireland +44 (0)28 9024 2746  
Republic of Ireland +353 (0)1296 0790

diameter and extended up to 47m horizontally.

**Ground Movement Control**

Having assessed the anticipated ground movements likely to arise from the various stages of the works, it was essential to monitor what actually happened during construction. A sophisticated monitoring and instrumentation system was set up for structures around the KCC site and the Harrods store itself. This system included real-time monitoring with built-in radio-paging alarm systems backed up by sophisticated surveying techniques. The system was designed with a degree of redundancy and to be self-checking in critical areas. To enable the 35,000 pieces of data recorded per week to be analysed quickly and efficiently, a job specific software package was developed.



In order to co-ordinate all activities which could affect ground movement, excavation control manuals were produced for the key activities of shaft construction, tunnel excavation and basement excavation. Review teams met regularly to ensure that an overview was taken to ensure that no combination of individual activities could adversely affect the overall project.

**Summary**

The project, described by a knowledgeable visiting geotechnical engineer as one of the most complex projects being undertaken in Europe, was technically successful, completed on time and within budget. The geotechnical works were awarded the Construction Industry IT award and the DFI International Outstanding Project Award.

Technical Data

Client  
Harrods Technical Services

Main Contractor  
Skanska UK Building  
(formerly Kvaerner Trollope & Colls)

Engineer  
WSP, London

Trademark  
CEMLOC



The world renowned Harrods store in Knightsbridge London consists of a number of buildings that were originally built over 100 years ago and have subsequently been altered and extended to form the current store.

Following the acquisition of an adjacent listed building, the redundant Knightsbridge Crown Court (KCC), development was carried out within the store itself with the infill of an existing lightwell (known as X5) and the construction of a new lift shaft servicing a depth of 22m below ground level as well as the six storeys of the store. At the base

of the lift shaft, a 70m long tunnel was constructed (by others) to provide access to the seventh basement level of the redevelopment of the KCC site

The construction of the deep shaft while maintaining uninterrupted use of the store by the Client led to a number of innovative solutions being undertaken. Empirical assessments were made of settlements anticipated from the construction process which took place within a congested environment of existing foundations. Various elements were designed and installed to mitigate the effects of the inevitable ground movement on the surrounding overlying structure, which supported sensitive high quality finishes and mechanical and electrical installations.

Vertical ground displacement caused by the tunnel excavation was predicted, for a green field site, to be up to 35mm. These were limited to a maximum of 6mm by the implementation of compensation grouting.



To enable the seven-basement structure for the redevelopment of KCC to be constructed using top/down techniques, a 242m long diaphragm wall was installed together with tension piles and bearing piles with plunged columns. A retained façade, a six-storey building and a number of prestigious dwellings immediately surrounded this site. Consequently, both the design and construction sequence had to ensure that ground movements would not cause significant structural damage to these structures.

#### Scope of Geotechnical Works

The geotechnical aspects of the works value at £8,000,000 included the following works:

- Diaphragm wall 800mm wide, 242m long, 28m deep.
- Plunge column bearing piles, 39 No., 1500mm-1800mm diameter, 45m deep.
- Tension piles, 36 No., 1050-1200mm diameter, 40m deep.
- Monitoring and instrumentation of surrounding properties using electrolevels, precise levelling, 3D targets inclinometers, piezometers.
- Ancillary works including minipiles and contiguous bored pile wall.
- Hard/soft secant minipiled wall, 220 No., 30m long 285/235mm diameter.
- Sleeved bearing minipiles, 24 No., 285/235mm diameter, up to 40m long.
- Underpinning piles 17 No., 285/235mm diameter, up to 22m long.
- Monitoring and instrumentation of the Harrods store using instruments listed above together with water levels and horizontal in-ground electrolevels and extensometers.



- Compensation grouting using 51 No. horizontal tubes-a-manchette up to 47m in length, 125mm diameter.

#### Design

Design of the KCC diaphragm wall was undertaken using finite element analysis to enable horizontal and vertical ground movements to be ascertained as well as bending moments and shear forces. The profile of the ground movements enabled potential building damage to be assessed for adjacent properties. Additional tension piles were included to limit the maximum predicted ground movements.

Observational techniques were employed to enable two basement floor slabs to be initially omitted thereby saving twelve weeks programme time and £250k in construction costs.

Finite element analyses were impractical for the assessment of ground movements caused by the construction of the X5 shaft. Accordingly, three key structures adjacent to the shaft were analysed and empirical assessments made of all activities which could cause settlement of the structure. Various measures such as underpinning minipiles were



then designed to prevent movement becoming excessive.

#### Construction

The X5 works within the Harrods building had to be carried out without affecting the routine operations of the store. During store opening hours, all materials, plant and equipment had to enter and leave the working area via an opening just 1.5m wide and 2.0m high. Noise and vibration had to be strictly controlled and the majority of operations were undertaken within areas designated "confined Spaces" thus requiring additional health and safety precautions.

Throughout the project access to the KCC site remained difficult with only one access road (4.0m wide) from congested London streets. Working hours were strictly limited and noise and vibration were continuously monitored.

To enable successful top/down construction, achieving a programme saving of 15 weeks, steel columns 28m long, 900mm x 300mm were plunged into the wet concrete of the piles at 23m below the working level of +6.70m AOD. The required accuracy in plan position at ground level was  $\pm 10$ mm and at cut off level (-16mAOD) was  $\pm 20$ mm. Vertical tolerance was  $\pm 10$ mm. This was achieved using Cementation's proprietary CEMLOC™ system which can place columns to achieve structural steel tolerances.

The minipiles installed in the hard/soft secant wall for the cofferdam to enable shaft construction were installed to exceptional tolerances of 1:150 and were surveyed at three levels during the installation process. Watertightness was essential to enable subsequent construction.

As part of the compensation grouting works, drilling for the installation of horizontal electrolevels and tubes-a-manchette was carried out from within the shaft (approx 2.6m x 2.8m) at a depth below ground level of 9m to 12m. Boreholes were approximately 25mm

