

# Robin Hood was here (probably)

Minipiling is dealing with the problem of man-made caves beneath a new development in Nottingham city centre. Max Soudain reports.

Nottingham's caves have housed England's only underground tannery, a prison and countless pub cellars, including that of one of the country's oldest hostelries, Ye Olde Trip to Jerusalem, which opened in 1189.

The network of interconnecting man-made chambers beneath the city centre may also hold evidence pointing to the existence of the legendary outlaw Robin Hood.

A recently unearthed tunnel beneath the Galleries of Justice may be that featured in the story of Robin Hood's escape from the clutches of his arch-enemy, the Sheriff of Nottingham.

Developers in the city could be forgiven for seeing the caves in a less romantic light. More than 400 caves have been located but because excavations date back over 750 years there are likely to be many undiscovered chambers, which could prove hazardous to construction.

This was the problem confronted engineers working on the foundations for a mixed leisure development in the city centre. The triangular 0.4ha site is in the

centre of a busy junction, bounded to the north by Chapel Bar and to the south by Maid Marian Way.

"While caves are known to spread over 20% of the site, there was little information about the rest of the area," explains Cementation Foundations Skanska ground engineering technical manager Jim Martin.

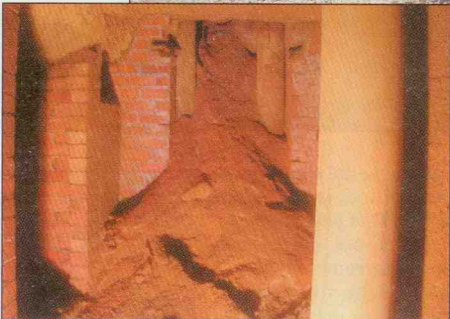
His firm is installing high-capacity minipiles with permanent steel casing where they penetrate the caves.

"This minimised ground disturbance in areas of archaeological interest and safely transferred the structural building loads through the caves and into the competent rock at depth," Martin explains. "It also gave greater certainty in the construction programme and cost and meant the caves could still be viewed in the future."

Martin says the alternative



Minipiling has preserved the caves for future generations.



would have been to grout up the caves – "costly, time-consuming and difficult to price, and the caves would have been lost to future generations".

Main contractor Miller and consultant WSP, working for client The Royal London Mutual, accepted Cementation's proposal in early summer 2001, and it was developed over the next 12 months. "There were various delays from the client during this period for a number of reasons, primarily involving tenants," Martin says.

There were other archaeological remains to deal with too. Developments in the 1950s and 1970s had uncovered sections of medieval town wall. Built between 1267 and 1334, these must be preserved *in situ* because they a protected ancient monument. Other medieval structures, including the town ditch – up to

15m wide and 8m deep – and the 10m wide rampart, together with an earlier Norman rampart, may also occur within the site.

Martin says that because of the uncertainty of cave location and the good chance more would be found, Cementation could not easily develop the minipiling scheme and come up with a guaranteed maximum price per pile (including money to cover the risk of encountering unknown caves).

Cementation decided to carry out a site investigation in sum-

mer 2001 to help the process. Ten 16m deep boreholes were put down, evenly distributed across the site outside the caved area. A number of simple pull-out tests were also done to verify the grout to ground bond capacity for the proposed minipiles.

Piling is done by three Casagrande C6 drill rigs. Open hole down-the-hole hammer drilling is used outside the caved areas to form piles up to 8m deep, with a minimum 5m rock socket formed in the Sherwood Sandstone.

In the caved area, the Mitsubishi Super Maxbit drilling system is being used. Basically a down-the-hole hammer system, the tool has two- or three-bit "wings" that are pushed out as the drill string rotates, forming an overcut and allowing casing to be installed behind.

Up to 9m of 220mm diameter permanent casing, with 10mm thick walls, is installed, with the 5m long rock socket formed below.

"The casing is supplied by Cleveland Tubes and is non-prime [recycled], which is attrac-

tive from an environmental and sustainability point of view," Martin says.

The casing is delivered to Cementation's plant and fabrication yard in Bentley, near Doncaster, where it is cut and threaded into 1.5m lengths and the casing shoes welded onto the lead casings.

All the minipiles incorporate a 50mm diameter MAC500 rebar to the full depth and a 1:1 colloiddally mixed sand cement grout.

Average 28-day grout strengths

of 45-50MPa are achieved.

Martin says the results of two static pile tests have been excellent: 7mm and 12mm movement at one-and-a-half times the 750kN working load for the uncased and cased minipiles respectively, with both recovering to 3mm.

"The difference can be simply explained by the elastic compression of the cased length," he says. Six dynamic tests to one-and-a-half working load have also been carried out.

Cave inspections have confirmed that the cased piles are "perfectly vertical, with no grout loss whatsoever," says Martin.

About 560 minipiles had been installed on the 10 week, £450,000 piling contract by the beginning of September, as well as eight more to support the tower crane base in the centre of the site.

Cementation then demolished and will return later this month to install a further 40 piles. In all, 110 piles needed permanent casing through the caves – "well within what we had allowed for", Martin says.