Drilling soil nails into the rock beneath the warehouse avoids the need for a retaining wall between the buildings

A mini pile installation technique was found to be the quickest and cheapest solution for both the soil nailing and piling

PILING AND FOUNDATIONS

NAILING THE SOLUTION

– Designed by Jim Martin

Novel soil nailing is helping to provide valuable extra space on a city centre development site. David Hayward reports from Birmingham.

Every square metre of extra building space, squeezed out of tight, expensive, city centre development sites, is an increasingly valuable bonus. And with government policy encouraging developers to explore more inner city brownfield sites, often sporting a history of multiple previous uses, techniques to maximise the new building's available footprint are at a premium.

Cementation Foundations Skanska (CFS) using its versatile mini-piling rigs for both piling and soil nailing is developing just such a service.

The company's first widespread use of the idea is on a congested site close to Birmingham city centre, where the site is challenged by Victorian buildings and busy side streets lying tight up to the site perimeter.

Soil nailing to strengthen vertical sided building foundations, and mini-piling to retain adjacent roads, is offering the client a fast, cost effective solution to containing the site perimeter, as well as the opportunity to maximise construction space by building tight against boundary structures.

By drilling rows of soil nails into the excavated vertical face of rock directly beneath the 100 year old warehouses bordering the site, the subcontractor needs no additional retaining wall between these existing buildings and basement excavation. This means the new apartment block can be built as close as possible to the site perimeter.

"A conventional contiguous piled retaining wall, even bored tight against the old building, would still have encroached into the site area by at least a metre," explains CFS contracts manager, Geoff Prudhoe. "Our solution provides zero site intrusion, allowing the proposed new apartments to butt directly against existing properties."

The extra space - made available for what will be a two level basement car park - offers 25 more parking spaces for client Chord Developments, who are keen to ensure all one and two bedroom apartments on this central site have their own parking spaces.

So the additional basement space directly increases the number of flats than can be included in the £21M, six storey building, now planned to house 176 apartments and an office complex.

Elsewhere along the site perimeter, sections of busy side roads need retaining to accommodate this basement excavation. Here, contiguous mini-piled walls emerged as the most practical space-saving solution.

As the rig crews could use the multipurpose Twin-Tech TD308 rig for soil nailing and for 220mm diameter mini-pile installation, it flagged the technique as the quickest and most cost effective option.

CFS became involved in the project's conceptual design over a year ago when Chord Developments despatched its consultant BWB to search for a solution offering maximum building space. The St Paul's Square site is a tight though very valuable 1.2ha plot just a few hundred metres from Birmingham's city centre Bull Ring shopping complex.

Two existing structures bordering the site posed particular challenges as they lay right on the proposed building line of the new development. It was here, alongside these old offices and an art gallery - a combined site perimeter totalling 94m – that BWB sought a basement excavation retention option that did not invade its client's land.

CFS had already employed a similar soil nailing solution on a nearby, equally congested site, so the company was brought in to carry out a similar design for BWB, and later with main contractor Costain.

The technique involves a relatively simple extension of soil nailing's conventional role in strengthening or steepening earth embankments. The difference here is this 'slope' is the vertical excavated side of foundation material directly beneath the building to be protected, and the material must meet a specific strength standard.

"The rock has to be soft enough to accommodate drilled nails, but also competent and self standing in the short period between excavation and nail completion," says CFS design engineer Jim Martin. "Fortunately the sandstone at this site was ideal and could safely be exposed for the maximum 12 hours we needed to install the nails."

The soft Wildmoor Sandstone has weathered upper layers becoming increasingly competent with depth, and when excavated or drilled, the spoil becomes easily managed red sand.

For this initial stretch of soil nailing, site workers used a conventional Casagrande M6A drill rig to install 250 high yield steel Dywidag nails, in up to three horizontal rows.

As the concrete strip foundation of the old building was exposed, during the relatively shallow 3.5m deep excavation for the new building's basement, its level varied along the length of the structure. This left varying depths of rock to be strengthened directly beneath the footings and the rig crew installed between one and three rows of nails to a 1m grid.

Nails, just 3m long and drilled to a shallow 20 degree dip, were all inserted from the same working platform level. The process involved augering a 140mm diameter hole, filling it with grout, and then inserting a 32mm diameter nail surrounded by a corrugated plastic sleeve (see box).

A 250mm square plate holds the nail in position while the vertical rock face is covered with steel mesh and sealed with sprayed concrete.

The operation was carried out sequentially in rows, but averaged out at about 30 minutes to complete each nail. This rate, claims Prudhoe, enabled the team to have the exposed rock face fully strengthened with shotcrete well inside the 12 hours allowed from the start of excavation.

The Wildmoor Sandstone proved easy to auger and left a clean, self-supporting hole. The subcontractor kept temporary casing tubes and a down the hole hammer drill on site in case the rock became either more weathered or harder.

At a contract price of £171,000, CFS claims the soil nailing technique to be less than half the cost of the only really viable alternative beneath the warehouses, a 300mm diameter mini-piled retaining wall. The rock, at depth, would be too strong to conveniently install either sheet piling or a continuous flight augered wall.

Of more relevance is that any piled retaining wall here would have also demanded a roughly 200mm thick concrete or brick inner facing; resulting in a total structure protruding at least 1m into the site – far too invasive for the apartment block's planned footprint.

Instead, the old building's concrete strip footings allowed the sandstone face beneath to be cut vertically back some 150mm underneath the structure. This rock space was then built up again with the shotcrete facing, resulting in a strengthened support lying on the exact boundary line, meaning no intrusion into the developer's land.

Additional benefits included no drilling vibration, noise or large plant. Even the risk of underground obstructions on this long developed brownfield site was removed.

For the second 50m section of soil nailing, CFS brought in the smaller Twin-Tech rig that demonstrated the technique's versatility. Discovery of an old 2m wide cellar entrance, along the face being soil nailed, threatened delay while the opening was backfilled and sealed.

But, instead of constructing a time consuming concrete wall facing over the backfill, CFS adapted its soil nailing technique using a tightly nailed mesh covering instead. Shuttered concrete was replaced by several layers of carefully applied sprayed shotcrete to create an equally solid 400mm thick plug.

Some 20 tell tales, fixed to the buildings above the soil nailing, confirm the system induces negligible movements in any direction.

Costain project manager Terry Evans says: "It is clean, quick, flexible and appears to achieve exactly what it claims it will, " he says. "Given the right ground conditions, I would willingly recommend its use elsewhere."

A quick back of envelope calculation estimates the developer is being offered – over the full six-story block of apartments and offices – at least £200,000 worth of extra useable space, with the additional basement car parking being pivotal.

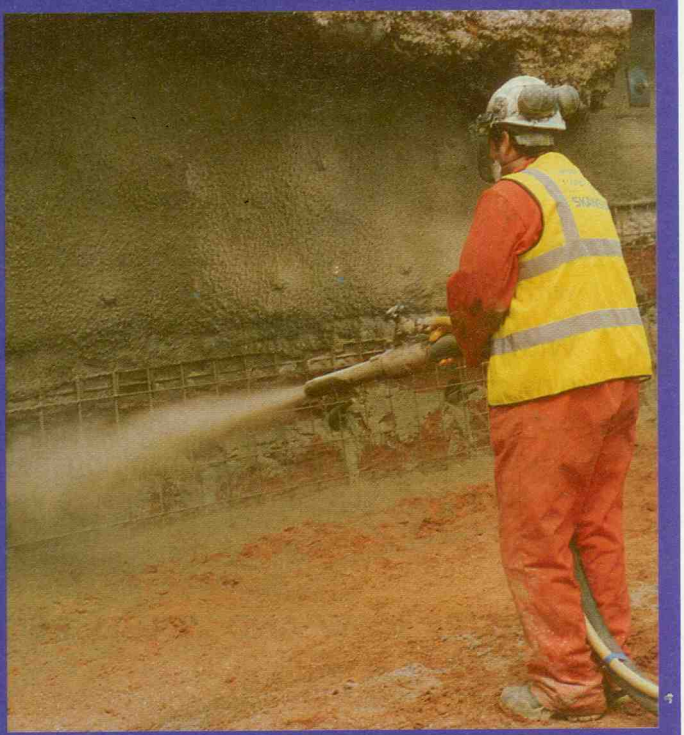
But engineers do stress that for this use of soil nailing to be successful, exactly the right ground conditions are essential. Exposed rock must be self supporting for at least a day, says Martin, pointing out that London Clay, for example, would not be as good a material for this system.

A second challenge could be the likely debate between designers, lawyers and party wall surveyors. As the nails encroach beneath a building not owned by the developer, wayleave permission is essential from the property's owner.

Such owners seek reassurance over long-term safety and possible building movement. At the Birmingham project, Martin accepts that both soil nail diameter and shotcrete thickness are slightly larger than strictly necessary, offering neighbouring property owners a robust design.

Where the retention method changed from soil nailing beneath building foundations, to a 220mm mini-piled wall along the perimeter roads, the same Twin-Tech rig stayed put. In less than an hour it was ready to sink over 80 mini-piles up to 7m deep.

The planned three-week wall programme was completed in two, with the CFS rig demobilising in early August.



The first stage of the soil nailing technique involves rotary drilling a 3m long hole, declined at 20 degrees beneath the building. This 140mm diameter bore is immediately filled with a neat cement grout.

A 60mm diameter corrugated plastic sleeve is pushed into the hole through the grout, and the 32mm diameter steel soil nail inserted inside this sleeve.

The hole is topped up with grout and when the exposed section of rock is fully soil nailed, it is protected with a 150mm layer of shotcrete and mesh.

The dry shotcrete mix has water added only through the spray nozzle to ensure a stiff, robust facing.

The unstressed nail strengthens the rock over its full 3m bond length while the corrugated sleeve protects the steel from long-term corrosion.

As the nail flexes, microcracking can occur in the surrounding grout, and the sleeve prevents moisture in the rock penetrating such cracks where it could threaten the steel's integrity.