



200t working load removable temporary anchors in Hong Kong

Multiple choice

Engineers are increasingly specifying single bore multiple anchors to enhance the capacity of poor ground, as Margo Cole discovers.

Ten years ago NCE reported on the opening of the Castle Mall shopping centre in Norwich. Nothing unusual: it was the tail end of the property boom, and large scale retail development had taken off in a big way throughout the UK.

What marked this development out, however, was a catalogue of ground condition problems and an equally impressive array of imaginative solutions to overcome them. One such solution was the award winning single bore multiple anchor (SBMA) system developed to support poor ground, and used at Castle Mall to tie back the main

retaining wall in weak chalk during the temporary works.

A decade on, the shoppers of Norwich have no doubt come to take Castle Mall for granted. But have engineers been similarly accepting of the SBMA system?

The short answer appears to be yes and no. Those who have used the system have almost unreserved praise – citing cost and time savings as key advantages over conventional anchor solutions. But some have yet to be convinced.

SBMAs consist of multiple anchors contained within a single grouted bore. Each unit anchor has its own individual tendon, its own fixed length of borehole and is loaded with its own stressing jack.

The system was developed by Tony Barley, formerly with Keller, now a consultant who markets it worldwide. His work stemmed from research into the phenomenon known as “progressive debonding” that affects conventional anchors.

Anchor design codes allow engineers to assume load is distributed uniformly through the length of an anchor, but experts acknowledge that the ultimate load is not proportional to the anchor's fixed length. As far back as the 1970s world expert Professor Helmut Ostermayer stated: "The increase in carrying capacity of an anchor tapers off steadily with length," adding that lengths of 6m to 7m were optimal.



SBMA installation in Natchez, Mississippi, USA.

The "tapering off" – particularly noticeable in weak ground - occurs because of the difference in elastic modulus of the anchor tendon, the grout and the ground.

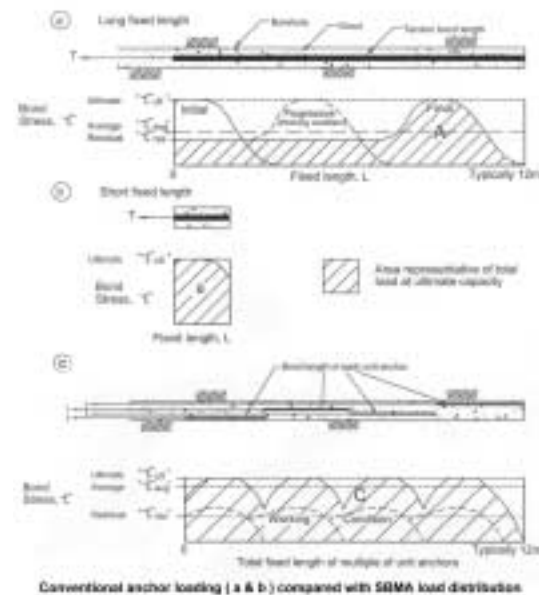
Barley, working with test data from installed anchors, devised an efficiency factor that could be applied to all types of ground to calculate this "tapering off", or progressive debonding. The formula – and empirical evidence – proved that progressive debonding was far less significant over short lengths, making load transfer far more efficient.

He concluded that a series of tendons with short bond lengths staggered in a single borehole, with each carrying the same load simultaneously, would almost eliminate the occurrence

of progressive debonding and increase efficiency in mobilising ground strength adjacent to the anchor borehole. Site trials in clay showed that a conventional 10m long anchor with a 6m tendon bond length had a capacity of 370kN. In an identical bore with a 10m fixed length containing four strands, each with a 2m bond length staggered at 2.5m centres and loaded simultaneously, achieved 640kN.

Since then, as the SBMA system has developed and been used in a wide variety of ground conditions, working loads of up to 2,000kN have been achieved.

Portsmouth City Council has used the system twice on marine projects in the city's commercial port. The first, in 1998, was to support a new sheet piled quay wall in Bracklesham Beds – a variable ground with thin bands of sand, silt and clay.



Ground anchors were the preferred option because of a high number of existing obstructions. However, David Clubb, the council's chief engineer for marine structures,

says: “We found that we couldn’t because we would have needed so many it would have prevented us from doing the piling.”

By the time funding had been secured – including a grant from the then Ministry of Agriculture, Fisheries and Food (MAFF) – SBMA’s were more firmly established on the market.

“With SBMAs we could do the job with only a quarter of the number of anchors because they are much more widely spread,” explains Clubb.

Confidence was boosted by testing each anchor to 150% of its working load of 130t.



SBMA testing in Singapore

Clubb says another advantage of the system was the opportunity to take account of the varying strata within the ground, as each anchor within a bore can be designed for different ground conditions.

Portsmouth’s second use of SBMA’s came a year later during construction of a new ferry berth in London Clay. While it was again successful, the project highlighted some of the issues designers need to consider.

“The contractor had to look closely at the sequence of operations,” explains Clubb. “The scheme became a chicken and egg situation: how do you support the sheet piles while you put

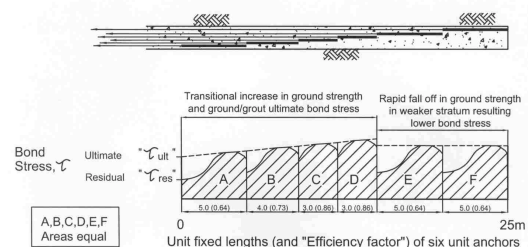
enough material behind to be able to get the ground anchors in? We were working in a tidal area, so the anchors had to be high enough to avoid the tide but low enough to be doing some good.”

Experts agree that the SBMA system is most effective in weak soils either to enhance capacity or to reduce the total number of anchors. However, they are not economically viable where the structural loading requires only low load anchors at wide spacings.

Barley quotes the example of a project in which 3,800 conventional anchors with a working load of 80t were replaced with 2,000 150t SBMAs. “Drilling costs account for 60% of the price of an anchor,” he explains, “If you halve the number of anchors you can reduce drilling costs by 40% - allowing for the additional complexity of the system – giving a total cost saving of 24%.”

He claims time savings can be as much as 30%.

Following considerable success in the Far East, SBMAs are to be launched in the US. Dr Donald Bruce, president of Pittsburgh-based consultant Geosystems, says time and cost are key to the system taking off : “The prime advantage is that achieving higher capacities means you can reduce the number of anchors required, so the owner gets substantial cost savings – and potentially time savings.”



He estimates the US anchor market to be worth between \$75M and \$100M a year. “In the US geotechnical industry advances have been driven by contractors,” he explains. “It’s the contractors that have to be convinced of its viability, and the first need has to be money. They won’t run with it unless they are convinced it will offer increased profit potential – as well as savings for the client. If contractors start to use them engineers will play catch up and start specifying them.”

Here in the UK, Professor Stuart Littlejohn of the University of Bradford believes engineers will specify SBMAs regularly once they have seen enough examples of the anchors being used in different soils, and they fully understand how the system works. “The best way the system will develop in practice is by usage and case histories,” he says. “But technically probably the best way is to do more sophisticated “gun barrel” tests:

controlled instrumented tests to find out how the load is actually distributed.

“Engineers want to see the effect of lateral restraint. How does the load distribution change as you go from a strong soil to a weak soil? If that was understood better, it would lead to better equations from a design point of view and a better explanation of how the anchors behave in practice.”

Professor Ostermayer has no doubt SBMAs have a key role to play in the future. “The system will become accepted on a worldwide basis and may be used on a large percentage of anchors founded in soils and weak rocks,” he predicts.

Licenses for the patented system are granted by Single Bore Multiple Anchor Ltd. on a country by country basis. Keller has rights to the UK patent.

www.Theanchorman.com

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Permanent SBMAs with 1000 kN working load in Newcastle, UK.

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