GROUND ENGINEERING

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Combining soil nailing with electrokinetics is enabling embankment stabilisation on a busy route through Kent to be carried out with minimal impact on nature and traffic. **Claire Symes** reports.

A LITTLE NAIL TREATMENT

Motorists using the busy A21 through Kent are the main beneficiaries of a new highway application of a high-tech ground improvement technique – and the best part of it is that they will probably never know. Use of electrokinetic geosynthetics (EKG) to dewater and improve an embankment before soil nailing is carried out means no lane closures are needed and no trees have been cleared from the site.

"We wanted to try to find an alternative to conventional soil nailing for this site after complaints from local residents about the stark look of the embankments on the other side of Stocks Green Lane, which was stabilised last year," explains Highways Agency senior geotechnical adviser Jan Marsden. "Although the approach worked well from the technical point of view and the site has been replanted, it will be some time before the vegetation recovers to hide the work."

The A21 embankments straddling Stocks Green Lane near Hildenborough were built in the 1970s from natural Weald Clay cut from elsewhere on site when the Sevenoaks and Tonbridge bypasses were constructed across the Eden Valley to form the dual-lane A21.

Embankment stability has been an ongoing issue for the Highways Agency and its managing agent, a joint venture between Balfour Beatty and Mott MacDonald, has been monitoring the site for some time. "The long history of instability at

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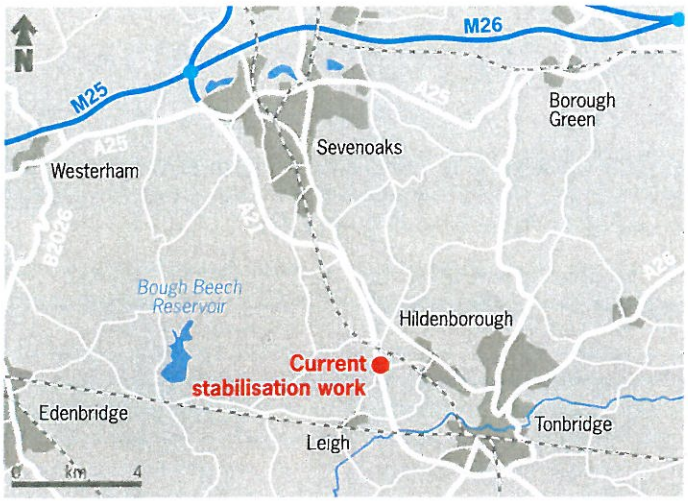
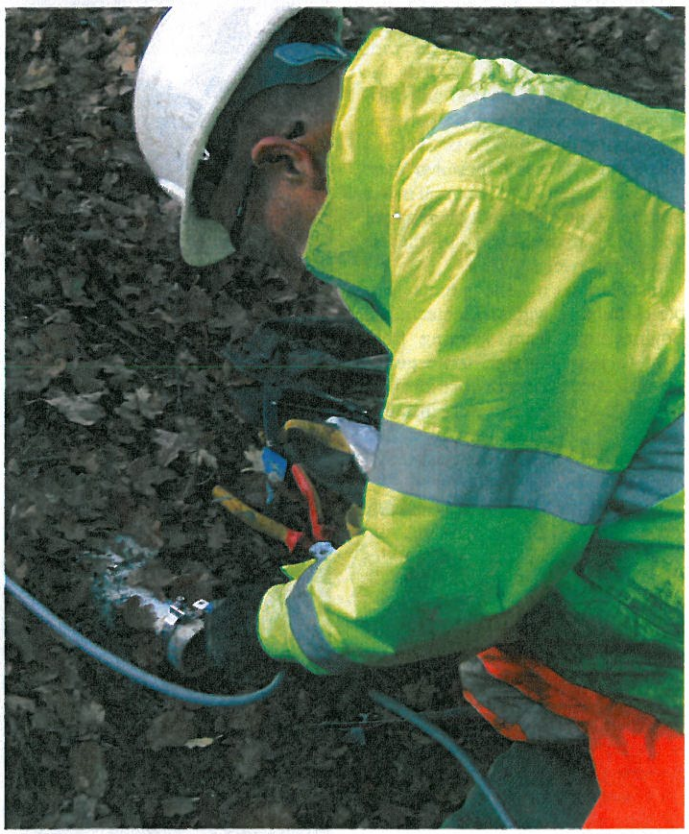
Jan Marsden
Highways Agency

The only hint that motorists on the A21 have of the work is the fencing at the top of the slope





Wired for action: (top right and right) with the anode and cathodes in place the system was wired up

the site is displayed in the bent trees," says Marsden. "While these slips are shallow surface ones, the problem is gradually creeping up the slope and when it starts to compromise the safety barrier, then we have a real problem."

Balfour Beatty/Mott MacDonald geotechnical team leader Stephen Board adds: "The slope has already failed and is in progressive failure."

Marsden first met Electrokinetic operations director John Lamont-Black at a conference where he was talking about slope stabilisation on a Network Rail site. "They had managed to carry out the EKG technique without removing all the vegetation, so I wanted to look at the potential to use it on a highway project," she says. The site on the A21 was an ideal candidate.

"We looked at alternative approaches, such as crest repairs, to try to minimise the look and reduce the volume of materials needed, but they couldn't provide the long-term solution that we needed," adds Marsden. "The main benefit of EKG is that no soil needs to be removed from site and very little vegetation has to be cleared so the habitats will quickly return to normal at the end of the work.

"For motorists there are benefits too as there is no need for traffic management on the main carriageway as access to the site is possible from local roads. The costs are also comparable to the conventional soil nailing approach."

The EKG technique is based on the electro-osmotic flow of groundwater when it is subjected to a voltage gradient to drive it from installed anodes to cathodes. This dewatering reduces the pore water pressure and induces consolidation in disturbed or unconsolidated materials.

While the main focus of the scheme is to consolidate the clay embankment using the EKG technique, cathode boreholes will be used to install soil nails at the end of the project to provide long-term slope stability.

"The EKG array does three basic things," says Lamont-Black. "It drives water away from the anode towards the cathode, it stiffens up the soil by increasing the shear strength which remains a permanent change after six weeks and the anode can then be used as a soil nail to provide on-going strength.

"The technique does not stop the groundwater returning but it works on consolidating disturbed material using high negative pore water pressure. The result is similar to what is achieved by surcharging."

Main contractor Interserve started site clearance in September last year – although the trees remain, the scrub on the face of the slope had to be cleared to improve access. Ground engineering contractor Geotechnical Engineering's work to install the anodes and cathodes began a week later.

While the technique is a new application for highway projects, the rig being used is also a new development. Geotechnical Engineering developed the P45K, which is based on a P60 slope-climbing rig, with EKG in mind – it has a side-mounted mast that can switch quickly between the auger and hydraulic hammer.

The anodes are driven in by hydraulic hammer, while the holes for the cathodes – formed by an HDPE slotted pipe covered in a geotextile and metal mesh – are augured by the rig.

At the A21 site, the project team is working on a 160m long section of embankment, with a 15m slope height and an average angle of 45 degrees, which has been divided into two phases.

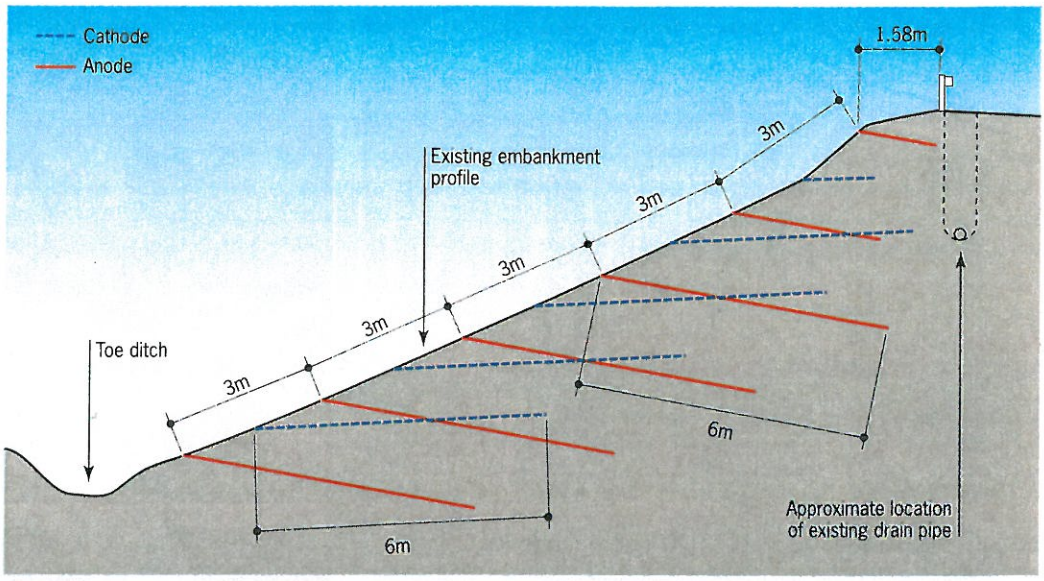
"There are 195 points in the first area – 96 of which are cathodes, and 186 points in the second area, with 95 cathodes," says Geotechnical Engineering business development manager Greg Adamson.

The 6m long anodes and cathodes have been installed at 3 degrees and 15 degrees to the slope to intersect with the shear surface, which is believed to be at 1.8m to 2m below the surface.

"The cathodes were effectively »

"The technique does not stop the groundwater returning but it works by consolidating disturbed material using high negative pore water pressure. **John Lamont-Black, Electrokinetic**

"The cathodes were effectively installed uphill, so will use gravity to help the water weep out of them" **Greg Adamson, Geotechnical Engineering**



Made to measure: Geotechnical Engineering developed the rig for this application

» installed uphill, so will use gravity to help the water weep out of them," says Adamson.

Installation of the cathodes and anodes went well. "The rig was designed specifically to cope with the different angles needed for the cathodes and anodes and also allowed us to switch quickly between the installation techniques," explains Adamson. "The side-mounted mast improved access. The potential issues from the centre of gravity being over one end were overcome with the use of a counterweight."

Installation of the points was pre-planned with Geotechnical Engineering's team working from right to left, although some points around the generator platform at the left side of the site were installed first to enable the generator and its platform to be moved onto site during the drilling work.

Geotechnical Engineering quickly got to grips with the new rig and installation time for the anodes was cut from 25 minutes to just 10, although the more complex cathodes took 30 minutes each to install.

All of the monitoring points have been installed, but only those in the first phase have been wired up to the on-site 275kVA generator. This is mainly due to operational costs – powering both sections at the same time would have been costly, but splitting the work into two phases means that the cost of the generator is reduced and the wiring may also be reused.

The Highways Agency's main reservation about the project was leaving expensive – and potentially lethal if tampered with – equipment on what is effectively the side of a road. As such, the site is protected with fencing and monitored with CCTV. There are also warnings about the presence of high voltage power on the site.

When *GE* visited site, the power to the cathodes and anodes had just been switched on and was being monitored three times a day to check on progress. "There is someone on site 24 hours a day and we have a warning alarm to alert us if the power goes off or if the system has been tampered with," explains Interserve project manager Darryl Allen.

Bags have been placed on each cathode to collect and measure the amount of water extracted. There are also inclinometers and peizometers on site to monitor the conditions before, during and after the work.

"The site has been very dry since April 2011 when the monitoring was installed," says Marsden. "We recorded movements of 1mm a month in the run up to the start of work on site, but under normal weather conditions we would expect this to be higher."

Power to phase one was switched on in early November and was completed before Christmas, allowing work to start on phase two. Dewatering of the final section is due to be completed in mid-February and work to convert the anodes to soil nails is expected to finish in March.

While Marsden expects a period of monitoring to follow on from the work on the A21, Adamson and Lamont-Black are already preparing to use the technique elsewhere on the highway network. "Equipment used here will be moved to another GKS project on the M5," says Adamson.