Charging the earth

A highway embankment is prepared to be charged to provide strengthening in a process known as electro kinetic stabilisation

Engineers have been using electricity to stabilise and strengthen an embankment by permanently changing the nature of the material in situ. Jackie Whitelaw reports on alchemy at work on the M5.

There has been a bit of magic performed in the southbound off slip road of the M5 at junction 7 near Worcester.

There a slipping clay embankment has been drained and converted into a stable structure with increased shear strength and stiffness. The magic involved is a relatively new technique of electro kinetic stabilisation.

On the slip road progressive shallow slope failures along a 265m long stretch of embankment were threatening to undermine the carriageway and remedial work was required.

Traditional options of digging out and replacing or soil nailing would have meant closure of the slip road and disruption. It was an opportunity for client the Highways Agency and its Area 9 managing agent Amey to try an idea based on electro osmosis to drain and stabilise the embankment in situ.

"The electro kinetic treatment involves drilling electrodes into the failed slope and passing an electrical current though which causes dewatering and strengthening of the failed soil mass," says Amey geotechnical director Christina Jackson.

"Electrodes are wired to a DC transformer powered by a diesel generator and a voltage is applied over a treatment period of four to six weeks. The anode and cathode electrodes are then left in the treated slope. Steel bars reinforce the anodes to form permanent soil nails which further strengthen the slope while the cathodes act as permanent horizontal drains," she explains.

"We are permanently changing the primary nature of the material in situ."
Christina Jackson

The technique was developed through research at Newcastle University and delivered by the university's technology transfer company Electrokinetic. The basic process of electro osmosis drainage of fine grained soils which causes water to flow through the soil by applying a voltage is not new. But the Newcastle researchers identified the potential for embankments and of using geotextiles in the electrodes to help draw the water through and properly realise the potential of the technique.

There are four processes in the stabilisation treatment as Ms Jackson explains. "Electro osmotic dewatering causes consolidation of failed and soft areas resulting in an increase in shear strength and stiffness," she says. "Physio-chemical changes in the soil also occur, such as cementation, >

> precipitation and flocculation and these also increase shear strength and stiffness and decrease the soil plasticity.

"A cemented zone is created around the anode increasing the bond and the load capacity. And the cathodes remain as permanent horizontal drains reducing porewater pressures in the slope.

"We are permanently changing the primary nature of the material in situ," Ms Jackson says. "It's very exciting."

The technique came to Amey's attention through its supplier Geotechnical Engineering which operates a slope climbing rig, just the tool for helping install the electrical array that does the work. "It demonstrates the benefit of networking," Ms Jackson says. "It was something we talked about at a conference."

In terms of the technique's extra benefits, out turn cost data from a previous project has demonstrated a 30% cost saving compared with soil nailing. And carbon footprint calculations are revealing an up to a 40% saving when compared with other techniques.

"Another significant benefit," Ms Jackson says, "is that this does not require lane closures and traffic management during the works, reducing disruption and risk to road users."

Although this is not the first time the technique has been implemented the work on the M5 is a demonstration project for its potential. "We are still collating and reviewing the information we have gathered from the job," Ms Jackson says. "And that data will be important in understanding the way the process works and will answer a lot of questions; for instance how much water has come out of the slope and how much settlement has there been."

There can be scepticism about new techniques, Ms Jackson points out. "Implementation of innovation requires an open and proactive approach to new challenges. Successful delivery of this full scale project has been possible because of the overarching support of the HA for this new technique and the collaborative approach of all of the design and delivery team members."

There will be a next time. Electrokinetic has carried out a successful trial for Network Rail Western Territory and testing and feasibility work is under way on at least two more projects for the Highways Agency.

How to install electro kinetic stabilisation

Access to site was gained from a field adjacent to the road and the carriageway remained open

The £925,000 treatment for the slip road embankment was carried out by Volker Laser with electrode installation performed by Geotechnical Engineering and electrical contractor Fuseland.

Area treated was 265m long with embankment heights varying from 6m to 10m at a slope angle of 26° to 29°. Material in the embankment core was reworked Lower Lias Clay overlain by a mantle of variable reworked Mercia Mudstone glacial or terrace deposits.

"The embankment was covered with vegetation and this was cleared to enable access and to establish accurate locations for anodes and cathodes," says Volker Laser site agent Russell Baron.

"Visible bank slips were then benched back to recreate the embankment gradient and a free draining surface, then anodes and cathodes were installed in a grid system with fixed centres.

The anodes were driven using Geotechnical Engineering's slope climbing rig and percussive hammer attachment while the cathodes were installed by auguring the hole to the required depth and pushing the cathode into the embankment.

"The grid was split into six panels, all wired and split to distribution boards connected directly into the DC current rectifier with everything powered by a 400kva generator.

"It took four weeks for the enabling works and regrade and the treatment process lasted 20 weeks."

Once the array was installed the staffing requirement was very low with basically just a security guard to protect the cabling. And once the treatment was complete the cables were coiled up and removed from site ready for the next job.

"We have learned a lot from this job. The technique was new and we worked out solutions as we went along."
Russell Baron

"It is hard to say if the process was quicker than digging out the embankment – you can move an awful lot of muck in 23 weeks," says Mr Baron. "But it was much more convenient for the public because if we had had to dig out we would have had to close the carriageway. With this system we gained access from an adjacent field."

The only disadvantage he highlights was the challenge of using a slope climbing rig on a 26° batter in extreme wet weather.

But as he points out Britain's monsoon summer has made all construction work tricky. "We have learned a lot from this job. Because the technique was new we were working out solutions to any challenges that came up as we went along. The next will be much easier."

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