SOIL MIXING

MIDDLE GROUND

Modified soil mixing combines the benefits of conventional dry and wet methods and is even extending the application of soil improvement as an alternative to conventional piling.

Soil mixing, as a soil improvement technique, has developed down two quite separate routes over the last 30 to 40 years. There is wet soil mixing, favoured by Japan and the US, and the Nordic approach of dry soil mixing with lime and cement pioneered in Sweden.

Now however – and very appropriately – a Swede living in California has developed modified dry mixing (MDM) that, it is claimed, combines the benefits of both.

The big problem with traditional wet mixing – in which a pre-mixed slurry is introduced into the ground as it is mixed – is that it is messy.

And a problem with conventional dry soil mixing is the mixing tool sometimes cannot penetrate surface layers of plastic, or simply too hard, clays.

Overall too, there is little overlap in the application of the two methods. Dry soil mixing is generally used in softer soils and the wet method in stiffer materials.

The modified dry mixing method can work in dry or wet mode, switching seamlessly between the two, and yet produces hardly any spoil, even when operating in wet mode.

In terms of equipment, MDM is essentially a develo pment of the dry method. Key to the system are pressure-sensitive valves in the mixing tool which control the injection of water as the mixing takes place. Water and binder are fed through individual conduits to the mixing tool and are injected into the soil through separate nozzles to prevent clogging.

In all other respects, the rigs are standard, albeit modern computer controlled, dry mixing units equipped with a separate water tank, water pump and flow cell.

The idea was developed by Johan Gunther, an entrepreneurial Swedish mechanical engineer living in California. He encountered soil mixing while looking into the timely problem of strengthening levee walls.

Gunther realised that US clients generally dislike the spoil produced by wet mixing – but dry soil mixing was not appropriate in the stiffer soil types encountered in the US. Additionally dry soil mixing cannot reliably produce the homogenous mixing demanded by cut-off wall applications.

The big advantage in adding water to the penetration process is that it eases up the mixing. "It's all about the effect of water on the mixing energy," says Swedish geotechnical consultant Håkan Eriksson.

Gunther holds the patent for MDM, through his Santa Monica based company LCTechnology. And the process had been developed into a commercially available foundation system through collaboration with Swedish foundation contractor Hercules, which also holds the MDM licence for Scandinavia.

Until recently, Eriksson headed up Hercules' innovation and design department and was instrumental in commercialising the MDM process. He describes it as "a unique, high mixing energy, dry binder system, where water and binder are added during the mixing process".

Eriksson says while the method is "a small modification to conventional dry soil mixing equipment, it is produces great flexibility". For instance, he adds, "MDM can be used in a broader spectrum of soils and essentially offers two different methods for the price of one".

MDM columns can be installed in very dense, dry sand and they can also be created where there is a very stiff dry crust. Furthermore, using MDM, consolidation in soft clay is achieved more quickly than conventional dry mix columns so the overall time, and cost, for a project is reduced.

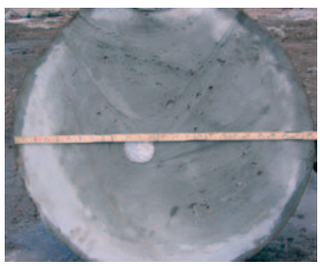
Reinforcement, such as a single steel bar or even a conventional pile reinforcement cage, can easily be installed in the column directly after installation. This means columns of higher capacity than conventional dry soil mixing can be created, which opens up new applications for soil mixing.

Hercules claims unconfined compressive strength in the order of 3MPa and 10MPa can be achieved in soft clay and sand respectively. Columns in combination with load transfer platforms creates high quality, cost effective solutions.

And in Sweden, Hercules has used the method as viable alternative to continuous flight auger piling (see box), although Eriksson concedes this would not be the case for all markets, such as the UK, where the CFA market is more competitive.

Typical applications envisaged by Hercules include foundations for light industrial buildings, parking areas, railway embankments, roads and even retaining walls.

MDM uses modified dry mixing equipment with pressure-sensitive valves to control water injection during mixing.



Soil mix columns were exhumed after testing on the Halmstad contract.

Water and binder are fed through separate nozzles on the tool.

Car park comparison

In its urban location, the foundations for a car park in Halmstad, on the west coast of Sweden, had to take account of structurally sensitive buildings nearby, and the local authority originally specified use of either a bored or augered piling.

Hercules won the contract on that basis but persuaded the client to run a trial of MDM columns as a means of evaluating and comparing quality, performance and costs with the piled solution.

The soil was layered, comprising sand overlying silty clay, more sand, very soft clay and finally sandy silt. The groundwater was 1.5m below ground level.

Hercules initially installed two test columns to a depth of 7m, each reinforced with a single 63.5mm GEWI-bar, inserted centrally into the column. The columns were load tested after a week and then exhumed – giving measured load performance in both compression and tension.

Next Hercules installed two blocks of nine overlapping columns to 12m to 16m below cut off, which were static load tested after three weeks.

The design loads for the blocks were 2100kN and the intention was to load them to 3000kN. The first block permanently settled by 4mm at the design load, well within the performance criteria of 40mm settlement and a maximum differential settlement of 1:800.

Failure of a reaction anchor at 2000kN meant the second test was aborted. However, the block's behaviour was perfectly elastic and there was no permanent settlement.

As a result an MDM solution was adopted. The general advantages, says Hercules, were lower cost and shorter installation time.

Additionally, the columns in this case were constructed without reinforcement. The horizontal forces were carried by direct shear in the columns and contact stress in the soil. Based on anticipated compressive strength of 3MPa, the design strength was set to 850kPa and Hercules installed about 500 columns with lengths varying from 14m to 16m below cut-off level.

Spoil was limited to 0.05m^3-0.1m^3 per column, regardless of column length.