KELLER
GROUND ENGINEERING

Lime Cement Dry Soil Mixing

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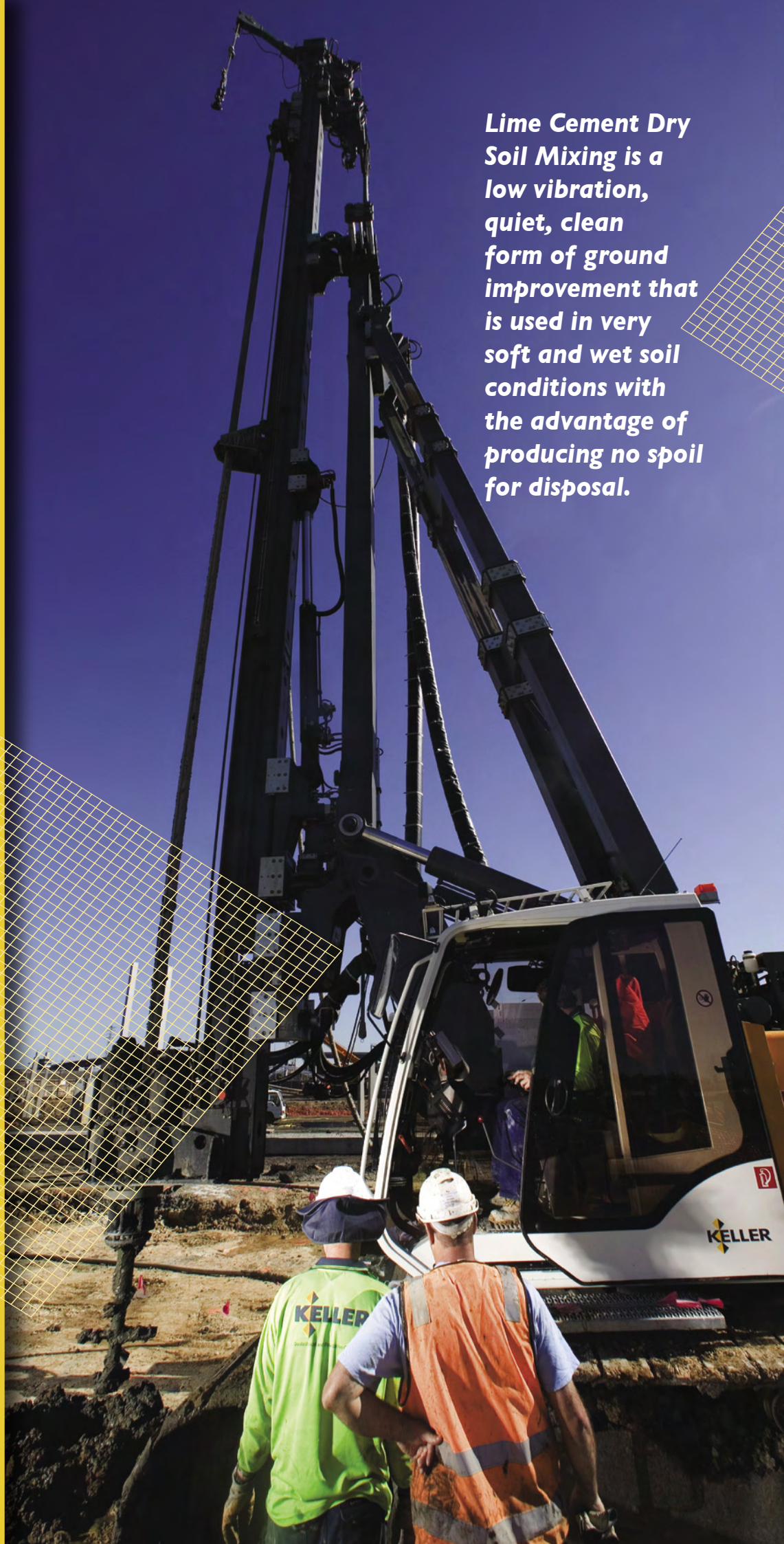
Lime Cement Dry Soil Mixing (DSM) is a highly effective ground treatment system in which lime or cement powder is added to soil particles to increase its shear strength and reduce its compressibility.

The system is particularly suited for very soft soils including marine clay and silt, peat and soft fill soils. The system, pioneered by Swedish company LCM Ltd, a subsidiary of Keller, in the 1970's has been applied by Keller companies throughout the world with in excess of 5 million cubic meters of soil treated.

Lime Cement Dry Soil Mixing is a low vibration, quiet, clean form of ground improvement that is used in very soft and wet soil conditions with the advantage of producing no spoil for disposal.



LIME CEMENT DRY SOIL MIXING

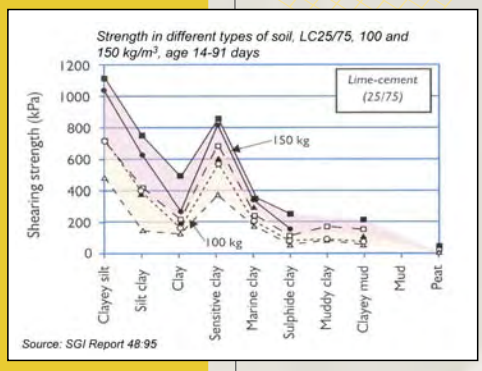
Soil Improvement by Lime Cement Dry Soil Mixing is environmentally sound and frequently the most economic improvement method for soft soils.

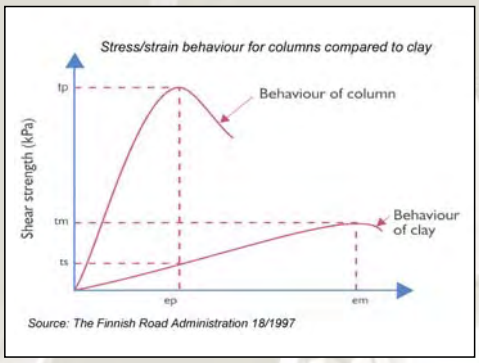
Keller offers two types of DSM; the deep column mixing method (DMM) and shallow mass mixing (SMM), the choice of method depending upon the soil characteristics, the depth of treatment and the required parameters.

Theory

Lime cement dry soil mixing works well in high moisture content (>50%) silty and clayey soils. The dry binder uses the insitu soil moisture during the hydration reaction.

DSM is a soil improvement technique and relies on the composite behaviour of the improved and natural soils. The column layout, diameters and spacing are determined by the performance requirements and the parameters of the improved and natural soils.





Binder Agent

The strength gains achieved are primarily a function of the nature of the existing soils, the type and dosage of the binder used, and the mixing efficiency of the process. Binder agents may include: cement, lime, gypsum or slag or combinations of these materials. Strength and stiffness generally increase with increasing binder dosage.

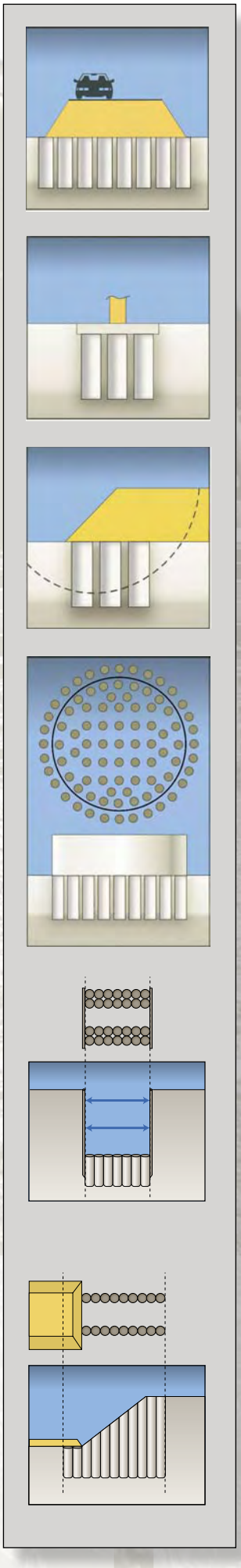
The amount of binder added during the mixing process is identified following initial laboratory trials and subsequently verified onsite during the installation of the initial columns. Amounts of binder range from 80kg/m3 of soil in soft silt and clay to as high as 300kg/m3 in highly organic high moisture content peat. It is important to note that results achieved in the laboratory cannot be directly applied to the field, correction factors of 0.25 to 0.50 being typical.

Design

The design is based upon the site investigation information and takes into account the type and thickness of the soft soil, the existing and planned loading, and the allowable deformations or settlement.

Laboratory testing is performed on samples of insitu soil mixed with various binder proportions and types. Laboratory testing typically yields strength gains for 10 to 50 times the initial soil strength.

Once the Dry Soil Mixing machine has been mobilized to a work site, verification columns are installed to confirm that the design improvement parameters are being achieved. Stone, boulders, foundation remnants, tree stumps and large roots must be removed before treatment can begin.



DEEP MIXING METHOD

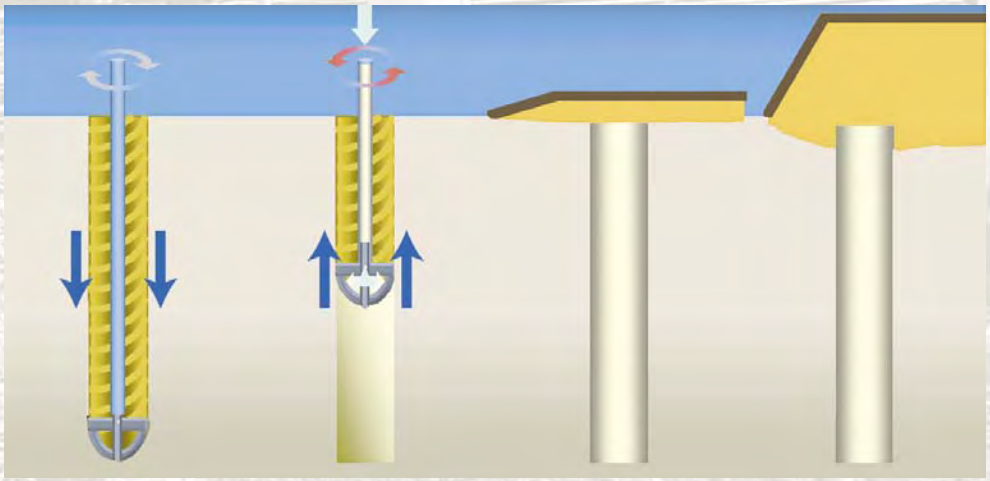
Method

Column positions are marked out on site prior to starting work, with each column given its own designation. The hollow drilling Kelly and mixing tool of the mixing machine are located at the column position and the tooling is rotated and advanced to the design depth.

At the base of the column, the binder agent, which has been pressurized in a separate storage tank is pneumatically conveyed into the ground. The rate of binder introduction is controlled by use of weigh cells and is synchronized with the upward movement of the mixing tool.

DSM columns of between 500mm and 900mm in diameter and lengths of up to 30m can be constructed. The columns can also be interlocked to provide a cellular structure. The mixing machines have a reach of 1m to 3m from the front edge of their tracks and a rotation speed of 100rpm to 200rpm.

Column mixing for new rail track on deep soft clay, Newcastle NSW



▲ *The soil mixing tool is rotated into the ground, once the tool has reached the required depth the binder is injected into the disturbed soil from nozzles located above the blades*

▲ *The tool is rotated at high speed during the withdrawal to mix the binder with the soil*

▲ *Shortly after column construction a soil surcharge pre-load is recommended to provide confinement and pre-compression during curing. The column gains strength within the first few hours and rapidly increases over the first week*

▲ *The final load can be placed soon after construction, with columns typically reaching 90% of the final strength within 3 to 4 weeks*

▲ *Typical column layouts*

MASS MIXING

Mass mixing or mass stabilization is suited for projects where economical reinforcement of shallow areas is required. The method provides an alternative to traditional solutions such as excavation, removal and replacement.

As with the Deep Column mixing method the binder generally consists of cement, lime, slag or a combination of these materials. Mass mixing is often used in combination with deep column mixing where the top very soft (possibly organic) soils are mass mixed and the underlying soft clay is stabilized with columns.

A recent development of the system is for the stabilization of dredged mud particularly when the mud is contaminated or has acid sulphate potential. The mixing process is typically performed in a basin close to the dredging site and then used as inert fill.

The process is carried out using a mixing tool mounted on a tracked machine fitted with low bearing pressure tracks, this allows the process to form its own working platform in very soft soils. The area to be mixed is divided into a series of cells, with each cell given an identification number for QA purposes. The total binder added into the cell is monitored and recorded by the on board PC.

Above Left: Mass stabilization of mangrove mud for road construction
Left: Keller's mixing head can mass stabilize soils up to 5m below ground level

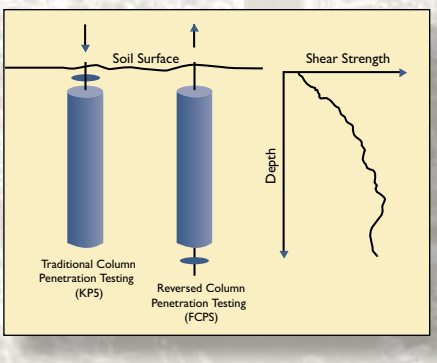
QA/QC TESTING

The on board computer records the as built mixing parameters

The quality assurance and control methods are similar for both mass stabilization and deep column mixing. To assist in monitoring and controlling the installation process our Soil Mixing machines are fully instrumented with an on-board computer system to monitor binder dosage and drilling parameters. Data such as binder and drill depth are recorded and displayed alongside target values on an in-cab monitor.

Post mixing testing is typically performed using a column penetration test. This involves pushing a winged probe through the centre of the column. The width of the probe is slightly less than the column diameter, the shear strength of the column is evaluated based on the force required to push the probe through the column.

The reverse column penetration test is a bottom to top version of the penetration test. This method utilizes a probe with a steel cable attached which runs from the probe at the bottom of the column to the ground surface. With this version of the test, it is easier to keep the probe centred. The probe is installed at the base of the column and is pulled up through the column after the required curing period. The force required to pull the probe is used to evaluate the shear strength of the column.



Column penetration testing is used to characterise insitu cured shear strength.

Keller Ground Engineering Pty Ltd

AUSTRALIA
NEW ZEALAND
PACIFIC ISLANDS
INDONESIA

Enquiries to:
PO Box 7974
Baulkham Hills NSW 1755

Level 1, 4 Burbank Place
Baulkham Hills NSW 2153
Australia
t: (02) 8866 1155
f: (02) 8866 1151
e: info@kellerge.com.au