Soil mixing

An efficient and flexible technology
to overcome a variety of soil problems

The cost-effective way to improve ground

Soil mixing is an advanced ground improvement technique requiring considerable expertise in planning, design and execution. The technique leads to significant improvement of the mechanical and physical properties of the in-situ soil, which is mixed with cement or compound binders to form the so-called soil-mix (or soil-cement). The resulting stabilised soil generally has a higher strength, lower permeability and lower compressibility than the original soil. For environmental treatment, chemical oxidation agents or other reactive materials may be also used to render pollutants harmless.

Deep soil mixing and mass stabilisation

Soil mixing can be done to a replacement ratio of 100% where all the soil inside a particular block is treated, as is the case for mass stabilisation, or to a selected lower ratio, which is often practised with deep mixing. Different patterns of installations are used to achieve the desired result by utilising spaced or overlapping and single or combined columns and also panels.

Wet and dry processes

The soil to be improved is mixed mechanically in-situ either with a binder in a slurry form (wet method) or with a dry binder (dry method). Slurry jetting can be also used to enhance mechanical mixing, and increase column diameter. The ability to choose between dry and wet processes enables Keller to offer tailored soil mixing applications.

Benefits of soil mixing

Soil mixing is based on the concept of improving natural soils or brownfield materials to match design requirements, eliminate problematic excavation and replacement or more expensive deep-foundation methods. The broad range of applications and different execution methods of soil mixing allow safe and very economical ground engineering solutions. The use of non-toxic binders as soil additives, including industrial by-products, and the reduction in spoil volumes compared with jet grouting or classical bored piles, for example, firmly positions soil mixing as an environmentally friendly technology.

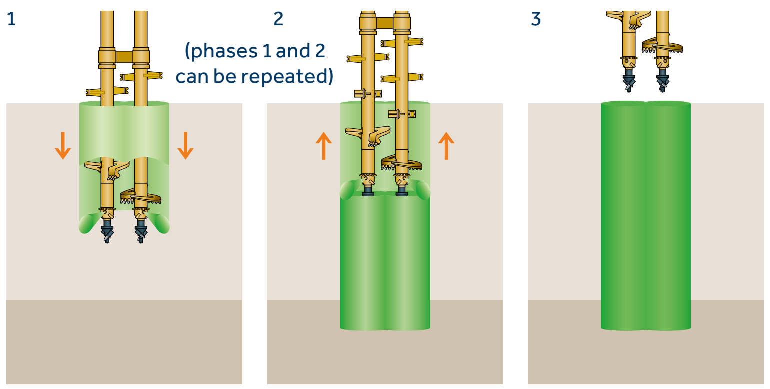
- Economical
- Can replace more expensive deep foundation methods
- Vibration free
- Flexible in application
- Reduces construction time
- Environmentally-friendly

Wet deep soil mixing

In the wet method, a special mixing tool is inserted into the ground which comprises single or multiple drilling shafts, transverse beams and auger bits. Penetration and withdrawal of the mixing tool is assisted by cement slurry outflow from nozzles purposely located at the end of the soil auger and, in the case of large diameter columns, also along the mixing blades. The mixing tool, which may also move up and down along the column length to improve the homogeneity of the soil-mix, assures thorough mixing of the slurry with the soil. The composition and the pumping rate of the slurry is adjusted and controlled to achieve the design properties of stabilised soil. The deep soil mixing columns are typically 0.6 to 2.4 m in diameter, depending on the application. Steel reinforcement can be inserted into fresh soil-mix to increase bending resistance of deep soil mixing columns used for excavation control.

Quality control

QC and QA are obtained from the column installation protocols and the results of relevant laboratory and field-verification tests. Each column is provided with a chart-log, which typically comprises: element identification, mixing tool details, mixing depth, mixing time, slurry specification, injection flow rate and pressure, total volume of slurry used, mixing tool velocities and rpm during penetration and withdrawal and torque of the shaft. From this information the mixing energy and binder content is calculated to match design requirements. Specimens of stabilised soils for testing are usually obtained from fresh columns with a wet grab. Advanced core drilling and other field-testing methods can also be used to obtain specimens and to inspect the continuity, uniformity and stiffness of deep soil mixing columns. The selection of suitable verification methods depends on their relevance, accuracy and applicability in relation to the purpose and pattern of soil treatment and design properties of stabilised soil.



Wet deep mixing process

Applications

- Road and railway embankments
- Support of strip, pad and slab foundations
- Bridge supports and abutments, wind-turbine foundations
- Retention systems and excavation support
- Slope stabilisation
- Liquefaction mitigation
- Dykes, cut-off walls and seepage barriers
- Ground improvement and site remediation with mass stabilisation
- Encapsulation and immobilisation of pollutants

Dry deep soil mixing

The dry method is applicable in soils that have a high moisture content to allow chemical reaction of the soil and groundwater with stabilising binders injected in dry form. The basic advantage of dry mixing is that stabilisation effects can be obtained in deep deposits of very soft soils, including organic soils, with high productivity, almost no spoil generation and at competitive cost. In addition, operations at low temperatures are possible.

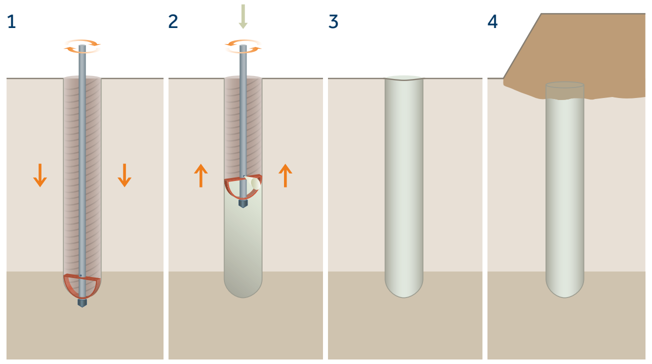
Typical equipment for dry deep soil mixing comprises stationary or mobile binder storage and feeding plant and a purposely designed drilling rig for installation of the columns, equipped with a special mixing tool at the end of the mixing rod. Typical column diameter is 0.6 to 1 m and the depth of treatment can be up to 25 m.

Charging and mixing of dry binder with soil takes place while the rod is withdrawn and the mixing tool is rotated in the opposite direction to that of the penetration phase. The binder is transported from the shuttle to the rig through connecting hoses using compressed air. Binder quantity is adjusted by changing the rotation speed of the feed wheel. Air pressure and the amount of binder are automatically controlled to supply the specified dosage of binder to the treated zone of soil. As a rule, plastic clays and silts are strengthened by lime, or cement with lime, while in organic soils, mixes containing blast-furnace slag are used.

Quality control

As with the wet method, quality control and testing are done both during execution and after completion of works. Instrumentation records data on each column. Upon completion control tests are carried out to ensure compliance with assumptions adopted in the design. Standard tests involve mainly probe testing. They are feasible in columns designed for lower strength and include modified cone-penetration tests and pullout-resistance Tests to avoid the problem of the cone's tendency to wander out of longer columns. Laboratory tests on specimens extracted from exposed columns can also be carried out if required.

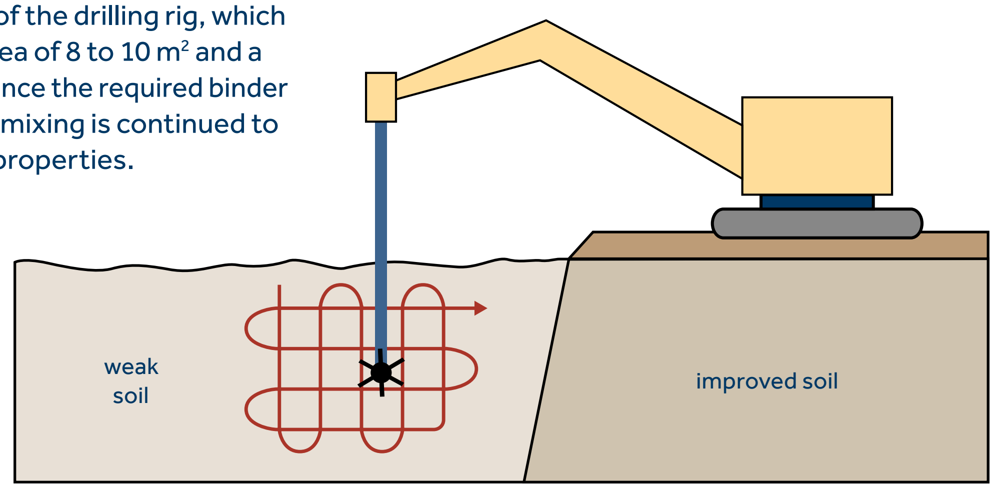
Dry deep mixing process



Mass stabilisation

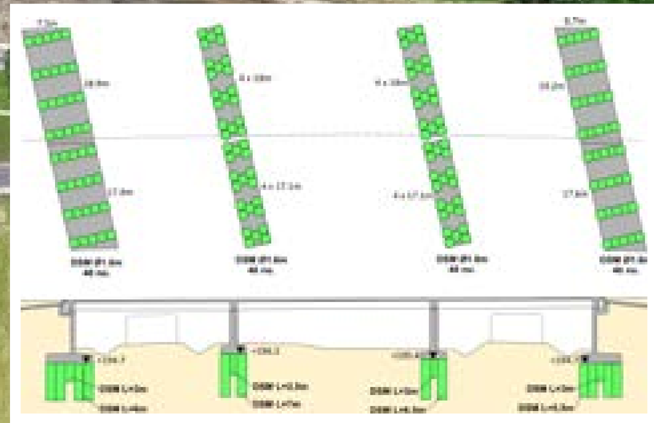
Mass stabilisation offers a cost-effective solution for ground improvement works or site remediation especially when dealing with substantial volumes of very weak or contamined superficial soils with high water content. Deposits such as dredged sediments, wet organic soils or waste sludge are appropriate for this. In this method special mixing tools are used, which are in most cases fixed to an excavator's rig arm. Mixing is done vertically or horizontally, with mixing tools that resemble screw propellers incorporating a central nozzle for the binder. The binder in a dry form is fed from a separate unit which houses the pressurized binder container, compressor, air dryer and supply-control unit. Alternatively, the wet method may be also used for mass stabilisation.

Stabilisation is executed in phases, depending on the operational range of the drilling rig, which generally comprises an area of 8 to 10 m^2 and a depth up to approx. 8 m. Once the required binder volume has been applied, mixing is continued to ensure the optimum mix properties.



Mass stabilisation process

Soil mixing project



Foundation for road viaduct, Poland

Keller Poland laid the foundation for a new viaduct constructed along the S7 express road near Kracow. In total, 160 no. deep soil mixing columns, 1.6 m in diameter and up to 7 m long, were installed within six working days to limit differential settlements of four viaduct supports to 15 mm. Using the wet method and blended cement type CEM II / B-V 32,5R, containing some 30% of fly ash, providing a cost-effective and environmentally-friendly solution and eliminating the need for conventional piling.

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