Wet soil mixing offers a cost-effective and efficient means to overcome a variety of soil problems.

Wet soil mixing is the controlled mechanical mixing of the in-situ soil with grout slurry using a rotary mixing tool. The wet method relies on the introduction of an engineered grout slurry to create soil-cement (soilcrete) elements for soil stabilization, or to support earth or building loads. The intent of the soil mixing program is to achieve improved engineering properties of the in-situ treated soil, generally a design compressive strength, shear strength and/or permeability. Soil mixing can also be used to immobilize and/or stabilize contaminants, or as a chemical treatment system.

Hayward Baker (HB) has designed and constructed soil mixing programs for over 20 years and has successfully completed over 150 projects. Experienced employees working with self-developed specialty mixing tools and proprietary data acquisition (DAQ) equipment and software enable HB to perform the highest quality soil mixing to meet each project’s requirements. For a variety of subsurface and project conditions, HB’s wet soil mixing may be the answer.
et soil mixing is applicable to a wide range of soils. For soils with high moisture content, dry soil mixing may also be considered. Soil mixing has been performed to depths up to 100 feet (30 meters). Soils vary widely in their ability to be mixed, depending on the soil type, strength, water content, plasticity, stratigraphy, and texture. Almost any soil type, including organics, can be treated, although they may require high binder contents and/or pretreatment to achieve required results. In cases when the target soil is very soft, including some very weak clays and peats, 100% of the soil may require treatment. This complete coverage of soil mixing is referred to as mass mixing, and treatment to depths of approximately 20 feet (6 meters) has been performed with the horizontal axis mass mixing tool. Deeper mass mixing depths can be accomplished by overlapping columns. Experienced HB representatives are available to discuss treatment in challenging soils.

Foundation Support
Structures such as tanks, buildings, and others with heavily loaded foundations can be supported by soil mix columns or mass mixing.

Liquefaction Mitigation
Liquefaction problems in seismic areas can be remedied by using soil mixing to support the structure and to resist lateral spreading.

Slope Stabilization
Soil mixing can provide substantial shearing resistance to stabilize slopes, excavations, or embankments. Shear walls can be constructed by interlocking columns or with the mass mixing tool.

Port Development
The soft soils often found at port facilities can be treated with soil mixing. Stabilization can provide structural support, and/or it can greatly reduce lateral loads on bulkhead walls.

Water Cutoff
Secant soil mix columns can be constructed beneath undeveloped sites or existing levees to produce a water cutoff wall.

Excavation Support
Soil mix columns can be used to construct in situ retaining structures. Structural steel elements are often installed into the uncured soil mix columns to add strength and provide load distribution should anchoring be necessary.

1. Settlement control for tank foundations in Alberta, Canada provided by soil mix columns.
3. A new high-rise building in Florida requiring soil mix columns to provide earth retention and bottom seal for a dry excavation near the ocean.
4. Deep soil mix columns (shown) and mass soil mix cap constructed for settlement control of new tanks in Louisiana.
5. Mass soil mixing to create vertical panels for water cutoff in restricted access and low headroom in Washington.
Wet Mixing Procedures
A range of mixing tool configurations can be designed to construct varied geometries in diverse soils. As the soil mixing tool penetrates the ground during column construction, grout slurry is pumped through the hollow stem of the shaft and injected into the soil through nozzles located on the rotating mixing blades. The mixing blades on the tool shear and mix the soil with the grout slurry. Injection and soil mixing continue to design depth. When design depth is reached, tool rotation and grout injection continue as the tool is withdrawn, leaving behind stabilized soilcrete columns. The columns may be designed as individual foundation elements or clustered to construct larger geometries over a wider area.

When mass mixing, initial conditioning of the soil may be performed with separate equipment. The binder agents are injected as the horizontal axis mixing tool passes throughout the soil mass being treated.

Depending on the soil type and required binder content, excess soilcrete generated may range from 20 to 50% of the treated volume.

Design Considerations
Soil mixing can treat a wide range of soil types. Soft cohesive soils are usually targeted as other soil types can often be treated more economically with other techniques. Variability of the product is largely a function of the variability of the soil. It is crucial to understand site geology and history, soil gradation, pH, and the in situ moisture content of each treatment stratum. The sulfate and organic content of each stratum should also be determined.

Soil mixing creates a soilcrete product that is stiff and strong, although final mix strength depends on many factors, some of which include soil type, water content, pH, organic content, grout quantity, and mixing energy. Therefore, it is recommended that laboratory bench scale testing using site soils and methods to simulate mixing procedures be conducted. The strength of field-mixed samples may vary from that of lab-prepared samples. Selecting a strength value for design should involve, among other things, considering the variations in strength that are inherent to this process. Additional recommendations for design can be found in the soil mixing chapter of Ground Improvement, by Dr. M. Topolnicki, Third Edition, Spon Press. ISBN 9780415599214.

It is challenging to mix low-plasticity clays with shear strength greater than 1,500 psf, high-plasticity clays with shear strength greater than 1,000 psf, and cohesive soils with moisture contents much lower than the liquid limits. However, with appropriate pretreatment even these difficult soils can be treated successfully. Obstructions need to be identified prior to implementation. Stiff soils and obstructions may require predrilling ahead of the soil mixing process.
Wet Mixing Rig
The base mixing rig is used to provide stability, depth capability, and power to the mixing tool. Drill heads vary from conventional hydraulic drill heads to dual-motor, crane-mounted turntables. Torque units range from 30,000 to 300,000 ft-lbs (40.7 kN-m to 406.7 kN-m).

The mixing tool can be a combination of partial flighting, mix blades, injection ports and nozzles, and shear blades. No single tool will be the best for all soil types, and field adjustments are sometimes performed. Column size ranges from 1 to 12 feet (0.3 to 3.6 meters) in diameter.

When performing mass mixing, a horizontal axis mixing tool is connected to the arm of a modified track hoe. The mixing tool is moved throughout the soil being treated as binder is injected through a port located at the rotating tool.

Grout Slurry Delivery
Depending on the in situ soil and required properties of the soilcrete, the volume of grout slurry necessary ranges from 20 to 50% by volume of soil treated, known as volume ratio.

Pre-production laboratory testing is used to prescribe the grout slurry design and volume ratio. Grout slurry is typically delivered on penetration as well as withdrawal. The grout slurry batching system can be a computer-controlled colloidal shear mixer, or a continuous jet mixing system. Grout slurry is continually agitated while it is held in storage. The grout slurry is pumped to the mixing rig from the storage unit at a delivery rate necessary to produce the designed volume ratio.

The grout slurry flow per cubic yard of soil being mixed is adjusted to the requirements of the design mix and the results of testing. Flow monitoring devices are installed in the grout slurry delivery line to monitor flow, density, total injected grout, and pressure.

Grout Slurry
The grout slurry consists of water and cementitious binders and may contain swelling clays. Cementitious binder is typically Portland cement, but fly ash, lime, and ground granulated blast furnace slag (GGBFS) may also be used.
**Quality Control . . .**

**Pre-Construction**
Prior to soil mixing, samples of the soil to be treated are retrieved for laboratory bench scale testing. The samples are mixed in a laboratory with varying slurry types and volume ratios to help identify the mix design that will achieve the required performance.

**During Construction**
To assist in monitoring and controlling the construction process, HB has developed proprietary data acquisition (DAQ) equipment and software for real-time monitoring of all parameters. Soil mixing rigs are fully instrumented with an on-board computer system to monitor the slurry dosage and mixing energy. During column mixing, the system also regulates the penetration and lift rates to keep the dosage within the specified range. Data are recorded and displayed on an in-cab monitor.

It is also possible to remotely monitor the feedback. All data are transmitted in near real-time to an online central database via cell modem.

The following information is documented prior to and during construction:
- Column or cell identification
- Working grade
- Column diameter or cell volume
- Slurry type
- Mixing time
- Slurry dosage rate and pressure
- Tool rpm
- Total quantity of slurry added during mixing
- Mixing depth
- Lab tests on soilcrete samples

Fresh soilcrete is sampled immediately after mixing for casting into cylinder molds for later laboratory strength and permeability testing.

**Post-Construction**
Core sampling is common but challenging in the relatively low-strength soilcrete. Coring crews experienced with coring lower strength materials with appropriate equipment are required to retrieve quality samples. Soil inclusions are common, but should not exceed a size that will adversely affect the required performance of the soilcrete system. Rock fragments in soilcrete may break free during coring and grind up the core sample, resulting in low recovery from high-quality soilcrete.
Advantages of Hayward Baker Wet Soil Mixing

Wet soil mixing offers a cost-effective and efficient means to overcome soft soil problems for a variety of soil types, loadings, and project requirements. Possible benefits include:

- Development of otherwise unusable (cost/time-prohibitive) sites
- Accelerate construction schedule
- Possible elimination of site dewatering
- Often economical compared to remove-and-replace options
- Low vibration and noise
- Rapid mobilization
- Excess soilcrete can often be used as a fill material
- Often combined with other ground improvement systems to increase savings
- Contaminant solidification/stabilization

You have a strong partner with Hayward Baker

Hayward Baker Inc. (HB) is North America’s leader in geotechnical construction, offering the full range of pre- and post-construction services for foundation rehabilitation, settlement control, liquefaction mitigation, soil stabilization, groundwater control, slope stability, excavation support, underpinning, and environmental remediation. HB is annually ranked #1 in the profession by Engineering News-Record (ENR).

Headquartered in Hanover, Maryland, HB has over 25 offices servicing North and Central America. Since its inception, HB has established itself in the forefront of geotechnical specialty contracting, evolving and expanding to meet the increasingly complex needs of the construction community. HB is capable of offering full design-build services for any geotechnical construction application.

HB has the experience and innovation to assist engineers, contractors, and owners with identifying and constructing the most economical solution that satisfies the technical requirements of each project, typical or unique.