KELLER

Solutions matrix
The solution to any geotechnical challenge

- Bearing capacity/settlement control
- Environmental remediation/containment
- Groundwater cut-off
- Heave control/expansive soil treatment
- Heavy foundations
- Marine structures support
- Mine stabilization/void filling
- Railroad subgrade stabilization
- Releveling structures
- Seismic/liquefaction mitigation
- Sinkhole/karst remediation
- Slope stabilization
- Support of Excavation
- Tunneling stabilization
- Underpinning

GROUTING

Compensation (fracture) grouting is the intended discrete hydro-fracturing of soil with slurry grout to produce a controlled heave of soil or a foundation, or to compensate for soil loss during tunneling.

High mobility (cement slurry) grouting is the injection of flowable particulate grouts into cracks, joints, and/or voids in rock or soil.

Injection systems is the pressure injection of aqueous solutions into the ground. The composition of the aqueous solution depends on the application, which commonly includes stabilization of expansive soils and railroad subgrades.

Jet grouting erodes the soil with high-velocity fluids and mixes the eroded soil with grout to create in situ cemented geometries of soilcrete (full or partial columns, panels, or bottom seals).

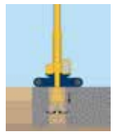
Low mobility (compaction) grouting is the injection of viscous mortar grout to displace soil and densify granular soil when present. Compaction grouting is also commonly used as a void filling material and to stabilize sinkholes.

Permeation grouting (chemical, cement, or pressure grouting) permeates granular soils and also fills cracks or voids in soil and rock to create a cemented mass.

Polyurethane grouting is the injection of polyurethane grouts into concrete joints or cracks for permanent seepage control. HB PolyLift® is the injection of lightweight polyurethane foam at shallow depths for concrete leveling and void filling.

Slab jacking is the controlled injection of grout through a concrete slab at strategic locations to relevel the slab.

GROUND IMPROVEMENT



Cutter soil mixing is a wet soil mixing technique that mechanically blends in situ soil with slurry grout in panels to achieve improved engineering properties, such as strength and stiffness.

Dry soil mixing is the in situ mechanical blending of wet soil with dry cementitious materials (binder) to achieve improved engineering properties, such as strength and stiffness.

Dynamic compaction is a densification technique used to treat a range of loose or porous soil types by the controlled impact of a crane-hoisted, heavy weight (10-30 tons) on the ground surface in a predetermined grid pattern.

Earthquake drains are high flow capacity, prefabricated vertical drains wrapped with a geo-textile. Earthquake drain programs are designed to limit seismically induced pore pressure buildup to mitigate liquefaction.

GROUND IMPROVEMENT

Rapid impact compaction (RIC) applies impact energy to the ground surface which results in densification of loose granular soils and increased bearing capacity and soil stiffness.

Rigid inclusions are low-mobility grout columns constructed through compressible soils to reduce settlement and increase bearing capacity.

Vibro compaction is the densification of clean, cohesionless soils above and below the water table using a depth vibrator that vibrates in the horizontal direction.

Vibro concrete columns are concrete inclusions constructed with a depth vibrator and attached tremie pipe to reinforce soil and densify adjacent granular soils when present.

Vibro (aggregate) Piers® are vibrator densified aggregate piers that engage the surrounding soil, providing reinforcement and increased shear resistance. The stiff piers increase bearing capacity, reduce settlement, and increase global stability.

Vibro stone columns (vibro replacement) are aggregate columns constructed using a depth vibrator to densify the aggregate backfill and surrounding granular soil.

Wet soil mixing is the mechanical blending of in situ soil with slurry grout to achieve improved engineering properties, such as strength and stiffness.

Wick (PVD) drains are prefabricated geotextile filter-wrapped plastic strips with molded channels. These act as drainage paths to take pore water out of soft compressible soil so it consolidates faster, often from decades to months.

DEEP FOUNDATIONS

CFA (auger cast) piles are constructed by rotating a continuous flight hollow stem auger into the soil to a specified depth. Concrete or grout is pumped through the hollow shaft, filling the cylindrical cavity created as the auger is slowly withdrawn.

Displacement CFA piles are constructed by rotating a displacement hollow stem auger into the soil to a specified depth. Concrete or grout is pumped through the hollow shaft, filling the cylindrical cavity created as the displacement tool is slowly withdrawn.

Drilled shafts are reinforced concrete elements cast into drilled holes that transfer heavy loads to a deeper competent soil or rock stratum.

Driven piles are timber, concrete, or steel deep foundation elements driven vertically to design depth, transferring loads through weak soil layers to a suitable bearing layer of soil or rock.

DEEP FOUNDATIONS

Franki piles, also know as pressure injected footings (PIFs), are high-capacity cast-in-place deep foundation elements constructed using a drop weight casing. This technique has been used to support buildings, tanks, towers, and bridges.

Helical (screw) piles are steel piles with discontinuous helical flights that are screwed into the ground to act as compression or tension structural support elements.

Jacked in piles are small diameter pipe piles hydraulically pushed into the soil using the structure as the reaction load.

Load bearing elements (barrettes) refer to the use of single or multiple arrangements of rectangular elements to support significant structural loads for structures.

Macropiles® are ultra-high-capacity micropiles, with high-strength grout, steel reinforcement, and increased diameter. A macropile is drilled and typically bears on or in rock, but can also bear in very dense soils.

Micropiles are small-diameter, low- to high-capacity structural elements that can provide compressive, tensile, or shear support as foundation or slope stabilization components. Micropiles can be installed in almost any type of ground, and in restricted access or low headroom situations.

Tangent bearing elements (TBEs) are a deep foundation solution that can support tall, slender buildings within a constricted site and reduce excavation or dewatering efforts.

EARTH RETENTION

Anchors are composed of steel bars or strands grouted into a predrilled hole to resist lateral and uplift forces.

Anchor block slope stabilization consists of discrete, anchored concrete blocks placed in a pattern on a slope to provide stabilization. The anchor force acts on the block, increasing the normal stress within the soil and resistance to shear failure.

Diaphragm walls are very rigid walls offering significant resistance to bending from lateral loads as well as being very water-resistant.

Gabion systems are rock-filled galvanized steel baskets that are stacked to construct a tiered or sloped gravity retaining wall, or placed to protect channel linings or slopes from erosion.

Interlocking pipe piles consist of tightly interlocked pipe piles using an innovative mechanical "ball-and-socket" type connector welded to the full length of the pipe to create a continuous watertight wall that can be either temporary or permanent.

EARTH RETENTION

Micropile slide stabilization system (MS^3) incorporates an array of drilled and grouted micropiles acting in tension and compression. Micropiles are connected by a reinforced concrete beam creating an integral, stabilized ground reinforcement system.

Pit underpinning is the strategic excavation of narrow trenches under an existing structure that are filled with concrete for structural support to allow for adjacent excavation.

Sculpted shotcrete is an aesthetic covering for vertical cuts reinforced by soil nails or other elements. Shotcrete is sprayed onto the surface and can then be sculpted, stained, and textured in a variety of ways.

Secant or tangent (contiguous) piles are columns installed adjacent to (tangent) or overlapping (secant) each other to form structural walls that resist lateral pressures and groundwater inflow.

Sheet pile walls are installed by inserting interlocking steel sheets to provide temporary or permanent earth retention systems. Anchors can be incorporated to increase lateral support.

Soil nailing consists of the installation of relatively small, closely spaced inclusions (usually steel bars) to reinforce, stabilize, and retain a soil mass. A surface facing, typically shotcrete or panels, is then applied.

Soldier piles and lagging is a retention system in which vertical piles laterally support lagging that horizontally spans between the piles, providing earth retention. Anchors can be used to increase lateral support capacities.

GROUNDWATER CONTROL

Dewatering involves the installation of predrainage devices (wells, wellpoints, or ejectors) to lower the groundwater table or relieve groundwater pressure so that excavation can be done "in the dry" and under stable ground conditions.

Ground freezing converts in situ pore water to ice through the circulation of a chilled liquid via a system of small diameter pipes placed in drilled holes. The ice acts to fuse the soil or rock particles together, creating a frozen mass of improved compressive strength and impermeability.

Groundwater treatment methods effectively remove contamination and sediment from pumped groundwater or site construction water so water can be appropriately discharged.

Slurry cutoff trenches are continuously excavated and backfilled with low permeability material to provide a groundwater barrier wall.

TRD - soil mix walls is a wet soil mixing technique using a full-depth cutter post to mix in situ soil with cement-based slurry. The result is a mixed-in-place wall with a high degree of homogeneity.

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CHALLENGES / SOLUTIONS	GROUTING								GROUND IMPROVEMENT												DEEP FOUNDATIONS										EARTH RETENTION											GROUNDWATER CONTROL					
	Compensation (fracture) grouting	High mobility (cement/slurry) grouting	Injection systems	Jet grouting	Low mobility (compaction) grouting	Permeation (chemical) grouting	Polyurethane grouting	Slab jacking	Cutter soil mixing	Dry soil mixing	Dynamic compaction	Earthquake drains	Rapid impact compaction	Rigid inclusions	Vibro compaction	Vibro concrete columns	Vibro Piers®	Vibro stone columns	Wet soil mixing	Wick drains	CFA (auger cast) piles	Displacement CFA piles	Drilled shafts	Driven piles	Franki piles (PIFs)	Helical (screw) piles	Jacked in piles	Load bearing elements (barrettes)	Macropiles®	Micropiles	Tangent bearing elements (TBEs)	Anchors	Anchor block slope stabilization	Diaphragm walls	Gabion systems	Interlocking pipe piles	Pit underpinning	Micropile slide stabilization system (MS3)	Sculpted shotcrete	Secant or tangent (contiguous) piles	Sheet piles	Soil nailing	Soldier piles and lagging	Dewatering	Ground freezing	Groundwater treatment	Slurry cutoff trenches	TRD - soil mix walls
Bearing capacity/ settlement control	●	●	●	●	●	●	●			●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●															
Environmental remediation/ containment			●	●					●	●									●																					●				●	●	●	●	●
Groundwater cut-off		●		●		●	●		●										●															●		●				●	●			●	●		●	●
Heave control/ expansive soil treatment			●							●									●																													
Heavy foundations																					●	●	●	●	●	●		●	●	●	●			●													
Marine structures support				●							●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			●					●	●						
Mine stabilization/ void filling		●			●		●																																								
Railroad subgrade stabilization			●		●																																										
Releveling structures	●				●		●	●																		●	●			●																	
Seismic/liquefaction mitigation				●	●	●			●	●	●	●	●		●		●	●	●																												
Sinkhole/karst remediation		●			●						●				●			●																														
Slope stabilization				●					●	●							●	●	●	●			●									●	●	●	●	●		●		●	●	●	●	●	●			
Support of excavation				●		●			●										●													●		●	●	●	●		●		●	●	●	●		●			●
Tunneling stabilization	●	●		●	●	●													●																●									●	●			
Underpinning				●		●																				●	●			●						●										●			

This chart represents techniques that could apply to the listed geotechnical challenges. The actual applicability of a particular technique will be dependent upon the soil character (soft, loose, stiff, dense, organic, collapsible, etc.) and its composition (clay, silt, sand, cobbles, boulders, etc.). Occasionally, multiple techniques used simultaneously could provide a more economical solution. Other considerations include accessibility, availability of materials, presence of utilities or other underground obstructions, and many other internal and external influences. Consult with your local Keller representative to discuss specific site conditions and appropriate Keller geotechnical construction solutions.

INSTRUMENTATION & MONITORING In combination with these techniques, we also provide automated instrumentation for monitoring the safety and stability of buildings, excavations, bridges, railways, roads, tunnels, dams, embankments, and slopes.