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

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GROUTING

Compensation (fracture) grouting uses grout to hydro-fracture the soil, producing a controlled heave of soil or existing structure, often used to compensate for anticipated or occurring settlement during tunneling.

Crack injection for seepage control is the pressurized injection of a grout (commonly polyurethane or high-mobility grout) into and behind a structure to cutoff water flows through it.

Rock/fissure grouting is the injection of high-mobility grout into apertures, joints, and/or voids in rock or soil to create a seepage barrier or stabilize the mass.

Injection systems are 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 is the hydraulic erosion of soil using a high-energy fluid jet to erode and mix the soil with a binder, creating in situ cemented geometries of soilcrete (full columns, partial columns, or panels).

Compaction grouting is the controlled injection of low-mobility grout to displace and/or densify soil, with the intention of improving the strength and stiffness of the existing soil.

Permeation grouting is the injection of a chemical solution or high-mobility cementitious grout into the pore space of granular soils to increase strength and decrease permeability.

Slab jacking / structural releveling is the controlled injection of grout (low-mobility, polyurethane, or high-mobility) beneath a concrete slab/tank or other structure at strategic locations to relevel it.

Void fill grouting is the use of low-mobility, polyurethane, and/or high-mobility grouts to fill/partially fill and stabilize an in situ void, mine, or sinkhole.

GROUND IMPROVEMENT

Cutter soil mixing is a wet soil mixing technique that mechanically blends in situ soil with grout slurry, using vertically oriented counter-rotating mixing heads, to create panels with improved strength, permeability, and stiffness.

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

Dynamic compaction is a densification technique used to treat non-cohesive soils by the controlled impact of a crane-hoisted weight (10-30 tons from heights of 30 to 90 feet) on the ground surface in a predetermined grid pattern.

GROUND IMPROVEMENT

Earthquake drains are prefabricated vertical drains wrapped with a geo-textile installed on a predetermined grid pattern. Earthquake drain programs are designed to limit seismically induced pore pressure buildup to mitigate liquefaction and seismically induced settlement.

Mass soil mixing is the mechanical blending of shallow in situ soil with grout slurry, using excavator-mounted blending tools, to achieve improved strength, permeability, and stiffness.

Rapid impact compaction (RIC) applies energy to the ground surface using a mast-mounted impact hammer, resulting in densification of loose granular soils and improved soil strength and compressibility.

Rigid inclusions are discrete, vertical grout columns constructed through compressible soils to reduce settlement, increase bearing capacity, and decrease compressibility of the improved soil. They are typically separated from overlying foundations by a Load Transfer Platform (LTP).

Vibro compaction is the densification of clean, cohesionless soils above and below the water table, using a depth vibrator that imparts energy horizontally.

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 and reduce settlement.

Vibro replacement (stone columns) 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 a grout slurry, using an auger-style blending tool, to achieve improved strength, permeability, and stiffness.

Wick drains (PVDs) are molded plastic strips wrapped in geotextile fabric. The channeled plastic strips provide drainage paths for pore water generated in loaded compressible soils, accelerating the consolidation of this material.

DEEP FOUNDATIONS

Continuous-flight auger (CFA) or augered cast-in-place (ACIP) piles are constructed using a continuous-flight hollow-stem auger to drill through the soil to a specified depth. Concrete or grout is pumped through the auger as the auger is withdrawn, filling the remaining cylindrical cavity. A reinforcing cage is installed in the wet concrete.

Displacement piles are constructed by rotating a specialized tool into the soil that horizontally displaces the soil while penetrating to a specified depth. Concrete or grout is pumped through the stem of the tool, filling the cylindrical cavity created as the tool is slowly withdrawn. A reinforcing cage **is installed in the wet concrete.**

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

DEEP FOUNDATIONS

Driven piles are timber, concrete, or steel elements installed into the soil through impact or vibrational energy applied to the top of the element. The elements transfer loads from the surface to suitable bearing layers of soil or rock.

Franki piles, also known as Pressure Injected Footings (PIFs), are installed by driving a casing with a drop hammer and filling the installed casing with pressurized concrete. The concrete forms an enlarged base and fills the cavity as the casing is withdrawn. This technique is used to support heavy structures.

Helical (screw) piles are discontinuous steel helix plates attached to steel casing. The piles are torqued into the ground and can act as compression or tension structural elements.

Jacked piles also known as push piles, are small-diameter pipe piles that are hydraulically pushed into the soil, with the structure serving as the reaction load.

Load Bearing Elements (LBE) or "barrettes" are cast in place rectangular reinforced concrete elements that 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 typically drilled and socketed into rock, but can also be installed in very dense soils.

Micropiles are small-diameter steel and grout 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, including restricted access or low headroom areas.

EARTH RETENTION

Anchors are post-tensioned steel bars or strands grouted into a predrilled hole to resist lateral and uplift forces.

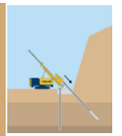
Anchor block slope stabilization consists of discrete, anchored concrete blocks placed in a pattern on a slope to provide stabilization. The anchor force acts on the block, increasing the resistance to shear failure.

Diaphragm walls are reinforced concrete walls created by sequentially cutting panels into existing soil or rock and placing steel-reinforced concrete in place.

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 pile walls use a "ball-and-socket" type connector, like some sheet pile joints, welded to the length of the pipe to connect adjacent casing elements structurally. The resulting connected pipe wall can be temporary or permanent and can mitigate water inflow.

EARTH RETENTION



Micropile slide stabilization system (MS³) 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.

Shotcrete is the application of concrete by spraying it on a surface at high velocity. It is commonly used for vertical cuts, reinforced by soil nails or other elements. The sprayed shotcrete can then be sculpted, stamped, stained, or textured in various ways.

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

Sheet pile walls are installed by driving or vibrating 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 mesh, is then applied.

Soldier piles and lagging is an earth retention system where vertical piles are installed to resist soil lateral loads, and wooden or concrete lagging is placed horizontally between the piles as the excavation progresses to prevent sloughing of the soil. Anchors can be used to increase lateral support capacities.

GROUNDWATER CONTROL

Dewatering is performed using wells, wellpoints, or ejectors to lower the groundwater table or relieve groundwater pressure, allowing excavation to 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, allowing the water to be discharged appropriately.

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

Trenched soil mix walls are created using a full-depth cutter post to mix in situ soil with cement-based slurry. The result is a mixed-in-place wall for earth retention and/or cut-off applications with a relatively uniform strength and permeability.

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CHALLENGES	GROUTING									GROUND IMPROVEMENT											DEEP FOUNDATIONS										EARTH RETENTION											GROUNDWATER CONTROL					
SOLUTIONS	Compensation (fracture) grouting	Crack injection	Rock / fissure grouting	Injection systems	Jet grouting	Compaction grouting	Permeation grouting	Slab jacking / structural releveling	Void fill grouting	Cutter soil mixing	Dry soil mixing	Dynamic compaction	Earthquake drains	Mass soil mixing	Rapid impact compaction	Rigid inclusions	Vibro compaction	Vibro Piers®	Vibro replacement (stone columns)	Wet soil mixing	Wick drains (PVDs)	Continuous-flight auger (CFA) or augered cast-in-place (ACIP) piles	Displacement piles	Drilled shafts	Driven piles	Franki piles	Helical (screw) piles	Jacked piles	Load bearing elements (LBE)	Macropiles®	Micropiles	Anchors	Anchor block slope stabilization	Diaphragm walls	Gabion systems	Interlocking pipe pile walls	Micropile slide stabilization system (MS3)	Pit underpinning	Shotcrete	Secant or tangent (contiguous) piles	Sheet piles	Soil nailing	Soldier piles and lagging	Dewatering	Ground freezing	Groundwater treatment	Slurry cutoff trenches	Trenched 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.