Over the past forty years, earth retention technology has evolved from relatively simple methods of temporary shoring for excavation support to complex subterranean reinforcement for permanent stabilization of deep cuts and slopes. When excavations are planned near existing structures, Hayward Baker can employ underpinning techniques to support the adjacent structures.

Better equipment, use of the latest soil and rock anchoring techniques, and innovative use of soil nailing allow cost-effective and safe support of excavations as well as slope stability control. The innovative use of micropiles, often in combination with anchors, to construct walls has proven to be a valuable tool for increasing the factor of safety of landslide prone areas.

Crucial to the successful use of these technologies is a thorough understanding of geotechnical engineering as well as the structural mechanics of the retention system itself. That is why Hayward Baker should be the first company that you call. We are highly experienced in earth retention and are able to apply this experience to complex soil-structure interaction projects.
Ground Anchors

Ground anchors transfer loads using grouted thread bars or strand tendons connected to a structure and bonding into stable soil or rock. These projects are typically for retaining walls, temporary shoring, or other grade separation requirements.

Hayward Baker incorporates ground anchors into structural walls for additional support when required. Other applications include landslide stabilization, resistance of overturning, support of excavations, marine bulkheads, and resistance of vertical uplift. Ground anchors offer a cost-effective solution for either temporary or permanent applications.

Technique

- Drill hole.
- Insert thread bar or strand tendon.
- Grout in place.
- Extract casing (if used).
- Connect anchor head to structure face.
- Post-tension.

Geotechnical Considerations

Suitable soil or rock in which to bond the anchors beyond any instability on failure plane must be identified.

Structural Retaining Walls

Hayward Baker provides design-build solutions using retaining walls consisting of soldier piles with lagging, sheet piles, secant piles, tangent piles, and diaphragm walls. The structural members resist lateral pressures from the retained soil and adjacent structures and prevent soil raveling. Ground anchors or bracing can be incorporated into the design for additional lateral support. The anchors transfer lateral loads from earth pressures and adjacent structures into competent zones of soil or rock behind the potential failure plane of the retained soil.

Cantilever

Cantilever walls provide lateral earth support solely by the bending and shear strength of the wall and by passive resistance of the soil in which the wall’s vertical elements are embedded.

Braced and Anchored

Internally braced lateral support can be provided by bracing with rakers into the excavation base to deadmen or by bracing with struts between adjacent walls.

Anchored walls resist lateral forces by incorporating ground anchors. The face of the wall may consist of soldier piles and lagging, sheet piles, secant piles, tangent piles, or a diaphragm wall. The anchors may be installed as coupled bars or coiled strands to minimize access requirements.

Applications of Braced and Anchored Walls

- When lateral earth pressures are high and/or minimal passive soil resistance is available.
- Wall heights exceeding 12 to 15 feet in most soil types.
- Limiting wall deflection and ground movement behind the wall is critical.

Design Considerations

- Consider soil conditions and temporary and permanent water tables when selecting wall types.
- Design wall and lateral support for allowable deflection, especially if adjacent structures or utilities are present.

Design/Build

Hayward Baker offers complete design-build services for all of our earth retention systems. Advanced 3D modeling software assists with efficient design on the complex projects, enabling avoidance of subsurface conflicts between existing or planned structures.

3D CAD modeling was undertaken to avoid conflicts between soldier piles, grouted tiebacks, soil nails, and existing active utilities at the Calumet Water Reclamation Plant in Chicago, IL.
Hayward Baker installed an anchored soldier pile and lagging wall for excavation support for construction of the new Ernie Davis Hall at Syracuse University in Syracuse, NY.

Jet grouting created this internally braced secant pile wall for a WWTP addition in Providence, RI.

Hayward Baker installed four levels of permanent ground anchors to support a diaphragm wall excavation for the construction of the Elm Road Generation Station Pump House in Oak Creek, WI.

- Consider if wall will be a part of the permanent structure when selecting type and corrosion protection.
- Consider global stability, as with all walls.

**Technique**

**Soldier Piles & Lagging**
- Drive steel H-sections or pipe piles with a vibratory or impact hammer, or insert into predrilled holes along planned excavation limits.
- Insert timber, concrete, or steel lagging between piles as excavation proceeds.

**Sheet Pile Walls**
- Drive with a vibratory or impact hammer or press interlocking steel sheets along panned excavation limits or seawall alignment.

**Secant or Tangent Pile Walls**
- Install overlapping or adjacent drilled shafts, jet grouted solicrete or soil mix columns, or augercast piles along excavation limits.
- Stiff walls.

**Structural Slurry Walls**
- Excavate slurry-filled trench.
- Upon reaching design depth, replace slurry with reinforced concrete.
- Stiff walls.
- Generally offered through our sister company, Case Foundation Company.

**Advantages**
- Speedy excavation for project schedule acceleration.
- Effective in wide variety of subsurface conditions and work environments.
- Sheet pile, secant pile, and structural slurry walls provide ground water control.
- Variety of systems can be installed without vibration.
Grouted Soil Walls

Grouted soil walls are created by cementing soil particles together in situ. Excavation can proceed once the grouted soil has cured sufficiently. Grouted soils can be formed beneath existing foundations to provide underpinning as well as excavation support.

The two primary methods of creating grouted soil walls are jet grouting and soil mixing. These methods mix the binder and soil in situ to create soilcrete. Permeation grouting can also be used to inject chemical grout or cement grout into soils. All of these methods are suitable for vibration-sensitive sites.

Applications

Jet Grouting, Permeation Grouting
- When internal bracing is able to be avoided, it speeds up the excavation process.
- Restricted access construction, inside and outside.
- Grouting around in situ obstructions.
- Underpinning structures adjacent to excavations.
- Enhance or complete other retention systems where utilities interfere with their installation.

Jet Grouting, Soil Mixing
- When internal bracing is able to be avoided, it speeds up the excavation process.
- Increase slope stability.
- Mitigate lateral spreading.
- Construct rings of columns that support access shafts, once excavated.
- When the columns toe into an impermeable layer or when a jet grout bottom seal is constructed, ground water control is provided so excavation can be completed in the “dry.”

Design Considerations

With each soil wall grouting technique, care must be taken when laying out the mixing and injection locations to ensure that the required soilcrete geometry is achieved.

Ground anchors or internal bracing can be incorporated into grouted walls if required, for lateral support.

Jet Grouting and Soil Mixing
- Can be performed in most soils.
- Soil gradation affects binder selection and dosage as well as final soilcrete strength.
- A laboratory mix design using the soil from the site is often performed prior to final soil mix design.

Permeation Grout
- Can only be used in granular soils with low fines content.
Techniques

Jet Grouting
- High-velocity jets erode and blend in situ soils with grout slurry.
- Process initiated at bottom of planned column depth.
- Consistent, uniform rotation and lifting.
- Overlapped soilcrete columns form wall.

Wet Soil Mixing
- Advance drill rod while injecting cement slurry grout through mixing paddles.
- Overlapped soil mix columns form wall.

Trench Remixing Deep (TRD) Walls
- Innovative deep soil mixing method.
- Uses vertical chainsaw-like mixing tool.
- Simultaneously cut and mix in place without open trench.
- Creates high-quality wall up to 170 feet deep.
- Operable where other methods would be exceedingly difficult.

Permeation Grout Walls
- Grout injected into granular soils through ports along sleeve port pipes for accurate placement.
- Grout cements the soil particles together.
- Spheres of grouted soil overlap to create the required geometry.

Advantages

Jet Grouting and Permeation Grouting
- Effective and safe methods of direct underpinning of structures and utilities.
- Can double as earth retention/excavation support system.
- Suitable for open or restricted access.
- Targeted treatment of specific depth intervals possible.
- No harmful vibrations imparted to surrounding structures.
- Permeation grouting produces no appreciable waste.

Soil Mixing
- Suitable for nearly all soil types.
- No harmful vibrations imparted to surrounding structures.
Soil Nail Walls

Soil nail walls utilize patterns of soil nails installed across the face of a cut or a slope to provide stabilization and earth retention. Soil nails are passive, tension-resisting steel elements installed in the ground to create a reinforced soil mass that provides lateral support. The completed wall face can follow the existing curvature of the soil mass for an aesthetically pleasing appearance.

Drainage systems are incorporated into the soil nailed wall, reducing hydrostatic pressure and preventing saturation of the reinforced ground. Drainage systems often utilized are geotextile faced drain board, drilled-in-place relief wells, and slotted plastic collection piping. Surface drainage control above and behind the retaining wall is also critical to the system.

Applications
- Embankment stabilization.
- Temporary and permanent excavation support/retaining walls.
- Where some movement can be tolerated.
- Above the water table.
- Retaining wall repair.

Design Considerations
- Suitable for firm clays, heterogeneous and stratified soils, weathered rock, and talus slope deposits.
- Not practical in very soft clays, organics/peat, cohesionless soils, low density and/or saturated soils, certain fills (rubble, cinder, ash, etc.).
- Since limited movement of the retained soil occurs during excavation, consideration must be given to adjacent structures.
- Drainage.

Installation
- Excavate 3 to 6 feet of soil.
- Drill near-horizontal holes into exposed face, typically on 3- to 6-foot centers.
- Place grout and steel bar.
- Install drainage system on exposed face.
- Install facing, typically reinforced shotcrete.
- Fix bearing plates.
- Repeat process until design wall depth is reached.
- Apply second coating of shotcrete for aesthetics and corrosion protection of permanent wall, if desired.

Advantages
- Cost effective.
- Versatile.
- Easily constructed over curved faces and in restricted access.

When the original segmental block retaining wall failed, Hayward Baker constructed a soil nail and anchor remediation with an attached new mechanically stabilized earth face preserving the look of the original wall, in Tallahassee, FL.

Soil nails and shotcrete stabilized 5,000 square feet of a failing MSE wall behind apartment buildings in Owings Mills, MD.

Completed soil nail wall with shotcrete facing for temporary excavation support at the Patewood Medical Center in Greenville, SC.
Soil Nail Installation Sequence

1. Excavate
2. Drill
3. Insert nail and grout
4. Drainage board and reinforcement
5. Shotcrete, then repeat 1 through 5

Completed Soil Nail Walls

- This stained shotcrete facing over permanent soil nails covered 14,000 square feet to remediate failing timber cross-tie retaining walls near residences in Atlanta, GA.
- This 3,300-square-foot permanent shotcrete faced soil nail wall was constructed on the property line to support a sidewalk and highway immediately adjacent to the site of a new drugstore in Dayton, TN.
- Soil nail wall covering 3,600 square feet to provide earth retention for a new ramp for the Marquette Interchange in Milwaukee, WI. Permanent concrete face was cast against the soil nail wall.

This completed soil nail wall with shotcrete facing provided permanent excavation support once faced with concrete for the Dallas Cowboys Stadium in Arlington, TX.
Anchored Reaction Block Walls

Anchored reaction block walls consist of discrete, anchored concrete blocks placed in a pattern on a slope to increase the slope stability. The blocks act with the soil to resist the movement of the surrounding soil.

Applications
- Landslide stabilization.
- Slope stability control.
- Repair of damaged or failing retaining walls.

Design Considerations
- Identify failure plane location.
- Identify suitable soil or rock for stable anchor bonding.
- Determine anchor forces by calculating driving and resisting forces by means of a global stability analysis.
- The blocks are typically 5 feet by 5 feet to 12 feet by 12 feet, depending on the allowable bearing pressure of the soils.
- Depending on wall height, multiple rows of reaction blocks at different elevations may be required.

Technique
Multiple levels of anchored blocks are stepped to stabilize slopes, or are installed across the face of existing retaining walls for remediation.
- Excavate along slope to facilitate equipment access, if necessary.

Initially, a costly anchored sheet pile wall was designed to permanently stabilize this 250-foot-long, 50-foot-high cut slope in Montgomery, NY (top and above). Hayward Baker designed and constructed a value-engineered alternative consisting of 43 anchored reaction blocks at three elevations for permanent stabilization.

Drilling high-capacity ground anchors through the reaction blocks at the US-61 South permanent slope stabilization project near Vicksburg, MS.
Place precast concrete or cast-in-place reaction block.

Drill anchor hole, insert anchor tendon, and grout anchor.

Tension anchor after grout cures.

**Advantages**

- Cost-saving solution for landslide repair and slope stability control.
- Can be designed for permanent or temporary support.
- Crane-mounted equipment can reach even the most difficult access slopes.

Hayward Baker designed and constructed 354 anchored reaction blocks to repair three failing MSE walls behind a shopping complex in Hoover, AL (above). Access was via suspended drilling and work platforms (top). The tieback anchors averaged 110 feet long, each with a design capacity of 300 kips.

Left and above: After a landslide closed US-6 in April 2008, the Colorado DOT contracted Hayward Baker to repair the landslide and stabilize the slope between I-70 and US-6. Hayward Baker installed 285 anchors, each with a capacity of 140 kips with pre-cast anchor blocks on five bench levels. The anchor work was completed almost a month ahead of schedule.
The micropile slide stabilization system (MS³) is typically a slope stabilization system as opposed to an excavation support system. MS³ retains soil by connecting an array of drilled and grouted micropiles, sometimes in combination with ground anchors, to a reinforced concrete beam constructed near the ground surface. Acting in tension and compression, the micropiles effectively create an integral, stabilized ground reinforcement system capable of resisting driving forces in the slope that could otherwise cause instability or failure.

**Applications**
- Landslide stabilization.
- Side hill fill stabilization.
- Ideal for sites with limited access and/or restricted right-of-ways or creeping slopes, such as with highway cuts and remediation.

**Design Considerations**
- The wall should be placed near the midpoint of the failing mass.
- The landslide failure plane should typically be less than 50 feet in depth.
- Access required to reach the approximate midpoint of the failing slope with personnel and equipment.
- Some walls may also require tieback anchors to be installed and stressed against the concrete cap if landslide forces are large.
- Sequencing of pile and tieback installation is important.

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Section view (above) of MS³ walls Hayward Baker constructed to permanently repair a 300-foot-wide unstable soil mass extending from a section of Highway 26-89 down to Snake River in Alpine, WY (top).

Hayward Baker constructed 300 linear feet of MS³ wall to stabilize the slope behind this resort development in Bridgetown, Barbados.
Technique
- Construct concrete beam near ground surface. While it is typical to construct the concrete beam first, it may also be constructed after micropile installation.
- Drill angled micropiles in a fanned array through the beam and into competent stratum.
- Grout the micropiles.
- Install ground anchors through concrete beam for increased lateral resistance, if required.

Advantages
- Micropiles are constructible in any soil type.
- Minimal excavation and environmental impact.
- Visibility of finished MS³ wall is little to none.
- Constructed without vibration.

Quality Assurance/Quality Control

Quality control is an integral part of any Hayward Baker project.

Quality control begins with procedural inspection and documentation. Installation location and inclination are accurately performed, measured, and documented, as well are injection volumes, rates, and pressures. In certain situations, proprietary equipment and software allow for real-time monitoring of installation parameters during construction.

Material testing may include grout, soilcrete, concrete, or shotcrete samples collected on a regular basis for independent laboratory testing for strength, homogeneity, or permeability if applicable. Corrosion protection of steel elements ensures long-term performance of permanent works.

Anchor performance and proof testing follow industry accepted Post-Tensioning Institute test criteria. All anchors are proof tested while selected anchors receive performance tests. Micropile design capacities may be verified by full-scale load testing on production piles or on sacrificial test piles.

When required, inclinometers and optical surveys of fixed targets are installed to monitor vertical and lateral movements.
Advantages of a Hayward Baker Earth Retention System

- Full design/build service.
- Suitable for restricted access.
- Rapid mobilization.
- Fast excavation for project schedule acceleration.
- Wide range of options results in cost-effective design.
- Temporary or permanent systems available.
- If required, Hayward Baker can also provide a full range of underpinning techniques.

Why Should You Choose Hayward Baker’s Earth Retention?

As North America’s largest geotechnical contractor, Hayward Baker has the resources to build your project efficiently, and at a competitive price. Our network of offices and full-service equipment yards means fast mobilization and reduced start-up costs. Our dedication to quality control ensures that project specifications are achieved. We customize and design our equipment and tooling, ensuring that performance and reliability are the best in the industry.

Hayward Baker has the experience and innovation to assist engineers, contractors, and owners with identifying, developing, and implementing the best earth retention system, whether the situation is typical or unique.