Construction and Quality Control Manual

Reinforced Earth® MSE Retaining Wall System – Square Concrete Facing Panels and Steel Soil Reinforcements

Version v2025.1

CONTENTS

PREFACE

This Construction and Quality Control Procedures Manual has been prepared as a guide in building Reinforced Earth® Mechanically Stabilized Earth (MSE) wall structures.

Its contents should be thoroughly reviewed by the Contractor and the superintendent responsible for construction prior to the delivery of Reinforced Earth materials to the job site.

Geoquest USA, Inc. (formerly The Reinforced Earth Company) will provide construction advisors to assist the Contractor in the implementation of correct construction procedures. However, in the event of any conflict between the Plans, Specifications or Contract Documents and this Manual, the former will prevail. If there is any doubt with regard to any aspect of Reinforced Earth construction, contact **Geoquest USA** before commencing or continuing work.

Compliance with the guidelines in this Manual does not relieve the Contractor of the responsibility to adhere to the project Plans, Specifications and Contract Documents, or for complying with all safety standards and procedures, including fall protection, at the job site.

NON-DISCLOSURE NOTICE AND DISCLAIMER

1. This Document is the property of **Geoquest USA, Inc. (formerly The Reinforced Earth Company)** and contains information which is proprietary to **Geoquest USA**, including the patented process and techniques relating to mechanically stabilized earth (MSE) structures known as "Reinforced Earth" structures.

2. This Document is being made available solely for use in connection with your interest or participation in the proposed Reinforced Earth project, and for no other purpose.

3. Except as specified in paragraph 2 above you must not, without the prior express written consent of **Geoquest USA**, use any of the information contained in the Document whether to construct, design, manufacture, fabricate, assemble, produce or install, or otherwise utilize - or cause the same or any of them to be done - any elements of Reinforced Earth (whether or not patented), or special forms of equipment unique to the production, manufacture, fabrication, assembly, installation, or utilization of Reinforced Earth, or for any other purpose.

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5. Receipt of Document gives no entitlement to any property right in the Document or in the information contained therein by virtue of the temporary supply of the Document in accordance herewith.

6. Reinforced Earth structures designed by **Geoquest USA** comprise or are based solely upon:

    a. The internal stability of the Reinforced Earth structure based upon the design assumptions noted on all **Geoquest USA** drawings relating to the structure and the external loads, surcharges and site geometries supplied by or on behalf of the Owner.

    b. The layout and geometry of the structure based upon survey details, plans and drawings supplied by or on behalf of the Owner.

    c. The Job Specifications.

    The design does not include a check of the overall stability of the foundation soils below and behind the structure, or a check of any potential failure planes external to the structure, or a check of the stability of any permanent or temporary slopes above or below the wall or temporary excavations. Based on the completeness and accuracy of the above information used or relied upon in designing the structure, **Geoquest USA** is responsible for the internal stability of the structure only.

7. Upon demand, the Document and all copies thereof must be immediately surrendered and returned to **Geoquest USA**.

SAFETY BULLETIN

Safety reminder for Reinforced Earth Panel Installation:

Please review the Reinforced Earth Construction Manual carefully and practice safety in all aspects of handling and installing Reinforced Earth wall materials. The following provides important safety reminders when handling and installing wall panels:

1. Panels at the levelling pad course should be externally braced as shown in the construction manual upon installation and before additional panels are installed.

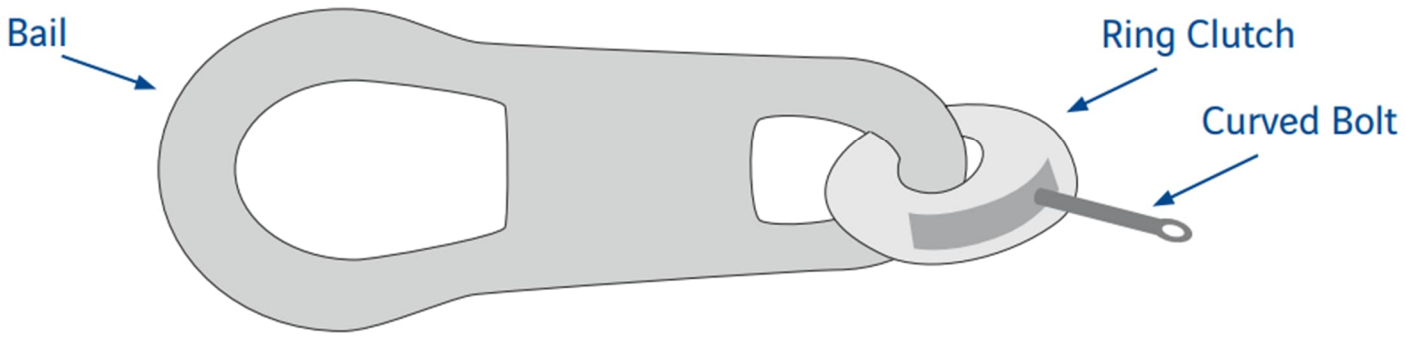
2. Panels must remain attached to lifting equipment until such time as external bracing, wedges and shoulder clamps are in place and secured.

3. All subsequent panels must remain attached to the lifting equipment until alignment adjustments have been made and wedges and clamps have been installed and secured.

4. Cut panels adjacent to a cast-in-place structure require special attention. Bracing, wedging and clamping is required before releasing the panel from the lifting equipment. Timber or steel angle can be anchored to the vertical surface of the adjacent cast-in-place structure and then the cut panel can be wedged and clamped to the secured timber or angle.

5. The last panel at the free end of wall should be externally braced on the free end as well as secured with wedges and a clamp to the adjacent panel.

PROPER POSITIONING OF RING CLUTCH FOR LIFTING PRECAST PANELS



To ensure that the ring clutch properly engages the anchor, position the ring clutch so that the bail is **ABOVE** the clutch. When lifting, **DO NOT** pull towards the panel.

INTRODUCTION

Reinforced Earth® is a composite material formed by the association of a frictional soil and reinforcing strips. In concept, it is like reinforced concrete; that is, Reinforced Earth is an economical means of improving the mechanical properties of a basic material, earth, by reinforcing it with another.

Reinforced Earth is a concrete faced MSE wall system, using steel strip soil reinforcements.

Stresses produced within the soil mass are resisted by the strips; stresses are transferred to the strips by friction.

A Reinforced Earth structure constructed using this material is shown as the "reinforced volume" in Figure 1. Precast concrete panels are used at the face of the reinforced volume to prevent erosion of the backfill and to provide an attractive, finished appearance.

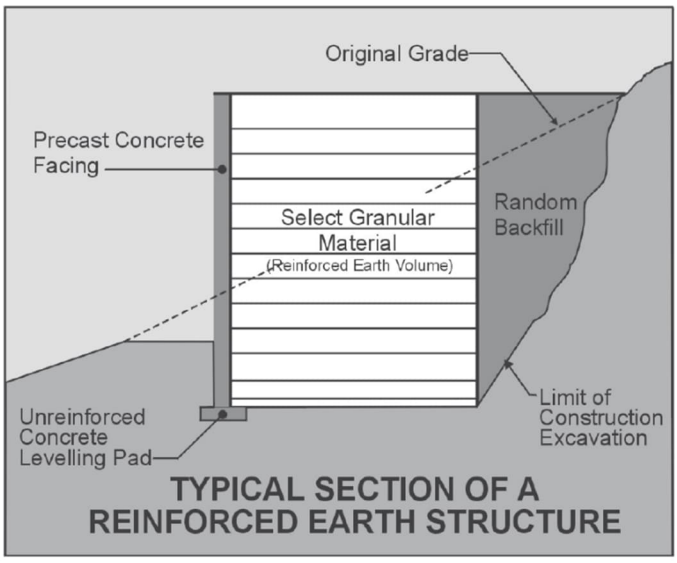


Figure 1: Reinforced Earth Typical wall section.

A. PURPOSE

This document is intended to provide the Owner, Contractor, Engineer, and the inspection staff - those who are responsible for overall quality control and inspection during construction - with the criteria necessary to monitor the erection of Reinforced Earth structures for compliance with the Plans, Specifications, and Contract Documents.

B. RESPONSIBILITIES

It is the Contractor's responsibility to complete construction in strict accordance with the Plans, Specifications, and Contract Documents. To assist the Contractor in this regard, **Geoquest USA** provides recommended erection procedures in the Procedures Manual. Nothing in this document is intended to relieve the Contractor of the responsibility of complying with all safety standards and procedures, including fall protection, at the job site.

It is the responsibility of the Geotechnical Engineer to determine and verify the global stability; bearing capacity; primary, secondary and differential settlement of the foundation soils.

The Contractor and Owner should verify that the Erecting Contractor's on-site personnel are in possession of and are familiar with the recommendations of this Procedures Manual.

Technical Advisors from **Geoquest USA** may assist the Contractor with material scheduling and coordination, and provide advice on the recommended construction procedures for Reinforced Earth structures as set out in this Manual. Technical Advisors are available on-site during initial construction and thereafter on a request basis.

Technical Advisors are not available on-site on a full-time basis, and are not provided with the intent of replacing the Owner's and Contractor's designated quality control and/or inspection staff.

Only the Engineer can enforce the requirements of the Plans, Specifications, and Contract Documents.

C. PLANS, SPECIFICATIONS, LAYOUT

1. Prior to commencing any site work, the Contractor should verify that the latest issue of the Plans, Specifications, and Contract

Documents, approved for construction, are being used to build the Work**.**

2. The Contractor should also confirm that the Work is being constructed at the proper location by verifying line, grade, offset, and other location criteria.

D. COMPONENTS

Reinforced Earth structures consist of the following four components:

Concrete Leveling Pad
A cast-in-place or precast unreinforced concrete leveling pad serves as a smooth, level surface for placing panels. Generally this pad is 6" thick and 12" wide. Refer to the Plans and Specifications for dimensions and requirements.

Precast Concrete Facing Panels

- Full-size – or A_n – panels are used for the majority of the structure. The subscript "n" in panel designations indicates the number of reinforcing strip connections or tie strips on each panel. Field cut or bent panels (by contractor) as required by the geometry of the structure.
- Half-size – or B_n – panels are alternately used in the initial course with the full-size panels. P_n and Qn panels may also be used on the initial course. Top-course panels are designated C_n, D_n, E_n, F_n, G_n, H_n, K_n, and L_n panels. These panels all have a flat top.

Specifically cut, bent, or sloping panels as required by the geometry of the structure.

Facing Panel Joint Materials

- Rubber Bearing pads are placed in the horizontal joints throughout the structure to prevent concrete to concrete contact. Rubber shims are used as needed to adjust for minor variations in panel height.
- Geotextile is applied with adhesive to the backfill side of the panels to cover all the horizontal and vertical panel joints.

Reinforcing Strips

- Ribbed strips are supplied in a 50-mm (2.0-in.) width and varying lengths as required by the design of the structure.
- High Adherence (HA) ladder strips are supplied in 100-mm (4in.) width and varying length as required by the design of the structure.

Both types of reinforcing strips are either galvanized for permanent applications or black steel for temporary applications.

Fasteners
During construction, reinforcing strips are fastened to tie strip connections embedded in the back of each facing panel using ½ in diameter bolts, washers and nuts made of galvanized structural steel.

Select Granular Backfill
Backfill conforming to Contract Specifications must be used within the reinforced volume.

E. MATERIALS AND SERVICES PROVIDED BY GEOQUEST USA

- Layout and internal stability design of the Reinforced Earth structure.
- Precast concrete facing panels.
- Horizontal and vertical joint material, with adhesive.
- Reinforcing strips.
- Bearing pads and shims.
- Structural bolts, nuts, and washers.
- One set of panel lifting devices.
- Delivery of **Geoquest USA** furnished materials to the site (F.O.B.), with two hours of time allowed for unloading.
- Initial on-site technical assistance.

Reinforcing strips, bolt sets, geotextile, adhesive, bearing pads, and other special items provided by **Geoquest USA** are bundled and packed to minimize damage in unloading and handling.

Certificates of compliance with project specifications for all materials are furnished by **Geoquest USA.** However, it is the Contractor's responsibility to verify that all materials received at the job site are in accordance with shipping documents and project requirements. Any discrepancies should be reported immediately to **Geoquest USA**.

Materials should be thoroughly inspected upon delivery to the job site. Any damaged items should be set aside, and Geoquest USA notified immediately. Materials should be handled and stored to prevent damage or theft. Geotextile must be stored in a sheltered location and protected from sunlight. Adhesive must be stored in a dry location and protected from the elements.

To prevent construction delays, the Contractor should continuously monitor the quantity of materials on hand to ensure an adequate supply consistent with the Plans, Specifications, and Contract Documents.

F. EQUIPMENT, WORK, MATERIALS AND TOOLS SUPPLIED BY CONTRACTOR

Materials and equipment supplied by the Contractor:

- Panel lifting – a hydraulic crane, boom truck or similar equipment is required. A standard 5 ½ in. thick A_n facing panel weighs 1,700 lbs. A 7 ½ in. thick A_n panel weighs 2,100 lbs. Panels with architectural finish may be heavier. Consult the Plans or contact **Geoquest USA** for the weight of other panel types.
- Backfilling - Dump trucks, scrapers, dozers, graders, front-end loaders, water trucks, etc. are used for hauling, dumping and spreading backfill (Specific equipment selection will depend on backfill, lift thickness, compaction specifications, etc.).
- Compaction - Large smooth-drum vibratory rollers are used for mass compaction of most backfills. Fine uniform sands are compacted using a smooth-drum static roller.
- Small walk-behind vibrating rollers or flat-plate compactors are needed for compaction within 3 ft. of the wire facing panels.
- Clamps – one per vertical joint for the length of the structure under construction. Additional clamps will be needed to brace the initial course of panels (Figure 2 and Figure 3).
- Wooden wedges in a quantity at least sufficient to provide 4 to 6 wedges per vertical joint for the length of the structure under construction (Figure 4).
- Wooden spacers, 3/4-in. (Figure 5).
- Nylon slings for unloading panel stacks.
- Lumber for the initial course of panels.
- Crowbars (pinch bars) – 24 in. to 30 in.
- A 4-ft. carpenter level.
- Wrenches or socket sets (7/8 in.)
- Claw hammers and 16 penny duplex nails.
- A sledge hammer.
- Chalk line.
- Brooms or brushes.
- A plumb bob.
- Equal length cables with shackles to connect panel lifting devices.
- Large size caulking gun for 2-lb tubes.
- Survey equipment.

Summary of Work Performed by Contractor

- Site preparation including excavation and installation of drainage systems as required.
- Forming and pouring concrete leveling pads.
- Mark wall layout line on leveling pads.
- Construction of the Reinforced Earth structure consisting of the erection and positioning facing panels, installation of joint materials, connection of reinforcing strips, and placement and compaction of Select Granular Backfill.
- Placement of any concrete coping, traffic barrier, or other C.I.P. concrete as required.
- Design and installation of fall protection systems.

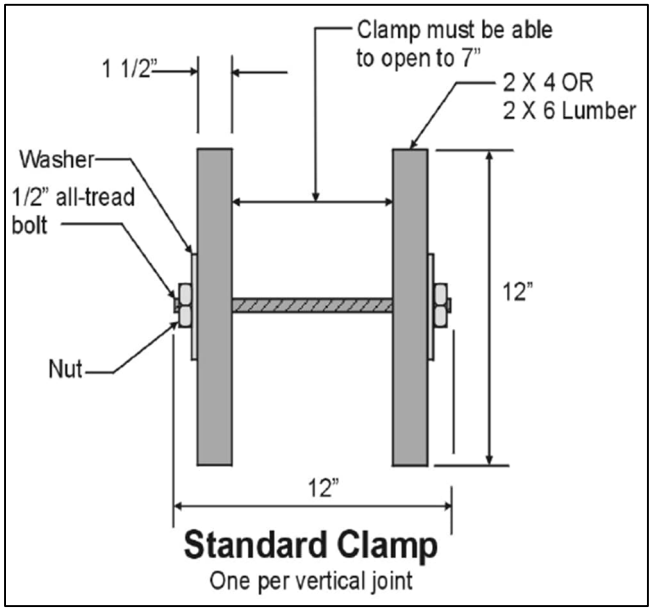


Figure 2: Standard clamp.

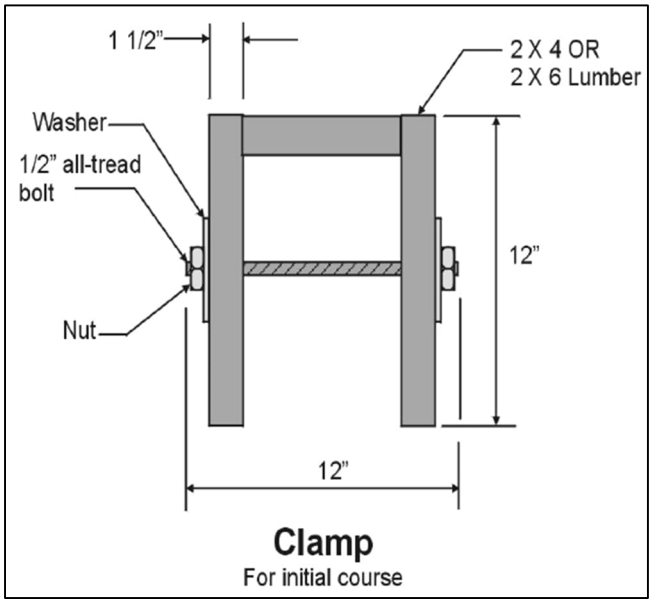


Figure 3: Clamp for initial panel course.

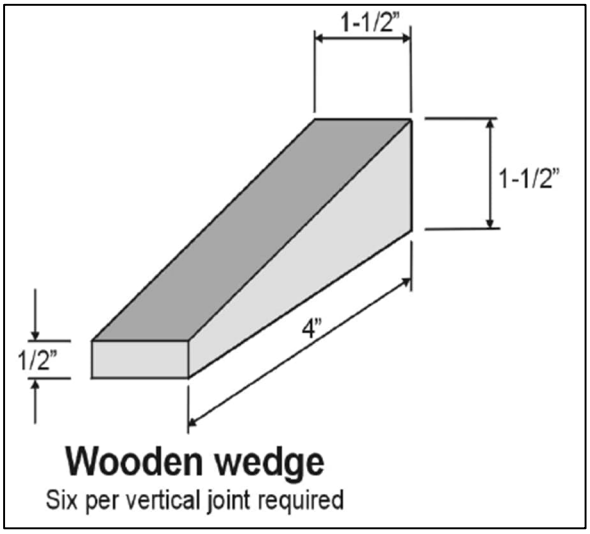


Figure 4: Wooden wedge.

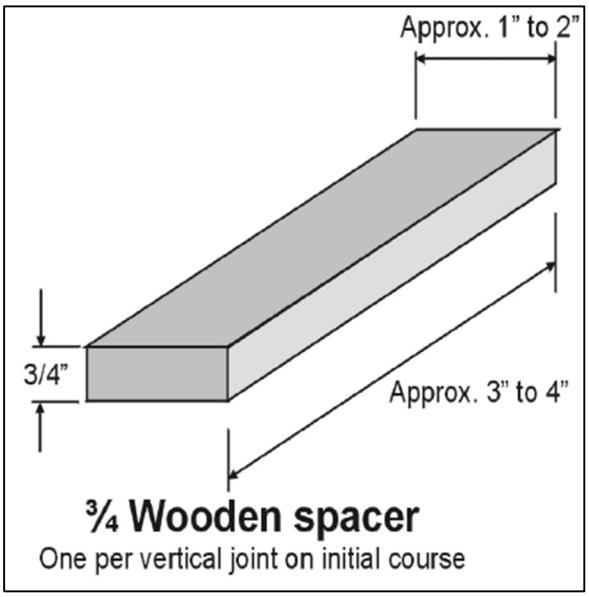


Figure 5: Wooden spacer.

HANDLING REINFORCED EARTH MATERIALS

A. CONCRETE FACING PANELS

Panel delivery: Prior to the start of construction, the Contractor should establish a facing panel delivery schedule which will allow **Geoquest USA’s** operations group to match its facing manufacturing/delivery output to the Contractor's

construction schedule.

Panels are usually delivered on flatbed trailers in stacks of 4 or 5 panels high. The delivery point is made as close to the structure as a truck can be driven under its own power.

Unloading facing panels: Under normal conditions, a two-hour period is allowed per delivery for panel unloading. In this time, panels may be placed directly onto the structure being constructed or temporarily stacked following either of these methods:

- By using lifting devices to lift and handle individual panels (Figure 6) OR
- By using nylon strings to lift and handle individual panels or stacks of panels (Figure 7).

Care must be taken to protect facing panels from damage during handling and storage.

Panels can be stored at the job site by re-stacking. Select a location with firm, level ground for both stability and to protect panels from staining. Carefully lift and place each panel face down on the nylon pads of the dunnage. Stacks should be no more than 5 panels high with dunnage used between each panel as illustrated below.

Note: All dunnage and pallets remain the property of Geoquest USA. They should be stacked and made available for pick-up as soon as they are no longer needed for panel storage.

Figure 6: Lifting devices for handling individual panels.

Figure 7: Lifting devices for handling individual panels.

Never re-stack panels without dunnage. Never place panels face down directly on the ground. Never stand panels up on end.

Panel storage: Panels should be securely set and blocked on firm, level ground to prevent damage and staining during storage.

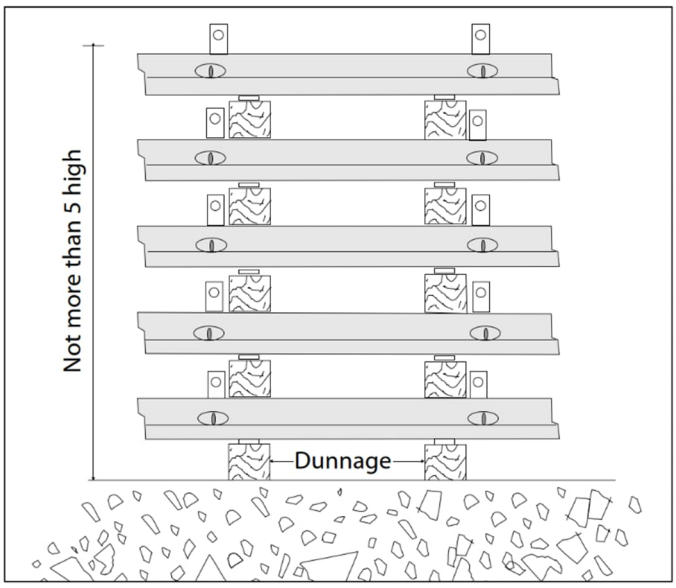


Figure 8: Panels re-stacked on site.

Figure 9: Reinforcing strip bundles stored on site.

B. REINFORCING STRIPS, FASTENERS, AND JOINT MATERIALS

Reinforcing Strips: Strips may be up to 32 ft. long and are delivered to the site in bundles of 25 each. Each bundle weighs approximately 30 lbs. per linear ft. Storage in the open is acceptable but bundles should not be placed directly on the ground.

High-Adherence (HA) Ladder Reinforcing Strips: Alternate reinforcement type if noted in the Plans.

Figure 10: HA Ladder reinforcing strips stored on site.

Fasteners: Sets of 500 bolts, washers, and nuts are packed in containers, each weighing 125 lbs.

Bearing Pads: Rubber bearing pads are packed in cartons each weighing 50 to 75 lbs.

Figure 11: Fasteners and bearing pads.

Geotextile: Geotextile is supplied in 12-inch or 18-inch-wide rolls. Adhesive for geotextile is supplied in appropriate containers. Foam strips (if required) are supplied in plastic bags, each containing up to 100 of the 2x2-in., 7 to 9-ft. strips. In addition to normal security, Geotextile and foam must be stored in a sheltered location, protected from sunlight.

Figure 12: Geotextile rolls.

Figure 13: Adhesive

CONSTRUCTION PROCEDURES

BASIC CONSTRUCTION SEQUENCE

The basic construction sequence for a Reinforced Earth structure can be summarized in these steps:

- Prepare the site including excavation, proof-rolling and installation of drainage systems if required.
- Survey and stake out wall location.
- Form and pour leveling pad.
- Set and brace the initial course of facing panels, which consists of alternating half and full-height panels.
- Use wooden wedges and clamps to hold panels in position.
- Attach geotextile with adhesive.
- Spread and compact backfill in lifts (10” max) up to 1 or 2 in. above the lowest level of panel tie strips.
- Connect reinforcing strips to panel tie strips.
- Spread and compact backfill in lifts to within 3 or 5 in. of the top of the half panels.
- Place bearing pads and set the second course of full panels.
- Repeat cycle of backfilling and compacting in lifts, connecting reinforcing strips, placing geotextile and bearing pads, and setting panels until the design height is reached.

- As each course is completed, remove the wooden wedges from the panels in the course three levels below.
- Set top panels, connect reinforcing strips, and complete backfilling and compaction.
- Remove all wedges and clamps.
- Install concrete coping, traffic barriers, or any C.I.P. concrete as required.

The finished appearance of a Reinforced Earth structure depends to a large extent on the care taken in erecting and positioning facing panels. For this reason, particular attention must be paid to the initial course of facing panels and to backfill placement.

Close attention to detail and accuracy at this point will help ensure trouble free and rapid construction of the remainder of the structure.

ALIGNMENT PROCEDURES

The following panel position and alignment procedures should be reviewed prior to the start of construction.

Lifting, placing and spacing panels: Panels can be lifted from the horizontal, or stacked position, directly to a vertical position by attaching a lifting device to each of the two cast-in-place lifting inserts at the top edge of the panel (see HANDLING REINFORCED EARTH MATERIALS). Use dunnage as blocking to prevent damage as each panel rotates from horizontal to vertical (see figure below).

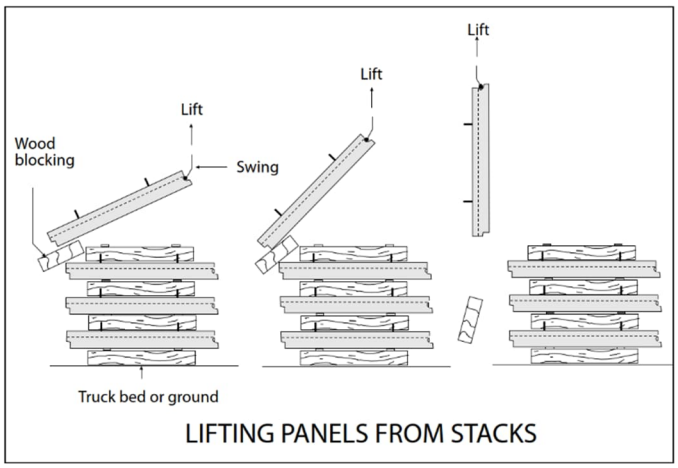


Figure 14: Lifting panels from a stack.

As each panel is lowered into its place in the structure, use the ¾" wooden spacer to achieve approximately a ¾" joint (see figure below).

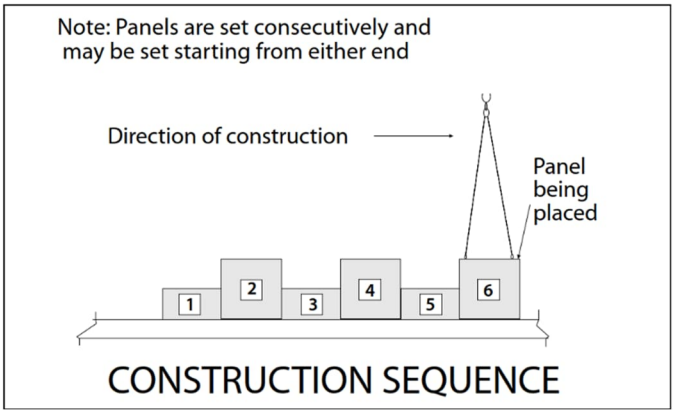


Figure 15: Use of spacer block to set panel spacing.

Check alignment: Visually check the alignment of each panel in relation to either the control line on the leveling pad for the initial course of panels or to the panel below in subsequent courses. Make adjustments with a crowbar on the fill sides of the panel (see figure below) so that the surfaces of successive panel courses are aligned. Do not attempt to adjust the panel by using the crowbar on the front side, which can result in unacceptable chipping or spalling.

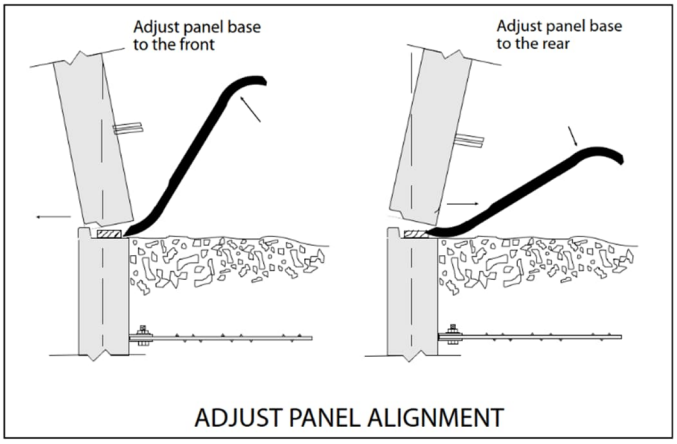


Figure 16: Adjusting panel alignment

Check horizontal level: The horizontal level of each panel should be checked and adjusted in order to assure a uniform appearance and even joints throughout the structure. Small rubber shims are provided to aid in leveling the panels.

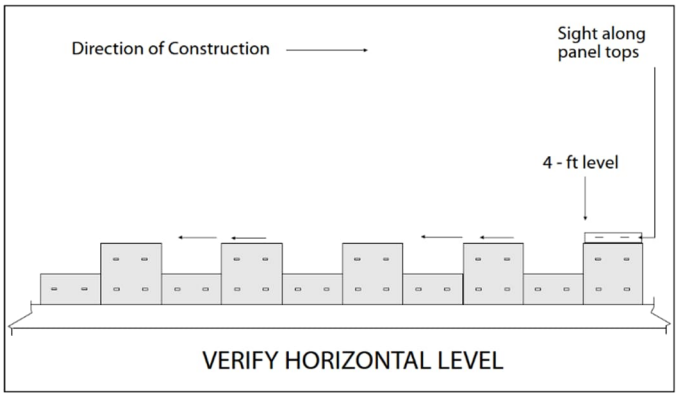


Figure 17: Verify horizontal level

As shown in the above figure, use a 4-ft. level to verify that the new panel is level. Then sight back along the tops of the panels to ensure that the new panel is at the elevation of the others in its course.

Correct any variations by lifting the panel slightly and inserting rubber shims in the horizontal joint at the panel base. Recheck the horizontal spacing and alignment after any such adjustment.

Set batter: Panels must be given a slight batter, or tilt, toward the backfill in order to compensate for a subsequent outward movement, which occurs during backfill placement and compaction. This movement will tend to push the panel to a true vertical position. Measure batter using a 4-ft. level. See the figure below.

Figure 18: Set panel batter

Set the batter by pulling back on the top of the panel from the fill side. To maintain the batter, drive one wooden wedge from the face of the structure into each of the short horizontal panel joints at the shoulder of the panel and clamp the panel to the adjacent panels (see Erecting the Initial Panel Course).

The wooden wedges should remain in place during the erection of three subsequent courses but must be promptly removed. If wedges are left in place for more than three courses, removal will be diffi cult and spalling can occur.

The amount of batter varies and depends on the type and moisture content of the backfill, required compaction, type of compaction equipment, and length of the reinforcing strips. A batter of ½ in. in 4 ft. is generally used as a starting point. Coarse backfill, such as crushed stone, may require less batter, while fine backfill, such as sand, may require more.

Monitor the actual movement of panels during the placement and compaction of each lift of backfill and adjust the amount of batter according to field conditions.

Vertical Alignment Check: During construction, check the overall verticality of the structure daily using a plumb bob. Make any changes in batter necessary to assure that final verticality is within tolerances (see specifications), in subsequent lifts of panels.

ERECTION TOLERANCES

- The overall vertical alignment tolerance, or plumbness, from top to bottom of the structure, shall not exceed ¾ in. per 10 ft. of height.
- The maximum allowable offset between any two panels shall not exceed 1 in.
- Horizontal and vertical joints should be uniform in appearance.

Vertical and horizontal alignment tolerance, and plumbness, shall not exceed ¾ in. when measured with a 10-ft. straight edge on a selected wall section. Vertical and horizontal alignment should be checked at every course throughout the erection process.

Corrective action should be taken immediately when any of the specified tolerances are exceeded.

DETAILED CONSTRUCTION PROCEDURE

A. FOUNDATION PREPARATION

STEP A-1, Excavation: Excavate the site to the depth and width specified on the Plans for the length of the section to be built. Remove all unsuitable material and replace it, as necessary, with compacted fill as directed by the Engineer.

If required by the Specifications and as directed by the Engineer, proof-roll the foundation to a density suitable for the bearing pressure shown on the Plans.

In the event of an over-excavation of the sub-grade, the gradation, placement, and compaction of replacement material must be approved by the Engineer.

Evaluation and approval of foundation suitability is the responsibility of the Engineer. Any foundation soils found to be unsuitable shall be removed and replaced with material approved by the Engineer. The material shall then be compacted, as directed by the Engineer, to a density suitable for the applied bearing pressure as shown on the Plans, Specifications, and Contract Documents.

Foundation evaluation and control are critical; the behavior and performance of a Reinforced Earth structure is largely dependent upon the foundation on which the reinforced volume is placed.

STEP A-2, Drainage System(s): Install drainage systems as required by the Plans and Specifications or as directed by the Engineer.

STEP A-3, Leveling Pad: An unreinforced smooth finish concrete leveling pad is formed and cast at each foundation elevation. Leveling pads have nominal dimensions of 6 in thick by 1 ft wide and are cast using a minimum 2,000-psi, 28-day compressive strength concrete. Leveling pads should cure for a minimum of 12 hours before the setting of panels.

Leveling pads must be cast to the design elevations as shown on the Plans. The allowable elevation tolerances are +0.01 ft (1/8 in) and –0.02 ft. (1/4 in.) at design elevation.

An improperly placed leveling pad can result in subsequent panel misalignment and decreased wall construction productivity.

If the Plans call for the structure to have a step-up in elevation, pour the higher leveling pad so that its surface is 1.23 or 2.46 ft. above those of the lower pad depending on the Plans. Leave a 12-in. maximum gap between the higher pad and the start of the lower pad at the step-up location (see figure below).

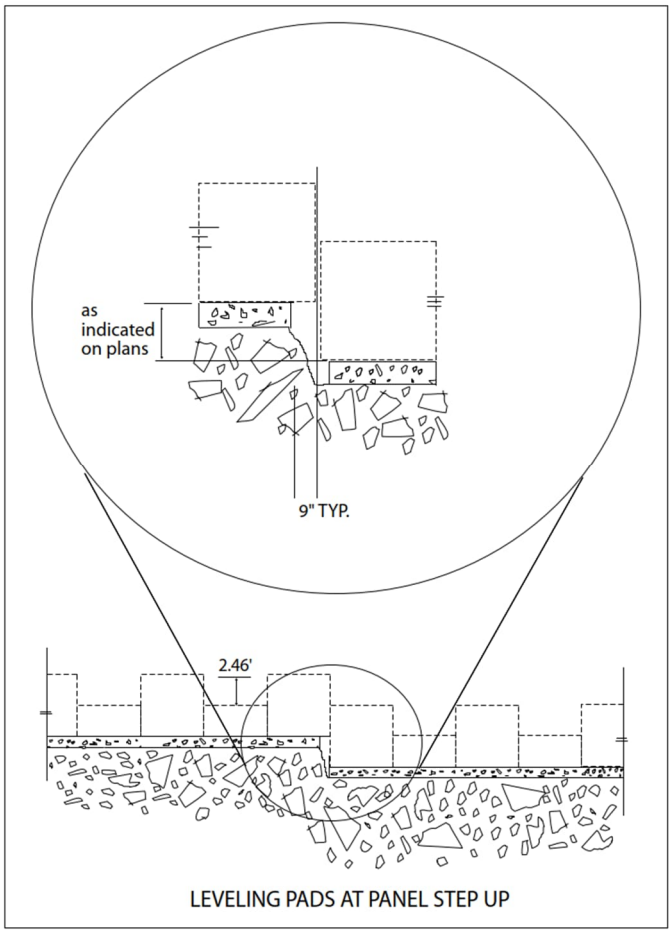


Figure 19: Leveling pad at panel step-up

STEP A-4, Wall Line*:* On the leveling pad, establish a layout line (LOL) for the face of the structure. This may be different than the wall's LOL given in the contract documents.

B. ERECTING THE INITIAL PANEL COURSE

STEP B-1, Panel Placement: Panel layout usually begins at the lowest leveling pad or a fixed point such as a corner or existing structure (see figure below). Place the first B_n (half) panel (1) on the leveling pad. Check the horizontal level and shim as needed. Align the face of the panel along the layout line. Using bracing in addition to wooden wedges at the base of the panel, set the batter for the panel.

Throughout construction it is of utmost importance that the panel type and number of tie strips of each panel match the requirements as shown on the approved Plans.

Bearing pads are not used under the first course of panels between the leveling pad, unless specifically shown on the Plans or separately authorized in writing by **Geoquest USA.** If needed, only rubber shims may be used to shim between the leveling pad and first course of panels. Permanent wood shims are not permitted at any point in the structure.

Brace the initial course of panels by securing an adequate lumber brace to each full height (A or P) bottom panel and to any panel taller than 3ft. External bracing is not required on subsequent courses.

Panels should be free of any surface defects that may occur in transportation, unloading, or storage at the construction site, including:

- Chipped or broken front corners.
- Permanent stains on exposed face.
- A crack in the panel's exposed face.

These panels may be repaired before they are used in the structure.

Any repairs to panels must be completed to the satisfaction of the Engineer.

Panels must be braced as shown in B-3 prior to releasing the crane from the panel.

STEP B-2, Second Panel Placement: Place the second panel (2) on the leveling pad and place a ¾ in. spacer between it and panel (1) (see figure below). These spacers should remain in place until the wall is backfilled to the height of the half size panels. Spacers must be used during panel erection. Spacers are supplied by the Contractor and may be fabricated from any available ¾ in. material.

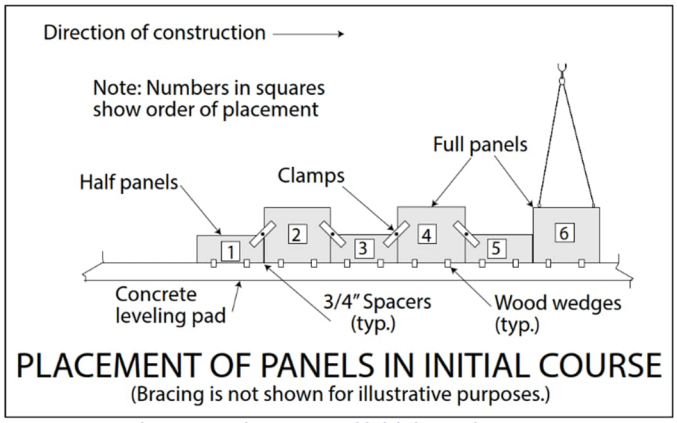


Figure 20: Placement of initial panel course.

STEP B-3, Setting Panel Batter: Set the panel's batter as before. Wooden wedges are used temporarily at the panel shoulders to set batter in the panels. These wedges must be removed once the wall is three panels high. Clamp the panel to panel (1) as shown below. Tighten clamps sufficiently to hold the panel in position without movement.

Brace the initial course of panels by securely attaching an adequate lumber brace to a bracing clamp attached to the top of each full panel and to any panel in excess of 3'-0" in height (see figures below). Bracing is not required on subsequent courses.

Figure 21: Panels secured with a clamp.

Figure 22: Braced initial course of panels.

Bracing must remain in place until the braced panel has all the reinforcing strips attached and the backfill has been placed and compacted up to the top of the braced panel.

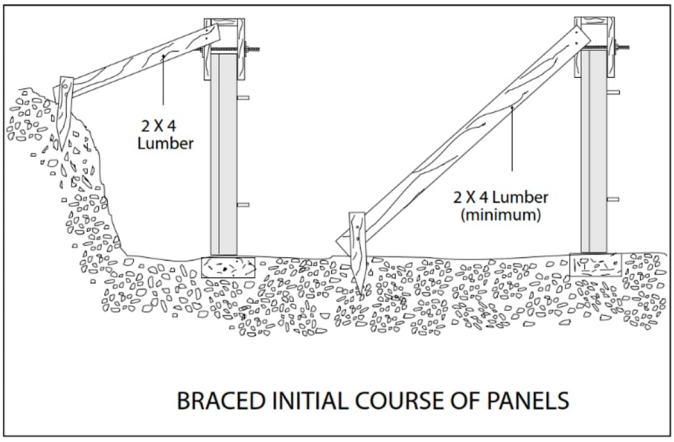


Figure 23: Panel bracing

STEP B-4: Place a third panel (3), aligning the panel with the control line and use a ¾-in. spacer to ensure spacing. Check the horizontal level of the panel and shim as necessary. Set the panel's batter.

STEP B-5*:* Continue setting the panels in this manner and site back along the tops of the full height panels to assure that each new panel is at the elevation of the others in that course **(See Overview > Check Alignment).** After ten panels have been set, recheck the wall's alignment by sighting along the wall face. Adjust panels if needed to obtain a true line.

C. JOINT MATERIALS

STEP C-1: Joint materials are installed only from the backfill side of the structure only. Geotextile prevents the loss of fine backfill particles while allowing the structure to be free draining. Bearing pads prevent concrete-to-concrete contact between facing elements vertically.

- Geotextile is affixed to the backfill side of both the vertical and the horizontal panel joints (see figure below) using several dabs of a contact adhesive.
- The adhesive provides a temporary attachment for the geotextile and should be used sparingly. It is not recommended that the geotextile be glued solid to the back of the panel. Geotextile is not generally required at the base of the wall where the panel rests on the leveling pad.
- Bearing pads are placed in grooves on top of each panel. Thickness and/or quantity at various levels within the structure may differ and must be in strict accordance with the Plans.

Bearing pads are designed to compress during the construction process. The initial joint created by the bearing pads may decrease in size to accommodate the specified design width when the wall is completely constructed.

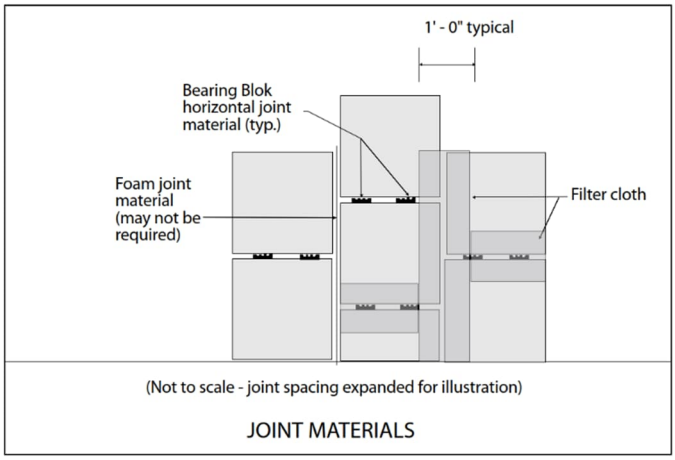


Figure 24: Joint material.

D. BACKFILLING

The constructability and performance of a

Reinforced Earth structure directly relates to the quality of the Select Granular Backfill and to the manner in which it is installed.

Prior to placing the Select Granular Backfill, the Contractor shall certify to the Engineer that the material conforms to the requirements stated in the Plans, Specifications, and Contract Documents for Reinforced Earth structures.

Select Granular Backfill material to be used in the reinforced volume must be tested and shown to strictly conform to the Specifications. Material, which does not conform, cannot be used as Select Granular Backfill.

STEP D-1: Place and compact initial lifts of Select Granular Backfill up to the bottom row of panel tie strips (Figure 25). Note that the uniform loose thickness placement of each lift of backfill material must not exceed 12 in. The level of the compacted backfill should be 2 in. above the tie strips as shown in Figure 26. In order to avoid pushing the braced panels out of alignment, initial lifts of backfill are neither placed nor compacted against the back of the panels.

Only after the first layer of reinforcing strips has been connected to the panel tie strips as detailed in Section E, and a lift of backfill placed and compacted over the strips can backfill then be placed and compacted against the back of the panels illustrated in Figure 27.

Compact each backfill lift using a large smooth-drum vibratory roller except within a 3-ft. zone directly behind the panels where a small hand-operated vibratory compactor must be used to avoid undue panel movement.

After compaction has taken place, check wall alignment visually and with a level adjust panels as necessary.

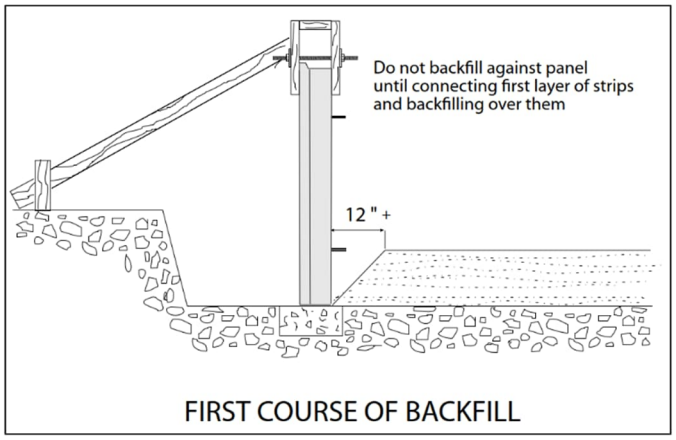


Figure 25: First course of backfill.

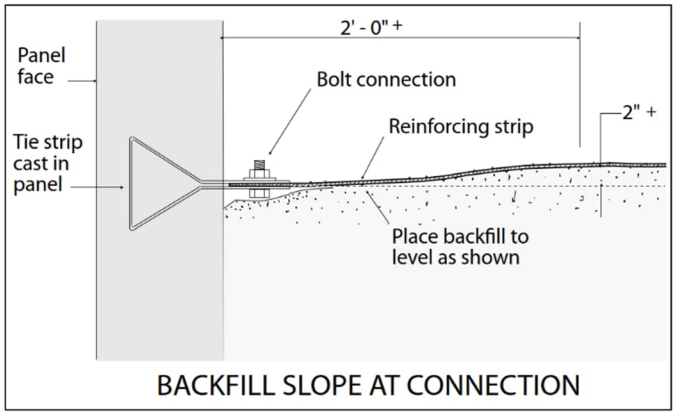


Figure 26: Backfill slope at connection.

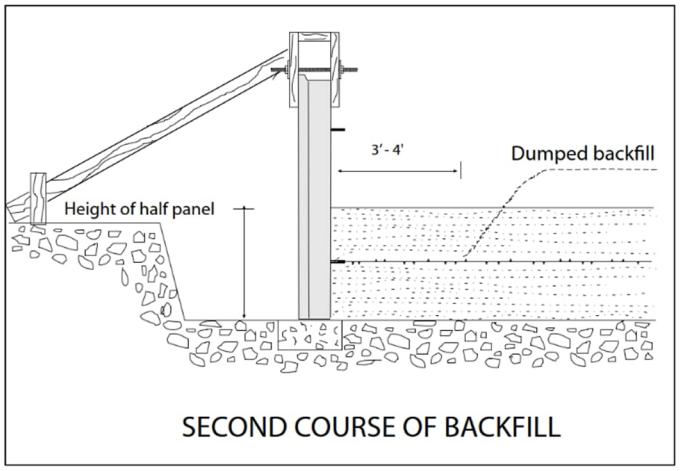


Figure 27: Second course of backfill.

The gradation of the Select Granular Backfill should be tested periodically during construction to assure compliance with the Specifications. This gradation testing should be performed for every 2,000 cubic

yards of material placed and/or whenever the appearance or behavior of the material noticeably changes.

Immediate gradation and moisture testing is required if either excessive panel movement or backfill pumping occurs during construction.

STEP D-2, Compaction: Large smooth-drum vibratory rollers are used to accomplish mass compaction of Select Granular Backfill materials, except for fine uniform sands.

Sheep foot Rollers are never to be used for compaction of Select Granular Backfill.

Fine uniform sands, which contain more than 60 percent passing a No. 40 sieve used for Select Granular Backfill, must be compacted using a smooth-drum static roller.

Vibratory compaction equipment should not be used to compact fine uniform sands.

Compaction within 3 ft. of the back face of the panels shall be achieved by at least three passes using a lightweight mechanical tamper, roller or vibratory compactor. Compaction testing should not be performed in this 3-ft. zone.

At a minimum, Select Granular Backfill material must be compacted to 95% of maximum density, per AASHTO T-99, methods C or D (with oversize correction as outlined in Note 7).

If 30% of the Select granular Backfill material is greater than ¾ in. in size, AASHTO T-99 is not applicable. For such material, the acceptance criterion for compacting is either a minimum of 70% of the Relative Density of the material as determined by ASTM D-4253 and D-4254, or a Method Specification based on a test compaction section which defines the type of equipment, lift thickness, number of passes of the specified equipment and placement moisture content.

Moisture content of Select Granular Backfill material during placement should be approximately 1% to 2% less than its optimum moisture content.

The minimum frequency of compaction testing shall be one test per lift of Select Granular Backfill material placed. Test locations are determined by the Engineer.

STEP D-3, Grading: At the end of each day's work, backfill must be graded to slope away from the back of the panels in order to divert water runoff from the structure area.

Failure to properly grade the backfill can result in excessive water in the Select Granular Backfill and cause subsequent movement of the panels beyond alignment tolerances.

E. PLACEMENT OF REINFORCING STRIPS

STEP E-1: Place reinforcing strips on the compacted backfill. Position strips perpendicular to the facing panels, unless otherwise shown on the Plans. Reinforcing strips are supplied in lengths as shown on plans, with a tolerance in length from 0 in. to +8 in.

Connect each reinforcing strip to the embedded panel tie strip by inserting the end of the reinforcing strip into the gap between the two exposed ends of the tie strip. Match the three holes and push a bolt through the holes from below, placing a washer on top, threading on a nut (Figure 28), and tightening. Bolts must fit up through both tie strip flanges, perpendicular to the steel surfaces, and have full bearing of the bolt head and washer/nut against the tie strip flanges. Use a crescent or socket-head ratchet to securely hand tighten the nut.

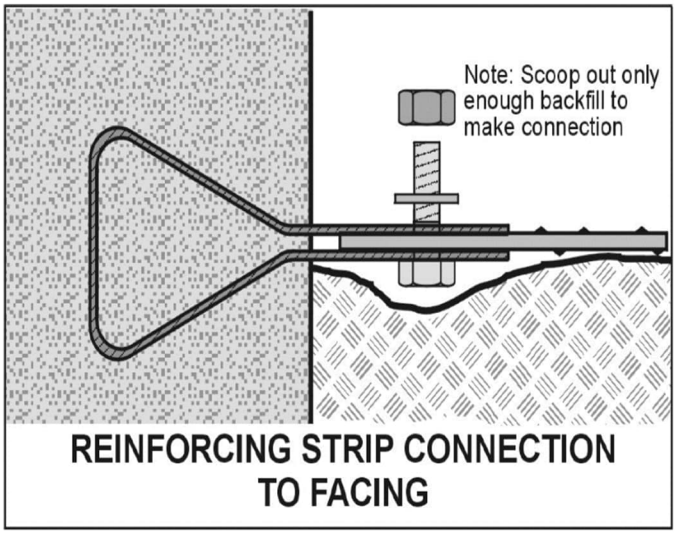


Figure 28: Reinforcing strip connection to facing.

In specific, limited situations it may be necessary to skew a reinforcing strip from its design location (perpendicular to the facing panel) in either the horizontal or vertical plane.

Design of the Reinforced Earth structure is based on the perpendicular placement and connection of reinforcing strips, unless otherwise detailed on the Plans, and on installation of the correct density and length of strips to each panel.

The placement of any reinforcing strip in a skewed manner, unless shown on the Plans, Specifications, and Contract Documents, must be authorized in writing by Geoquest USA prior to placement in the field.

STEP E-2: Dump backfill onto the reinforcing strips so that the toe of the backfill pile is 3-4 ft. from the panels. Spread the backfill by pushing the pile parallel to the panels and wind rowing it toward the panels and toward the free end strips. If strips are long, a second load may be required to backfill to the ends of the strips. If so, dump and spread this load only after spreading the first. Continue to backfill to the full height of the half panels (Figure 27).

Metal tracks of earthmoving equipment must never come in contact with the reinforcing strips. Rubber-tired vehicles, however, can operate directly on the exposed strips if backfill conditions permit and care is exercised.

STEP E-3, Step-up: If required to make a step-up in elevation of the wall, use the following procedure.

Mark a wall layout line on the upper level pad to establish a wall-face control line. Place the next required panel along the control line, spaced ¾ in. set its batter and brace if necessary. Then continue construction of the upper course using the procedure used on the lower level.

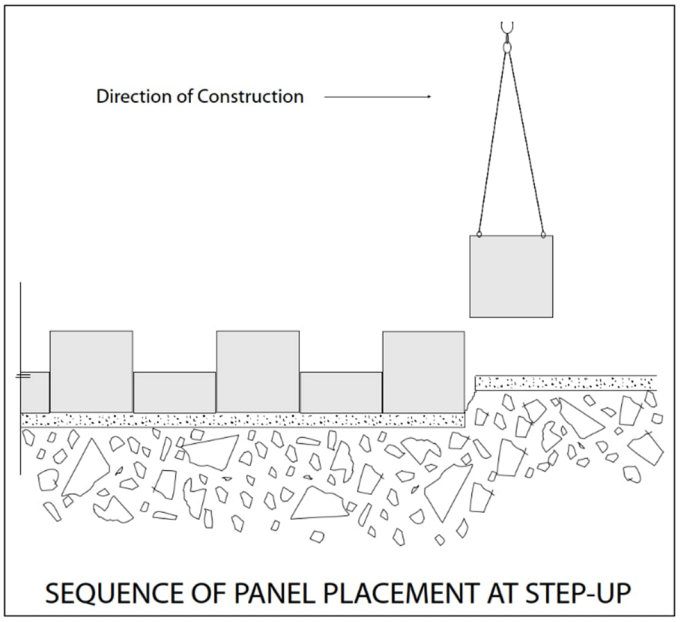


Figure 29: Sequence of panel placement at leveling pad step.

F. CONSTRUCTING SECOND AND SUBSEQUENT COURSES

STEP F-1: Only after the backfill has reached the top of the B (half) panels can construction of the second course begin. Throughout construction, panels should only be set after backfilling and compaction to grade have been completed.

Placing any panel atop a panel, which has not been completely backfilled can create an unstable situation, and lead to misalignment of panels, and is strictly prohibited.

Begin the second and subsequent courses of panels at the end of the wall where construction began (Figure 30).

STEP F-2: Remove the two shoulder clamps

holding A panels (2) and (4) to B panel (3). As each course proceeds, remove only two clamps at a time to allow for setting of each new panel. To prevent concrete-to-concrete contact at horizontal joints, set two bearing pads onto the top edge of panel (3). Refer to Figure 30.

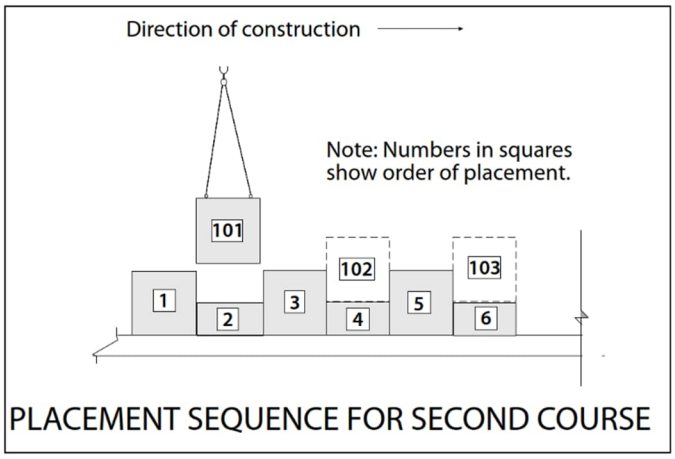


Figure 30: Placement sequence for second course.

STEP F-3: Set A panel (101) onto B panel (2) (Figure 30), centering the panel to ensure equal vertical joints and matching the panels front face to that of panel (2). Set the batter of the panel the same as the first course using wedges at the ear. Clamp the new A panel (101) to the initial course panels (1) and (3). Don't over tighten the clamps as they may remove the batter set in the panel (101).

STEP F-4: Remove the next pair of clamps; place bearing pads onto the half panel (4); and set A panel (102) onto it. Match the face of the panel just placed to that of the panel below and set its batter. Clamp the panel (102) to adjacent panels (3) and (5).

Continue to set A panels in the same sequence. As the work proceeds, check the wall's alignment frequently. Install joint materials as in Step C.

STEP F-5: When the course of panels is complete and after vertical and horizontal geotextile has been installed, place backfill in lifts according to the Plans, Specification, and Contract Documents up to 2" above the tie strip level. Figure 31 illustrates the sequence for backfilling the second and subsequent courses.

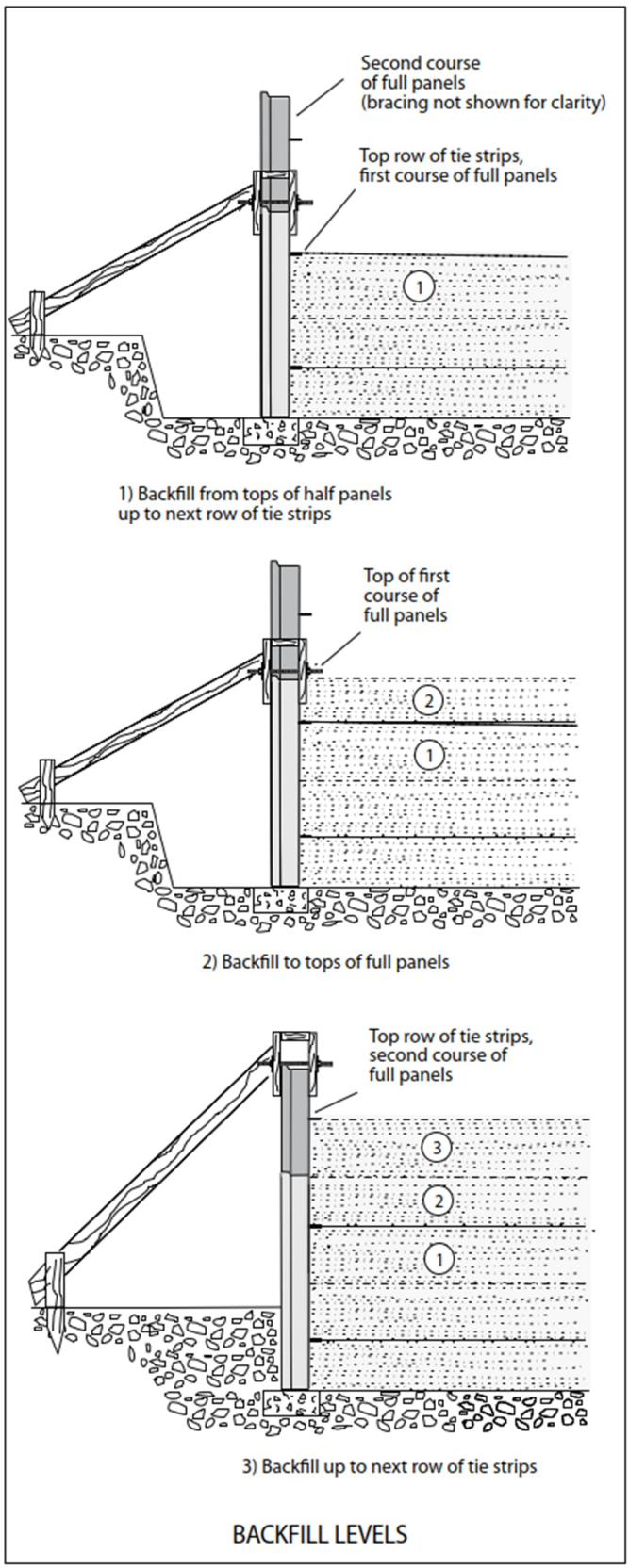


Figure 31: Backfill levels.

STEP F-6: After backfilling, recheck the batter and alignment of the wall, then place and connect the next layer of reinforcing strips as in Step E.

STEP F-7: Backfill up to the top of the A (full) panels of the initial course and the bracing can now be removed. If after backfilling to the top of the A panels, panels of the initial course did not become almost vertical, or if panels have gone beyond the vertical, adjust the amount of batter in the second course so that the third row will become vertical after backfilling.

Placement and compaction of part or all of a berm or an embedment at the lower front surface of the structure can begin (Figure 32).

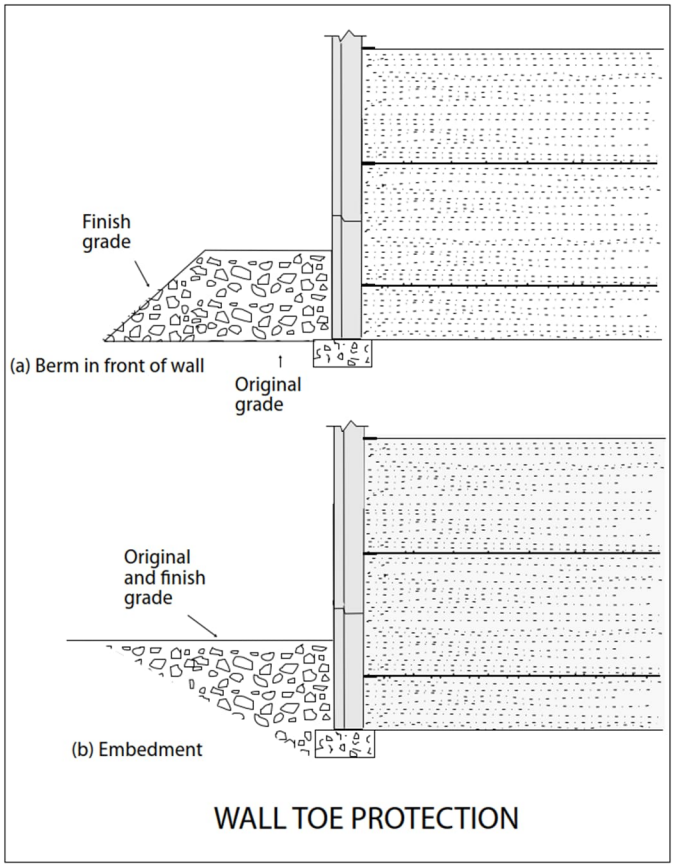


Figure 32: Wall toe protection.

Reinforced Earth structures with a leveling pad at or above existing grade requires placement of an earth berm as toe protection along the face. Structures with a leveling pad below existing grade require the placement of an embedment in front of the wall. The height of the berm or the depth of the embedment is shown on the Plans.

The berm or embedment must be placed immediately to prevent erosion before the wall reaches 50% of its height or 20', whichever is less.

STEP F-8: When backfill reaches the top of the initial course of full panels (which is halfway up the second course), begin placing the next course of panels.

Repeat steps F-1 through F-5 for panel installation, backfill placement and compaction, reinforcing strip installation, and placement of horizontal/vertical joint materials. Follow these same procedures for the second and subsequent panel courses until the structure is ready to be topped off. No external panel bracing is required for second or subsequent courses.

After the erection of each course of panels, the wooden wedges of that course and the two courses below it should be checked to ensure that they are securely seated.

At least two, but no more than three rows of panel wedges should remain in place at all times during erection. When construction is complete, all wedges must be removed.

Panel batter should be checked after backfilling each course with necessary adjustments made in subsequent courses to ensure plumbness.

Quality control requirements for Select Granular Backfilling, including density and placement moisture, are the same for the second and subsequent courses as for the first course, unless otherwise indicated in the Plans or Specifications.

G. COMPLETION OF THE WALL

STEP H-1: In placing top course panels, the construction sequence continues as previously outlined. However, top course panels have either a flat or a sloping edge and may be supplied in varying heights to meet finished-elevation requirements. Refer to the Plans for the location of specific top panels.

STEP H-2: After backfilling is complete, remove all

clamps and wooden wedges from the structure.

STEP H-3: Install top wall treatment, if required. Several types are commonly used:

- Cast-in-place: If required, rebar for connection will protrude from top panels. All necessary attachment details for a barrier, coping, parapet, or paved ditch will be shown in the Plans.
- Precast coping: If approved, precast coping will be supplied. Attachment details will be shown in the Plans.
- Plain: The top of panels will remain exposed with no further treatment necessary. Sometimes called stepped-top.

FACING PANEL TYPES AND NOMENCLATURE

PANEL DESIGNATIONS

All design and/or shop drawings, and precast panels are designated as follows:

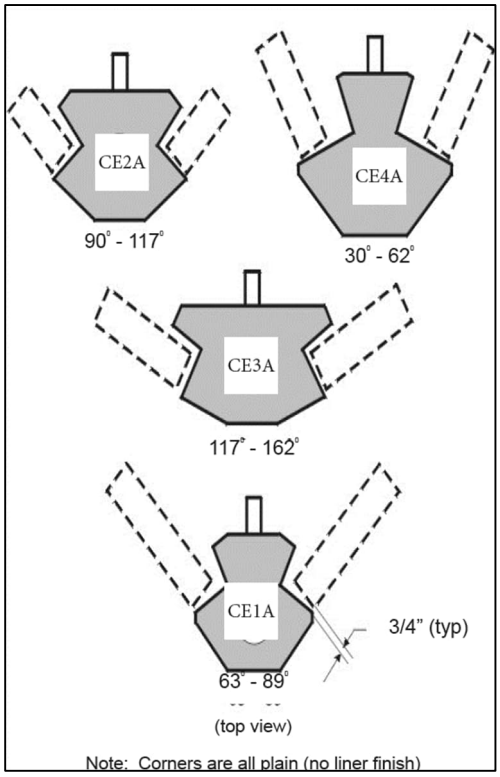
Key to Panel Designation:

XX – X – RX – X.XX

Basic Panel Type
Panel Modification
Number of Tie Strips
Panel Reinforcement
Panel Width
Or
Deflection Angle (for bent panels)
Where (X) can be a letter or digit

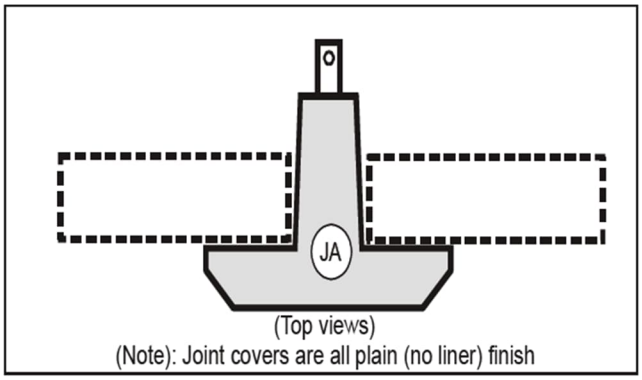
CORNER ELEMENTS

Corner elements are designed to accept vertical cut panels and cover a range of bends. The corner element designations are CE1A, CE2A, CE3A, and CE4A. The letter following indicates corner element height. Corner element details and shape may vary. Refer to the Plans and Specifications.



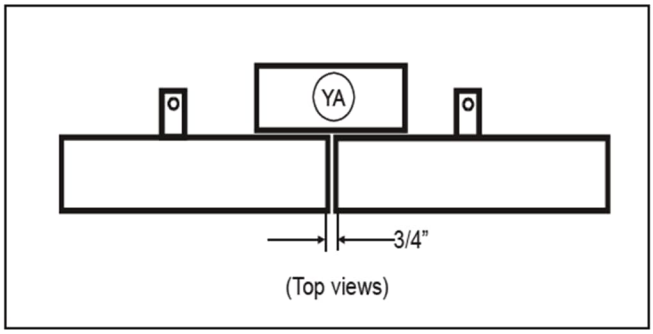
SLIP JOINT COVER

Slip joints are designed to accept vertical cut panels and provide system flexibility and rapid changes in elevation. The cover designation is the letter J. The following letter indicates the joint height.



BLIND SLIP JOINT

Again, the slip joint is designed to accept vertical cut panels and provide system flexibility for varying foundation conditions. The cut panels are assembled with a ¾" butt joint. The letter Y designates the backup panel and the following letter indicates the panel height.



CONDITION-CAUSE RELATIONSHIPS

Reinforced Earth structures are to be erected in strict compliance with the structural and aesthetic requirements of the Plans, Specifications, and Contract Documents. The desired results can be achieved through the use of quality materials, correct construction procedures, and proper inspection. However, considering the nature of construction work, there may be occasions when dimensional tolerances and/or aesthetic limits are exceeded. Corrective measures must be taken immediately to return the structure to acceptable tolerances.

Below are several examples of these condition-cause relationships:

Condition	Cause
1. Distortion in the wall. a. Differential settlement or low spot in the wall b. Overall wall leaning c. Panel-to-panel contact, resulting in spalling or chipping.	a) The foundation (subgrade) material is too weak or wet for proper bearing. If fill material, poor quality or improper compaction.
2. First course is difficult to set and/or maintain level.	a) Leveling pad is not within tolerance.
3. Wall is leaning out.	a) Panels not battered sufficiently. b) Large backfill placing and/or compaction equipment working within 3-ft. zone of the back of the wall. c) Backfill material placed wet of optimum moisture content. d) Backfill contains excessive fine materials (beyond the Specifications for percent of materials passing a No. 200 sieve). e) Backfill material pushed against the back of wall before being compacted on the reinforcing strips. f) Excessive or vibratory compaction on uniform fine sand (more than 60% passing a No. 40 sieve). g) Backfill material dumped close to free end of reinforcing strips, then spread toward back of wall, causing bulge in the strips and pushing panel out. h) Wedges not seated correctly i) Clamps not tight j) Excessive compaction effort. k) Excessive lift thickness. l) Plasticity Index (PI) of backfill material is in excess of Specification limits.
4. Wall is leaning in.	a) Excessive batter set in panels for select granular backfill being used. b) Inadequate compaction of backfill. c) Differential settlement of foundation soils.
5. Wall is out of horizontal alignment tolerance, or bulging.	a) See causes 3-c through 3-g, and 3i b) Backfill is saturated (heavy rain or improper grading of backfill after each day's operation.
6. Panels do not fit properly in intended locations resulting in subsequent panels spalling or chipping.	a) Panels are not level. b) Differential settlement (see Condition 1). c) Failure to use spacers between panels. d) Leveling pad incorrect.

GLOSSARY OF TERMS

Agency: The person(s), firm, or corporation acting as Agent for the Owner.

Contract Documents: The Owner-Contract agreement, including the conditions of the Contract (general, supplementary, and other conditions), the drawings, Specifications and the provisions of the agreement between the Contractor and **Geoquest USA**; and also including all addenda issued prior to execution of the Contract, all modifications thereto and any other items specifically stipulated as being included in the Contract Documents.

Contractor: The individual, firm, or corporation undertaking the execution of the Work under the terms of the Contract, and acting directly through its Agents or employees.

Engineer: The person(s) designated by the Owner, as having authoritative charge over certain specific engineering operations and duties.

Inspector: The authorized representative assigned to make a detailed inspection of any or all portions of the Work or materials thereof on the Owner's behalf.

Owner: The Owner of a project. The agency, person, firm, or corporation with which a Contract has been made for the payment of the Work performed under the Contract.

Plans: The official approved plans, profiles, typical cross-sections, working drawings, and supplemental drawings, or exact reproductions thereof, which show the locations, character, dimensions and details of the Work to be performed.

Specifications: A description, for contract purposes, of the materials and workmanship required in a structure(s), as also shown on the related working drawings. The written material containing the standard provisions and special provisions, as may be necessary, pertaining to the quantities and qualities of materials to be furnished under the Contract.

Technical Advisor: Representative of **Geoquest USA** or licensed precaster who may be available to assist the Contractor with material scheduling and coordination, and give advice on the recommended construction procedures applicable to **Geoquest USA's** structures as set out in this manual.

Work: The entire scope of the Work to be performed at the site of the construction project including labor, materials, equipment, transportation and such other facilities as are necessary to fulfill all obligations under the Contract.

SAFETY TIPS FOR UNLOADING GEOQUEST USA PRODUCTS

1. Upon arrival of truck, examine the load for any shifting or unstable conditions prior to removing tie downs.
2. The truck should be on level ground when unloading. Unloading on unlevel ground could result in shifting of precast units or possibly precast units falling from trailer.
3. Lifting equipment (straps, cables, ring clutches, etc.) should be checked for excessive wear or cracking prior to unloading truck.
4. Do not move the tractor while the product is not tied down.
5. If drivers are required to remove chains or binders next to lane of moving traffic, cones and flagman should be used to direct traffic away from the trailer and driver.
6. Drivers are not trained as riggers or swampers and should stay in cab or clear away from unloading operations. The drivers are acting in a delivery capacity only.
7. Personal protective equipment required by the general contractor on site should also be required of delivery drivers.
8. Personnel should not be allowed under a suspended load.
9. Once removed from the trailer, precast units not placed directly on the wall should be stacked or secured on flat ground to prevent tipping or falling.
10. Areas between the truck and crane should be restricted to personnel required to unload the trailer.
11. If any unsafe situations exist while loading or unloading **Geoquest USA** products, contact **Geoquest USA** immediately to eliminate any hazards or exposure to illness or injury.

CONTACT INFORMATION

Geoquest USA maintains full-service offices throughout the United States. Contact the office serving your state for technical assistance.

Location	States Serving	Phone Number
Aurora, CO (Denver) 3033 South Parker Rd., Suite 1100 Aurora, CO 80014	AK, CO, ID, KS, MT, ND, NE, OR, SD, WA, WY	(303) 790-1481
Aurora, IL (Chicago) 1444 North Farnsworth Ave., Suite 505 Aurora, IL 60505	IA, IL, IN, MN, MO, WI	(630) 898-3334
Clermont, FL (Orlando) 17011 State Road 50, Suite 204 Clermont, FL 34711	FL	(407) 226-2840
Mission Viejo, CA (Los Angeles) 25910 Acero, Suite 200 Mission Viejo, CA 92691	AZ, CA, HI, NV, UT	(949) 275-2723
North Richland Hills, TX (Dallas) 9001 Airport Freeway, Suite 800 North Richland Hills, TX 76180	AR, LA, NM, OK, TX	(817) 283-5503
Peachtree Corners, GA (Atlanta) 6625 The Corners Pkwy., Suite 450 Peachtree Corners, GA 30092	AL, GA, MS, SC, TN	(770) 242-9415
Raleigh, NC 9208 Falls of Neuse Rd., Suite 201 Raleigh, NC 27615	DC, DE, KY, MD, NC, VA, WV	(984) 275-2723
Sterling, VA (Washington, DC) 45610 Woodland Rd., Suite 200 Sterling, VA 20166	DC, DE, KY, MA, ME, MD, MI, NC, NH, NJ, NY, OH, PA, RI, VA, VT, WV	(703) 547-8797

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About Geoquest USA, Inc.
In 2025, The Reinforced Earth Company (RECo) rebranded globally as Geoquest. We continue to serve the heavy civil construction industry with Reinforced Earth® MSE retaining walls, T-Wall®, TechSpan®, and a variety of other geotechnical infrastructure solutions.