

**Reinforced eARTH**<sup>®</sup>  
SUSTAINABLE TECHNOLOGY

## Construction and Quality Control Manual



# GeoMega<sup>™</sup> Structures with Concrete Facing Panels





## **SAFETY BULLETIN**

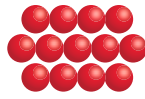
February 25, 2014

### **Re: 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:

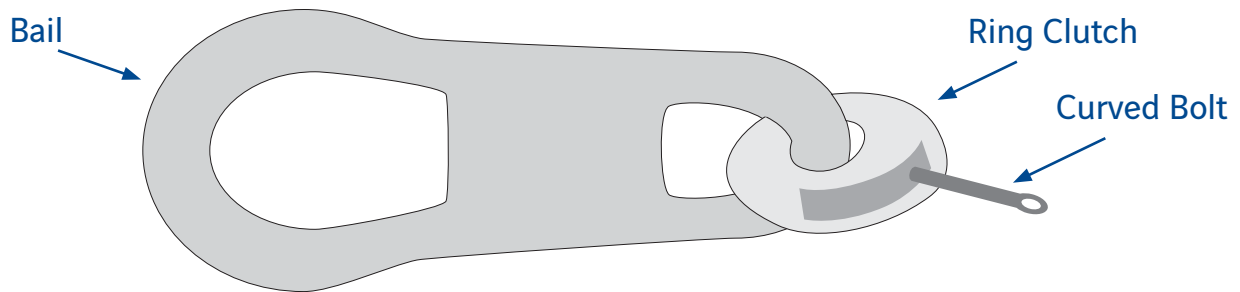
1. Panels at the levelling pad course should be externally braced as shown in the construction manual upon installation and before additional panels are installed.
2. Panels must remain attached to lifting equipment until such time as external bracing, wedges and shoulder clamps are in place and secured.
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.

Please ensure your crew is aware of the above safety reminders.



REINFORCED eARTH®

## 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.





## 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.
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- 5** The last panel at the free end of wall should be externally braced and secured with wedges and a clamp to the adjacent panel.

Please ensure your crew is aware of the above safety reminders.





# CONSTRUCTION AND QUALITY CONTROL MANUAL

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# **I. Preface**

This Construction and Quality Control Procedures Manual has been prepared as a guide in building Reinforced Earth structures using The GeoMega System.

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

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 the Reinforced Earth construction, contact The Reinforced Earth Company before commencing or continuing work.

The Reinforced Earth Company supplies precast concrete facing panels and accessories to be used in conjunction with other materials in the construction of GeoMega retaining walls detailed from the construction drawings. The construction and quality control procedures manual furnished by The Reinforced Earth Company is intended to provide a general explanation of the system. It is the Contractor's obligation to devise and execute a project specific erection sequence, panel unloading, handling and bracing system, and fall protection system. The bracing system shown in the construction and quality control procedures manual is general in nature and does not account for project specific criteria. Compliance with the guidelines in this manual does not relieve the contractor of its responsibility to adhere to the project plans, specifications and contract documents or compliance with all fall protection, safety laws, standards and procedures at the job site. Contractors should take special precautions to prevent the panels from shifting or falling during the erection process.

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"Reinforced Earth", "GeoStrap", the cruciform shape of the panels and the Reinforced Earth logo are registered trademarks of The Reinforced Earth Company. "GeoMega" is a trademark of The Reinforced Earth Company.

## **II. Non-Disclosure Notice and Disclaimer**

1. This Document is the property of The Reinforced Earth Company, with headquarters at 45610 Woodland Road, Suite 200, Sterling, VA 20155, and contains information, which is proprietary to The Reinforced Earth Company. 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.
2. Except as specified in the paragraph above you must not, without the prior express written consent of The Reinforced Earth Company, use any of the information contained in this 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.
3. This Document and the information contained herein must not be copied or disclosed in any manner or form, in whole or in part, to any third party without the prior express written consent of The Reinforced Earth Company.
4. 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.
5. GeoMega structures designed by The Reinforced Earth Company comprise or are based solely upon:
  - (a) The internal stability of the Reinforced Earth structure based upon the design assumptions noted on all drawings provided by the The Reinforced Earth Company 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; and
  - (c) The Job Specifications.

The design does not include a check of the overall stability of the foundation soils below or behind the structure, nor a check of any potential failure planes external to the structure, nor 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, The Reinforced Earth Company warrants the internal stability of the structure only.

6. Upon demand, the Document and all copies thereof must be immediately surrendered and returned to The Reinforced Earth Company.



### III. Introduction

GeoMega™ is a Reinforced Earth application formed by the interaction between a frictional soil and GeoStraps®. GeoMega is an economical means of improving the mechanical properties of basic material, earth, by reinforcing it with another, geosynthetics. The GeoStraps resist stresses produced within the soil mass; stresses are transferred to the GeoStraps via friction.

A Reinforced Earth structure constructed using this technique 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 attractive, finished appearance.

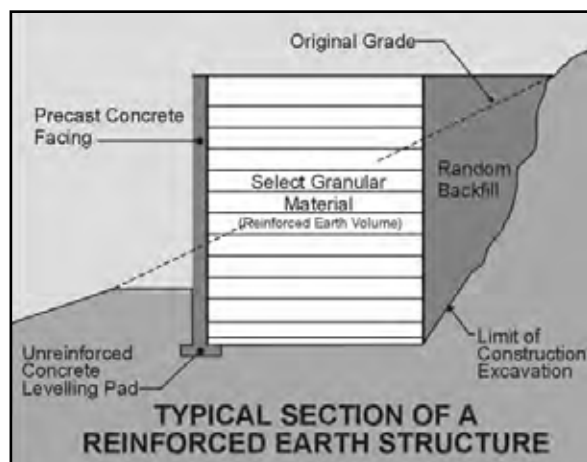


Figure 1

#### 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, The Reinforced Earth Company provides recommended erection procedures in this manual. Nothing in this document is intended to relieve the Contractor of the responsibility of complying with all safety standards and construction procedures, including fall protection, at the job site.

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

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

**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.**

#### 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 retaining wall.

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

#### D. Components

Reinforced Earth structures consist of the following:

**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**

The size and shape of the facing panels are controlled by the Project Specifications and will be provided in the Shop Drawings for the individual project.

A description of the panel nomenclature is provided below:

- Full-size – or  $A_n$  – panels are used for the majority of the structure. The subscript “n” in panel designations indicates the number of geostrap connections or recess on each panel.
- Half size or  $B_n$  – panels are alternately used in the initial course with the full size panels.  $P_n$  and  $Q_n$  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.

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

### Facing Panel Joint Materials

- Rubber Bearing Bloks 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.
- Filter cloth is applied with adhesive to the backfill side of the panels to cover all the horizontal and vertical panel joints.

### Reinforcing Strips (“GeoStrap”)

The GeoStraps consist of high tenacity polyester fibers (HTPET) encased in a polyethylene sheath. The GeoStraps supplied in a 49.5mm (+/-0.5mm) width and 328 ft. (100 meter) length.

**Recess Connections** – During construction, geostraps are threaded through the recess onsite after panels are set in the wall. The opening for the Geostrap is covered with tape, or caps, to prevent concrete from entering the recess during precasting and water from entering during storage (Figure 2).



Figure 2

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

### E. Materials and Services Provided by The Reinforced Earth Company

- Engineering and design of the GeoMega structure.
- Precast concrete facing panels.
- Horizontal and vertical joint material (filter fabric) and adhesive.
- GeoStraps.
- Bearing Bloks and shims.
- One set of facing panel lifting devices.
- Delivery of The Reinforced Earth Company furnished materials to the site (F.O.B.), with two hours of time allowed for unloading
- Sublicense to build the structure.
- Initial on-site technical assistance.

GeoStraps, filter fabric, adhesive, Bearing Bloks, and other special items provided by The Reinforced Earth Company are packed to minimize damage in unloading and handling.

**Materials should be thoroughly inspected upon delivery to the job site. Any damaged items should be set aside and The Reinforced Earth Company notified immediately. Materials should be handled and stored to prevent damage or theft. GeoStrap and Filter fabric must be stored in a sheltered location and protected from sunlight. Adhesive must be stored in dry location and protected from rain.**

Certificates of compliance with project specifications for all materials are furnished by The Reinforced Earth Company. 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 to The Reinforced Earth Company immediately.

**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, Materials, Tools and Work 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<sub>n</sub> facing panels weighs 1,700 lbs.; a 7 1/6 in. thick A<sub>n</sub> panel weighs 2,100 lbs.; the heaviest panel weighs 3,000 lbs.
- 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 facing panels.
- ¾" Wooden Spacers (Figure 3).
- Wooden wedges in a quantity at least sufficient to provide 4 to 6 wedges per vertical joint for the length of structure under construction (Figure 3).
- Clamps, one per vertical joint for the length of structure under construction. Additional clamps will be needed to brace the initial course of panels (Figure 3).
- Nylon slings for unloading panel stacks.
- Lumber for the initial course of panels (Figures 13, 17 and 18)
- 24" to 30" Crowbars (pinch bars)
- A 4-ft. carpenter level
- 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 to panel
- Lifting devices
- Large Size Caulking Gun for 2lb 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 pad(s).
- Mark wall layout line on leveling pad(s).
- Construction of the GeoMega structure consisting of the erection and positioning of facing panels, installation of joint materials, inserting and pulling geostraps through the recesses, placement and compaction of Select Granular Backfill.
- Placement of any concrete coping, traffic barrier, or other C.I.P. Concrete as required.

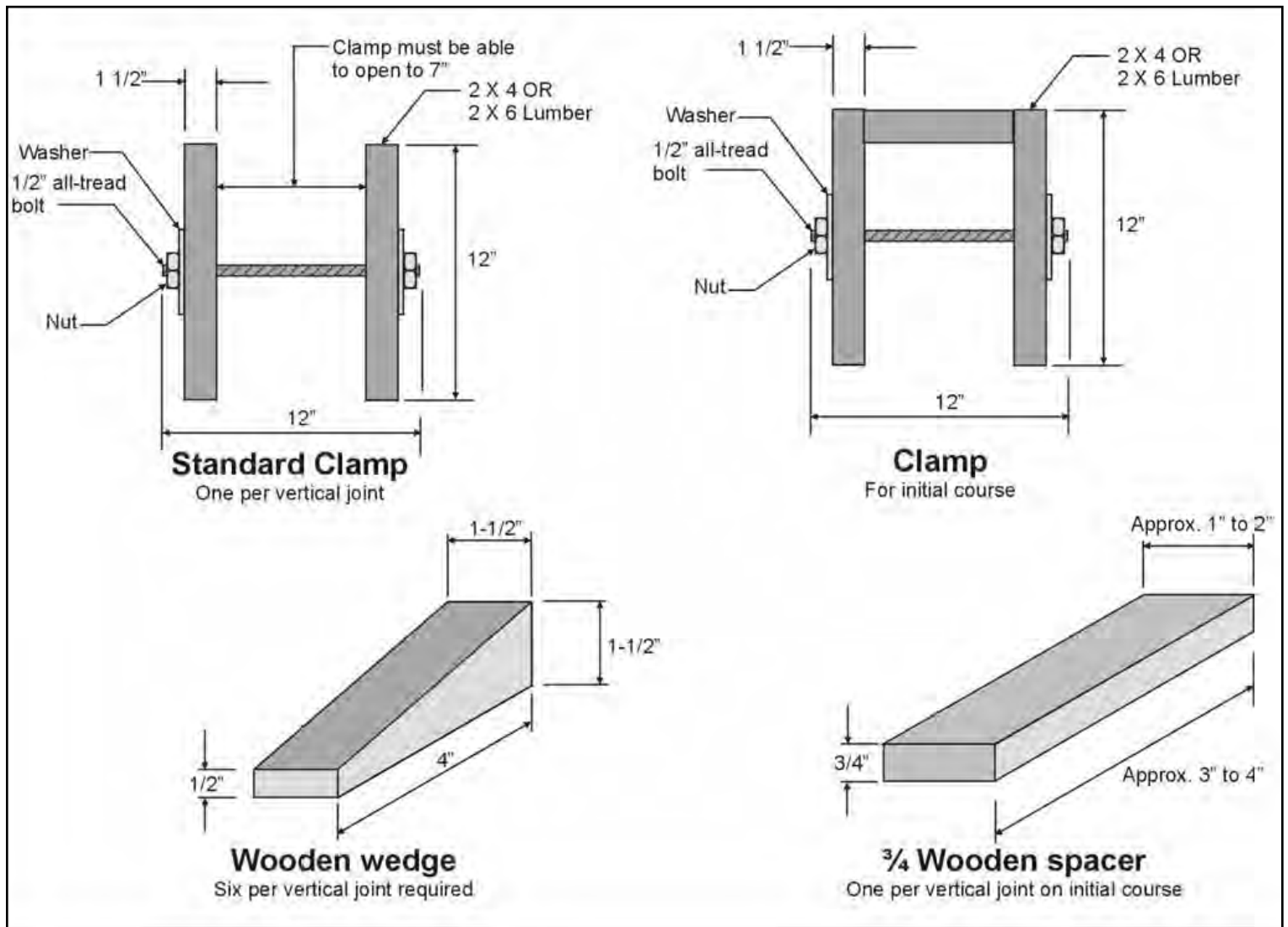


Figure 3

## **IV. Handling Reinforced Earth Materials**

### **A. Concrete Facing Panels**

**Panel delivery.** Prior to the start of construction, the Contractor should establish a panel delivery schedule that will allow The Reinforced Earth Company's precaster to match their panel production and delivery to the Contractor's construction schedule.

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

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

- 1) by using lifting devices to lift and handle individual panels (Figures 4 and 5), or
- 2) by using nylon slings to lift and handle individual panels or stacks of panels

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 five panels high with dunnage used between each panel as illustrated in Figure 6.



Figure 4

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

Note: All dunnage and pallets remains the property of The Reinforced Earth Company. They should be stacked and made available for pick-up as soon as they are no longer needed for panel storage.



Figure 5





Figure 6

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

## B. GeoStraps and joint materials.



Figure 7

**GeoStraps** GeoStraps are supplied in rolls of 49.5mm (+/-0.5mm) width and 328-ft. (100M) in length. GeoStraps shall be cut in the field to twice the lengths required by the design of the structure plus 3 ft. GeoStraps stored on site for more than one month shall be protected from direct sunlight. Covering with an opaque tarp or storage within a trailer is adequate to protect the GeoStraps.

**Bearing Bloks.** Rubber Bearing Bloks are packed in cartons each weighing 50 to 75 lbs.



Figure 8

**Filter cloth.** Filter cloth is supplied in 12in. and 18 in. wide rolls. Adhesive for filter cloth is supplied in appropriate containers.



Figure 9

## V. Construction Procedures

The basic erection sequence for a GeoMega structure can be summarized in these steps:

- Prepare the site including excavation and installation of drainage systems if required.
- Form and pour leveling pad (see Step A-3 for tolerances).
- Set and brace the initial course of facing panels, which consists of alternating half and full-height panels.
- Use wood wedges and clamps to hold panels in position.
- Attach filter cloth with adhesive.
- Spread and compact backfill in lifts up to 1 or 2 inches above the lowest level of panel recess connections
- GeoStraps are placed through recesses.
- Spread and compact backfill in lifts to within 3 or 5 inches of the top of the half panels.
- Place Bearing bloks and set the second course of full panels
- Repeat cycle of backfilling and compacting in lifts, placing GeoStraps, placing filter cloth and Bearing Bloks and setting panels until 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; place GeoStraps, complete backfilling and compaction.
- Remove all wedges and clamps.
- Install concrete coping, traffic barriers, or any C.I.P. concrete as required.

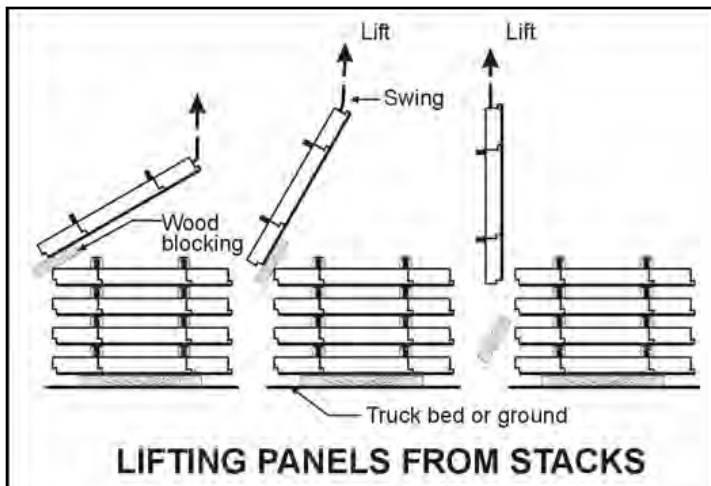


Figure 10

The finished appearance of a GeoMega 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 for the remainder of the structure.

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

**Lifting, placing and spacing panel** 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 (Figure 10). Use dunnage as blocking to prevent damage as each panel rotates from horizontal to vertical.

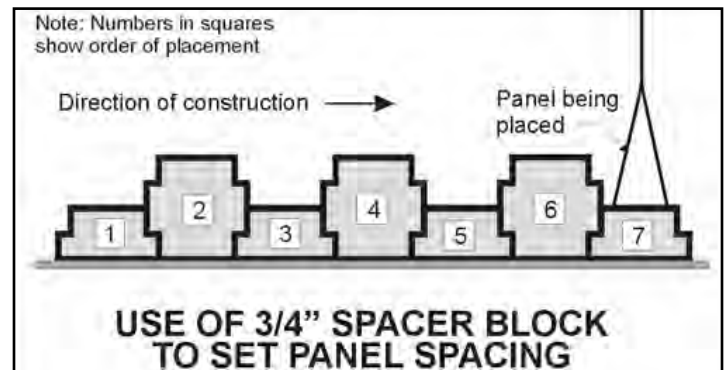


Figure 11

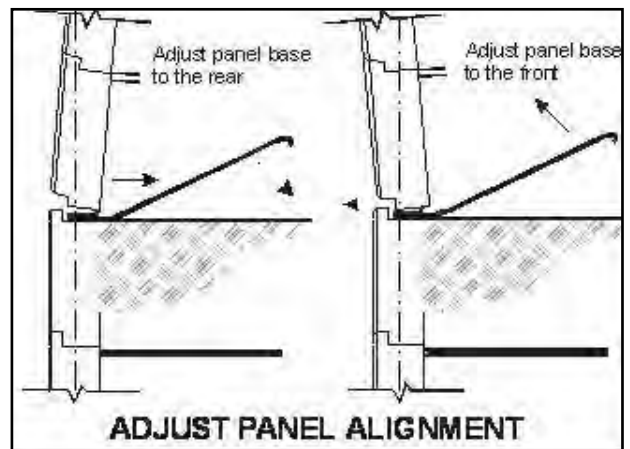


Figure 12

As each panel is lowered into its place in the structure, use the  $\frac{3}{4}$ " wooden spacer to achieve approximately a  $\frac{3}{4}$ " joint.



**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 (Figure 12) 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 – this can result in unacceptable chipping or spalling.

**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.

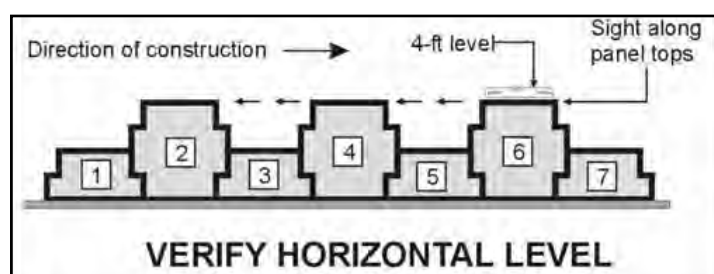


Figure 13

As shown in Figure 13, 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.



Figure 14

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 (Figure 14).

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 (Figures 16, 17 and 18).

**Note that wooden wedges should remain in place during the erection of three subsequent courses but then must be promptly removed, if wedges are left in place for more than three courses, removal will be difficult 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 1-½ in. in 5-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; adjust the amount of batter according to field conditions.

**Vertical Alignment Check** During construction, check the overall verticality of the structure using a plumb bob. This should be done on panels completely backfilled. 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.

**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**

- The maximum allowable offset between any two panels shall not exceed one inch.
- Horizontal and vertical joints should be uniform in appearance.

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

## 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 Engineer must approve the gradation, placement, and compaction of replacement material.

**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 bearing pressure as shown on the Plans, Specifications, and Contract Documents.**

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

**Step A-2, Drainage System(s):** Install any 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. gap between the higher pad and the start of the lower pad at the stepup location (Figure 15).

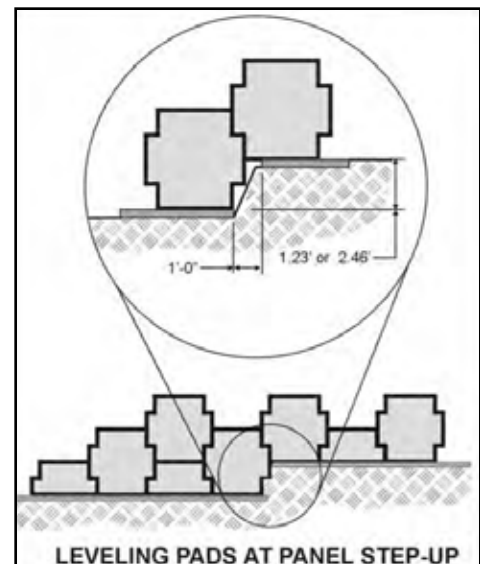


Figure 15

**Step A-4, Wall Line:** On the leveling pad. Establish a layout line 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 and from left to right when facing the front of the structure (Figure 17). Place the first B<sub>n</sub> (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; and using 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 recesses of each panel match the requirements as shown on the approved Plans.**

Bearing Bloks 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 The Reinforced Earth Company. If needed, only rubber shims may be used to shim between the leveling pad and first course of panels. Wood shims are not permitted at any point in the structure.

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 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.**

**Step B-2:** Place the second panel 2 on the leveling pad and place a  $\frac{3}{4}$ " spacer between it and panel 1 (Figure 17). 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  $\frac{3}{4}$ " material.

**Panels must be braced as shown in Figures 18 and 19 prior to releasing the crane from the panel.**

**Step B-3:** 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 in Figure 16. Tighten clamps sufficiently to hold the panel in position without movement.



Figure 16

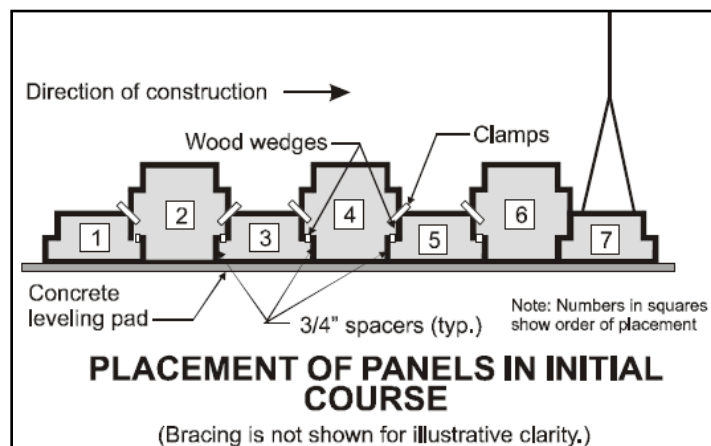


Figure 17



Figure 18

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 ft. 0 in. in height (Figures 18 and 19).

**Bracing is not required on subsequent courses. 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.**

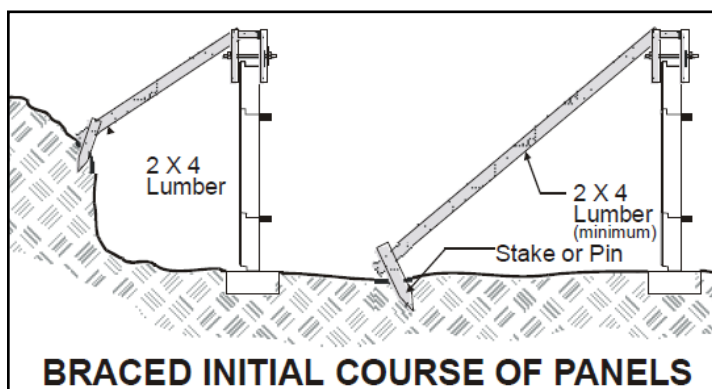


Figure 19

**Step B-4:** Place a third panel 3, aligning the panel with the control line and use a  $\frac{3}{4}$ " 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 (Figure 13). 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. Filter cloth prevents the loss of fine backfill particles while allowing the structure to be free draining. Bearing Bloks prevent concrete-to-concrete contact between facing elements vertically.

- Filter Cloth is affixed to the backfill side of both the vertical and the horizontal panel joints (Figure 20) using several dabs of a contact adhesive.

- Bearing Bloks 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.

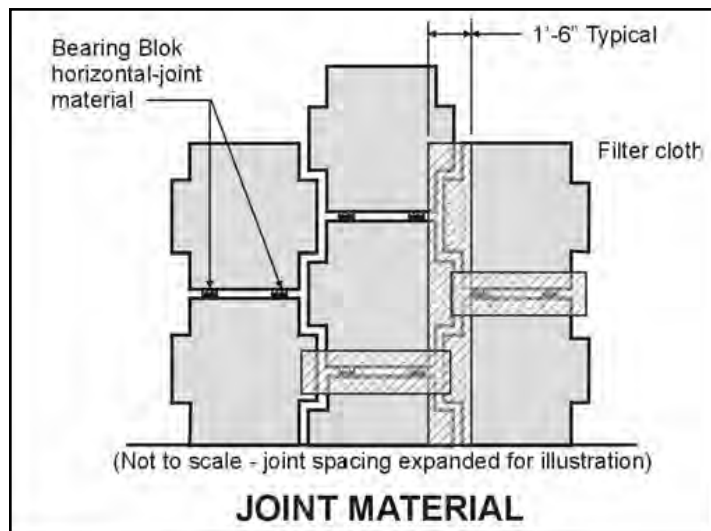


Figure 20

## D. Backfilling

The constructability and performance of a GeoMega 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 bottom row of panel recesses (Figure 21). Note that the uniform loose thickness placement of each lift of backfill material must not exceed 12 inches. The level of the compacted backfill should be at or slightly above the geostrap level as shown in Figure 22. 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 GeoStraps have been inserted through the panel recesses as detailed in section E, and a lift of backfill placed and compacted over the geostrips can backfill then be placed and compacted against the back of the panels illustrated in Figure 23.

Compact each backfill lift using a large smooth-drum vibratory roller except within a 3ft. 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, and adjust panels as necessary.

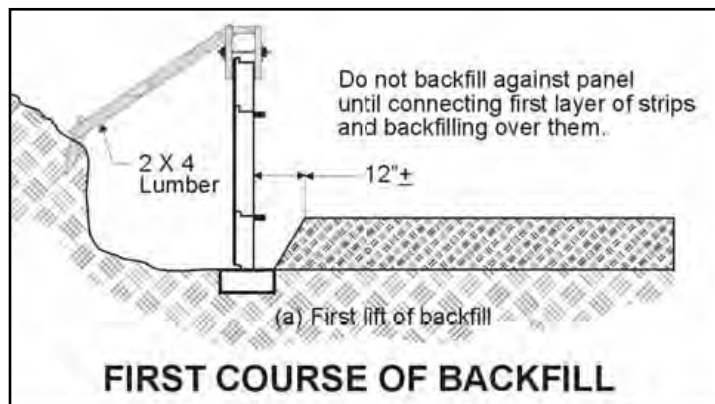


Figure 21



Figure 22

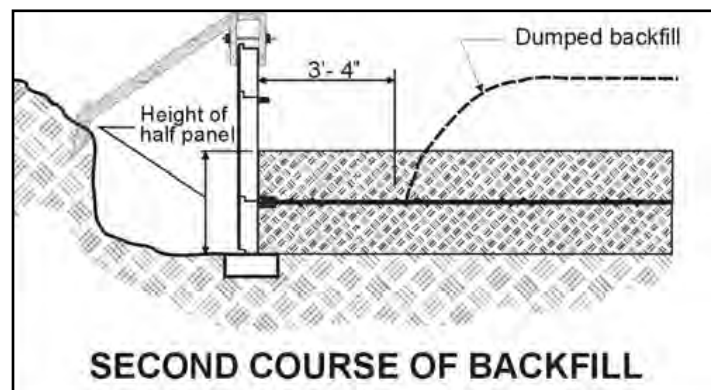


Figure 23

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 feet 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 foot 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  $\frac{3}{4}$  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. GeoStraps

**Step E-1:** Place geostraps on the compacted backfill. Position strips perpendicular to the facing panels, unless otherwise shown on the Plans. Geostraps are cut in the field to the lengths required by the design of the structures. The required length per connection is calculated by 2 times the design length plus 3 ft (0.9 M) to account for the length of the geostrap inside the recess.

A threading device consisting of a wire or banding material may be used to pull the geostrap through the recess (Figures 24 to 26).



Figure 24



Figure 25



Figure 26



GeoStraps may be rolled up and tied or placed over the top of the panels (Figure 27).



Figure 27

Develop a method for keeping the GeoStraps anchored and flat on the backfill. Either of the following methods may be employed, or a project specific method may be developed by the contractor.

1. Prepare a small trench or holes at the free ends of the GeoStraps and secure end of the strip with nail/stake or backfill in the depression to create a taut condition (Figure 28). See Appendix D.

2. Staple GeoStraps to an anchored piece of timber and place backfill on top of the strapping while held taut by laborers using hand tools (Figure 29). The timber needs to be removed as backfill is being placed. See Appendix E.



Figure 28



Figure 29

GeoStraps should be very tight and have no slack at this point, allowing backfill to be placed at end of GeoStraps for continued tightening (Figure 30).



Figure 30

In specific, limited situations it may be necessary to skew a GeoStrap from its design location (perpendicular to the facing panel) in either the horizontal or vertical plane. For skewing in the horizontal plane, a special connection device is needed.

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



**The placement of any GeoStrap in a skewed manner, unless shown on the Plans, Specifications, and Contract Documents, must be authorized in writing by The Reinforced Earth Company prior to placement in the field. A special connection device needs to be obtained from The Reinforced Earth Company for horizontal skewing. See Appendix C.**

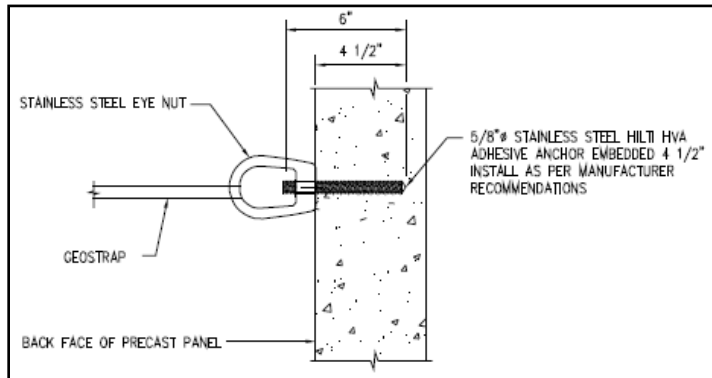


Figure 31

In specific, limited situations, it may be necessary to use an alternate device to attach the GeoStrap to the panel. Figure 31 provides the special connection that will be used for such cases.

**Step E-2:** Dump backfill onto the GeoStraps 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 GeoStraps 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 23).

**Metal tracks of earthmoving equipment must never come in contact with the GeoStraps. Rubber-tired vehicles, however, can operate directly on the exposed GeoStraps 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, space  $\frac{3}{4}$ " set its batter and brace if necessary. Then continue construction of the upper course using the procedure used on the lower level.

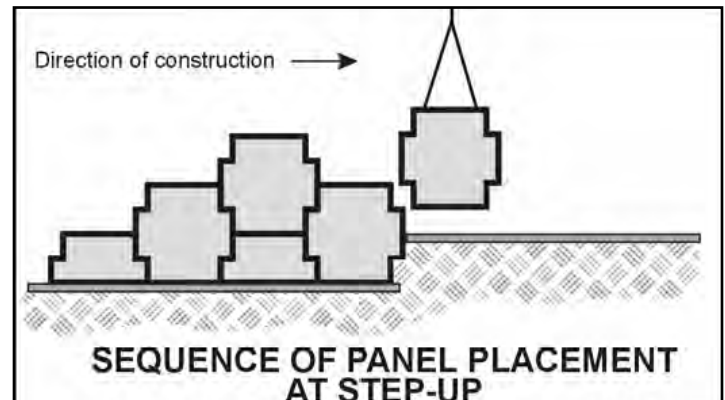


Figure 32

## F. Constructing second and subsequent courses

**Step F-1:** Only after 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 has 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 33)

**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 - Figure 30). To prevent concrete-to-concrete contact at horizontal joints, set two Bearing Bloks onto the top edge of panel 3.

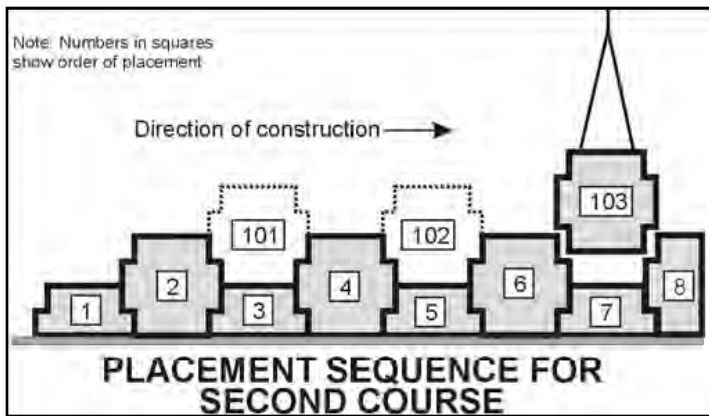


Figure 33

**Step F-3:** Set A panel 101 onto B panel 3 (Figure 33), centering the panel to ensure equal vertical joints and matching the panels front face to that of panel 3. 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 2 and 4. 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 Bloks onto the half panel 5; 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 4 and 6.

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-1.

**Step F-5:** When the course of panels is complete and after vertical and horizontal filter cloth has been installed, place backfill in lifts according to the Plans, Specification, and Contract Documents up to 2" above the recess level. Figure 34 illustrates the sequence for backfilling the second and subsequent courses.

**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-1.

**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.

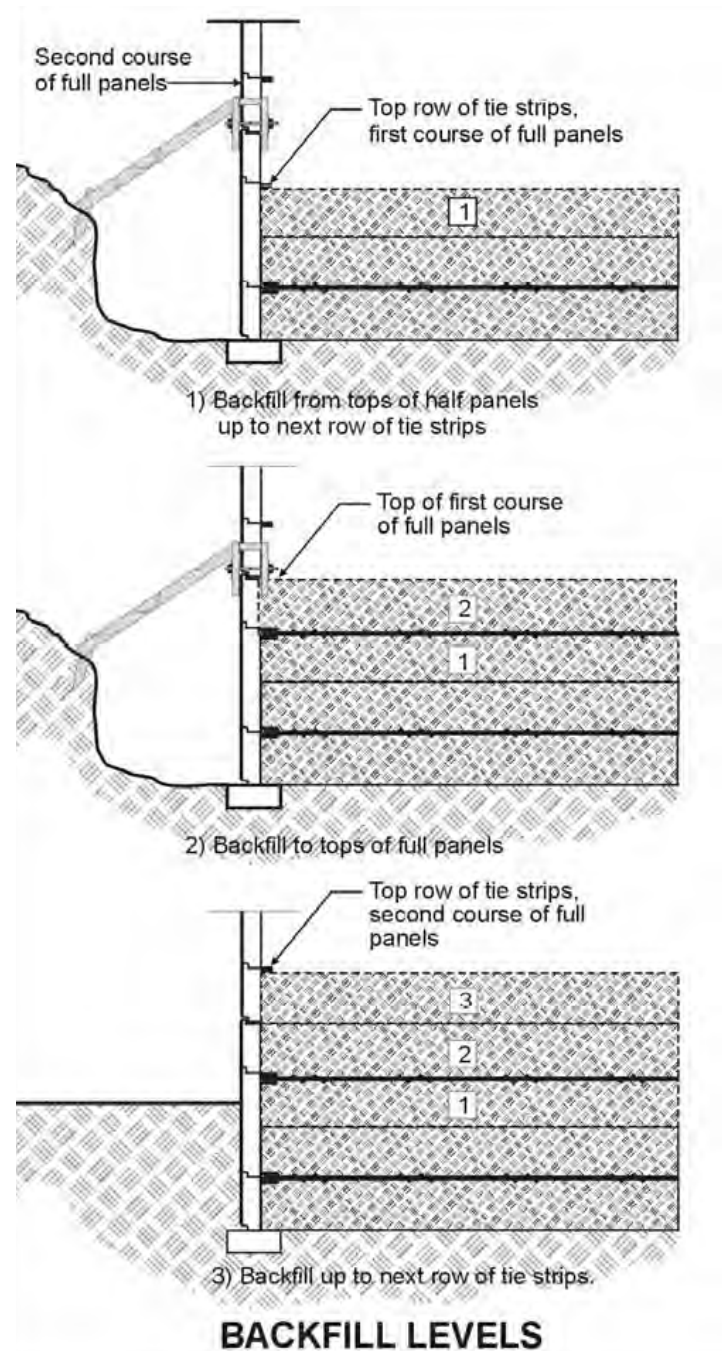


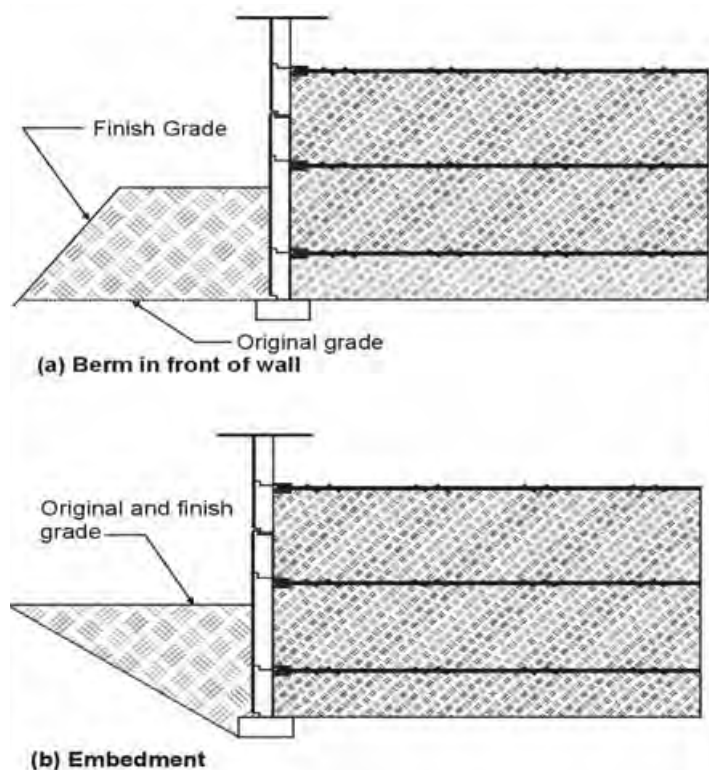
Figure 34

Placement and compaction of part or all of a berm or an embedment at the lower front surface of the structure can begin (Figure 35).

GeoMega 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.



## WALL TOE PROTECTION

Figure 35

Repeat steps F-1 through F-5 for panel installation, backfill placement and compaction, geostrap 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 content, 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 Wall

**Step G-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 G-2:** After backfilling is complete, remove all clamps and wooden wedges from the structure.

**Step G-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.

## **VI. Condition-Cause Relationships**

GeoMega 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**

<b>1. Distortion in Wall</b> (a) Differential settlement or low spot in wall (b) Overall wall leaning (c) Panel contact, resulting in spalling/chipping	Foundation (subgrade) material too weak or wet for proper bearing. If fill material, poor quality or improper compaction.
<b>2.</b> (a) First course difficult to set and/or maintain level. (b) Panel-to panel contact resulting in spalling and/or chipping.	Leveling pad not within tolerance.
<b>3. Wall Leaning Out</b>	(a) Panels not battered sufficiently. (b) Large backfill placing and/or compaction equipment working within 3-ft. zone of back of 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 back of wall before being compacted on strips. (f) Excessive or vibratory compaction on uniform fine sand (more than 60 percent passing a No.40 sieve). (g) Backfill material dumped close to free end of geostraps, then spread towards back of wall, causing bulge in strips and pushing panel out. (h) Wedges not seated securely. (i) Clamps not tight. (j) Excessive compactive effort. (k) Excessive lift thickness. (l) Plasticity index of backfill material in excess of specification limits. (j) Geostraps not properly tensioned (i.e. not taut)
<b>4. Wall Leaning In</b>	(a) Excessive batter set in panels for Select Granular Backfill material being used. (b) Inadequate compaction of backfill.
<b>5. Wall Out of Horizontal Alignment Tolerance, or Bulging</b>	(a) See causes 3c, 3d, 3e, 3f, 3g, and 3l. (b) Backfill saturated (heavy rain or improper grading of backfill after each day's operations).
<b>6. (a) Panels do not fit properly in their intended locations.</b> <b>(b) Subsequent panels are spalling or chipping</b>	(a) Panels are not level. (b) Differential settlement (see Condition 1). (c) Failure to use spacers between panels. (d) Leveling pad incorrect.

## **VII. Appendix**

### **A. Glossary of Terms**

<b>Agency</b>	The person(s), firm, or corporation acting as Agent for the Owner.
<b>Contract Documents</b>	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 The Reinforced Earth Company; 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.
<b>Contractor</b>	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.
<b>Engineer</b>	the person(s) designated by the Owner, as having authoritative charge over certain specific engineering operations and duties.
<b>Inspector</b>	Inspector the authorized representative assigned to make a detailed inspection of any or all portions of the Work or materials thereof in the Owner's behalf.
<b>Owner</b>	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.
<b>Plans</b>	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.
<b>Specifications</b>	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.
<b>Technical Advisor</b>	Representative of The Reinforced Earth Company who may be available to assist the Contractor with material scheduling and coordination, and give advice on the recommended construction procedures applicable to Reinforced Earth structures as set out in this manual.
<b>Work</b>	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.

## **B. Safety Tips for Unloading Reinforced Earth 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 panels or possibly panels 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 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 swammers 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, panels not placed directly in 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 trailer.
11. If any unsafe situations exist while loading or unloading RECo products, contact The Reinforced Earth Company immediately to eliminate any hazards or exposure to illness or injury.



## **D. GeoStrap Anchoring Method 1**

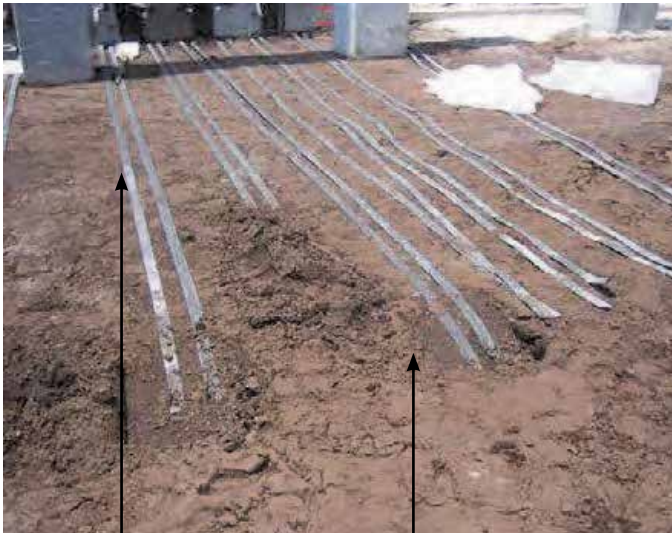
1. Spread and compact backfill in lifts up to 1" above the lowest level of geostraps.
2. Dig 6" x 6" hole within 2' of the end of the design length of the geostrap.
3. Lay geostrap flat on backfill and secure end of strip with nail/stake.
4. Fill hole and top of geostrap with select backfill.
5. Begin select backfill over end of strip and lightly compact to ensure end of strip is secure. Geostrap should be very tight and have NO slack at this point.



(4)



(5)



(1)

(2)



(3)





(6)

6. Then spread backfill to the backface of panel. Spread and compact backfill in lifts to within 3, or 5 inches of the top of the half panels. Place Bearing Blocks and set the second course of full panels.



(7)

7. Repeat cycle of backfilling and compacting in lifts, placing strips, placing filter cloth and Bearing Bloks and setting panels until design height is reached.



(8)

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

## E. GeoStrap Anchoring Method 2

### Installation and Tensioning of GeoStraps

1. Install Tensioning Timber: Drill four holes in 16 ft. long 2 x 6 timber and stake down with 2 ft long steel forming pins. The drill holes should be 1 inch clear of the far edge of the 2 x 6 to prevent it from tipping due to tension on GeoStraps. Use of a 2 x 8 is also acceptable. 4 equally spaced pins secure the timber in place.



2. Install GeoStraps: Pull flat on compacted fill one pair at a time. Staple one end of the strap to the timber, then the other. Pull all the slack out of the GeoStraps. Due to the thickness of the 2 x 6 timber, the strap will actually lift off the ground due to the tension. Use at least 4 staples per strap. If you use less, they may pull out. Allow

the strap to overlap beyond the back edge of the timber by at least 6 inches so you can grip it and pull on it while stapling.

3. Install Backfill: Backfill over middle of straps as usual. Have two men with flat shovels stand on the GeoStraps and hold down the geostraps with the shovel just in front of the lift of fill being pushed. Keep the lift thick so it falls forward on the straps and does not roll over the straps or displace them horizontally windrow fill to within 1 ft of  $2 \times 6$ . Don't cover the 2 x 6 timber, windrow fill toward panels only after the majority of the GeoStrap length is covered with a thick lift of fill. Once fill is in place, pull steel pins, roll over 2 x 6 and peel away from GeoStraps. Staples will pull right out. Now push fill to flatten and cover tails of GeoStraps.







4. Compact backfill & windrow backfill up to panels. Compact within 3 ft of wall face with walk behind flat plate tamper, compact beyond 3 ft of wall face with large vibratory roller.

5. Advance the Timber: Use 4 or more pieces of timber in this process, as fill is advanced and timber is retrieved, you can move the timber down station and continue to advance the fill. Stay ahead of backfilling with the tensioning operation.

## **F. The Reinforced Earth Company Offices**

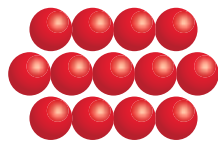
The Reinforced Earth Company maintains full-service offices throughout the United States. Contact the office serving your area for technical service.

Southeast Region	Atlanta, GA	(770) 242-9415
Northeast Region	Boston, MA	(978) 664-2830
Central Region	Dallas, TX	(817) 283-5503
Midwest Region	Chicago, IL	(630) 898-3334
Southwest Region	Mission Viejo, CA	(949) 427-3601
Western Region	Denver, CO	(303) 790-1481
Central-Northeast & Mid-Atlantic Region	Sterling, VA	(703) 547-8797
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