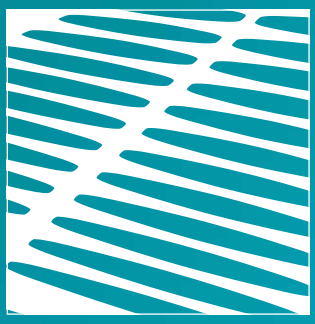
ARES®
RETAINING WALL SYSTEMS

TENSAR® GEO-STRIP™

INSTALLATION GUIDE AND CONSTRUCTION MANUAL

Tensar®

When long-term performance and speed of construction are important, ARES® Retaining Wall Systems offer unmatched advantages.



Tensar® Geogrids

ARES Retaining Wall Systems owe their long-term performance and durability to high strength **Tensar® Uniaxial (UX) Geogrids**. Due to their stiff interlocking capabilities, these geogrids stand the test of time, outperforming other commercially available geosynthetics. For more information, visit **www.TensarCorp.com**.

ARES® Retaining Wall Systems

Departments of Transportation, contractors and engineers have long appreciated the many advantages of panel walls. Panel walls' wide range of appearances and finishes, combined with the simplicity and speed of construction, make them attractive when compared to other types of wall systems. Unfortunately, the shortcomings of some reinforcing materials and the narrow and expensive range of acceptable backfill materials limited the widespread use of panel walls until the introduction of geogrids manufactured by Tensar International Corporation (Tensar). By combining Tensar® Geogrids with the advantages of panels, Tensar® ARES® Retaining Wall Systems offer a high-performance, cost-effective and aesthetically pleasing solution.

NO METAL – NO CORROSION

With soil reinforcement that is 100% polymeric, ARES Retaining Wall Systems are proven concrete panel wall solutions that eliminate the corrosion concerns of soil reinforcement. ARES Systems offer cost advantages over conventional panel walls, while eliminating risks associated with low-resistivity soils or stray electric current potential and long term exposure to chlorides or sulfates. Such properties make the system the logical choice for "hot" backfill soils, transformer platform areas and electrified rail systems.

As testimony to the durability of the ARES Systems, one of the first Tensar-reinforced panel walls was built as a seawall on the Gaspe Peninsula in Canada. After 30 years of North Atlantic storms and constant exposure to salt water, there are no signs of deterioration of the soil reinforcement. In fact, some of the first ARES installations were instrumented and carefully observed to verify the effectiveness and long-term performance of the systems. As part of an Federal Highway Administration (FHWA) study at the Tanque Verde project in Arizona, the Tensar Geogrid sections behind an ARES wall were excavated to validate the geogrid's durability. Thirty years after the original installation, the walls continue to perform as designed with no maintenance issues.

PURPOSE OF THIS DOCUMENT

This document is intended to provide the Owner, Engineer, Contractor and the Inspector with the guidelines and criteria required to facilitate construction and quality control of the ARES Precast Panel Retaining Wall System.

ARES® Retaining Wall Systems Components

COMPONENT	FUNCTION
Tensar Geo-Strip™	High-density polyethylene (HDPE) structural geogrids internally reinforce the fill materials. Inert to chemical degradation, they can be used with different backfill materials, even crushed concrete.
Precast Panel Facing	Available in standard 5 ft x 5 ft (1.5 m x 1.5 m), 5 ft x 9 ft (1.5 m x 2.75 m), 5 ft x 10 ft (1.5 m x 3.0 m) or can be customized for full height construction.
Bodkin Connector	A non-corrosive HDPE Connector for high connection efficiency.
Full Engineering and Construction Services	Detailing, design, site assistance and stamped drawings for each ARES project upon request.

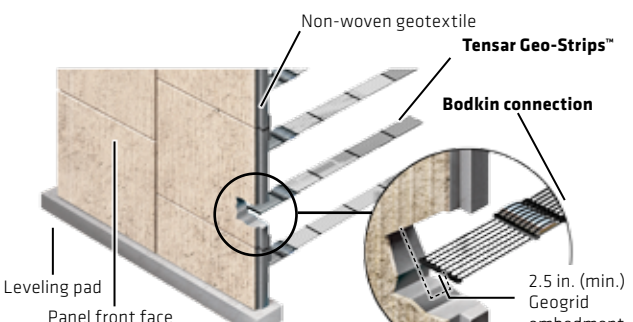


FIGURE 1: *ARES® Retaining Wall System – incremental 5 ft x 5 ft panel*

Wall Component Definitions

Below are standard terms used for the ARES® Retaining Wall Systems. Refer to Figures 1 and 2 for a typical cross-section and the associated terms.

- **Bearing Pads** – Wall panel spacers are typically ribbed elastomeric or polymeric pads. They are inserted at the horizontal joint between panels to help provide the proper spacing. Proper spacing keeps the panels from point contact and spalling the concrete.
- **Bodkin Connection** – The connection made between the wall facing panel and the soil reinforcement.
- **Concrete Leveling Pad** – Unreinforced cast-in-place concrete pad for precast panel placement on a level foundation.
- **Coping** – Cast-in-place or precast element used to tie in the top of the wall panels and to provide a pleasing finish to the wall top.
- **Filter Fabric** – Typically a non-woven geotextile fabric used to cover the joint between panels. Placed on the backside of the panel joints, it keeps the soil from piping through the joints and allows the outflow of excess water.
- **Random Backfill** – Backfill that is retained.
- **Select Backfill** – Select granular backfill within the reinforced mass that meets the gradation, unit weight, internal friction angle and any other requirements.
- **Temporary Wooden Wedges** – Help hold the panels at the correct batter during the backfilling operation.
- **Tensar Structural Geogrid** – Soil reinforcement that holds the wall facing panels in position and provides reinforcement for the soil.
- **Wall Facing Panel** – Panels made of precast concrete used to hold the soil in position at the face of the wall.

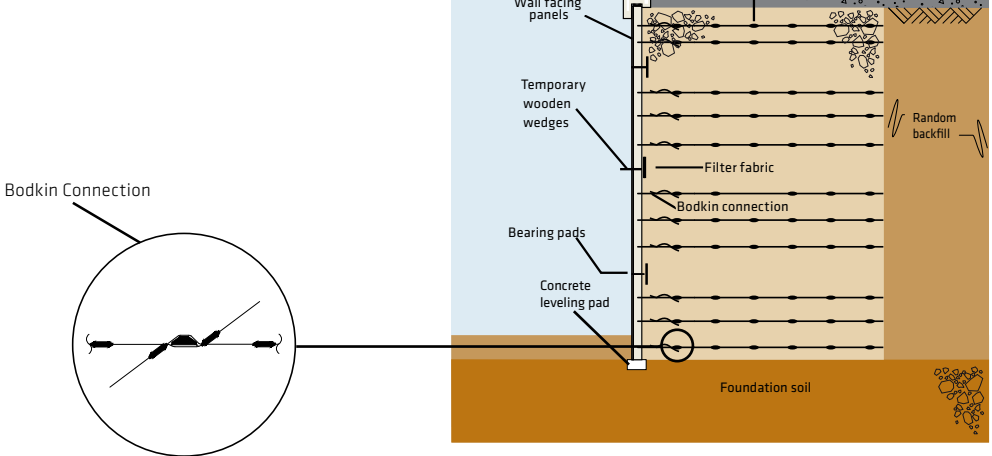


FIGURE 2: *Typical Cross Section*

Mechanically Stabilized Earth (MSE) Wall Construction Best Practices

- Confirm receipt of the Tensar approved construction drawings.
- Verify backfill material has been tested and approved before it is brought to the job site.
- Review the approved construction drawings.
- Ensure the Contractor's field supervisor has a copy of and is familiar with both the approved construction drawings and the Tensar Installation Guide and Construction Manual.
- Confirm the foundation soils are in accordance with project specifications.
- Confirm the leveling pad elevations, alignment and step locations prior to pouring the concrete.
- Notify the Tensar Project Manager of the expected start date for panel installation.
- Ensure panels, geogrid and accessories are properly stored to prevent damage.
- Inspect geogrid, accessories and panels for damage. Notify Tensar of any materials that are not in compliance with the plans or specifications.
- Install panels in accordance with the plans and specifications.
- Use corner panels at all corners. If corner panels are not indicated on the Tensar approved construction drawings, notify Tensar immediately.
- Ensure wedges are installed on each course of panels. Use hardwood wedges.
- Check the batter of the panels daily (at a minimum) and adjust the initial batter accordingly. The vertical alignment of the previously backfilled panels may be affected by the compaction of the soil behind the next layer of panels.
- When installing the filter fabric to a panel, apply the adhesive to the panel and then apply the fabric.
- Place and compact fill in accordance with the plans and specifications. If fill lift thickness is not included in the plans and specifications, do not exceed fill lifts thicker than 10 in. (250 mm) loose. Thick lifts may cause the panels to move out of alignment.
- Confirm that the geogrid reinforcement can be installed around all obstructions without skewing the Tensar Geo-strips™ more than 15 degrees from normal. Notify Tensar of any obstructions not shown on the Tensar approved construction drawings.

Responsibilities for Construction Compliance

- The Contractor is responsible for executing construction in accordance with the contract documents and for coordinating wall construction with related work.
- The Contractor is responsible for using the most recent set of approved construction drawings to perform the work and for verifying the lines, grades and offsets needed to install the wall according to the location indicated in the contract documents.
- The Contractor is responsible for monitoring material supply and for ensuring that adequate lead time is given for each request for delivery and that the ordered quantities are available to prevent construction delays.
- The Contractor is responsible for unloading and inspecting materials upon delivery to the job site, and for providing proper storage and protection of the materials.
- The Engineer is responsible for enforcing the requirements of both the contract documents and the approved construction drawings.
- The Tensar Project Manager will be available at the start of the project to advise the Contractor's project team on the recommended construction procedures as defined in this manual. The Tensar Project Manager is not a member of the inspection or quality control staff on the project.

Work provided by the Contractor includes:

- All wall site preparation and survey layout
- Forming and pouring the leveling pad
- Wall construction in its entirety according to approved construction drawings
- Installation of the top-of-wall treatment where required

If requested, services provided by Tensar include:

- Wall construction drawings
- On-site technical assistance at the start of construction

Materials

TYPICAL MATERIALS SUPPLIED BY TENSAR

- Precast concrete facing panels
- HDPE Tensar® Uniaxial (UX) Geogrid
- Filter fabric
- Bearing pads
- Bodkin bars

Materials supplied by Tensar are generally delivered in full truckload quantities. Off-loading is scheduled by the Contractor.

Any damage to the materials or discrepancies in quantities must be noted by the Contractor on the delivery ticket at the time of delivery and reported promptly to Tensar. The materials must be properly stored in a location and in such a manner to avoid damage or theft.

MATERIALS AND TOOLS PROVIDED BY THE CONTRACTOR

- Nylon slings for unloading panels
- Equal length cables with shackles to connect the lifting devices
- Devices for lifting panels by the embedded lifting inserts
- Tensar® T-Rod™ Rake for tensioning Tensar® Geo-Strips™ (Image A)
- Wide Tensar steel rake for tensioning single layers of Tensar® Geo-Strips™
- Lumber for bracing, staking, and the fabrication of clamps, as well as threaded rod, washers and nuts
- Hardwood wedges (Figure 3)
- Standard and bracing header clamps, and the corresponding threaded rods, washers and nuts (Figures 4 and 5)
- ¾ in. (19 mm) plywood spacer to set panel vertical joint gaps
- Spray paint for marking Tensar Geo-Strips and panels
- Standard grade construction adhesive such as Liquid Nails Adhesive or 3M 77 to attach the filter fabric to the panels at the joints
- Crowbars, 4 ft (1.2 m) long
- Wrenches for clamp nuts
- Sledge and claw hammers
- Broom for sweeping the leveling pad
- Sharp blade or scissors to cut the filter fabric
- 4 ft (1.2 m) level
- Chalk line
- Plumb bob

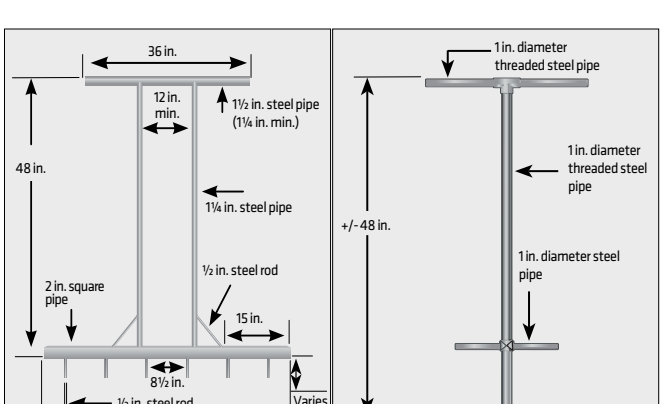


IMAGE A: *Sample configuration of steel rake and T-Rod Rake for tensioning Tensar® Geo-Strips™ (not to scale).*

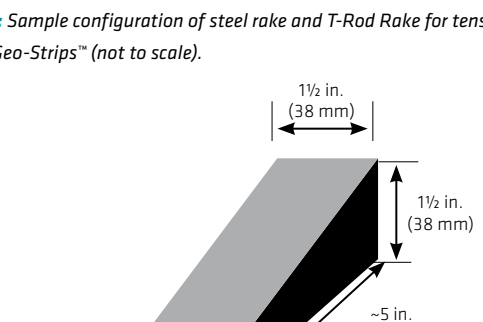


FIGURE 3: *Temporary wooden wedge: two per horizontal joint required on 5 x 5 panel walls and four per horizontal joint required on 5 x 9 and 5 x 10 panel walls.*

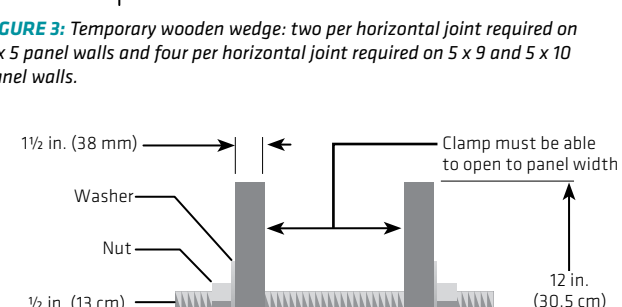


FIGURE 4: *Standard clamp: one per vertical joint*

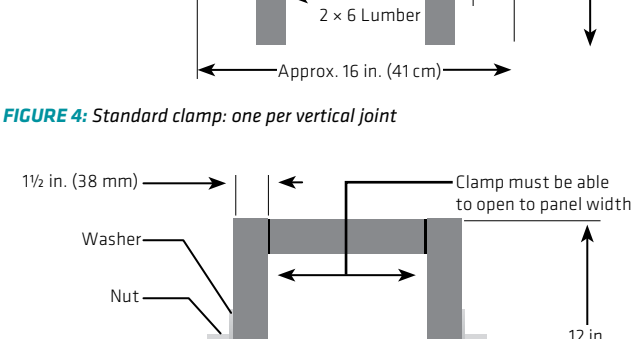


FIGURE 5: *Bracing header clamp: for initial course only.*

Materials (continued)

EQUIPMENT PROVIDED BY THE CONTRACTOR

- Panel handling and setting equipment – excavator, loader or similar equipment capable of properly lifting and placing the precast concrete facing panels.

  NOTE: Typical weight of largest standard panel is approximately 3,000 lbs (1,360 kg) for projects using nominal 5 ft (1.5 m) wide, 5.5 in. (140 mm) thick panels, approximately 5,500 lbs (2,495 kg) for projects using nominal 9 ft (2.75 m) wide, 5.5 in. (140 mm) thick panels, and approximately 6,000 lbs (2,720 kg) for 10 ft (3 m) wide, 5.5 in. (140 mm) thick panels.

- Equipment to transport the select fill to the wall site.
- Equipment, such as a rubber-tired loader and small track dozer, preferably with an angle blade, for placing and spreading the select fill.
- Large, smooth-drum roller for mass compaction.
- Small, hand-operated, vibratory plate tamper or roller for compaction within 3 ft (0.9 m) of the back face of the wall panel.

  NOTE: Use of a Jumping Jack is not recommended.

Handling Materials Supplied by Tensar

All materials supplied by Tensar shall be properly stored in a secure location to prevent damage or theft.

PRECAST CONCRETE FACING PANELS

- The Contractor is responsible for scheduling the delivery of the panels in accordance with the installation schedule. Proper coordination will help avoid delays by having the precasting performed in unison with the wall construction schedule.

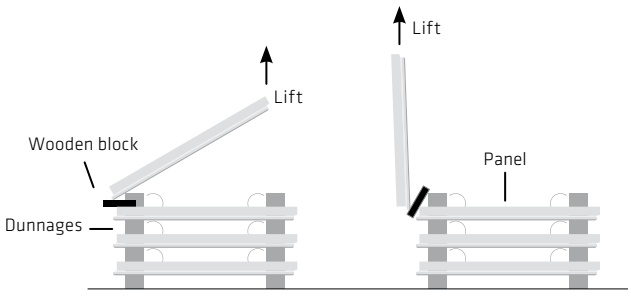


FIGURE 6: *Suggested stacking and lifting procedures for ARES segmental panels.*

- ARES panels are usually delivered on flatbed trailers. The Contractor must provide a level, stable area to unload and stage the panels. The acceptability of this access is at the discretion of the driver or the driver's employer. The Contractor is allowed one hour to unload each truck, unless specifically agreed otherwise in writing with Tensar.
- The Contractor must take care to protect the panels from staining due to rain splash or damage due to improper placement of the dunnage. The number of panels in a stack shall not exceed five 5 x 5 panels, four 5 x 9 panels or four 5 x 10 panels as shown in Image B.
- The dunnage shall be properly spaced to avoid uneven loading in the panel stacks. (Figure 6) **All dunnage is the property of Tensar or its precaster and should be stacked by the Contractor for loading on a subsequent panel delivery truck.**
- Delivery tickets are included with each shipment and indicate the panel types furnished in that load. It is the responsibility of the Contractor to confirm the accuracy of the tickets and to note any damage that is visible prior to accepting delivery. Tensar and its precaster must be notified immediately if any panels have been damaged.

BEARING PADS FOR HORIZONTAL JOINTS BETWEEN PANELS

- Bearing pads will be delivered in cardboard cartons.
- The quantity of the cartons shall be noted on the delivery ticket and confirmed by the Contractor.

IMAGE B: *ARES panels should be stacked on a level, stable surface provided by the Contractor. Dunnage shall be carefully selected to allow panel separation and placed to avoid panel cracking.*

Materials (continued)

GEOGRID REINFORCEMENT

- Geogrid reinforcement shall be delivered in rolls and shall be labeled by type. The labels must be protected until the geogrid is color coded at the job site. The Contractor should retain any certifications included with the packing slip for the Engineer.
- The Contractor should immediately color code each of the geogrid types using spray paint on the edges and ends of the rolls. (Image C) The Contractor may choose to highlight geogrid types on the approved construction drawings using corresponding colors. In addition, the Contractor may elect to color code the rear face of the panels to correspond with the geogrid rolls. (Image D)
- The Contractor is responsible for cutting the Tensar Geo-Strip or Geogrid to length in the field. Precut Tensar Geo-Strip or Geogrid should then be tagged for length and type. The first transverse bar (at the connection) of each section of Tensar Geo-Strip or Geogrid should be neatly trimmed to expedite the connection of the Tensar Geo-Strip or Geogrid to the wall facing. Do not cut into the transverse bar of the Tensar Geo-Strip or Geogrid. (Figure 7 and Image E)

FILTER FABRIC

- The filter fabric will be delivered in rolls and must be covered to protect it from direct sunlight.

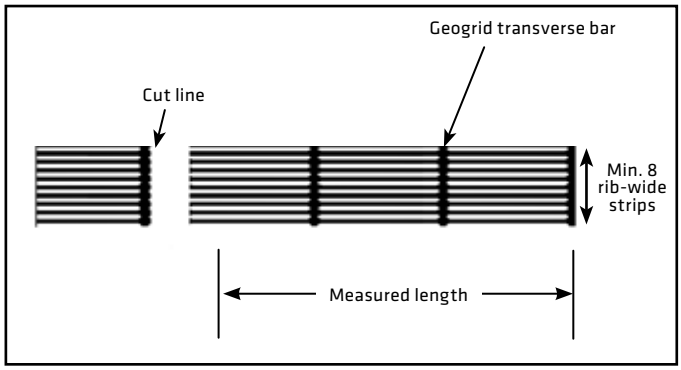


FIGURE 7: *Tensar Geo-Strip measured length and cut line*

IMAGE C: *Color coding of geogrid panels allows for quick, accurate identification even after labels are removed.*

IMAGE D: *Color-code the geogrid tabs on each panel to correspond with the geogrid rolls.*

IMAGE E: *Safe cutting of Tensar Geo-Strip can be done with a variety of cutting tools. Care should be taken to avoid cutting the transverse bar.*

Construction Procedures for ARES® Retaining Wall Systems

EXCAVATION, FOUNDATION AND DRAINAGE

- Excavation will be performed to the lines and grade required for the installation of the entire wall system.
- The Contractor is responsible for the wall excavation. All work to support the excavation or to fill the void behind the wall is the responsibility of the Contractor.
- Evaluation and approval of foundation suitability is the responsibility of the Engineer. Any foundation soils found to be unsuitable by the Engineer shall be removed and replaced with material suitable to the Engineer. The material shall be compacted to the density required to obtain the bearing pressure stipulated by the contract documents, including the project plans and specifications.
- The foundation shall be prepared according to the contract documents and the project specifications. The foundation is crucial to the performance of any panel wall system.
- The wall drainage system shall be installed as required in the contract documents.

CAST-IN-PLACE LEVELING PAD

- Once the foundation is prepared and approved by the Engineer, an unreinforced concrete pad is constructed. The pad serves as a level surface for the wall panel construction. During construction, there is significant loading on the leveling pad so it must be properly constructed and on a firm foundation in order to minimize potential wall movement. The leveling pad is not intended for structural foundation support in the final configuration of the wall.
- The leveling pad is important to the overall construction of and the horizontal and vertical alignment of the wall. The leveling pad must be in the correct horizontal position, level and at the correct grade.
- Unless otherwise shown in the contract documents or approved in writing by the Engineer, the leveling pad shall consist of 6 in. (150 mm) thick by 12 in. (300 mm) wide unreinforced concrete, which shall be formed and poured in place. The concrete strength shall be in accordance with the contract documents or a minimum of 2,500 psi (17MPa), whichever one is greater. The leveling pad must cure for a minimum of 12 hours prior to the placement of the panels.
- The leveling pad shall have formed sides and a smooth, level surface set to the grades as shown on the approved construction drawings and shall be finished so the elevation variance is less than +⅛ in. (3 mm) or -¼ in. (6 mm). An inaccurately placed leveling pad will create problems with wall alignment and joint spacing during the construction process.
- Where steps in the leveling pad are shown on the approved construction drawings, the actual location of each step should be located and the bulkhead for the upper leveling pad step set back 9 in. (225 mm), nominal. (Figure 8 below and Image E on pg. 9)
- After the concrete cures and the forms removed, lay out the front face of the wall and establish the location on the leveling pad by striking a chalk line at the front face of the bottom course of panels. (Image F on pg. 9) For panels with an architectural finish, the panel location should be based on the face of the structural, non-architectural portion of the panel, i.e. immediately behind the architectural relief.
- Do not allow the panels to overhang the leveling pad. If this happens, stop construction and investigate the problem.

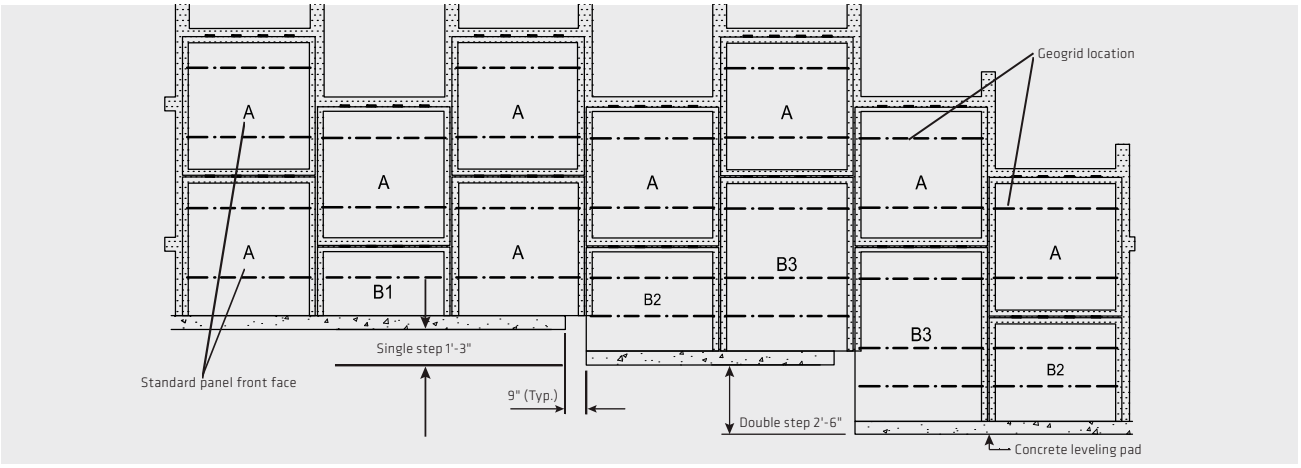


FIGURE 8: Example of leveling pad and typical panels configuration.

Construction Procedures for ARES® Retaining Wall Systems (continued)

PANEL PLACEMENT – BOTTOM COURSE

- At this point, the foundation has been constructed, drainage added, the materials checked and the leveling pad completed. Shop drawings must be checked to ensure that the correct panels are being used in the proper location along the wall.
- It is generally preferable to start a wall at the lowest leveling pad elevation and at the location of any fixed point such as a corner and/or existing structure. (Image G)
- The bottom course is made up of alternating tall panels and half panels (Figure 8 on pg. 8), with the tall A and B3 panels above the half B1 and B2 panels.
- The alignment of the first course of panels largely determines the resulting appearance of the wall. Considerable attention must be paid to the setting and positioning of these panels.
- Remove the panels from the stack using proper lifting devices. Wood blocking must be placed under the bottom of the panel prior to lifting. (Figure 6 on pg. 6) The wood blocks protect the face of the panel being lifted from being scarred by the lower panel.
- Prior to setting any panel, sweep off the top of the leveling pad or lower panel, and the bottom of the panel being set. This is to ensure that no foreign material is trapped under the panel, which could affect horizontal level. Bearing pads are not required between the leveling pad and the panels of the bottom course.

Below is the suggested sequence for placing panels on the bottom course: it is important to note that the panel should NOT be released prior to the step specifically calling for that action:

- Lower the panel into position on the pad, using one person on each end of the panel. (Image G)
- Using crowbars, position the base of the panel so that it matches the chalk line.

IMAGE E: *Upper leveling pad offset 9 in.*

- Use a temporary spacer to ensure that the ¾ in. (19 mm) space across the vertical joint is consistent between panels. (Image I on pg. 11) Without the correct joint spacing, panel corners may crack and spall.
- Check the panel for horizontal level. If the panel is not level, place shims under the panel to bring the panel to level. Galvanized metal washers or rubber shims are allowed. A maximum combined total shim height of ⅜ in. (9.5 mm) at any location is allowed. If more shims are required then the leveling pad is not level.
- Set the batter on the panel. (See "An Important Note on Batter" on pg. 11)

  NOTE: Shims shall consist of permanent material that will not deteriorate.
- Using the 4 ft (1.2 m) level with a predetermined blocking attached to one end, push the top of the panel back until the level reads plumb. (Image H on pg. 10)
- On the taller panels, install a header clamp and brace and tighten the clamp securely. Drive a stake in front of the wall at the midpoint of the panel for adequate bracing. (Figure 9 on pg. 10) Nail the bottom of the brace into the stake. Check the batter and then nail the brace to the header clamp.

IMAGE F: *Recommended location of chalk line on leveling pad.*

IMAGE G: *Placement and bracing of concrete panels.*

Construction Procedures for ARES® Retaining Wall Systems (continued)

- On the half-panels, the header clamp and staking are unnecessary; the half-panels should be held in place by clamping to the adjacent taller panels. At every vertical joint, position a standard clamp at the top of the half-panel (so that it results in one clamp on either end of the half-panel) and loosely fasten it. (Figure 9)
- The panel may be released after verifying it is supported by the clamps as described in the previous step.
- Pull the half-panel to the same batter as the taller panel; tighten the clamps; and check the panels for alignment, batter and level.
- Drive wedges at the quarter points of the bottom front of the panel to maintain the batter.
- Nail 2 x 4 wooden blocks at the panel joint to prevent sliding during backfill of the first course. (Figure 9)

Below is the suggested sequence for placing panels on all subsequent courses: it is important to note that the panel should NOT be released prior to the step specifically calling for that action:

- Subsequent panel rows are positioned between the previously placed panels. The ability to properly space and align these rows depends on the proper placement of the lower rows. Any errors in the lower rows are propagated upward and are difficult to correct. The same leveling, joint spacing, vertical and horizontal alignment applies to all subsequent rows as well.
- Prior to placing a panel on the next course, the panel below should be backfilled to the point that its uppermost layer of Tensar Geo-Strip or Geogrid is covered with at least one lift of compacted fill.
- Check the batter of the panel immediately below the panel being set. Constant attention to the amount of rotation occurring in the adjacent panels and compensating in the next rows of panels will yield the best results.
- Place bearing pads on lower panel. (Figure 9)
- Set the panel into position on the top of the lower panel bearing pads. Use one person on each end of the panel during placement.
- Using crowbars, position the panel and visually align it with the adjacent panels.
- Confirm that the ¾ in. (19 mm) space across the vertical joint is consistent between panels. (Image I on pg. 11)
- Check the panel for horizontal level and shim if required. This is particularly important for tall walls to prevent the alternate opening and closing of the vertical joints.
- Wedges may be temporarily placed in the vertical joints to maintain alignment until another panel is placed on top.
- Position and loosely fasten a standard clamp on each side of the new panel.
- The panel may be released after verifying it is supported by the clamps as described in the previous step.
- Set the batter on the panel. (See "An Important Note on Batter" on pg. 11)
- Tighten both side clamps and recheck the panel for alignment, batter and level.
- Drive the hardwood wedges at the quarter points between the top of the lower panel and the bottom of the new panel to assist in maintaining batter. The wedges should be checked during compaction and re-driven if they become loose.

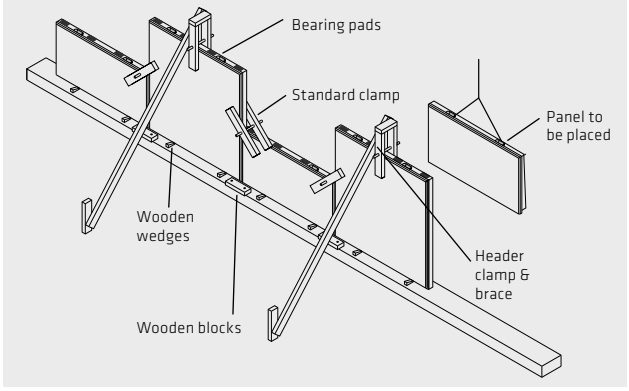


FIGURE 9: *Layout of bearing pads, wedges and clamps.*

IMAGE H: *Establishing batter of ARES® panels.*

Construction Procedures for ARES® Retaining Wall Systems (continued)

AN IMPORTANT NOTE ON BATTER

The amount of batter applied to the panel is a function of the type, gradation and moisture content of the select fill. It is recommended that the batter in sands be initially set at 1 in. (25 mm) in 4 ft (1.2 m), and for coarser material to be set at ¾ in. (19 mm) in 4 ft (1.2 m). The batter on subsequent rows of panels should be adjusted based on the results of the previous courses of panels when they have been backfilled to the top. In addition, particularly in sand backfill, the required batter tends to be less on panels with more than two layers of Tensar Geo-Strip or Geogrid. Guidance for determining and adjusting the batter is available from the Tensar Technical Advisor.

NOTE: Failure to properly use wedges and clamps may result in excessive rotation of the panel.

The lowest wedges in the column should be removed from the panels after three levels of wedges are in place above. Failure to remove wedges at this time can make subsequent removal difficult and may cause spalling of the concrete.

The vertical alignment of the overall wall should be checked daily using a plumb bob. These checks should be used to adjust the batter of subsequent panels. If the initial batter was set at ¾ in. (19 mm) and if after the panel is backfilled, a ¼ in. batter remains, the next course of panels should be set with ½ in. (13 mm) batter. Alternatively, if the backfilled panel has a negative batter of ¼ in. (6 mm), the next course should be set with an additional ¼ in. batter. If for any reason the backfill source changes, this process should be repeated. Monitoring and adjusting the batter of the panels will help maintain the vertical wall tolerances required by the contract documents.

PLACING THE JOINT MATERIALS

- The Contractor should equally space the required bearing pads along each horizontal joint between panels.
- Filter fabric is placed across the joints so that the backfill does not pipe through the joints to the outside of the wall. A minimum of an one foot overlap shall be maintained between fabric sections. On each side of the joint a 6 in. minimum lap is required. These requirements apply to both horizontal and vertical joints. (Images J and K)
- The filter fabric is typically provided in a 12 in. (300 mm) wide strip and, as shown in the contract documents, should be centered over all panel-to-panel joints and at special locations where the wall abuts other structures. If necessary, slit the joint fabric to fit around any geogrid tabs.

IMAGE I *Placement of 5 x 5 panels. Subsequent course: panels placed, positioned, aligned, clamped, battered and wedged. All but the top course are backfilled.*

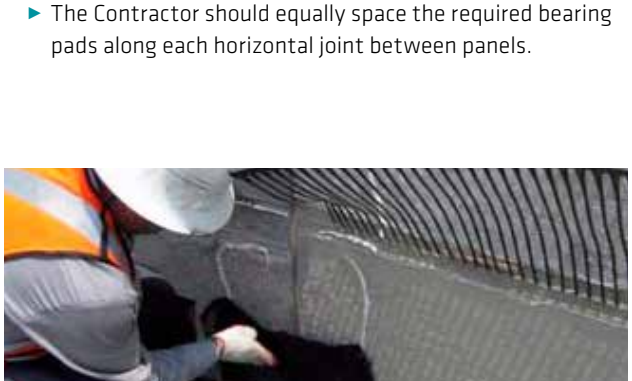


IMAGE J: *Placement of filter fabric at ARES® vertical joint.*

IMAGE K: *Area immediately behind panel may be left open until Tensar Geo-Strip is covered by one lift of compacted backfill.*

- Prior to select fill placement, use construction adhesive to hold the filter fabric in place. Apply adhesive to the panel about 2 in. from the fabric edges, including any areas where the filter fabric was slit. The filter fabric needs to fully adhere to the back of the ARES® panels at all joint locations to ensure that the backfill does not leak through the joints.

GEOGRID IDENTIFICATION

- It is recommended that the Contractor color code the Tensar Geogrid types on the construction drawings and spray paint the geogrid tab and geogrid the corresponding color. (Image D on pg. 7)
- It is recommended the Contractor mark the Tensar Geo-Strip embedment length for the panel sections on the back of the associated panel faces. (Image D on pg. 7)

PLACEMENT OF THE TENSAR® GEO-STRIP™

- Install the Tensar Geo-Strip as specified in the approved construction drawings, using the type, width, length, and number as shown for each location within the wall. Coordinate the installation of the Tensar Geo-Strip with the panel and fill placement. The Tensar Geo-Strip must be connected to the panels using the Bodkin connection as shown on the approved construction drawings.
- At the Contractor's discretion, prior to fill placement, the Tensar Geo-Strip may be connected to the panels and then temporarily flipped over the front face of the wall. The select fill shall be brought up to the level of the Tensar Geo-Strip connection after compaction and be compacted and level for the entire Tensar Geo-Strip embedment length prior to placing the Tensar Geo-Strip.
- The Contractor should ensure the level of the compacted fill is flush to the back face of the panel and up to the level of the geogrid tab.
- The Tensar Geo-Strip shall not be placed on the grade until the necessary testing and acceptance of the in-place fill material has been obtained from the engineer.
- Position the Tensar Geo-Strip perpendicularly to the face of the panel so the tension is relatively uniform across the width of the connection and the Tensar Geo-Strip lays flat on the grade for the entire embedment length.
- The Tensar T-Rod™ Rake is then inserted in front of one of the transverse bars to provide adequate tensioning from the panel and then pushed down into the select fill. (Image L) Then, using the Tensar T-Rod Rake, pull the Tensar Geo-Strip with sufficient force to remove all slack. Proper technique is important to apply and maintain proper tension.
- While maintaining tension on the Tensar Geo-Strip, select fill should be placed on the Tensar Geo-Strip between the Tensar T-Rod Rake and the back of the panel (preferably immediately beyond the 3 ft (0.9 m) zone behind the panels). (Image O on pg. 13)
- The Tensar T-Rod Rake may be withdrawn immediately after initial placement of approximately one cubic yard (.76 m^3) loose or more of select fill on the section of Tensar Geo-Strip.

REINFORCEMENT FILL PLACEMENT

- Fill placement shall be performed in a manner that prevents the development of slack in the Tensar Geo-Strip. Spread the select fill away from or parallel to the face of the wall. The spreading will ensure any slack that develops will be shoved toward the free (back) end of the Tensar Geo-Strip. Further care should be taken during fill placement to avoid shoving the Tensar Geo-Strips and causing them to shift sideways.
- Place and compact the select fill in accordance with the approved construction drawings and the contract documents. Compact the select fill to a minimum of 95%

IMAGE L: *Tensioning of uniaxial geogrid or single layer Tensar Geo-Strip prior to fill placement.*

IMAGES M and N: *Example of Tensar T-Rod Rake and method for tensioning compound layers of Tensar Geo-Strip.*

of the maximum dry density as determined in accordance with AASHTO T-99 or as required by the contract documents, whichever is more stringent. Unless otherwise directed by the Engineer, the select fill lift thickness shall not exceed 10 in. (250 mm) loose. The lift thickness allowed is at the discretion of the Engineer, provided the Contractor can meet compaction requirements and maintain proper alignment.

- Static rolling is normally adequate to achieve the required compaction; heavy vibratory equipment may cause movement of wall components and potential misalignment of the wall facing, particularly in sand fill. The actual procedure used should be determined based on field trial results.
- Only use hand-operated lightweight compaction equipment within 3 ft (0.9 m) of the panel's back face. Lightweight vibratory equipment and/or lightweight roller may be used for this purpose. The use of a Jumping Jack is not recommended.
- Do not operate tracked construction equipment directly on the Tensar Geo-Strip or Geogrid. A minimum of 6 in. (150 mm) of fill is required between the tracks and the Tensar Geo-Strip or Geogrid. Rubber-tired equipment may be operated directly on the Tensar Geo-Strip or Geogrid, provided the subgrade is not pumping or rutting. Minimize the turning of all equipment to prevent dislocation or damage to the Tensar Geo-Strip or Geogrid. The equipment must travel slowly and with sufficient care to avoid dislocating the Tensar Geo-Strip or Geogrid.
- At the end of each day, the Contractor must ensure that the reinforced fill zone is compacted and graded to drain away from the face of the wall and that berms or ditches are in place and functioning to prevent the entrance of runoff into the wall construction site.
- **Proper installation and tensioning of the Tensar Geo-Strip or Geogrid and the select fill is critical to the alignment, appearance and performance of the ARES® Retaining Wall Systems. Care should be taken to ensure that the Tensar Geo-Strip or Geogrid is properly tensioned and the select fill is properly placed.**

WALL TOLERANCES

Unless otherwise noted in the approved construction drawings or the contract documents, ensure the following:

- Deviation in vertical and horizontal alignment does not exceed ¾ in. (19 mm) when measured with a 10 ft (3 m) straightedge. Offsets at the joints (measured perpendicular to wall face) between panels do not exceed ¾ in. (19 mm).
- Gaps at horizontal and vertical joints between adjacent panels are not less than ½ in. (12 mm) and not more than 1¼ in. (32 mm).
- Deviation in the final verticality (plumbness from top to bottom) of the completed wall does not exceed ½ in. per 10 ft (4 mm per m) of wall height.

THE ARES® SYSTEMS ADVANTAGE

For more than 30 years industry professionals have been using Tensar® Geogrids to build economical, long-lasting structures. With clear advantages in performance, design and installation, ARES® Systems offer a proven technology for addressing the most challenging projects.

For more information on Tensar Geo-Strips or ARES Systems, visit **www.TensarCorp.com,** call **800-TENSAR-1**, or send an e-mail to **info@tensarcorp.com**. We are happy to supply you with additional information, system specifications, design details, conceptual designs, preliminary cost estimates and much more.

IMAGE O: *Placement of fill on tensioned Tensar Geo-Strip.*

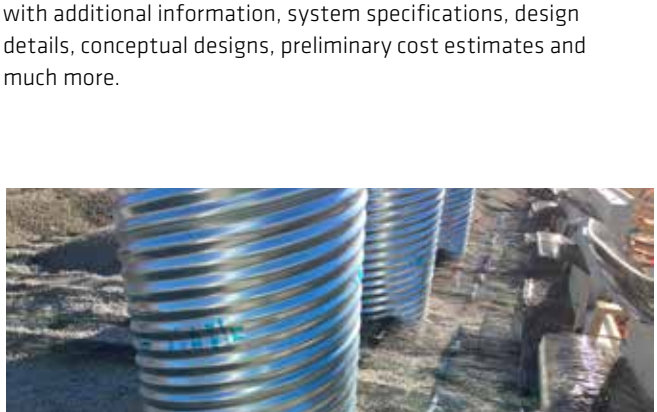
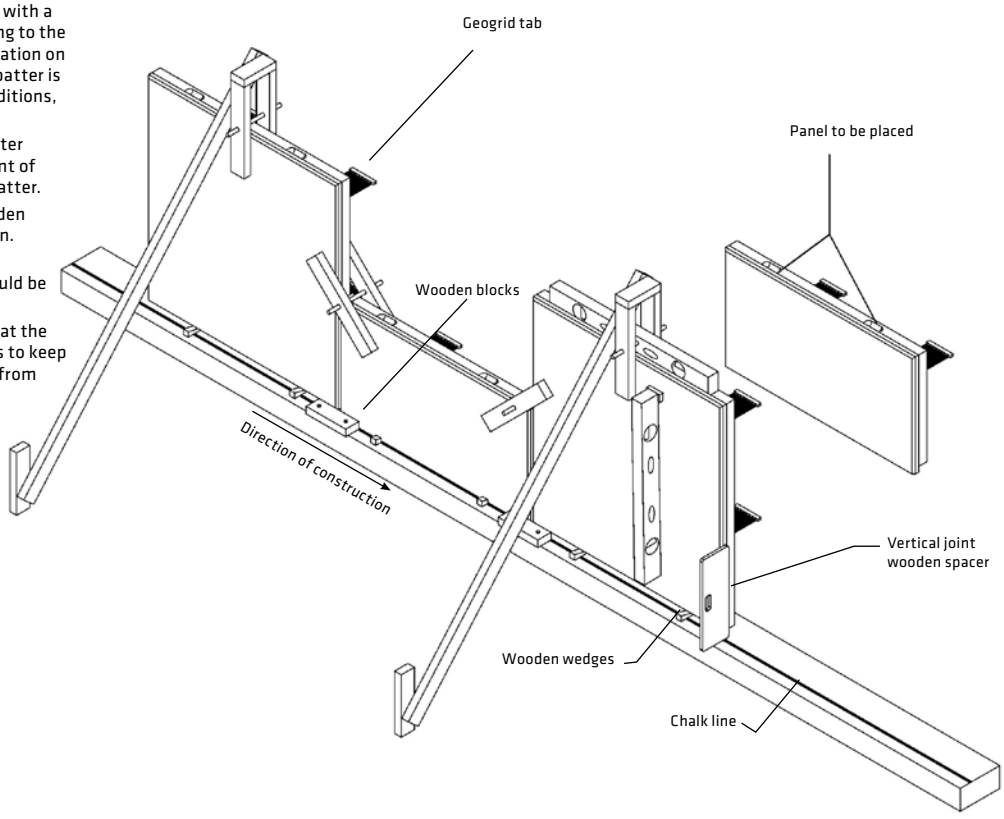


IMAGE P: *Placement of Tensar Geo-Strips around vertical obstructions.*

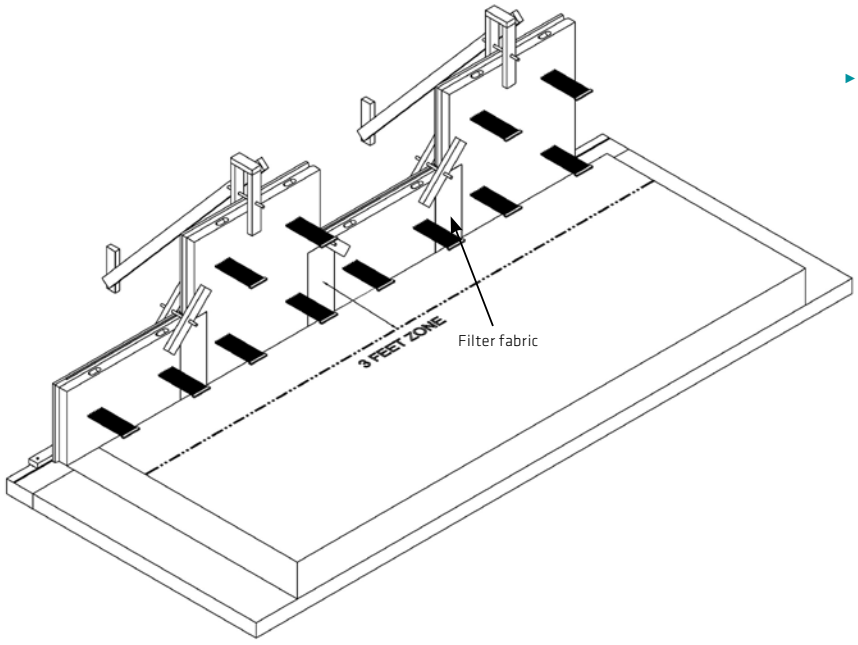
STEP 1: PLACE FIRST ROW OF PANELS

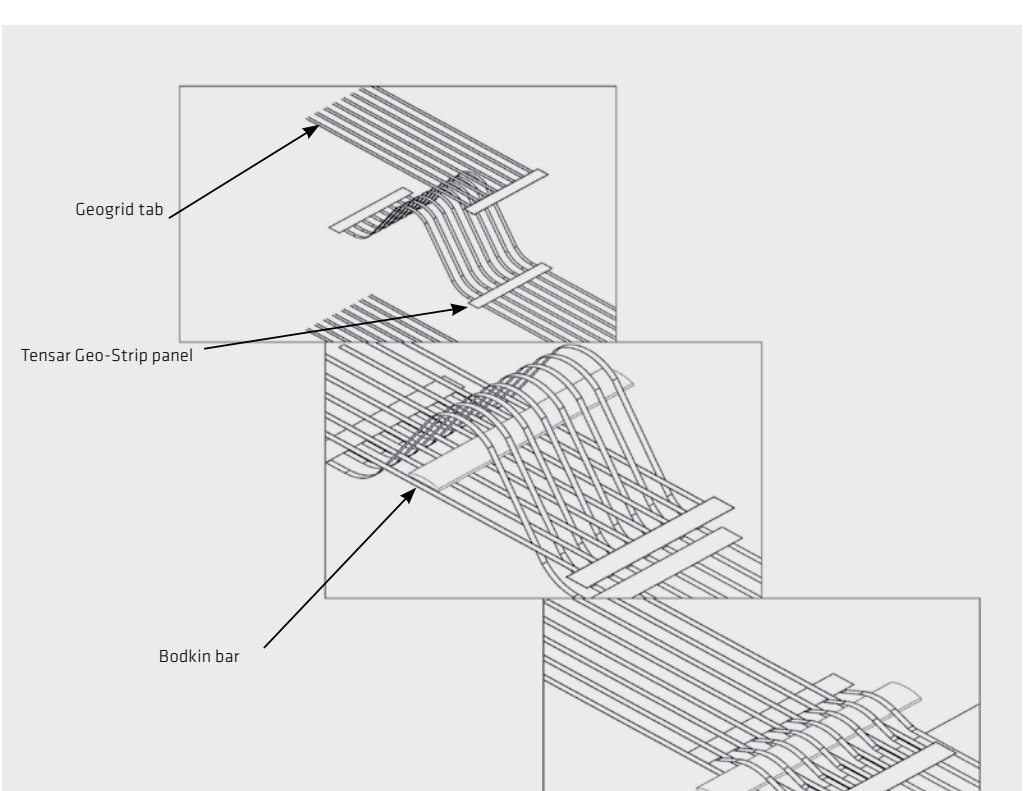
- The first row of panels are placed on the leveling pad and braced.
- The panels should be set with a backward batter according to the panel batter recommendation on page 11. Important: The batter is adjusted for the site conditions, e.g. backfill properties.
- Drive wedges at the quarter points of the bottom front of the panels to maintain batter.
- Use a ¾ in. (19 mm) wooden spacer to achieve the ¾ in. (19 mm) vertical joints.
- Adjacent half panels should be clamped together.
- Nail 2 x 4 wooden blocks at the joint of the panels; this is to keep the bottom of the panel from "kicking out."



STEP 2: INITIATE BACKFILL PLACEMENT

- Place the filter fabric over vertical joints.
- Place and compact initial lifts of selected granular backfill up to the bottom of the first geogrid tab, per project specifications.
- Use a hand-operated vibratory compactor in the 3 ft (900 mm) zone behind the panels.



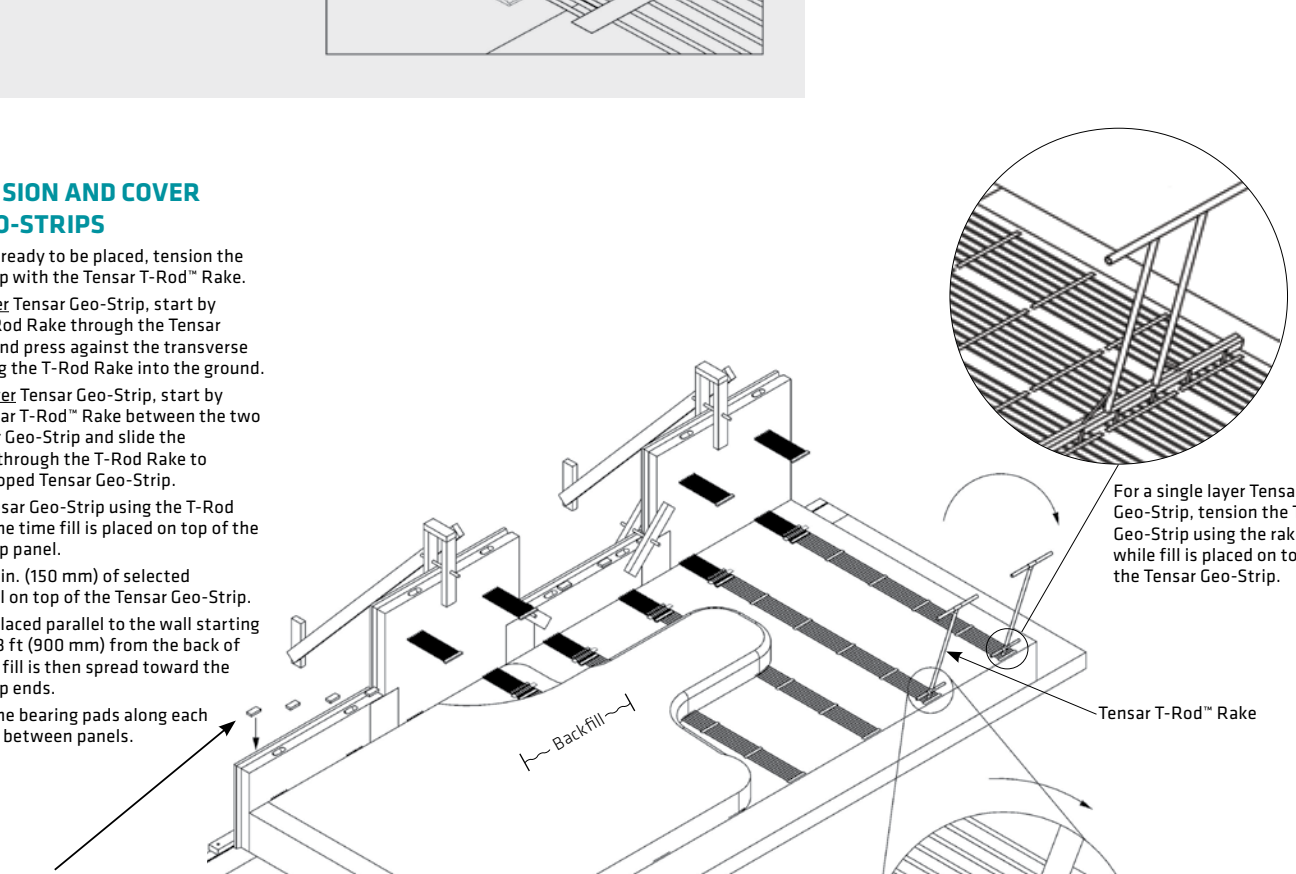


STEP 3: CONNECT TENSAR GEO-STRIPS

- Connect each Tensar Geo-Strip panel to the geogrid tab embedded in the panel with the Bodkin bar.
- Start by bending the Tensar Geo-Strip through the tab to create a tunnel.
- Slide the Bodkin bar through the tunnel that was formed by the Tensar Geo-Strip panel and the geogrid tab.
- Pull the Tensar Geo-Strip snug by hand.
- For a double layer Tensar Geo-Strip, the Geo-Strip may be cut to double the required embedment length and both ends connected to the corresponding double layer grid tabs.

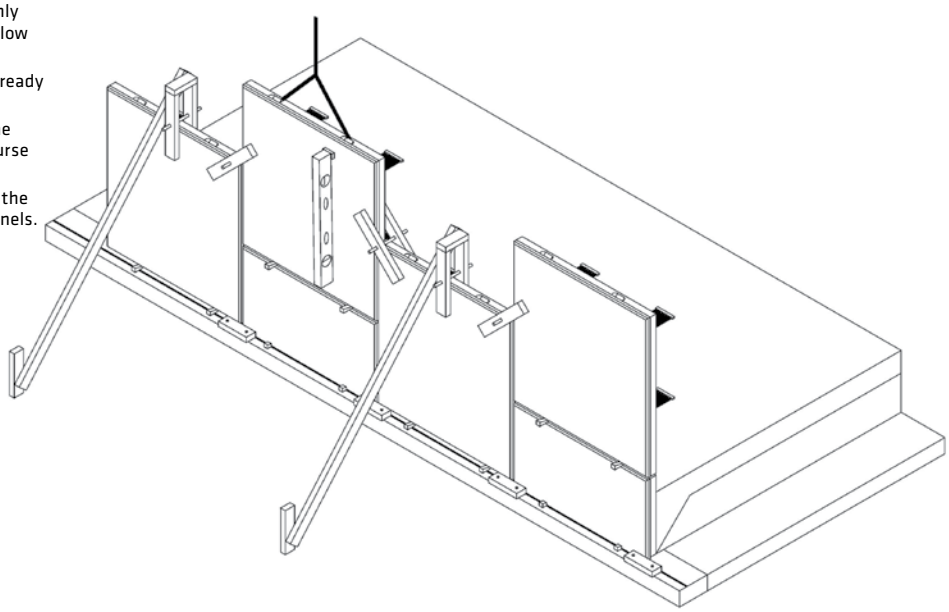
STEP 4: TENSION AND COVER TENSAR GEO-STRIPS

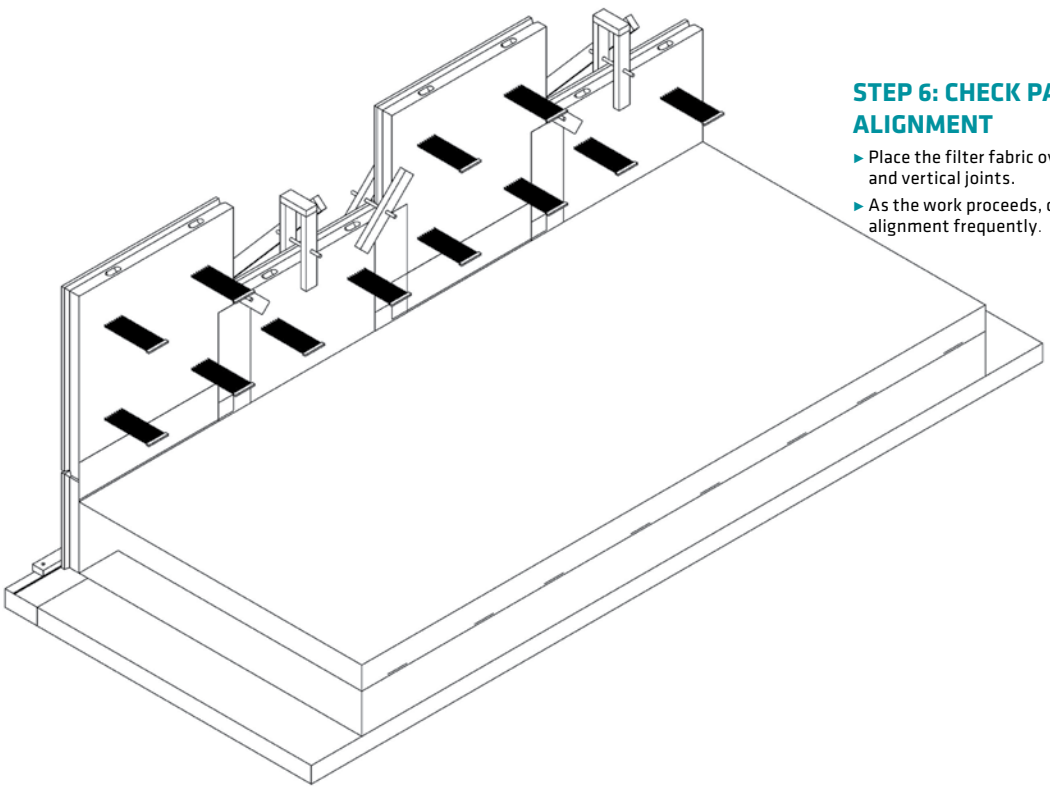
- When the fill is ready to be placed, tension the Tensar Geo-Strip with the Tensar T-Rod™ Rake.
- For a single layer Tensar Geo-Strip, start by pushing the T-Rod Rake through the Tensar Geo-Strip ribs and press against the transverse bar while driving the T-Rod Rake into the ground.
- For a double layer Tensar Geo-Strip, start by sliding the Tensar T-Rod™ Rake between the two layers of Tensar Geo-Strip and slide the horizontal bar through the T-Rod Rake to interlock the looped Tensar Geo-Strip.
- Tension the Tensar Geo-Strip using the T-Rod Rake at the same time fill is placed on top of the Tensar Geo-Strip panel.
- Place at least 6 in. (150 mm) of selected granular backfill on top of the Tensar Geo-Strip.
- The backfill is placed parallel to the wall starting approximately 3 ft (900 mm) from the back of the panels. The fill is then spread toward the Tensar Geo-Strip ends.
- Equally space the bearing pads along each horizontal joint between panels.



STEP 5: PLACE SECOND ROW OF PANELS

- Place the second row of panels only after backfill has reached 6 in. below the half panels.
- When the next row of panels are ready to be set, remove the clamps.
- Place the next row of panels in the "window" created by the first course of panels.
- Check the batter and then install the wedges and clamp to adjacent panels.



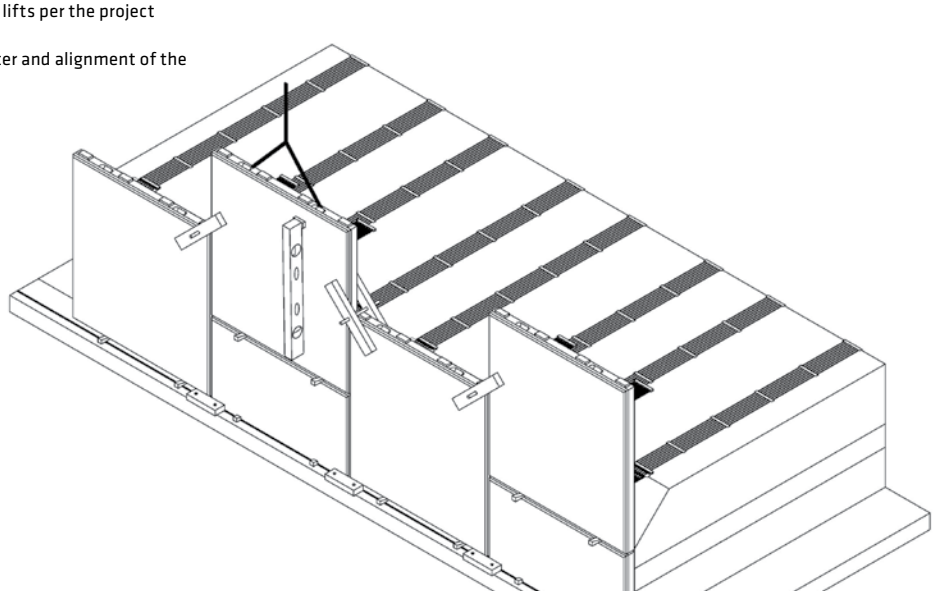


STEP 6: CHECK PANEL ALIGNMENT

- Place the filter fabric over the horizontal and vertical joints.
- As the work proceeds, check the panel's alignment frequently.

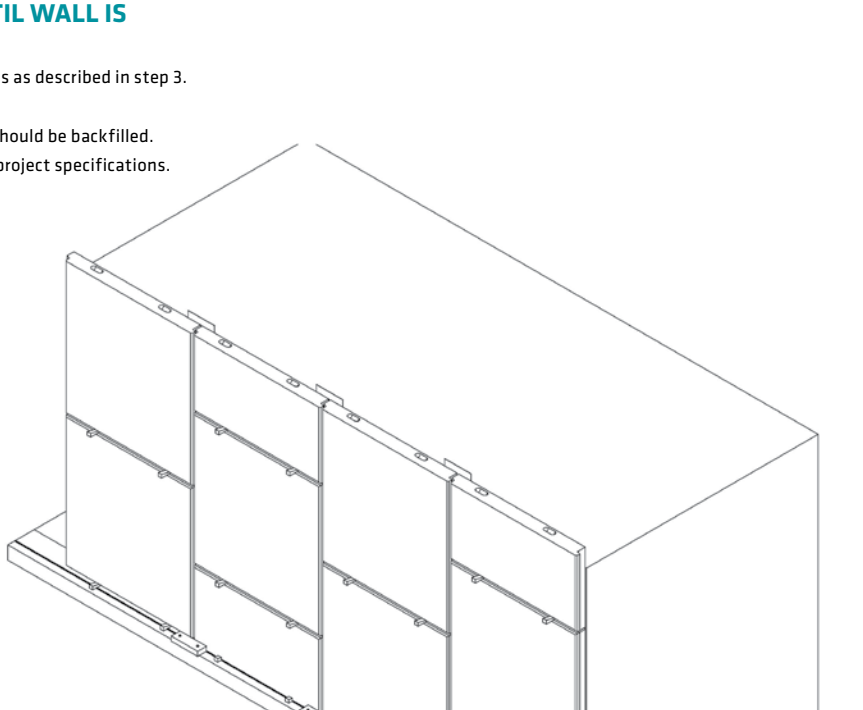
STEP 7: INITIATE BACKFILL PLACEMENT (FOR SECOND ROW OF PANELS)

- Place selected granular backfill in lifts per the project specifications.
- After backfilling, recheck the batter and alignment of the panels.



STEP 8: REPEAT PROCESS UNTIL WALL IS COMPLETED

- Connect and install Tensar Geo-Strip panels as described in step 3.
- Repeat steps 4 to 7.
- As soon as possible, the front of the wall should be backfilled.
- The top wall treatment is then placed per project specifications.



General Terms

Approved Construction Drawings
The final wall drawings provided by Tensar to the Contractor for submittal to the Owner/Owner's Engineer and subsequently approved by the Owner/Owner's Engineer for construction.

Contract Documents
The agreement between the Owner and the Contractor including the plans and specifications, the conditions and provisions of the agreement, including any addenda and other modifications issued prior to or after the bid and the execution of the original contract.

Contractor
The individual, firm or corporation acting directly through its agents or employees to undertake the execution of the work under the terms of the contract.

Engineer
The Owner's representative with authoritative charge over the inspection and acceptance of the wall construction in accordance with the contract documents.

Inspector
An authorized representative of the Owner assigned to see that the workmanship and materials are in accordance with the terms of the contract.

Owner
The owner of the project with whom a contract has been made for payment for the work performed under the terms of the contract.

Plans
The part of the contract documents consisting of the plans, profiles, typical cross-sections, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions and details of the work to be performed.

Precaster
Every precast panel manufacturer under contract with Tensar.

Specifications
The part of the contract documents consisting of a description of the quality and quantity of the materials and workmanship that will be required of the Contractor in the execution of the work under the contract between the Owner and the Contractor.

Tensar Technical Advisor
An authorized representative of Tensar that is available on site at the start of the project to advise the Contractor on recommended construction procedures within the scope of this document. The Tensar technical advisor is not an inspector or member of the quality control staff on the project.

Work
All work items to be performed by the Contractor under the terms and conditions of the contract that are necessary to fulfill the obligations of said contract.

A Tensar® Temporary Wall is often used during staged construction projects, and is an economical and more straightforward alternative to traditional solutions.

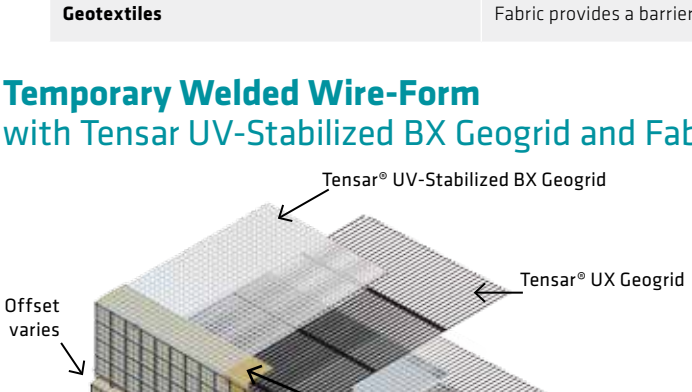
TENSAR® TEMPORARY WALL

Temporary walls are a necessity for many types of staged construction, but the conventional means of installing them are expensive, requiring heavy lifting and pile-driving equipment. Structures such as soldier piles and lagging walls or sheet piling typically require toe penetration equal to or greater than the wall height, and they may also need secondary bracing or deadmen to retain the fill safely. These walls require the use of expensive equipment and labor, resulting in significantly increased project costs.

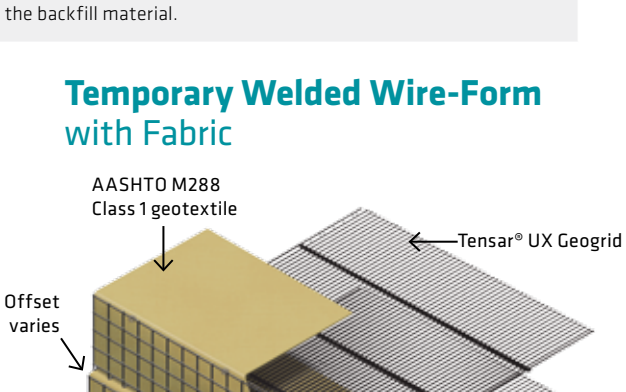
Fortunately, there is a proven technology that allows you to build temporary walls without the challenges and expense of traditional techniques. The Tensar® Temporary Retaining Wall System uses an inexpensive wire-form facing system along with Tensar® Geogrids to reinforce the fill. As a result, Tensar Temporary Walls can simplify planning and allow for quicker construction of bridge improvement, road widening, surcharge load cell, phased or staged projects and more. Tensar Temporary Walls are both durable and flexible; they may be left in place or easily removed as needed.

Tensar® Temporary Wall System Components	
Component	**Function**
Tensar® Uniaxial (UX) Geogrids	Primary reinforcement that internally reinforces soil structure and fill materials.
Tensar® UV-Stabilized Biaxial (BX) Geogrids	Secondary reinforcement that provides surficial stability to the wall structure.
Black Steel Welded Wire-Forms	Wire-form baskets that provide temporary facial stability during placement and compaction of fill material, and simplify facing alignment. Dimensions: 18 in. tall x 18 in. deep x 10 in. long.
Black Wire Struts	Struts attached to the Temporary Wall System's basket tail that help stiffen the facing element to maintain alignment.
Geotextiles	Fabric provides a barrier to confine the backfill material.

Temporary Welded Wire-Form with Tensar UV-Stabilized BX Geogrid and Fabric



Temporary Welded Wire-Form with Fabric



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