TRITON®
COASTAL & WATERWAY SYSTEMS

INSTALLATION GUIDE







Tensar
INTERNATIONAL

The Triton® Coastal & Waterway Systems are a durable, non-corrosive solution to many coastal and inland waterway erosion issues.

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TENSAR® GEOGRIDS

The Triton Systems owe their strength and durability to **Tensar Uniaxial (UX)** and **Biaxial (BX) Geogrids,** Tensar's patented reinforcement geogrids. Due to their stiff interlocking capabilities, these geogrids stand the test of time, performing better than other commercially available geosynthetics. For more information, visit www.tensar-international.com.

1. Introduction

Construction in coastal areas has never been easier since the development of the Triton® Coastal & Waterway Systems from Tensar International Corporation. Because they provide durable, cost-effective solutions for applications in and around the water, Triton Systems are typically used for:*

- Erosion control projects
- Foundations or cores for breakwaters, groins, etc.
- High-strength fills built in submerged conditions or with weak fill materials
- Channel linings and bridge scour protection
- Causeways, levees, dikes and bridge approach projects
- Protective cover for subaqueous utilities/pipelines

Assembled with advanced geogrid and geotextile materials, they can be integrated with readily available, natural fill material or vegetation to create highly resilient, flexible cells. That flexibility allows the Triton Systems to conform to land contours and irregular subgrade conditions far better than conventional solutions. And, by utilizing some unique deployment techniques, the Triton Systems can substantially reduce overall project cost when compared to conventional solutions, such as riprap.

***Note:** The following guide provides specifications for installing Triton Marine Mattresses, Triton Grid Composites, Triton Gabions and Triton Filter Mattresses. It cannot account for every possible scenario, but does cover most applications. If you have questions regarding a specific project, please call 800-TENSAR-1 or visit www.tensar-international.com.

TRITON Systems' Components

COMPONENT	FUNCTION
Marine Mattress	Coastal Foundation; Riverbank and Shoreline Revetment
Grid Composite	Riprap/Revetment Underlayer
Gabions and Gabion Mats	Retention Structures; Channel Lining
Filter Mattress	Bedding and Filtration; Deep Water Geotextile Installation

2. Tools Required

Table 1: Provided by Tensar International Corporation

	MARINE MATTRESS	FILTER MATTRESS	GABIONS
Prefabricated Units	X	X	X
Braid (For remaining seams)	X	X	X
Additional Grid (For anchoring)	X*	X	
HDPE Bars (For splicing)	X		

*Additional grid for anchoring provided as indicated in project plans & specifications.

Table 2: Provided by Contractor

	MARINE MATTRESS	FILTER MATTRESS	GABIONS
Stone Fill	X	X	X
Filling Frames	X		
Geotextile Fabric	X*		X*
Plastic Cable Ties (For temporarily securing grid or bodkins)	X		X
Shovels (To aid filling)	X	X	X
1.5 in. – 2 in. Bars (For rodding stone fill)	X		
Metal Snips or Shears (For cutting grid)	X	X	X
Handmade Wire Tool [To help thread braid through grid (optional)]	X	X	X
Rotary Drill with ⅜ in. Spade Bit (For making holes in the HDPE bars)	X		
Front End Loader (For moving stone and filling the units)	X	X	X
Crane or Large Backhoe (For lifting units)	X	X	
Steel Lifting Bar (6-8 ft. long, 4 in. or larger diameter, schedule 80) (For placing in the lifting hoop to lift units)	X	X	
Spreader Bar or I Beam (if lifting unit by both ends) **with Lifting Eyes** (Spreader bar/beam should typically be about the same length as the filled unit being lifted)	X	X	
Choker Cables, Lifting Cables, Shackles and Other General Rigging	X	X	
Winch (or Windlass and Straining Wire)			X
Steel Rods (½ in.)			X
Wooden Insert Frames (For filling compartments)		X	X

*Geotextile fabric, per project plans and specifications, is available from Tensar International Corporation. The contractor may choose to procure fabric from an alternate source. Geotextile fabric is automatically included in BX Filter Mats as it is integral to the product.

3. Marine Mattress System

The Triton® Marine Mattress System is designed for the demanding conditions associated with erosion control armoring and submerged foundation projects. For a complete application description, please refer to the Triton Systems Overview Brochure. The following procedures are intended for the filling and installation of typical Triton Marine Mattresses with a nominal thickness of 12, 18 and 24-inches.*



Figure 1: Prefabricated Triton Marine Mattress Units.

***Note:** The use of other procedures is contingent upon approval by the engineer. Unless otherwise directed by the engineer, use materials and configurations conforming to the approved shop drawings.



Figure 2: Example of a hydraulic filling frame.

3.1 SPECIAL CONSIDERATIONS

Temperature

Operations involving handling of the polymer materials or mattress units should be avoided when the ambient temperature is lower than 23° F (-5° C). The polymer materials should be stored at temperatures above -20° F (-29° C).

Damaged Materials

If the unit is damaged, refer to the *Suggested Repair Guidelines for Triton Marine Mattress* supplement and consult with a Tensar Representative ***prior*** to filling, lifting or placing the unit.

Stockpiling of Materials

The fabricator should check the mattress materials upon receipt to verify that the proper material has been received and that the materials are free of flaws or damage occurring during manufacturing, shipping or handling.

The contractor should store and protect the materials as follows:

- Prevent excessive mud, wet concrete, epoxy or other deleterious materials from coming in contact with and affixing to mattress materials.
- Store mattress units neatly stacked to prevent unnecessary distortion, folds, etc.
- Handle the mattress units in a manner to avoid loss of bodkin rods. (Avoid dragging mattress units on hard surfaces such as asphalt and concrete.)
- Lay rolled materials flat or stand on end.
- In colder temperatures, it is helpful to stage prefabricated mattresses indoors for 24 hours prior to filling if possible. This helps the grid to maintain pliability and minimizes some difficulties in preparing and filling the mats.

3.2 FILLING PREPARATION

When preparing to fill, it may be necessary to stitch the third long side seam of the mattress and the short seams on each end (which form the corners) together to form a long box with one side remaining open to fill. Generally speaking, it is not important which of the two long seams is selected to be the third or which is selected to be the fourth.



Figure 3: Typical lock-stitch braiding configuration for mattress fabrication.



Figure 4: Knots should be tied in a manner to prevent slipping and cinching.



Figure 5: Stacked units are ready to fill. The third seam is complete.

Work Area

This seaming is typically accomplished in an open area adjacent to the filling operation. The units may be leaned against light support to prop them up on edge. This allows laborers to stand and walk along one side of the unit to perform the seaming at close to shoulder height.

Seaming

Using the seaming techniques and procedures as shown in Figures 3 and 4, complete the third seam and the short seam on each end of it. Units may be stacked. See Figures 5 and 6. After seaming, the unit is ready for filling.

*Production Rates**

As a rule of thumb for the third seam, two laborers can complete approximately 90-120 linear feet of seaming per hour. For 30-foot long mattresses, this equates to 3-4 units per hour.

***Note:** Production rates herein are provided for general estimating purposes only, based on previously completed projects. This does not assure that the contractor will meet these production rates.

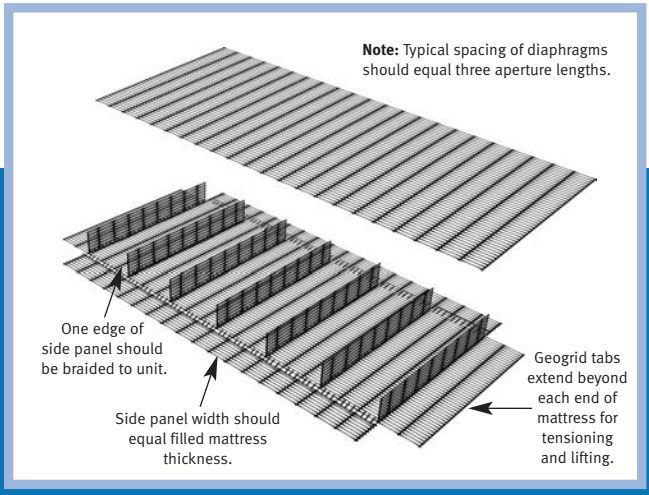


Figure 6: A typical configuration of a prefabricated mattress.

3.3 FILLING AND CLOSING

Work Area

One or more frames are typically used to accommodate the on-edge filling procedure. Vibration equipment is not considered a required feature of the filling setup; rodding by hand is generally required and more effective. The basic functions of the filling support are to:

- Hold the unit safely during filling and closing, in an upright, on-edge position so that its open side faces upward.
- Help guide the stone into the compartments of the unit.
- Provide laborer access for rodding the stone fill and braiding the remaining seams.
- Facilitate lowering the filled unit in a controlled manner to a horizontal position from which it can be lifted.

Alternate support setups have been used successfully for filling (see Figure 8). Contingent on approval by the engineer, the contractor may utilize an alternate support setup, which facilitates safe and complete filling and lowering of the units without causing unacceptable damage. Side support is required. Tensioning is recommended and may reduce the amount of side support needed. When placing a mattress unit in tension during filling and lowering, avoid damage to the lifting tabs by using connections similar to those used for lifting.



Figure 7: This wooden filling frame was constructed for a marine mattress project in Kauai, Hawaii.



Figure 8: If filling a mattress unit without a frame, support struts and tensioning are recommended.



Figure 9: For UX Marine Mattresses, the average stone fill diameter should be 4 inches.

The separation between the sides of the filling setup should be slightly greater than the nominal thickness of the mattress. For example, when filling a 12-inch thick mattress, the clearance between sides should be 14 to 15 inches. Typically the filling setup should include sufficient area for the equipment to load stone from one side of the unit, while laborers work from the opposite side.

Size of Stone Fill

Unless otherwise directed by the engineer, the gradation of the stone fill shall conform to the project plans and specifications. The following comments are provided as suggestions to facilitate and expedite proper filling:

- The average stone size should not be greater than 4 inches.
- The maximum stone size should not be greater than 6 inches. If large, individual stones are hanging up in the compartments, blocking complete filling or causing excessive distortion or damage to the units, these stones should be selectively discarded prior to placement in the mattress unit.
- The minimum stone size is generally 1.5 inches to 2 inches. Little or no amount of stone should fall out of a mattress unit as it is lifted and placed.



Figure 10: A mattress unit can be filled in approximately 40 minutes with a crew of four.

Filling the Compartments

The diaphragms of the mattress unit may tend to draw the unfilled compartments closed. It is often helpful to first use elastic straps or spacers to hold the main two layers of grid apart, helping to fully open the compartments for filling. Using a loader bucket (or similar) positioned slightly above the unit, drop stone fill into each compartment. See Figure 11. The filling should be staged to facilitate complete filling while avoiding excessive shoving or bowing of the diaphragms. A typical sequence is to:

- Fill to half-height.
- Rod each compartment.
- Fill to full-height.
- Rod each compartment again.
- Top off with additional stone, slightly heaped (+2 in.) above the edge.

Typically, the rodding is intended to eliminate voids in the stone fill and to cause complete filling evidenced by consistent bulging of each compartment. Tight filling is important to performance in some conditions and applications, by resisting shifting of the stone fill. Generally, incomplete filling of a unit is apparent during lifting shown by unfilled air space near the edge of one or more compartments.



Figure 11: Overfill so that stone is heaped slightly above the top of the unit.



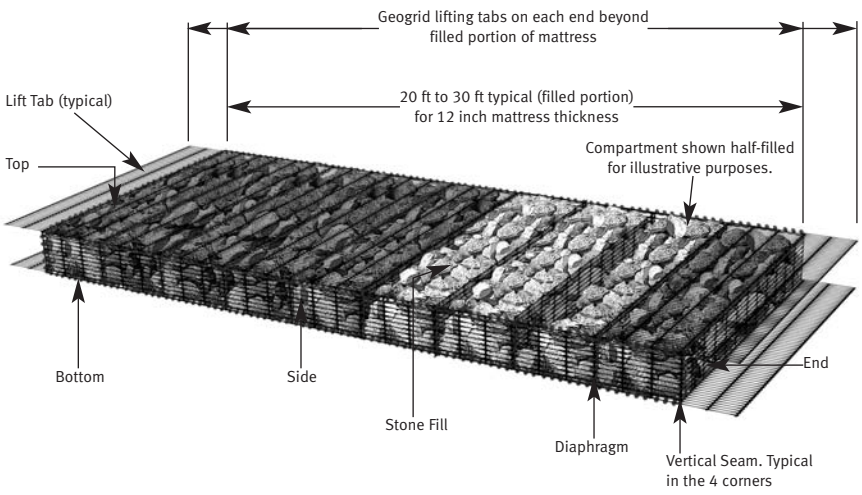
Figure 12: Rodding helps pack the stone fill so that shifting does not occur during lifting or placement of the mattress unit.

Closing

With the filled unit still supported in its upright, on-edge position, complete the fourth seam and the short seam on each end of it. Use the seaming techniques and procedures as shown in Figure 3 on page 7.

Production Rates

As a rule of thumb for the filling and closing stage, a crew of three laborers, plus a loader and operator, can fill a 30-foot long unit in about 40 minutes.



Notes:

- Ends, top, bottom, sides and any extra length used for lifting or anchoring purposes shall be composed of Tensar® UXTriton200 Geogrid.
- Internal diaphragms shall be composed of Tensar UXTriton100 Geogrid.
- Nominal width of units: 5 ft (filled), 4.4 ft (unfilled)
- Typical thickness (filled): 12 inches (also available in 18 and 24 inch thicknesses).
- Plastic cable ties may be used to secure bodkin connectors in position prior to tensioning or filling of mattress unit.

Figure 13: Typical configuration of filled mattress units.

3.4 TRANSPORTING A FILLED MATTRESS UNIT

Lowering to a Horizontal Position

In order to be lifted, each filled unit must be rotated from the upright position – standing on its side, down to a flat position – lying on its broad bottom. This can be accomplished by using a stable frame with a stout, hinged side, and rotating the unit by slowly lowering the side of the frame with equipment.

Forming Lifting Hoops

Use a bodkin connection as shown in Figure 14 to form the lifting hoop. Use cable ties (or similar) to prevent the connector piece from sliding out when tension is not applied. The hoop may be configured in either of two ways (see Figures 15 and 16):

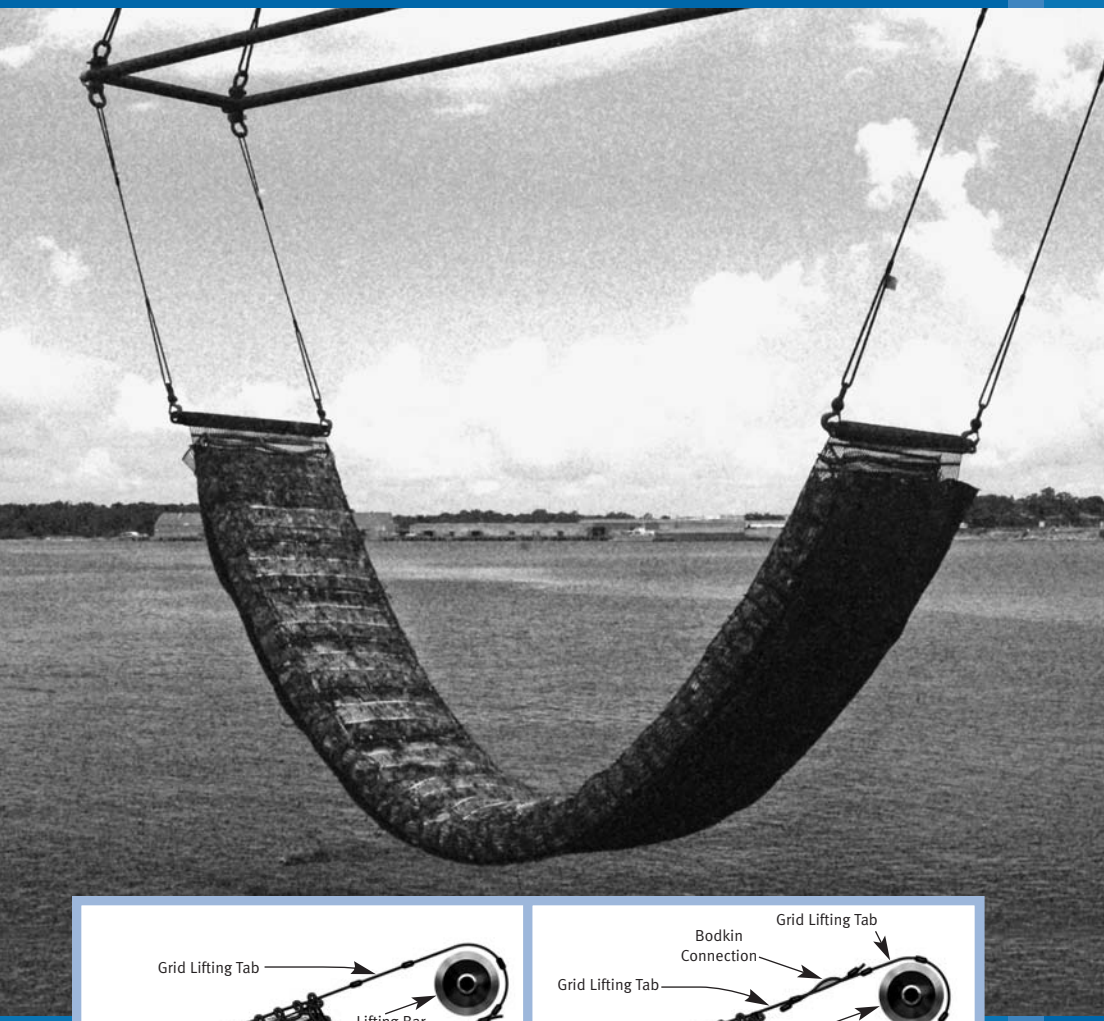
- On each end of the unit, connect the pair of lifting tabs directly to each other; or
- On each end of the unit, use a separate piece of the same type of grid to form a longer hoop. Connect each end of the separate piece of grid to one of the lifting tabs. (This type of hoop may be more advantageous for some conditions.)

Production Rates

As a rule of thumb for moving the filled unit, a crew of three laborers, plus a large backhoe or small crane, and operator can move a filled unit and place another unfilled unit in the filling setup in about five minutes. If a filling frame is not used, an additional five to ten minutes may be required to set up each unit for filling.



Figure 14: Use a bodkin connection to form a lifting hoop.



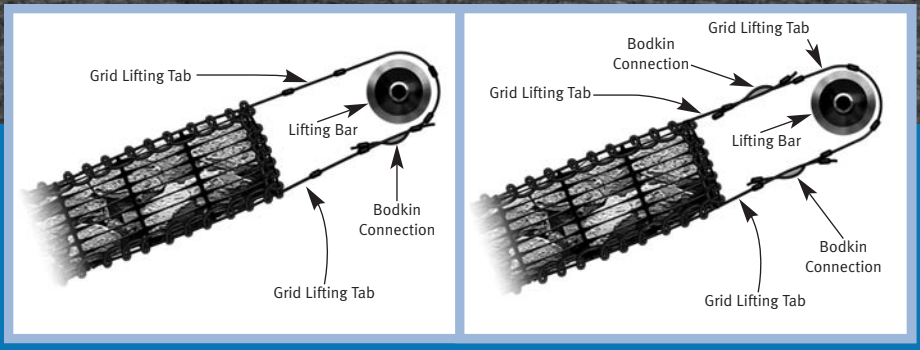


Figure 15: Lifting hoop formed by connecting lifting tabs directly.

Figure 16: Lifting hoop formed by connecting lifting tabs to a lifting tail.



Figure 17: Notice the importance of the pivot point for free swinging of the lifting bars, whether lifting by one end or both ends of the mattress.

3.5 LIFTING A FILLED MATTRESS UNIT

The contractor is responsible for checking that the geogrid is not damaged, to provide adequate rigging and equipment, and to use safe procedures in the lifting, handling and placement of the filled mats.

Uniform Loading

The geogrid must be loaded uniformly across its width during lifting. This requires:

- The mat ends, lifting hoops and lifting bars hang in a level position during lifting.
- Each lifting bar is adequate enough to provide a safe hookup and to safely carry the load without bending, sagging or damaging the grid.
- Each lifting bar is rigged to pivot freely with the mats.
- The rigging, equipment and procedures are adequate enough to prevent excessive swinging, jerking or bouncing of the mats.

Safe Distance

Personnel must maintain a safe distance from the mats, rigging and equipment at all times during lifting. Tag lines (or similar) should be used as necessary to avoid personnel being in the area beneath a filled mat or the rigging during lifting.

Duration of Lift

No mat should be left lifted and hanging for an extended period of time. A typical timeframe for lifting, handling and placement is five to fifteen minutes.

Reuse of Lifting Tails

The lifting tails, or the extra length of grid sometimes used to form lifting hoops, may only be reused if they are not damaged. They should not be used for more than four lifts each.

End-to-End Splicing

When units are spliced together for lifting, both the top and bottom layers of the grid from the mattress should be joined by a bodkin connection as shown in Figure 14 on page 13. The overall mattress length when units are joined for lifting should not exceed the typical range as shown in Figure 13 on page 12.



Figure 18: In Buffalo, New York, this filled mattress was lifted by one end.

3.6 STACKING FOR STOCKPILING OR SHIPMENT

When stacking filled units for stockpiling or shipping, the stockpile should be limited to a stable height and should not exceed five feet – or the safe stacking height as determined by the contractor. For shipping, loads must be secured to prevent tipping or sliding of the stack or the individual units.



Figure 19: Mattress units were stacked in groups while awaiting deployment over a pipeline in Bay County, Florida.



Figure 20: A Triton Marine Mattress is lowered over an underwater pipeline for protection.

3.7 MATTRESS PLACEMENT (INSTALLATION)

General

Place the filled units (typically on a prepared subgrade and geotextile filter) as called for in the contract documents or as directed by the engineer. See Figures 20 and 21. With appropriate detailing, geotextile may be pre-attached to the filled units prior to placement.

Joining Adjacent Units

Side-to-side seaming of adjacent units is not typically required, but if called for, can be accomplished by using a special braid material. For steep slopes, end-to-end splicing of adjacent mats can be accomplished by using the HDPE bar to form a bodkin connection. See Figure 14 on page 13 and Figure 22 on page 19.

Anchoring Units

For steep, sloping installations anchoring of the units may be required. If an extra length of grid is to be used as an anchor tail, it should be spliced to the lifting tab of the mattress unit using the HDPE bar to form a bodkin connection once the mattress unit is in place. See Figure 23 on page 19. If soil anchors are used to anchor the end of the grid, then special detailing is required to distribute the load from the anchor to the grid. Contact a Tensar Representative for suggested details.



Figure 21: Completed installation for riverbank protection.

Finishing Treatments

Special finishing treatments, such as top-dressing with soil and seeding, grouting or pouring a concrete surface on top of the mats should be considered ahead of time. Contact a Tensar Representative for suggested details.

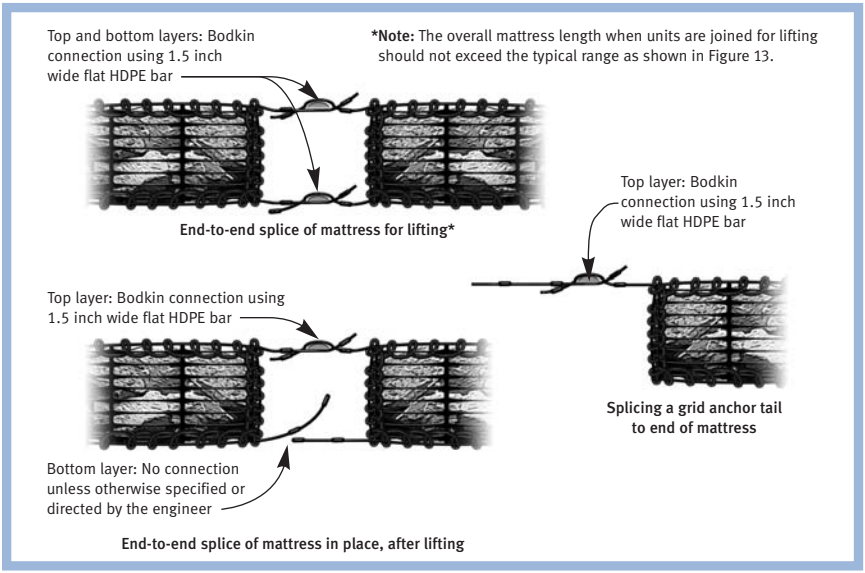


Figure 22: End-to-end splicing of adjacent mattress units.

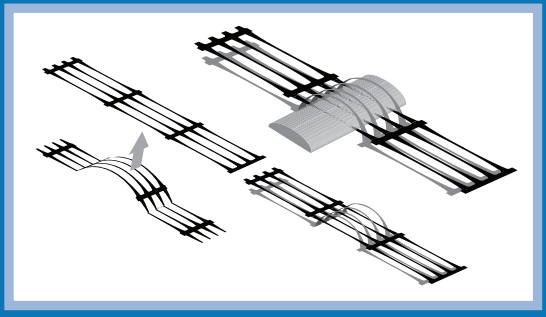


Figure 23: An HDPE bar forms a bodkin connection.



Figure 24: Armor stone was placed directly on Triton Grid Composite in constructing a coastal groin. Another width of grid composite will be placed next to overlap the exposed edge of grid composite. Stone placement will then proceed toward the water.

4. Grid Composite System

The Triton® Grid Composite System is specially developed for use beneath riprap and armor stone. By combining Tensar® Biaxial (BX) Geogrids with geotextile, grid composites provide an improved foundation and filtration layer for a broad range of riprap, rubble-mound and similar installations. For a complete application description, please refer to the Triton Systems Overview Brochure.

4.1 CUTTING GEOGRID STRIPS TO REQUIRED LENGTH

- Cut geogrids to lengths shown on the construction drawings.*
- Using a worktable, cut the geogrid with electric shears. See Figure 25.
- As each length of material is cut, mark it and tag it according to length, and stockpile it for later use.*
- You may want to connect several precut geogrid strips together side-by-side using HDPE braid. See Figure 26. This step can increase the speed of subsequent geogrid placement and is most often used on large projects.

***Note:** The correct geogrid lengths must be used at each section according to the project design.

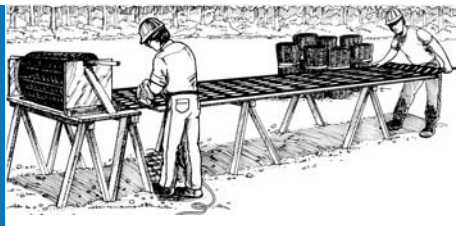


Figure 25: Cutting geogrid with a circular saw.

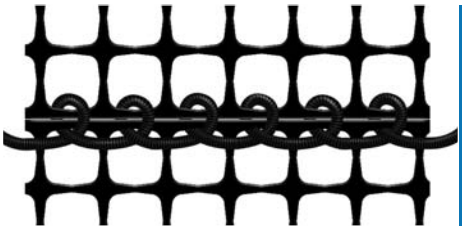


Figure 26: Connecting precut geogrid using HDPE braid.

4.2 ANCHORING TRENCH EXCAVATION

For use on grid composite slopes, excavate anchor trench as shown on the construction drawings or as directed by the engineer. See Figure 27.

4.3 PLACEMENT OF BIAXIAL (BX) GRID COMPOSITE

Unless otherwise directed by the engineer, the BX Geogrid should be placed with the fabric side down, such that contact is maintained between the geotextile and the subgrade.

- Form the geogrid to the configuration of the trench and place it into the trench perpendicular to the slope face.
- Place a small amount of aggregate onto the geogrid to secure it in place during installation.
- Place geogrid down grade of slope surface.
- Adjacent geogrid strips should overlap per construction drawings. (If permitted by the project engineer, overlap may be minimized by joining the adjacent pieces using HDPE braid provided by Tensar International Corporation.)

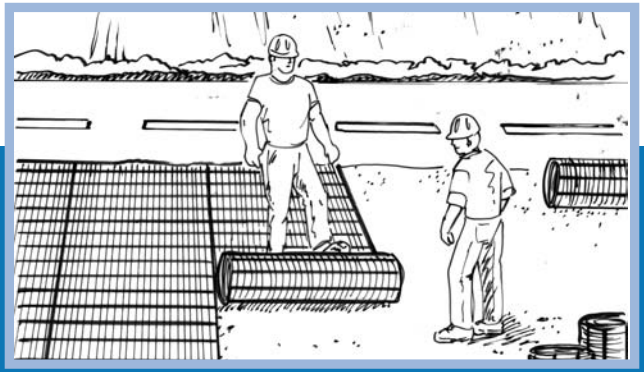


Figure 27: Excavate and unroll geogrid composite.

4.4 PLACEMENT OF AGGREGATE RIPRAP

- Fill in anchor trench. Additional aggregate should be placed on top of the anchor trench fill aggregate according to the engineering specifications.* All grid on top of slope must be fully covered to level as shown on construction drawings. See Figure 28.
- Place aggregate along side slopes. Aggregate placement should proceed from the toe of the slope and work to the top unless otherwise specified by the project engineer. Some projects may require the use of a backhoe. See Figure 29.

*Note: Do not drive tracked vehicles on the uncovered geogrids. Rubber tired vehicles may be operated on top of the geogrid; however, sudden stops, excessive speed (over 15 mph) and sharp turns should be avoided.



Figure 28: Spread and level aggregate.



Figure 29: Place aggregate from toe of slope to top.

4.5 INSTALLATION IN SUBMERGED APPLICATIONS

- Cut geogrid composite to lengths shown on the construction drawings.
- Construct a steel frame suitable for attachment of the geogrid composite. See Figure 31.
- Use nylon cable ties to secure the geogrid composite to the steel frame.
- Using appropriate machinery (crane, excavator, etc.), lower the frame with attached geogrid composite into position as indicated in the construction drawings.
- Place a small amount of aggregate around the perimeter of the geogrid composite panel to secure the panel in place for the removal of the frame.
- With aggregate materials in place, it should be possible to remove the frame without disturbing the geogrid composite. The nylon cable ties should break easily, releasing the composite from the frame.
- Continue placing aggregate according to project plans and specifications.

Figure 30: Triton Grid Composites provide an improved foundation and filtration system.



Figure 31: When placing Triton Grid Composite in a submerged application, a steel frame can be used for ease of installation.



Figure 32: Triton Gabion Mats provide long-term performance even in harsh chemical environments such as this saltwater tidal zone in Trinidad.

5. Gabions and Gabion Mats

Triton® Gabions offer a durable, non-corrosive and installation-friendly alternative to conventional steel wire gabions – including those galvanized and PVC-coated. They are advantageous for a number of earth stabilization and erosion protection applications. For a complete application description, please refer to the Triton Systems Overview Brochure.

***Note:** The following guidelines are suggested installation specifications for Tensar Gabion Baskets 1.5 feet and three feet deep.

5.1 ASSEMBLY

1. Open and stretch the pre-fabricated gabion on a hard flat surface. See Figure 33.
2. Raise the sides, ends and diaphragms, ensuring that all the creases are in the correct position and that the tops of all sides are even.
3. Bodkin joint, or lace, the two front face corners to the sides of the gabion. See Figure 34.
4. Lace the two remaining back-face-panel corners to the sides of the gabion, and then lace the internal diaphragms to the front and back panels.
5. To lace a gabion joint or corner, pass the cord around the two edges to be joined and tightly loop the cord twice through every aperture in turn.* Tie the cord off securely, turning the cord ends to the inside of the gabion upon completion. Cord lengths for lacing should not be less than three feet nor greater than six feet.

***Note:** When lacing a gabion joint or corner made from small (1 in. x 1.25 in.) aperture grid it is only necessary to loop the cord once through each aperture in turn.

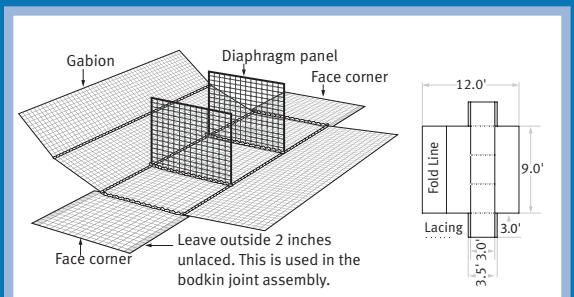


Figure 33: Typical Triton Gabion prior to site assembly.

6. Use only the HDPE cord supplied by Tensar for all lacing.* Use a curved, wire-formed "needle" to simplify the lacing operation.

7. Position the assembled gabion in the structure as required (see Figure 35). The front face of the gabion should be faced outward, such that the final lacing will be in an unexposed condition to close the top of the lid. Secure the side, or end, from which work is to proceed to either the existing work or to the temporary rods driven firmly into the ground at the corners. The rods must reach at least to the top of the gabion.

8. When placing additional gabions in the structure, lace all corners and diaphragm points to the preceding unit using two cord turns per aperture opening (the filling of which should be deferred to facilitate the connection, except in the case of stacked units).

***Note:** Ultimate tensile strength in excess of 400 lbs. and stabilized with a 2.5% carbon black.

5.2 TENSIONING

It is essential that the sidewalls of the gabion be tensioned before filling. With a firm anchorage, depending upon base friction, lengths of 24 to 60 feet may be tensioned simultaneously. A light winch secured to the free end of the gabion may be used to produce the necessary wall tautness and alignment. The tensioning force on each sidewall should not exceed 0.5 tons. See Figures 36 and 37 on page 27 and 28.



Figure 34: Lace (or bodkin joint) the two front face corners to the sides of the gabion to form a box.

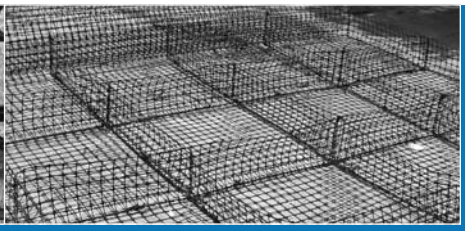


Figure 35: Assembled Triton Gabion Mat.

While the gabions are under tension, securely lace together adjacent gabions along and throughout the length of all common edges (front, back, top, bottom, sides and diaphragms). Lacing should be carried out in a similar manner to that described for assembly of individual units, using just one cored turn per aperture opening.

Do not release wall tension until sufficient fill has been placed to prevent wall slackening.

5.3 FILL MATERIAL

Fill material shall conform to the project plans and specifications. In general, Tensar recommends that fill material should be a clean, hard, durable rock, which does not deteriorate when exposed to cycles of wetting and drying, or freezing and thawing. It should have a minimum size of 2.5 inches and a maximum size of 10 inches. A minimum of 60% of the fill must be larger than 2.5 inches with no more than 10% passing the #4 sieve.

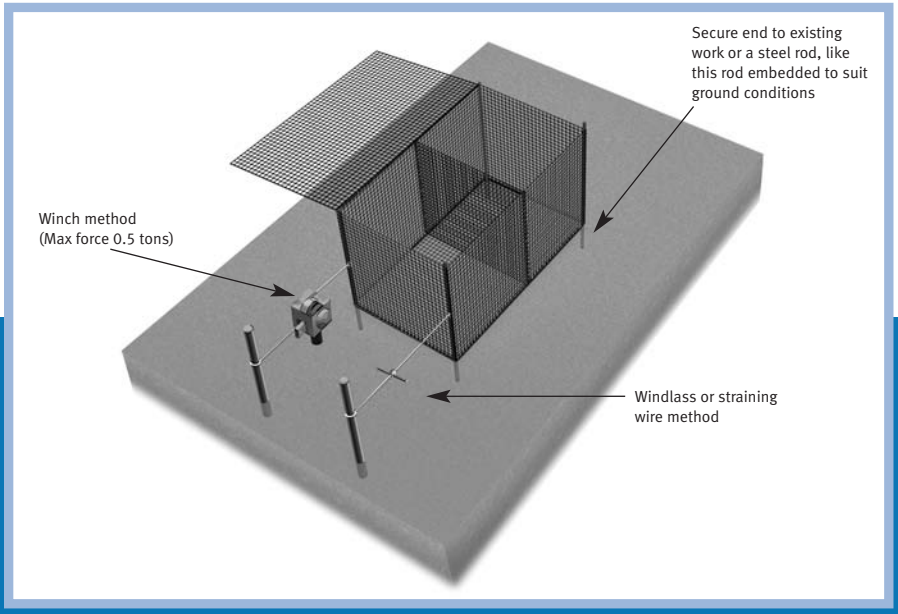


Figure 36: Triton Gabion tensioned in preparation for fill.



Figure 37: Triton Gabions should be filled with durable rock sized according to project plans and specifications.

5.4 FILLING

Filling *must* take place while the gabion is under tension.

1. Place the fill in order to produce the minimum amount of voids. (Only the mechanical equipment approved by the engineer may be used for filling operations.)
    - For fairface work, place select, squared rock by hand to provide a stable, dry joint with adjacent rocks.
    - Gabions should be overfilled by ¾ to 1.5 inches to allow for settlement.
2. Temporarily thread a ½ in. diameter rebar through the top of the diaphragm to prevent local deformation, or bulging, of the diaphragms during filling. Or, as an alternative, stage the filling of each compartment:
    - *For three feet deep gabions* – After the first gabion compartment has been filled, fill the second compartment to ⅔ its depth, and the third compartment to ⅓ its depth.
    - *For 1.5 feet deep gabions* – After the first gabion compartment has been filled, fill the second compartment to ½ its depth.

5.5 INTERNAL BRACING

To avoid excessive bulging of exposed gabion faces, internal bracing is required for three feet deep gabions. It should not be necessary for 1.5 feet deep gabions providing that a smooth curve, with an approximate three-inch eccentricity in the center of each panel, is acceptable to the engineer.

When the three feet deep gabion has been filled to a depth of 1.5 feet, it should be internally braced using HDPE cord, as specified.

1. In each compartment, use two lengths of cord per exposed face – placed equidistant from the ends, and running perpendicular to the exposed face.
2. Tie the cord around two adjacent diagonal rib nodes.
3. Pull the cord horizontally, hand tie and wrap it around a pair of nodes on the opposite face.
4. Tie-off without loosening tension.
5. Filling may then continue – taking care not to damage the cord bracing.

If internal bracing is required for 1.5 feet deep units, it should be fastened at mid-depth and tied in a similar manner to that described above for the three feet unit.



Figure 38: Triton Gabion Mats are lightweight, customizable and easy to handle – features that significantly ease installation.

5.6 SECURING THE LID

Once the gabion has been filled, stretch the lid tightly over the fill and temporarily secure it at the corners.

Tie the lid securely along the full length of all edges, ends and diaphragms by tightly looping the cord twice through every aperture and tying off securely. The length of any continuously tied joint should not be less than three feet nor greater than six feet. Turn the knotted ends of all cords into the gabion upon completion.

5.7 COMPLETED GABION

The exposed faces of the completed gabion should present a neat face and line, with minimal bulging or depressions. The gabion should have well-packed fill, tight mesh and be securely laced. See Figure 39.



Figure 39: This completed Triton Gabion in the Panama Canal is non-corrosive and extremely durable.

5.8 SPECIAL STRUCTURES OR ALTERATIONS

Where shown on the drawings, or otherwise directed by the engineer, the gabion grid may be cut, folded and laced together to form mitre joints, angles, curves or slopes to accommodate any special structure features that may be required. Odd size or shape gabions pose no special problems, if the following guidelines are adhered to:

- The grid must be cleanly cut with all surplus material cut completely off and removed.
- Some special corners may require the odd overlap to be neatly laced to an adjacent gabion face.
- The cut edges of the grid shall be securely laced together with HDPE cord, looping tightly two turns through the aperture opening, in the manner described above.

The assembly, erection, stretching, adjacent connections, filling and final lacing of the re-shaped gabions shall otherwise be carried out as described above.



6. Filter Mattresses

Triton® Filter Mattresses were designed for challenging underwater installations, providing a deployment method to place geotextile fabric in deep water and strong currents. The filter mat serves two primary applications:

- Submerged revetment foundation
- Submerged geotextile deployment



Figure 40: As a revetment foundation, the Triton Filter Mattress provides bedding and filtration, helping to prevent differential settlement. The mats also protect against scour at the toe of the revetment.

Figure 41: The Triton Filter Mattress System was installed to help improve the performance of the seawall protection at the Hereford Inlet Seawall project in North Wildwood, New Jersey.



Figure 42: Stand all baffles upright and hold in place with cable ties prior to lacing with braid material.

6.1 BOXING-UP

Work Area

Lay the mats flat; this work is typically accomplished directly on the ground or in a stack of mats on the ground. If worktables are used at this stage they will need to be roughly the same size as the mats. See Figure 42.

Box Up Assembly

Make all the vertical seams, including seaming the sides to the ends and baffles. See Figure 43. After this point of fabrication, avoid rolling or flattening the mats.

Optional Lining or Pre-Attached Geotextile

Where called for, place the geotextile within the compartments or attach it to the bottom of the mats prior to filling.* (Generally completed in prefabrication.)

***Note:** These optional details are typically reserved for special cases.



Figure 43: When lacing the various seams of the Triton Filter Mattress, use a standard half-hitch knot.

Figure 44: Once the baffles have been laced to the side panels, wooden frames can be inserted into the compartments to provide support to the baffles during the filling process.



6.2 FILLING

Work Area

Same as boxing-up stage, except worktables are typically not an option due to the weight of the filled mats. Edge support (such as a staked board, a heavy beam or a filled mat) is suggested for the sides and ends to expedite filling. Filling may be accomplished in place if desired.

Securing the Position of the Baffles

Use tension or manually placed stone fill to support the baffles in an upright position, ready for filling. Wooden frames can be inserted into the compartments for support as well. See Figures 44 and 45.

Filling the Compartments

Dump stone in each compartment by equipment bucket or hopper manually. See Figure 46. The filling operation should be conducted in a manner to avoid folding or flattening of the baffles, sides or ends. Spread the stone fill. If sufficient care is exercised to avoid damage to the mat materials, equipment may be used for the rough spreading of stone fill within the compartments.



Figure 45: It may be beneficial to secure the baffles to the frame with lightweight cable ties to prevent them from folding under the stone as it is placed within the compartments.



Figure 46: With the frames in place, stone fill can be loaded into the mattress unit.

Final spreading should be accomplished manually. The stone fill should be slightly heaped in the center of each compartment, such that the stone fill is slightly above the top of the sides, ends and baffles as shown in Figure 48. The average thickness of the mat should not exceed the nominal thickness shown on the drawings.

Positioning, Splicing and Securing the Top

Splice together the flaps of the main piece of grid over the top of the mat to form the top layer of grid. See Figure 47. Leaving sufficient length for the lifting hoop on each end of the mat, seam the ends, sides and baffles to the top. See Figure 49 on page 37. The top should be pulled down snugly against the stone fill such that the grid is reasonably taut and each mat is reasonably free of unfilled spaces. See Figures 50 and 51 on page 37.



Figure 47: Once filled, the geogrid at the ends of the mattress are laid over the filled portion of the mat to form the lid.



Figure 48: Each compartment should be filled slightly higher than the top of the baffles.



Figure 49: Tie the long seams of the mattress using the same stitch configuration shown here.

6.3 LIFTING, HANDLING AND PLACING FILLED MATS

1. Place the filled mats (typically on a prepared subgrade) as called for in the contract documents or as directed by the engineer.
2. The contractor is responsible for providing adequate rigging and equipment, and to use safe procedures in the lifting, handling and placement of the filled mats. See Figure 52.
3. The geogrid must be loaded uniformly during lifting. This requires that:
    - The mat ends, lifting hoops and lifting bars hang in a level and horizontal position during lifting.
    - Each lifting bar is rigged to pivot freely with the mats.
    - Each lifting bar is adequate to safely carry the load without bending or sagging.
    - The rigging, equipment and procedures are adequate to prevent excessive swinging or jostling of the mats.
4. Personnel must maintain a safe distance from the mats, rigging and equipment at all times during lifting. **Personnel should never be in the area beneath a filled mat during lifting.** Tag lines should be used to help guide and position the mats during installation.
5. No mat should be left hanging in the lifting position for an extended period of time. A typical timeframe for lifting, handling and placement is considered to be five to fifteen minutes.



Figure 50: Tie the lid to the baffles. It may be helpful to fabricate a wire hook to help pull the braid materials up through the mattress lid.

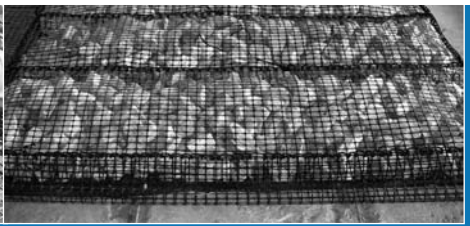


Figure 51: The completed mattress unit should appear full and slightly bulged in-between baffles.

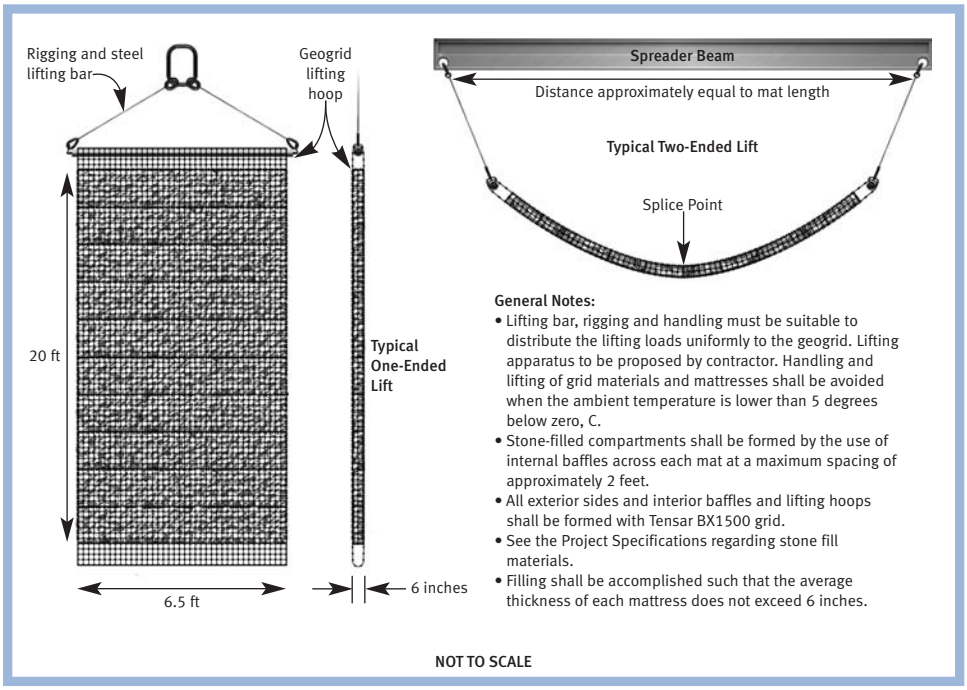
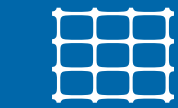


Figure 52: Typical configuration of filled Triton BX Filter Mattress Units.



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