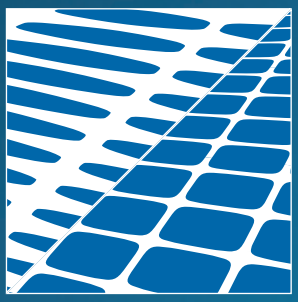
TRITON®
COASTAL AND WATERWAY SYSTEMS

TRITON®
MARINE MATTRESS

INSTALLATION GUIDE

Tensar®

The Triton® Systems can substantially reduce overall project cost when compared to conventional solutions, such as riprap.



TENSAR® GEOGRIDS

The Triton Systems owe their strength and durability to **Tensar® Uniaxial (UX)** and **Biaxial (BX) Geogrids**, Tensar's reinforcement and stabilization 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.tensarcorp.com**.

Introduction

Construction in coastal areas has never been easier with the development of the Triton® Coastal & Waterway Systems from Tensar International Corporation (Tensar). 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.

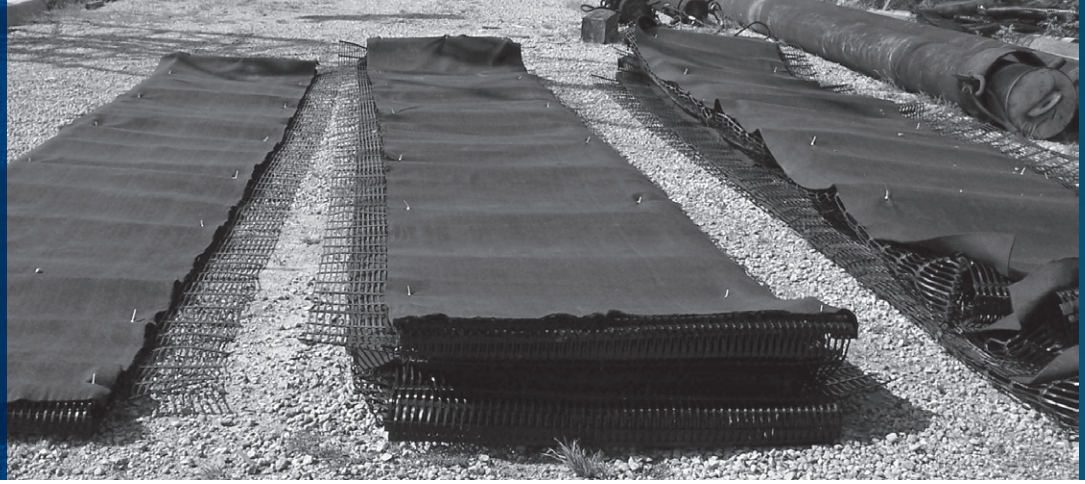
Tools Required

MARINE MATTRESS		
	Provided by Tensar	**Provided by Contractor**
Prefabricated Units	X	
Braid (For remaining seams)	X	
Additional Grid (For anchoring)	X*	
HDPE Bars (For splicing)	X	
Stone Fill		X
Filling Frames		X***
Geotextile Fabric		X**
Plastic Cable Ties (For temporarily securing grid or bodkins)		X
Shovels (To aid filling)		X
1.5 in. – 2 in. Bars (For rodding stone fill)		X
Metal Snips or Shears (For cutting grid)		X
Handmade Wire Tool (To help thread braid through grid [optional])		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
Crane or Large Backhoe (For lifting units)		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***
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***
Choker Cables, Lifting Cables, Shackles and Other General Rigging		X***

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

***Geotextile fabric, per project plans and specifications, is available from Tensar. The contractor may choose to procure fabric from an alternate source.*

****Mechanical filling frame, spreader bar, lifting bars and cables are available for rental from Tensar.*



Prefabricated Triton Marine Mattress Units.

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-in.*

*****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.*

Example of a hydraulic filling frame.

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, contact your Tensar Representative to obtain the *Suggested Repair Guidelines for Triton Marine Mattress* supplement and consult with the 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.

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

IMAGE 2: *Stacked units are ready to fill. The third seam is complete.*

FILLING PREPARATION

When preparing to fill, it may be necessary to stitch the third long side seam of the mattress. It will also be necessary to stitch 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.

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.

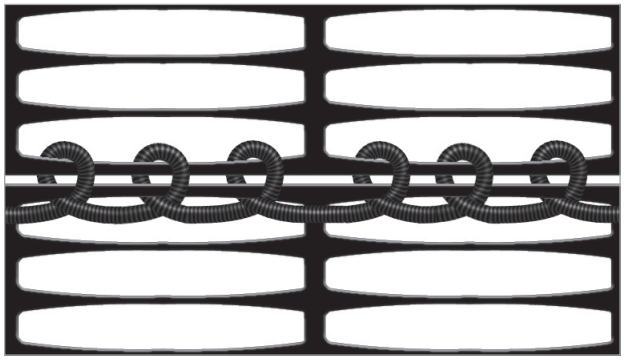


FIGURE 1: *Typical lock-stitch braiding configuration for mattress fabrication.*

IMAGE 1: *Knots should be tied in a manner to prevent slipping and cinching.*

Seaming – Using the seaming techniques and procedures as shown in Figure 1 and Image 1, complete the third seam if necessary and the short seam on each end of it. Units may be stacked. (See Image 2 and Figure 2). 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 ft of seaming per hour. For 30 ft 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.*

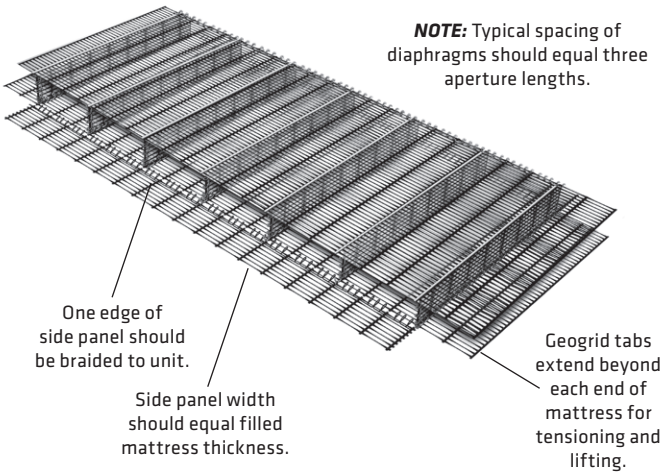


FIGURE 2: *A typical configuration of a prefabricated mattress.*

For UX Marine Mattresses, the average stone fill diameter should be 4 in.

FILLING AND CLOSING

Mattress Prep – Prior to filling the marine mattress, the contractor must close the vertical seams at the ends of the side panel that is closed in pre-fabrication (see Figure 3 on page 6).

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 Image 3). 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. 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.

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 in. thick mattress, the clearance between sides should be 13–14 in. 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 in.
- The maximum stone size should not be greater than 6 in. 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 1.5–2 in. Little or no amount of stone should fall out of a mattress unit as it is lifted and placed.

Example of filling frame available from Tensar.

***IMAGE 3:** This wooden filling frame was constructed for a marine mattress project in Kauai, Hawaii.*

Plywood spacers help hold the two main layers of grid apart, helping to fully open the mattress for filling.

Filling the Compartments – The diaphragms of the mattress 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 (refer to image above). Using a loader bucket (or similar) positioned slightly above the unit, drop stone fill into each compartment. (See Image 4.) 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
- Remove spacers
- Rod each compartment
- Fill to full-height
- Rod each compartment again
- Top off with additional stone, slightly heaped (+2 in.) above the edge

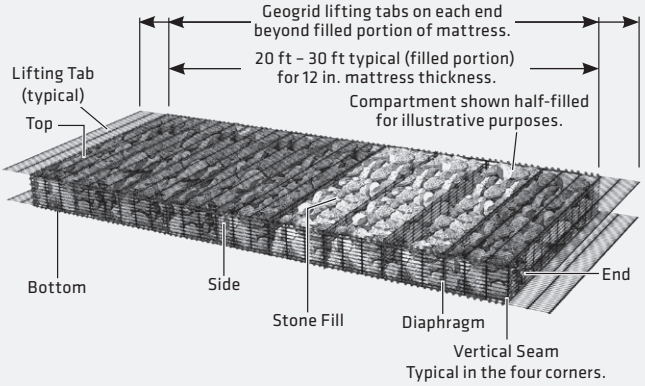
IMAGE 4: *Overfill so that stone is heaped slightly above the top of the unit.*

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

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.

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 1).

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 ft long unit in about 45 minutes.



NOTES:

- Ends, top, bottom, sides and any extra length used for lifting or anchoring purposes shall be composed of Tensar® UXTriton200 Geogrid or UXTriton300 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 in. (also available in 18- and 24-in. thicknesses).
- Plastic cable ties may be used to secure bodkin connectors in position prior to tensioning or filling of mattress unit.

FIGURE 3: *Typical configuration of filled mattress units.*

TRANSPORTING A FILLED MATTRESS UNIT

Lowering to a Horizontal Position – In order to be lifted, each filled unit must be rotated from the on edge position – standing on its side, down to a flat position – lying on its bottom panel. 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 (Image 5) 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 5 and 6):

- 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.)

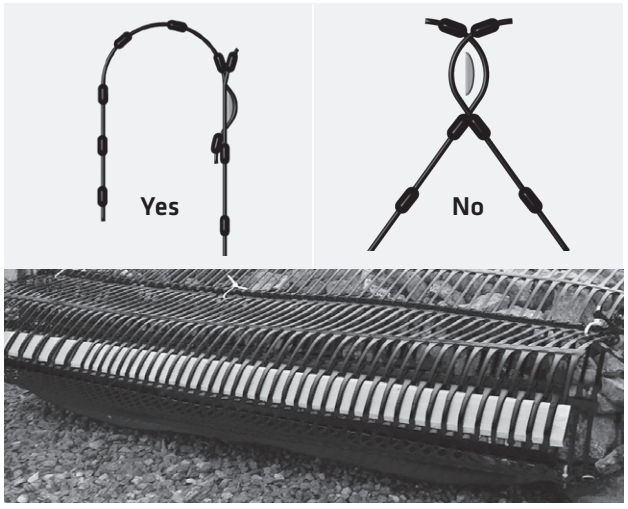


FIGURE 4: *Use a bodkin connection to form a lifting hoop.*

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 10 minutes. If a filling frame is not used, an additional five to 10 minutes may be required to set up each unit for filling.

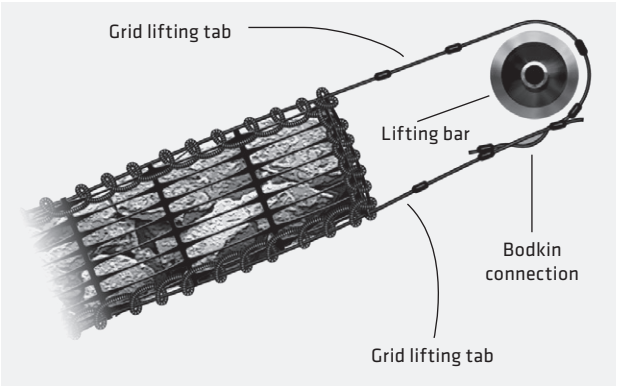


FIGURE 5: *Lifting hoop formed by connecting lifting tabs directly.*

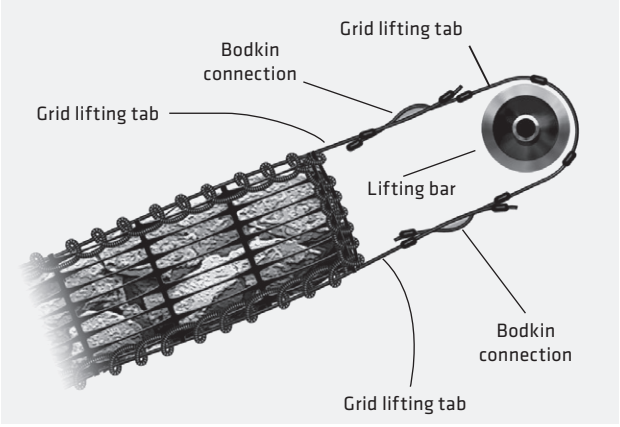


FIGURE 6: *Lifting hoop formed by connecting lifting tabs to a lifting tail.*

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.

LIFTING A FILLED MATTRESS UNIT

The contractor is responsible for checking that the geogrid is not damaged, providing adequate rigging and equipment, and using 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 mattress 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 mattress
- The rigging, equipment and procedures are adequate enough to prevent excessive swinging, jerking or bouncing of the mattresses

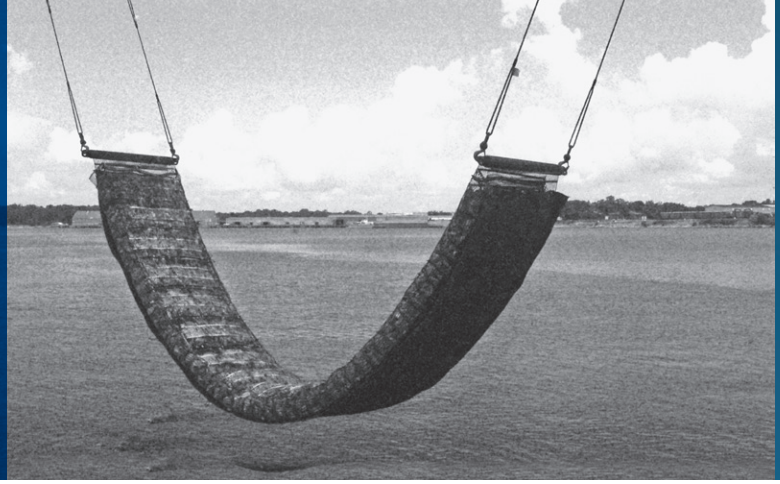
Safe Distance – Personnel must maintain a safe distance from the mattress, rigging and equipment at all times during lifting. Tag lines (or similar) should be used as necessary to avoid personnel being in the area beneath a filled mattress or the rigging during lifting.

Duration of Lift – No mattress should be left lifted and hanging for an extended period of time. A typical time frame for lifting, handling and placement is five to 15 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 (visual inspection of the bodkin is required to determine if it can be reused.).

End-to-End Splicing – When mattresses 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 4). The overall mattress length when units are joined for lifting should not exceed the typical range as shown in (Figure 3).

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



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.

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

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 Images 5 and 6). With appropriate detailing, geotextile may be pre-attached to the filled units prior to placement.

IMAGE 5: *A Triton® Marine Mattress is lowered over an underwater pipeline for protection.*

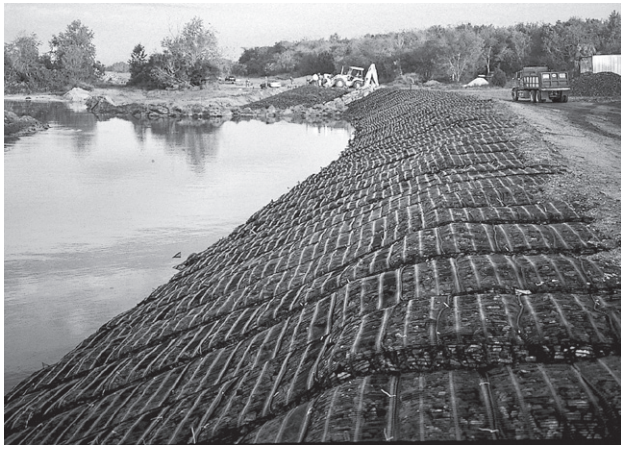
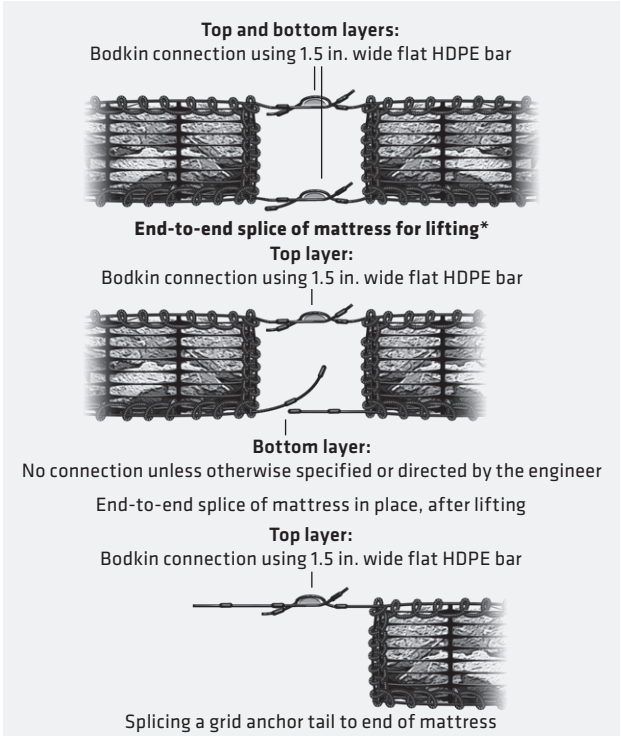


IMAGE 6: *Completed installation for riverbank protection.*

Joining Adjacent Units – For most revetment applications "free articulation" of horizontally adjacent Triton® Marine Mattresses is preferred. Side-to-side seaming of these mattresses is not typically required. If site conditions and project specifications call for side-to-side seaming of adjacent mattresses it can be accomplished using special braid material provided by Tensar® for Marine Mattress seaming. For steep slopes, end-to-end splicing of the vertically adjacent mattresses can be accomplished by using the HDPE bar to form a bodkin connection. See (Figure 7) for details on the end-to-end connection. Any gap between vertically adjacent mattresses should be filled with aggregate prior to connecting the mattress ends.



****NOTE:*** *The overall mattress length when units are joined for lifting should not exceed the typical range as shown in Figure 3.*

FIGURE 7: *End-to-end splicing of adjacent mattress units.*

Suggestions for "Wedge-shaped" Gaps – In some cases, placing marine mattresses around a curve in a channel may leave a wedge-shaped gap between the ends of the marine mattresses. In this situation, a simple procedure can be used to "field fabricate" an appropriate fix. (Figure 8.)

1. Prior to placing the first mattress lay a piece of BX150060 geogrid on the subgrade.
2. Lay both of the mattresses leaving as little gap as possible.
3. Cut a 12 in. piece of grid to tie vertically to connect the ends and sides of the mats. This should create a wedge shaped cell between the ends of the mats and the vertical piece of grid.
4. Fill the cell with gravel and cover with UXTriton200 geogrid. Tie all seams using the same stitch configuration used in closing the mattresses.
5. Cut and place UXTriton200 geogrid over filled area.
6. Secure the geogrid using the same braid and stitch pattern used for closure of the mats.

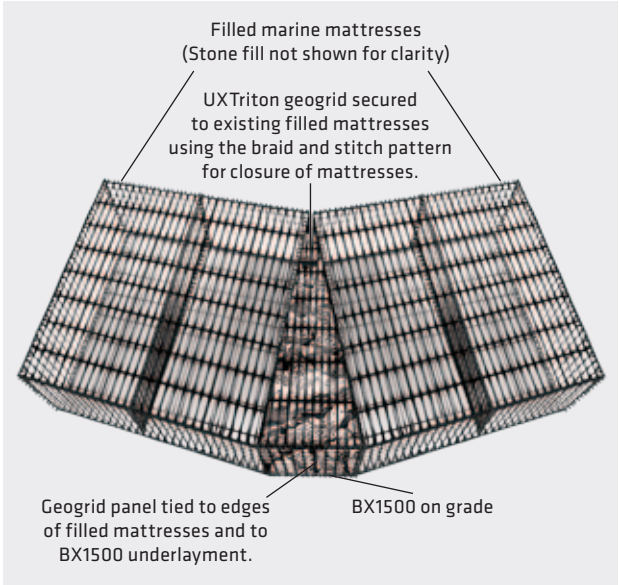


FIGURE 8: *Marine mattresses can accomodate wedge-shaped gaps.*

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 9.) 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.

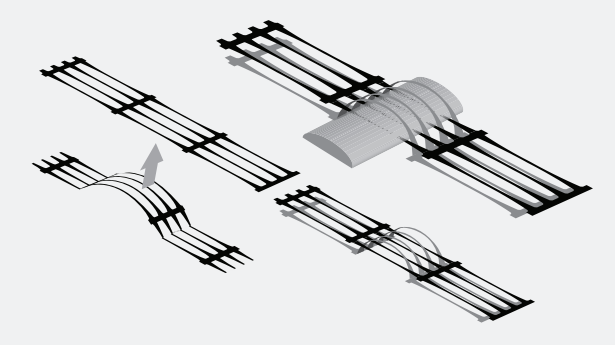


FIGURE 9: *An HDPE bar forms a bodkin connection.*

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.

For more information on Triton Systems, call **800-TENSAR-1,** visit **www.tensarcorp.com** or send an email to **info@tensarcorp.com**. We are happy to supply you with additional information, system specifications, design details, conception designs, preliminary cost estimates, and much more.

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