Coastal & Waterway Applications

Tensar International Corporation

Steve Williams
Industry Manager – Marine & Ports
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Why TRITON?

- Coastal Erosion: Long term loss or temporary redistribution of sediments along a coastline
  - Natural Causes
    - Coastal Process
    - Storms – Hurricanes
    - Sea Level Rise
Responses to Coastal Erosion

- Coastal Retreat
  - Locate future development farther from the water line
  - Move existing developments back from the water line
    - Very expensive
    - Not always practical

- Shore Protection Structures
  - Measured approach – Consider down-drift impacts
  - Often used to interrupt sediment transport
Design Issues

- Design guidance on in-water constructability suggests that design is planned for construction
  - Poor Visibility
  - Scour protection during construction
  - Differential settlement of the structure
  - Aggregate loss due to current (especially when placing the filter stone)

- Triton® Coastal & Waterway Systems are geosynthetic products designed to help overcome these issues
Geosynthetics in Coastal & Waterway Engineering

- Improved Performance
- Enhance Project Longevity
- Improved Constructability
- Sustainability
Why TRITON?

Common Applications:

- Bedding and Filtration
- Coastal Revetments
- Shoreline / Slope Protection
- Sediment Capping
- Scour Protection
Triton® Coastal & Waterway Systems

Geogrid Composite
Marine Mattresses
Triton® GC654050 Geogrid Composite
Fabrication and Roll Orientation

Notes:
1. BX1610 geogrid shall be trimmed to 11’ 8” to allow fabric to fold over the edges approximately 2 inches on both edges.
2. All stitching to be done with 12,000 denier thread
3. Finished rolls shall be rolled such that the geogrid is to the inside of the roll as shown in the diagram.
4. Geogrid and geotextile shall be as provided by Tensar and is subject to change depending on project specifications.
5. Finished rolls shall be shrink wrapped and labeled prior to loading.
Solutions Delivered

Triton® Marine Mattress

Gabion Mat
- Confinement, Porosity, Flexibility
- Handling, Lifting

Cabled Block Mat

Large Armor Stone
- Mass
- Uniformity, Strength, Stability
- Unique
Traditional Design

**Bedding & Filtration**
Bedding & Filtration

- Coastal / Submerged Foundations

12” Triton Marine Mattress

Geotextile Fabric Attached to bottom of Mattress unit
Assessing the Oyster Reef Development and Shoreline Protection Functioning of Three Structure Types over a 7-Year Period

Glen Curole
Coastal Resources Scientist, CPRA
&
Earl Melancon
Scholar, Louisiana Sea Grant College Program
Professor-Emeritus, Nicholls State University

CWPPRA Technical Committee Meeting
September 14, 2017
Louisiana Department of Wildlife & Fisheries
Baton Rouge, LA

- TE-45 PROJECT MODIFIED & RE-BID in JUN 2007
  - 3 STRUCTURE TYPES ELIMINATED from DESIGN
  - GABION MAT, A-JACK, & REEFBLK STRUCTURES SELECTED
  - CONSTRUCTION BUDGET INCREASED
  - REACH B RELOCATED
  - CONTRACTOR SELECTED

- CONSTRUCTION
  - BEGAN on SEP 13, 2007
  - ENDED on DEC 19, 2007
  - COST $1,653,301

- TE-45 PROJECT EVALUATED the 3 STRUCTURE TYPES for:
  - EFFECTIVENESS in REDUCING SHORELINE EROSION
  - ABILITY to DEVELOP & SUSTAIN OYSTER REEF HABITAT
Coastal Revetments

**Triton™ Gabion Mats**
(filled w/ limestone rocks)
(an on-shore structure)

5’W x 20’L x 1’Deep

geotextile grid material formed into a basket and interconnected to form a mat. Each with galvanized steel anchors

Weight @ 10,000-15,000 lbs each

Cost per Linear Foot = $536
**SHORELINE EROSION & ELEVATION SUMMARY**

- The pre-construction TE-45 shorelines transgressed at high and variable rates.
- All the structures and all the Reaches experienced reductions in shoreline erosion rates during the post-construction assessments.
- The Gabion Mat treatment is clearly the most effective shoreline protection structure at the TE-45 Reaches.
- The post-construction shoreline transgressions behind the ReefBlk and A-Jack treatments were temporally similar.
- All shoreline Reaches recorded volume losses during both pre- and post-construction intervals.
- The Reach A Gabion Mat and the Reach E structures have the lowest vertical profile.
- Gabion Mat structures incurred the greatest settlement.

**COST EFFECTIVENESS**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Structure Cost ($/m ($/ft))</th>
<th>Shoreline Change (m/yr)</th>
<th>Oyster Coverage (%)</th>
<th># Oysters per Linear Meter of Shoreline</th>
<th>Structure Settlement (m)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabion Mat</td>
<td>$1,758 ($536)</td>
<td>-0.28</td>
<td>26.5 ± 1.9</td>
<td>2,219 ± 135</td>
<td>0.21</td>
<td>1</td>
</tr>
<tr>
<td>A-Jack</td>
<td>$1,510 ($460)</td>
<td>-1.22</td>
<td>46.0 ± 2.5</td>
<td>490 ± 36</td>
<td>-0.14</td>
<td>2</td>
</tr>
<tr>
<td>ReefBlk</td>
<td>$1,310 ($399)</td>
<td>-1.19</td>
<td>Failed</td>
<td>Failed</td>
<td>-0.11</td>
<td>3</td>
</tr>
</tbody>
</table>

Coastal Protection and Restoration Authority of Louisiana
Case Study Summary
Stump Hole Revetment Improvements (FL)

**Location**
Cape San Blas, FL

**Owner**
Gulf County, FL

**Contractor**
Various Among 6 Phases

**Engineer**
Michael Dombrowski
MRD Associates, Inc.

**Installation Date**
August 2018

**Quantity**
400 Triton® UX-200 Mattresses
Case Study
Stumphole Revetment Improvements (FL)

**Location**
Cape San Blas, FL

**Owner**
Gulf County, FL

**Contractor**
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Engineer
Michael Dombrowski
MRD Associates, Inc.

Installation Date
August 2018

Quantity
400 Triton® UX-200 Mattresses
Case Study
Stumphole Revetment Improvements (FL)
Location
Manahawkin, NJ

Owner
NJDOT

Contractor
Schiavone Const.

Engineer
Parsons Brinkerhoff

Installation Date
2017

Quantity
1,317 Triton® UX-200 Mattresses
Case Study Summary
Route 72 Bridge, Manahawkin, NJ

Location
Manahawkin, NJ

Owner
NJDOT

Contractor
Schiavone Const.

Engineer
Parsons Brinkerhoff

Installation Date
2017

Quantity
1,317 Triton® UX-200 Mattresses
Case Study Summary
Kennedy Space Center Haulover Canal Bridge

**Location**
Cape Canaveral, FL

**Owner**
NJDOT

**Contractor**
Misener Marine

**Engineer**
Jones Edmunds & Assoc., Inc.

**Installation Date**
2010-2011

**Quantity**
1,281 Triton® UX-200 Mattresses
HAULOYER CANAL BRIDGE SCOUR PROTECTION PLAN
TECHNICAL SPECIAL PROVISIONS

FOR

SECTION T530 – GABION MAT, 12” THICK (POLYMERIC MARINE MATTRESS)

SR A1A OVER HILLSBORO INLET
BRIDGE NO. 860011

FINANCIAL PROJECT ID: 425935-1-52-01
BROWARD COUNTY

The official record of this Technical Special Provision is the electronic file signed and sealed under Rule 61G 15-23.003, F.A.C.

Hardesty & Hanover, J.L.C
1000 Sawgrass Corporate Parkway,
Suite 544
Sunrise, FL 33323
Certificate of Authorization No. 29741

Prepared by:
John Low, P.E. 72784
Date: 10/21/2013
Case Study Summary
Orleans Land Bridge

**Location**
New Orleans, LA

**Owner**
LA DOTD

**Contractor**
Bertucci

**Engineer**
USACE

**Installation Date**
2012-2013

**Quantity**
7,500 Triton® UX-200 18” Mattresses
Case Study Summary
Orleans Land Bridge

Location
New Orleans, LA

Owner
LA DOTD

Contractor
Bertucci

Engineer
USACE

Installation Date
2012-2013

Quantity
7,500 Triton® UX-200 18” Mattresses
Case Study Summary
Orleans Land Bridge
Vegetated Reinforced Soil Slope

- **Ware Avenue**
  - Tidal River = + 6 ft
  - Marine Mattress Scour Apron = 10 ft
  - Geogrid Wrap Face Slope = Tensar® BX1200 Geogrid
Vegetated Reinforced Soil Slope

- Ware Avenue VRSS Finished Product
  - 2 Years After Completion
- Vegetation Well Established
- Toe Materials Stable
Colorado State University (1984, 2009)

- Shield’s parameter = 0.1 to 0.30
- Permissible Velocity: 22.6 fps (avg)
- Permissible Shear Stress: 21.5 psf (avg)

What does this tell us?

- Mattresses have greater shear resistance than unconfined riprap.
- You can use 6-in. mat in place of 18-inches of stone.
Scour occurs when the applied hydrodynamic shear stress ($\tau_d$) exceeds the permissible shear stress ($\tau_p$) of the foundation material.

$$\tau_p \geq (FS)$$

$$\tau_d = F^* (\gamma_s - \gamma_w) D_{50}$$

$F^*$ = Shield’s parameter = $f$(particle Reynolds no.)

$D_{50}$ = mean stone size in mattress

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reynolds Number ($R_e$)</th>
<th>Shields Parameter ($F^*$)</th>
<th>Recommended FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconfined stone</td>
<td>$\leq 4 \times 10^4$</td>
<td>0.047</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>$4 \times 10^4 &lt; R_e &lt; 2 \times 10^5$</td>
<td>Interpolate</td>
<td>Interpolate</td>
</tr>
<tr>
<td></td>
<td>$\geq 2 \times 10^5$</td>
<td>0.15</td>
<td>1.5</td>
</tr>
<tr>
<td>Mattress</td>
<td>Entire Range</td>
<td>0.1 – 0.3</td>
<td>1.25 – 1.5</td>
</tr>
</tbody>
</table>

CSU hydraulic testing
Working Platform Analysis (Crane Pads)
Westergaard / SpectraPlatform

### Uniform Subgrade - Data Input

**Loadings**
- **Equipment type**: User specified
- **Pressure distribution**: Triangular
- **Westergaard Method**
- **Width of contact area, B (ft)**: 4
- **Length of contact area, L (ft)**: 27.0
- **Max. pressure at critical pick. (psf)**: 9000
- **Min. pressure at critical pick. (psf)**: 8999

**Factor to account for uncertainties**: 1.7

### Soil Parameters
- **Unit weight of fill, (pcf)**: 132
- **Unit weight of subgrade soil, (pcf)**: 132
- **Friction angle of subgrade, (degree)**: 27
- **FoS applied for friction angle**: 1.15
- **Undrained shear strength of subgrade, (psf)**: 1500
- **FoS applied for undrained shear strength**: 1.00

### Platform Properties
- **Unit weight of structure fill, (pcf)**: 125
- **Friction angle, (degree)**: 37
- **Factor of Safety for material property**: 1
- **Geogrid stabilized soil platform thickness, (ft)**: 1.00
Tensar Geogrid Stabilized Soil Platform Minimum Requirements
(Triangular Pressure Distribution)

- Thickness of Tensar Geogrid Stabilized Soil Platform: 1.00 (ft)
- Applied pressure on subgrade (Westergaard Triangular pressure distribution): 5,990 (psf)
- Bearing capacity of subgrade: 11,104 (psf)
- Factor of Safety: 1.85

Minimum Required Number of Tensar TriAx Geogrid: 1 (Layers)

Type of Tensar TriAx Geogrid: TX7

For saturated conditions a composite (Class 1 NW Geotextile + Tensar Geogrid) may be used for the first layer to be placed directly on top of the soft subgrade.

- Minimum recommended spacing between Tensar TriAx Geogrid Layers: 6 (in)
- Minimum Recommended slope angle for above ground platform: 10 H:1V
- Minimum Recommended lateral extents beyond working areas on all sides: 16.00 (ft)
- Minimum Distance back from top of any slope: 7.00 (ft)

Minimum Factors of Safety of 1.5 to 1.6 are acceptable for Critical Loading Conditions, provided Settlement & Global stability have been performed by others, have been verified & found acceptable for the loading conditions associated with the project. Critical Loading Conditions correspond to situations where the crane operator cannot assist in minimizing the potential of an imminent platform failure. Information related to operation of cranes & other equipment are outside the scope of this report & must be performed by others.
Petrochem Site – Coastal Louisiana
72” / 8 layers of TX7 / Rigid Pavement Surface
USES FOR MARINE MATTRESSES IN COASTAL ENGINEERING

By Steven A. Hughes

PURPOSE: The Coastal and Hydraulics Engineering Technical Note (CRESTN) described herein provides basic information on the Triton Marine Mattress System, which describes potential applications for marine mattresses in coastal engineering and community-aided emergency management projects at the U.S. Army Corps of Engineers and others.

DESCRIPTION OF MARINE MATTRESSES: Marine mattresses are rock-filled containers manufactured of high-strength geogrid as shown in Figure 1. The geogrid panels are located together to form mattresses that are filled with small gravel similar to construction of piers. The Triton Marine Mattress System was developed by the Tensar Corporation, manufacturer of the geogrid panels used to form the mattress. The system is not patented, and the mattresses could be constructed using similar geogrid products from another manufacturer. However, as of the date of this CRESTN, all mattress applications in the United States have been made using Tensar geogrid.

Figure 1: Portion of marine mattress showing geogrid container (photograph by Kevin Kreutz, Coastal and Hydraulics Laboratory (CHL))

1 This CRESTN is to provide a general description of the Triton Marine Mattress System and how the product can be used on coastal projects. This technical note should not be considered as official Corps of Engineer endorsement or recommendation of the Triton Marine Mattress System or of the private company Tensar Earth Technologies, Inc., manufacturer of the geogrid panel.
TECHNICAL NOTE NO. 1.4

Foundations - General – Filter Layer Design of Coastal Structures

Filter layers typically consist of well-graded gravel and a separator. Filter layers are used within coastal erosion by waves and currents. This Technical Note discusses the design of the Triton® Marine Mattress System as an alternative to conventional sedimentation systems.

Permissible Shear Stress, \( t_{ps} \)

Scour occurs when the applied hydrodynamic shear stress, \( t_s \), is greater than the shear resistance, or permissible shear stress, \( t_{ps} \), of the foundation material. Stone mattresses protect the underlying soil, thus the permissible shear stress of the mattress is not significantly affected by the erodibility of the underlying soil, assuming the major direction of flow is parallel to the mattress surface (Simon et al. 1984). However, if the marine mattress cannot withstand the applied hydrodynamic shear stress and mattress failure occurs, the underlying soil will be exposed to the erosive force of the flow. To achieve acceptable performance, the permissible shear stress of the marine mattress must be greater than or equal to the applied hydrodynamic shear stress with a suitable safety factor (Table 1.4–1):

\[
t_{ps} \geq SF \cdot t_s \tag{1.4–1}
\]

The permissible shear stress for unconfined riprap or gravel mattresses, as well as for marine mattresses, may be estimated based on the size of the mattress stone (Eqn. 1.4–2) with appropriate values of Shield’s parameter, \( P' \). Additionally, permissible shear stress for marine mattresses can also be estimated using Equation 1.4–3 and the largest resulting value should be used for marine mattress design (Kjelgren and Colton 2005):

\[
t_{ps} = P' (\gamma_s - \gamma_w) D_m \tag{1.4–2}
\]
\[
t_{ps} = 0.0091 (\gamma_s - \gamma_w) (MT + C) \tag{1.4–3}
\]

Where:
- \( P' \) = Shield’s parameter (dimensionless) (see Table 1.4–1)
- \( \gamma_s \) = unit weight of the stone (pcf)
- \( \gamma_w \) = unit weight of water (62.4 pcf)
- \( D_m \) = mean stone size in mattress (ft)
- \( MT \) = marine mattress thickness (ft)
- \( C \) = thickness constant = 4.07 for English units or 1.24 for SI units.

For unconfined riprap design, the Shield’s parameter \( (P') \) is linked to the particle Reynolds number (Eqn. 1.4–4) as shown in Table 1.4–1.

\[
R_{e} = \frac{\sqrt{\gamma_s D_m}}{\nu} \quad \left( \frac{gD_m}{\nu^{1.5}} \right) \tag{1.4–4}
\]
Questions?

THANK YOU!

Tensar International Corporation