Channel Bank Protection with Making Use of Sand Filled Fabricated Geosystems

TenCate Geotube® Sand Filled Mattress

Edwin Zengerink Bsc.

Bank protection

Common systems used for revetments construction
- Rock-filled gabion and mattress
- Riprap
- Concrete blocks
**Bank protection**

Geosystems used for revetment constructions

Alternative systems used for revetments construction

- Concrete mattress
- Sand filled mattress

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**What is a sand filled Mattress**

Trench to anchor the SFM during pumping. Backfill trench after filling

Pipe used to feed water and sand down into each tubular

Fill tubes sequentially

Direction of current

Riprap for scour protection at the toe of SFM

**Double fabric layer** product; the two layers of fabric are systematically linked with uniformly spaced parallel stitches in the machine direction

The top layer is an engineered composite fabric that provides excellent abrasion resistance and durability. It is capable of trapping settling sediments and particles.
Internal space created between the two fabric layers are filled with sand.
Retention Pond protection

Advantages of Sand Filled Mattress

- Cost effective
- Easy installation process
- Does not require heavy machinery for installation
- Flexible and can follow curves and bends easily
- Can be installed in water if required
- Can be filled with local available sand
- Low Carbon footprint.
Relative cost comparison

Comparison done based on a Malaysian project

Check for Design rules the booklet

• Geosystems Design rules and application
• www.Taylorfrancis.com
• ISBN: 978-0-415-62148-9
• Contains example calculations.
Design, input parameters

* Levels
  * Toe Level
  * Crest Level
  * Design SWL
* Revetment Slope \( (\phi) \)
* Design Flow \( (u_{cr}) \)
* Design Wave \( (H_s & T_p) \), and/or

**Revetment Design:**

Design Stability against flow

* The stability criterion of Sand Filled Mattress under longitudinal flow attack is as follows (Pilarczyk, 1990; CUR 217, 2006, Geosystems booklet 2012):

<table>
<thead>
<tr>
<th>Equation</th>
<th>Notations</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \Delta D_s \geq 0.035 \Phi \frac{K_T K_h}{\Psi} \frac{(u_{cr})^2}{2g} ]</td>
<td>( \Phi = ) Shields parameter [( \cdot )]; ( K_T = ) turbulence factor [( \cdot )]; ( K_h = ) depth parameter [( \cdot )]; ( \Psi = ) buoyant relative density of structural unit [( \cdot )]; ( D_s = ) effective thickness of revetment [m]; ( \Phi = ) stability parameter [( \cdot )].</td>
</tr>
<tr>
<td>( K_s = ) slope parameter [( \cdot )]; ( u_{cr} = ) critical flow velocity along the structure [m/s]; ( g = ) gravitational acceleration [m/s(^2)].</td>
<td></td>
</tr>
</tbody>
</table>
**DESIGN**

**Stability against flow attack**

- Design Chart may be used for design under following conditions:
  - Continuous top layer
  - Slope angle, $\alpha$ up to 1:1.5 (33.7°)
  - $K_t = 1$ for normal turbulence in channels
  - $K_t = 1.5$ for higher turbulence: channel bends
  - $K_t = 2$ for strong turbulence: hydraulic jumps, sharp bends, local disruptions

**Design Chart**

<table>
<thead>
<tr>
<th>Water depth, $h$ (m)</th>
<th>Critical velocity, $u_{cr}$ (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>6</td>
<td>4.0</td>
</tr>
<tr>
<td>7</td>
<td>4.5</td>
</tr>
<tr>
<td>8</td>
<td>5.0</td>
</tr>
<tr>
<td>9</td>
<td>5.5</td>
</tr>
<tr>
<td>10</td>
<td>6.0</td>
</tr>
</tbody>
</table>

**Stability against wave attack**

- The stability criterion of Sand Filled Mattress under wave attack is as follows (Pilarczyk et al, 1998; CUR 217, 2006; Geosystems 2012):
  - It should be pointed out that Sand Filled Mattress is not suitable for strong waves (generally $H_s < 0.5$ m)

For SFM, $S_m = 4$ to 5
**DESIGN**

**Filtration**

- Opening size of geotextile related to base soil
  - $\text{AOS} \leq f(d_n)$

- A minimum permeability is often required based on one of the following
  - Water flow rate
  - Darcy's permeability
  - Permittivity

**DESIGN**

**Sand Tightness Criteria**

<table>
<thead>
<tr>
<th>Hydraulic load</th>
<th>Requirement 1</th>
<th>Requirement 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary load (current)</td>
<td>$O_{90} &lt; 5D_{10} \sqrt{C_u}$</td>
<td>$O_{90} &lt; 2D_{90}$</td>
</tr>
<tr>
<td>Dynamic load (wave)</td>
<td>$O_{90} &lt; 1.5D_{10} \sqrt{C_u}$</td>
<td>$O_{90} &lt; D_{90}$</td>
</tr>
</tbody>
</table>

$O_{90}$ = pore size of the Sand Filled Mattress;  
$D_{10}$ = sieve size through which 10% fraction of the sand material passes;  
$D_{60} = $ sieve size through which 60% fraction of the sand material passes;  
$D_{90} = $ sieve size through which 90% fraction of the sand material passes;  
$C_u = $ uniformity coefficient ($= D_{90}/D_{10}$)
**DESIGN**

Geotechnical stability

- Assessment of risk of geotechnical failure
- Risk during construction
- Stability of completed structure
- Risk during intermittent scour events
- Risk during seismic events

Slip failure causing collapse of portion of revetment protected river bank

Slip failure analysis using SLOPE-W

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**Sand Filled Mattress**

Trenching

The Sand Filled Mattress should be terminated at a bench or crest, buried in a trench.

The trenching should be located above SWL and wave run-up limit
**DETAILING**

**Termination**

- Appropriate termination details should be adopted at the ends of the structure to prevent undermining of the structure.
- Methods may be similar to those used for crest and toe details but tend to be very site specific.
- Some examples:
  - wing walls
  - revetment curved back in plan
IGS Technical Committee on Hydraulics
Improving the Performance of Canals with Geosynthetics

November 17, 2021

Zengerink: Channel Bank Protection with Sand-Filled Fabricated Geosystems

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Model Specifications
Sand Filled Mattress

The specification for Sand Filled Mattress is dependent on the design and the selection of product grade, but typically includes the following:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide width tensile strength &amp; extension</td>
<td>(ISO 10319)</td>
</tr>
<tr>
<td>CBR puncture strength</td>
<td>(ISO 12236)</td>
</tr>
<tr>
<td>Drop cone perforation diameter</td>
<td>(ISO 13433)</td>
</tr>
<tr>
<td>Abrasion resistance</td>
<td>(BAW RPG 3.11)</td>
</tr>
<tr>
<td>UV resistance</td>
<td>(ASTM D4355)</td>
</tr>
<tr>
<td>Pore size</td>
<td>(ISO 12956)</td>
</tr>
<tr>
<td>Permeability</td>
<td>(ISO 11058)</td>
</tr>
<tr>
<td>ISO 9001 certified</td>
<td></td>
</tr>
<tr>
<td>QA/QC tested at laboratories with certified accreditations</td>
<td></td>
</tr>
</tbody>
</table>

Semenyih Water Dam 2, Dengkil, Malaysia
Non-woven geotextile filter stitched to the bottom of the sand filled mattress
INSTALLATION

- Some pre-installation planning is usually necessary; this may include estimation of panel sizes, as well as cutting and seaming of panels to suit a site situation.
- Slope preparation, trenching and other profiling may be needed before the Sand Filled Mattress is laid out according to the Engineer’s instructions.

INSTALLATION

- Panels of Sand Filled Mattress are placed over prepared slope.
INSTALLATION

Flexible enough to follow smooth curvatures
Shaping edges to handle sharp angular changes

INSTALLATION

• When the Sand Filled Mattress is laid out in position, sand is pumped into the internal space created in-between the two fabric layers
• This is typically done using a hopper system and water is used to wash down the sand;
• The sand fill meet the specifications provided by the Engineer.

Sand introduced through hopper
Lifting top layer to allow easy flow of sand
INSTALLATION

More information

Geotube@tencategeo.com
www.geotube.com