TenCate Geosystems in Marine constructions

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Organization

Royal Ten Cate

Participations

- Synbra Group (50%)
- Geofabrics Australasia (50%)

Advanced Textiles & Composites

Geosynthetics & Grass

Technical Components

- TC Nicolon
- TC Polyfelt
- TC Bidim
- TC Mirafi
- TC Baycor
We combine fibers and chemicals to create materials that outperform existing alternatives

Protective & Outdoor Fabrics

Aerospace & Armour Composites

Geosynthetics & Industrial Fabrics

Grass

Strategic product, market, technology combinations
# Key product / market combinations in functional materials

<table>
<thead>
<tr>
<th>Protective &amp; Outdoor Fabrics</th>
<th>Aerospace Composites</th>
<th>Geosynthetics</th>
<th>Industrial Fabrics</th>
<th>Grass</th>
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<tbody>
<tr>
<td>Emergency Response Clothing</td>
<td>Aircraft Composites</td>
<td>Spacecraft Composites</td>
<td>Trampolines, Pool &amp; Truck Covers</td>
<td>Sports Grass</td>
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<tr>
<td>Industrial Safetywear</td>
<td></td>
<td>Costal Protection &amp; Development</td>
<td>Agriculture &amp; Aquaculture</td>
<td>Landscaping Grass</td>
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<tr>
<td>Tent &amp; Awning Fabrics</td>
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<td>Road Stabilization &amp; Construction</td>
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<td>Personal &amp; Vehicle Armour</td>
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Systems made from woven geotextiles

- Mattresses for slope and scour protection and basal reinforcement
- Geotube® systems for bund construction
- Geocontainer® for bunds or breakwater cores in deep water
Geosystems

- Geobag system; 2 till 10 m³
- Geotube® system; 100 tot 750 m³
- Geocontainer® system; 100 tot 600 m³

Geosystems are sand filled elements made out of woven high strength textiles. The textiles used are special designed for Geosystems with the same strength in both directions.
Geosystem Application
Books and rules

In 2004 the book of the CUR, NL, Geotextiele zandelementen was printed. Experiences from out of Europe.
Application Geobags

Geobags used to create an artificial island.
Geotube® system

- Will be filled on position.
- Filling hydraulically with a mixture of sand and water.
- Lengths vary between 30 till 100 meter.
- Diameter vary between 1.6 till 5 meter diameter.
- In relative short period a dam can be constructed.
- Essential is fabric strength and confection, seam strength.
Geotube® systems: limit state modes

(i) Sliding stability
(ii) Overturning stability
(iii) Bearing stability

(iv) Global stability

(a) External limit state modes
   (i) Geotextile skin rupture
   (ii) Erosion of fill through geotextile skin
   (iii) Deformation of contained fill

(b) Internal limit state modes
   (v) Scour of foundation
   (vi) Foundation settlement
Geotube®: generated tensions

- Tensions generated at 3 locations – circumferential, axial and at filling port connections
- Tensions generated depend on size of tube and degree of filling
- First determine circumferential tensions, then axial tensions, and finally filling port connection tensions
Geotube® system: maximum axial tensions

- Generated axial tensions are a function of filling pressure and tube filling height
- As expected, good relationship between maximum circumferential tension and maximum axial tension
- The port connection tensions are a function of filling pressure and filling height
  - Can be significant when maximum tube filling heights are required
Geotube® system: distribution of circumferential tension

a) Circumferential tension distribution around a filled geotextile tube

b) Approximation of circumferential tension distribution in terms of $[T_{max}]_c$

10%-15% $[T_{max}]_c$

50%-70% $[T_{max}]_c$

100% $[T_{max}]_c$
### Design table for dimensions

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<thead>
<tr>
<th>diameter</th>
<th>circum</th>
<th>height</th>
<th>fill</th>
<th>width max</th>
<th>width base</th>
<th>recommended high strength fabric</th>
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<tr>
<td>D</td>
<td>C</td>
<td>H</td>
<td>F</td>
<td>W</td>
<td>Wb</td>
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<td>m</td>
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<td>16.3</td>
<td>6.4</td>
<td>6.0</td>
<td>GT 1000 M</td>
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Dimensions for a fill of 80 % and application under water.
Design with Geotube® systems

Determine the appropriate height:
• on shore 60% of theoretical diameter
• submerged 70% of theoretical diameter.
Installation/filling time

Giving: Geotube® diameter 4 meter
fillingheighth 2,4 meter, length 50 meters.

Total volume to be filled with $50 \times 10.4 = 520 \text{ m}^3$

pumpcapacity 400 m$^3$/hour at 15 % mixture (60 m$^3$/hour)

It will take around $520/60= 9$ hours to fill the Geotube®.
Geotube® system filling
Applications
Temporary Dam in Morocco

• Final Dam height 6 meter
• Constructed out 3 Geotube®, diameter 5 meter, fill height 3 m.
• 2 bottom Geotube® installed with a distance of 3 meter to create a flat installation surface for the top Geotube®.
• Geotube length approximately 70 meter.
• Material used Geolon® PP 200 S, seam strength 160 kN/m1.
• Finally covered with Nicoflex, impermeable liner.
Geotube® system

Building a temporary dam in Morocco
Geotube® system

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Building a temporary dam in Morocco
GEOTEXTILE TUBE APPLICATION FOR INCHEON BRIDGE PROJECT, KOREA
Introduction

• The Incheon Grand Bridge will be a 12.3 km, dual three-lane tolled bridge to connect Songdo City within the Incheon Free Economic Zone and Incheon International Airport located on Yongjong Island
• When completed it will be Korea’s longest bridge and anticipated to be the fifth-longest cable stayed-bridge in the world
**Introduction**

- A section consists of the symbolic cable-stayed bridge that will have a 74 m high navigational clearance to allow ocean going vessels of up to 100,000 tons to enter and leave the Port of Incheon
- However, 8.7 km of the sea crossing consists of concrete box girder viaducts built in shallow water over tidal mud flats
Introduction

Bridge layout superimposed over satellite map
Introduction

Artist impression of proposed Incheon Bridge
Introduction

- Geotube® systems were used as reclamation dykes, stacked in tiers up to a height of about 7 m over soft estuarial deposits.
- The Geotube® systems used comprised of 3, 4 and 5 m diameters, with lengths between 15 to 60 m.
Contractual details

- Detailed designs for the textile tube artificial island done by Seil Engineering Ltd and a geotechnical research team of the University of Incheon
- Design conditions (Shin & Oh, 2006) are summarized as follows:
  - Approximate H.H.W. : E.L. +4.635m
  - Significant wave conditions
    - Direction, WSW
    - Wave height : 2.06 m
    - Period : 10.0s
    - Wind velocity : 22.04m/s
  - Tidal conditions
    - Velocity : 0.58 to 0.73 m/s (low tide)
    - Maximum tidal difference : 9.27 m
    - Tide elevation : see Figure

Tidal elevation
Contractual details

Plan view of geotextile tube artificial island

Temporary construction platform formed with geotextile tubes

1.56 km

Incheon Grand Bridge alignment line

Temporary rock bund

Temporary steel bridge

Songdo City reclamation site
Contractual details

Typical cross section of Geotube® artificial island
Installation

- Tide
  - diurnal
  - range 9m
- Site is dry during low tide – laying of scour apron and textile tube
- Filling of textile tube during high tide when water is available for mixing with imported sand
Installation

- Sand supply barge – 1,800 m³
- Work barge
  - Crane
  - Mixing tank
  - Water pumps
  - Excavators
- Booster pump at 450HP, 1,500 rpm, delivering 150 to 180 m³/hr
- Pump outlet pressure at 3.5 psi
Installation

Overall view of one installation equipment setup for Incheon Bridge Project
Installation

Laying of scour mat during low tide
Installation

Laying of bottom Geotube® (outer) during low tide
Installation

Laying of bottom Geotube® (inner) during low tide
Installation

Sand filling and leveling between bottom Geotube® systems during low tide
Installation

Installation of sand mat above bottom Geotube® systems
Installation

Laying 2nd level Geotube® above sand mat

46 International Geosynthetics Society (UK Chapter)
Installation

Pumping of 2nd level Geotube® with sand slurry
Installation

Bottom & 2\textsuperscript{nd} level Geotube\textsuperscript{®} completed for 1 side of artificial island
Installation

Backfilling behind Geotube® dyke with residual soil
Installation

Installing upper level Geotube®
Installation

View of partially completed Geotube® artificial island
Installation

Bridge foundation and pier works in full swing on completed artificial island
Geocontainer®
**Geocontainer® system**

- Geocontainer® systems are in principle large big sandbags.
- These will be placed in a split barge and filled with sand. The Geocontainer® system will then be closed and the barge opened. The Geocontainer® system will then be dumped on the bottom.
- Capacity varies from 120 m³ till 600 m³
- Geocontainer® system are especially made for a given split barge
• Geocontainer® are installed by split-bottom barges

• Two types of applications:
  – Structural, submarine, mass-gravity units
  – Contained, submarine disposal of contaminated sediments

• For hydraulic applications container volumes are in range 100 to 600 m³
  – Smaller volumes give better installed tolerances and are more easily installed but are more costly
Geocontainer: tensions generated in fabric

- Filling of container in barge
- Reshaping of container to exit the barge
- Free-fall of container through water
- Impact of container on seabed
- Installed container on seabed

Geotextile container installation stages
Geocontainer® system
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Application:
• core for breakwater, dam or dike;
• under water berm;
• Filling of erosion holes;
• dispose of contaminated sludges.
New developments

- New guideline had been printed for designers and engineers, with calculation models the CUR 217
- Order at www.cur.nl.
- Currently only available in the Dutch language but translation will come out in 2008.
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