Innovative Technical Textiles for Earthquake Protection

Polyfunctional Technical Textiles against Natural Hazards

Integrated Project for small to medium enterprises (SMEs) financed by the European Commission under the 6th Framework Program

Monitoring + Reinforcement

One multifunctional product to increase strength, ductility, and safety!

Project Coordinator: Donato Zangani
Head, Innovation Division D’Appolonia S.p.A.
visit us at: www.polytect.net
D’Appolonia: Bridging Industry and Research

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- Infrastructure
- Manufacturing plants
- Power & energy
- Oil & gas
- Environment
- Transportation
- Space & Defense
- Innovation & Research

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Multifunctional Textiles: POLYTECT (Polyfunctional Technical Textiles Against Natural Hazards)

www.polytect.net

• EU Funded 4 Year Project (2006-2010)
• Part of FP6 targeting SMEs
• 27 Partners, 13 Countries

The Idea: Develop sensor embedded textiles for geotechnical and masonry applications in the field of Civil Engineering.
Video 1: Overview
Role of the Partners

ASSOCIATIONS
- TEXCLUBTEC (I)
- STFI (D)
- UNIK (D)
- UKA (D)
- CSGI (I)
- CENTEXBEL (BE)
- UCM (ES)
- BAM (D)
- ITIMADRAS (IN)

RESEARCH CENTRES
- EXTREME (I)
- AAT (I)
- SELCOM(I)

TEXTILE STRUCTURES
- POLYSTAL (D)
- SAFIBRA (CZ)
- IKH (EL)
- SMARTEC (CH)
- LS (N)
- GLOETZL (D)
- INTERLAB (ES)

INTEGRATED SENSOR MONITORING SERVICES
- MAYER (D)
- SLS (D)

MACHINERY/PROCESSING PROVIDER
- BGP (IL)

ADHESIVES AND NEW MORTARS PROVIDER
- APC (S)
- IMMGL (EL)
- CETMA (I)
- IRIDEX (RO)

CONSTRUCTION INDUSTRY/SEISMIC ENGINEERING

TECHNOLOGY INTEGRATOR
- DAPP (I)

MULTIFUNCTIONAL TECHNICAL TEXTILES FOR CONSTRUCTION (EARTHWORKS AND MASONRY STRUCTURES)
### Project Consortium: A Strong Partnership of Diverse Functionalities

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Why Textiles? Textiles are Widely Utilized in Civil Engineering

Landfills

Reinforcement of Masonry Structures

Civil infrastructure construction is the largest industry in the world accounting for 10% of world GDP. Textiles are routinely utilized in infrastructure projects. In ground construction, textiles stiffen or strengthen soil, and can act as filter membranes or water blockers. In building construction, textiles provide an efficient reinforcement strategy. This is especially common in older masonry structures that are vulnerable to natural hazards.

Embankments

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Why Smart/Technical Textiles?

- Provide a warning
- Reveal unknowns
- Evaluate critical design assumptions
- Assess contractor’s means and methods
- Minimize damage to adjacent structures
- **Control construction**
- **Control operations**
  - Provide data to help select remedial methods to fix problems
  - Document performance for assessing damages
  - Inform stakeholders
- **Satisfy regulators**
- **Reduce litigation**
  - Advance state-of-knowledge
  - Assessment and observation of cracks and their formations
  - Capture structural response to extreme events (earthquake, blast, etc.)
  - Assess or validate retrofit actions
  - Provide data for structural health monitoring
  - Provide data for life-cycle management

Multifunctional
Existing Problem
Standard/Regulation
Compelling cost saving
POLYTECT Applications

Multifunctional Sensor-Embedded Reinforcing Textiles for Geotechnical & Masonry Applications

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Is there a need for such Products?

GEOTECHNICAL
Motivation / Application: Geotechnical
Nachterstedt, Germany: 18 July 2009

Ground failure at closed mine
1.4 million m³ soil displaced

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What are we doing about this?
Case Study: A different site in Germany

Encroaching slope failure
Companies Involved:
Gloetzl
Alpe Aldria Textile
Smartec
BAM
STFI

Damage Indicator:
Soil Movement

“We are not saying it will be better, we are only saying it may be better and that is enough.”
- Rainer Gloetzl

Microbending

Willingness to pay for Multifunctionality
Case Study: Field Testing at Chemnitz Railhead

**Primary Result**: Sensors rugged enough to survive normal construction operations in a winter environment. System remains in place today.

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Case Study: Field Testing at Belchatow, Poland

Primary Result: Fault was growing 2mm/day enabling a slope stability analysis. Owner conducted repairs prior to any loss of operating hours or incident at the mine site.
Is there a need for such Products?

MASONRY
Motivation / Application: Unreinforced Masonry Structures
L’Aquila Earthquake: 6 April, 2009  5.8 Richter Scale  6.3 Moment Magnitude Scale
Motivation/Application: Haiti Earthquake: 13 January, 2010  7.0 Magnitude
Damage under assessment. Millions displaced. 233,000 casualties. Catastrophic disaster.
Motivation/Application: Chile Earthquake: 27 February, 2010  8.8 Magnitude Damage under assessment.  500,000 homes damaged.
What are we doing about it?
The Seismic Wallpaper Concept

URM (stone or brick)
Potential for textile interface
Outer mortar / cement / plaster layer
Horizontal load (H):
• 1,000 kN
• Cyclic load Application (pseudo dynamic control system available)

Vertical Load (V1 & V2):
• 4 x 1,000 kN
• Discrete control of each cylinder

Decoupled Arrangement:
• Isolation of horizontal displacement of head beam from vertical load mounting to prevent reciprocal interaction using low friction slide bearings

Measuring system:
• 32 channels
• High frequency measurement
• Values: inductive displacement sensors (vertical and horizontal), forces (vertical and horizontal), time, head moment

RC Head and Bottom Beam:
• For realistic simulation of interaction between wall and structure around, bearing of the wall was realised using RC beams

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Textile Integration and testing on 2D Walls

Video #2: Testing KIT

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Strengthening

Reinforced vs URM Masonry - Hysteresis

Qualitative comparison:
Hystereses are in use to analyse cyclic behaviour.

Considerable differences between URM and Reinforced Masonry are:
• Maximum Force
• Maximum plastic deformation
• Energy dissipation
By using a hybrid textile structure, WP5C-8300, displacement before collapse can be increased up to 243%. Effect of Reinforcement on Initial stiffness is negligible.
Testing on 3-D Structures: Uniaxial Reinforcing Strips
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Testing on 3D structures: Multiaxial Full-Coverage Solution

Testing at the EUCENTRE, Pavia, Italy

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Video #4: Testing at EUCENTRE

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Repair Phase

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Progress Towards a Sensing Skin Concept

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What can sensor-embedded textiles do?

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<th>Earthquake</th>
<th>Before</th>
<th>During</th>
<th>After</th>
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<td>Reinforce Structure to make it stronger and more flexible</td>
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<td>Capture and record the stresses and loads on the structure</td>
<td>Assist engineers in assessing the condition of damaged buildings</td>
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<td>Collect data to characterize structural performance over time</td>
<td>Shut of gas and other emergency measures when key thresholds are breached</td>
<td>Facilitate the prioritization of effort to restore normalacy</td>
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<td>Assist first responders in knowing which buildings are safe and which are not safe</td>
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Views of Different Products

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What the Products Look Like
Views of Different Products

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Innovating Tomorrow Today

GEotextile with DIstributed SEnsing

Views of Different Products: Marketing Brochure

GEotextile with DIstributed SEnsing

Verteilte Sensortechnik
durch Anwendung von Polymerfasern

- Der Antrieb
  Die Textilfaser wird im Rahmen des EU Förderprogramms PfV (Partnerschaft für Fortschrittliche Vielfalt) von der MESSERVEY entwickelt. In Zusammenarbeit mit der IAM (Institut für Architektur und Materialwissenschaft) entwickelt sie eine innovative Sensortechnologie.

- Die Idee

- Das Ergebnis
  Die Textilfaser (GEotextile) wird in die Statik einer Brücke integriert, was eine höhere Sicherheit und Flexibilität in der Bauweise ermöglicht.

- Datenerfassung
  Die Vernetzung der Sensoren mit der Überwachung und Auswertung ermöglicht eine optimale Anpassung an den Bedarf. Die Daten werden im System gespeichert und in Echtzeit ausgewertet.

Technical Data

- Diameter: 40 µ
- Max. Stress: 100 (psi)
- Failure: 1 N
- Damping: 1 cm
- Employability: Not applicable

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GEDISE
Verteilte Sensortechnik in Geotextilien

durch Anwendung von Polymerfasern


> Die Sensoren sind nicht nur für die Überwachung von Gebäuden, sondern auch für die Automatisierung von Prozessen, wie zum Beispiel in der Produktion von Textilien, nutzbar.

> Advanced Solutions

Kontakt

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Weitere Informationen finden Sie unter www.glotzl.com
Views of Different Products: Hardware & Software

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Views of Different Products: Services

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Main Square (Vittoria), Pavia, Italy
Yes it is ok to have brick covered by mortar

Invasive strengthening can cause additional damage
The design, application, and use of multifunctional textiles for the reinforcement and monitoring of civil infrastructure

Sensor Selection
Textile design
Interrogation system
Data processing
Data interpretation
On line access to structure information
Actionable information

Safer, longer lasting, more optimally managed infrastructure
Manufacturing is Relevant

To be adopted by the market, smart materials have to:

• be mass producable
• be cost effective
• meet existing codes and regulatory standards
• work

This is not an afterthought
Manufacturing
Landfills: Albota Landfill, Romania

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Vision

Industrial Smart Material Applications (ISMA)
*Manufacture, Build, Monitor, Assess, Predict, and Manage*

Selcom  
Airbus  

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Conclusions

- Multifunctional sensor-embedded textiles fulfill a need, are a value-added product, and make Europe more competitive.

- Please feel free to contact us for additional information and to refer others to us [www.polytect.net](http://www.polytect.net). We are intent on bringing these products to market because they are a better way of doing construction.

- We will take these ideas into other sectors. We welcome collaboration.

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