CONTEX-T – TEXTILE MATERIALS FOR TENSILE SURFACE STRUCTURES

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Introduction Contex-t – Project background

Contex-T is an EU-funded integrated project for SMEs that brought together a consortium of 29 partners from ten countries. It ran from August 2006 till August 2010. Each partner has been carefully selected for its expertise and knowledge in the field. This has resulted in a multi-disciplinary group where high-tech SMEs, research institutes and universities integrated their activities to develop a new generation of multifunctional textile materials. From Belgian side, several (textile) partners were involved: VUB – department textile architecture, BBRI (i.e. Wetenschappelijk en technisch centrum voor het Bouwbedrijf), Sioen Industries, Bexco and Centexbel as coordinator of the project.

Project rationale

Membrane structures consist of membranes and of structural elements which provide the necessary supporting and tensioning. The membranes are usually PVC coated polyester fabrics or glass fibre fabrics with a PTFE coating. These membranes are tensioned by steel cables and supported by a structure usually steel, aluminium or wood. Today the membrane provides a passive shelter with limited lifetime.

Within the Contex-t project different routes were investigated to develop new concepts and knowledge for the development and manufacturing of membranes which offer a safe and comfortable shelter. The approach did not only comprise the development of new materials but also addressed the intelligent use of the materials in the applications.

Because of the number and variety of partners, a main challenge in the project was also the coordination and streamlining of the partner activities. Therefore, knowledge management and collaboration tools for multi-sector product development were explicitly integrated in the project activities.

Developments related to the structural elements
Rigid structural elements based on textile reinforced Vubonite

Membrane based structures are generally supported by steel construction and steel cables. This steel construction unfortunately is prone to corrosion and therefore the consortium looked for alternative solutions for these steel components. Cementitous composites offer interesting alternatives either for the complete structure or for parts of the structure. In the project Vubonite was studied and further developed. Vubonite is an inorganic phosphate cement and was developed by the Vrije Universiteit Brussel, that was a partner in the project. It is based on a room hardening two component system. Without reinforcement, its properties are similar to concrete or ceramics. However, since it can be reinforced with glass fibres, thin but strong elements can be produced.

Vubonite can be made using standard composite materials technology but it can meet the structural requirements essential for application in the construction sector. As such it is presently a unique material.

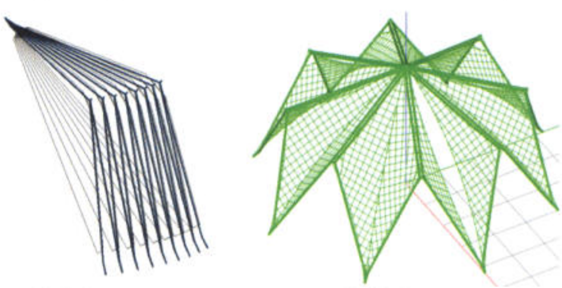
Within Contex-t, the use of textile reinforcement to reinforce the Vubonite components was studied. Different scrim structures were analysed in order to find satisfying fibre matrix interaction and for optimising the fibre content in the Vubonite matrix.

Feasibility of using polymer cables instead of steel ones

The replacement of steel cables by ropes was studied and especially the design of the suitable connectors and terminators for ropes proved to be very challenging. The problem was successfully solved and a patent is pending on the design of the connectors.

Foldable membrane constructions

Generally speaking, kinetic structures in architecture consist of a 'skeleton' and a 'skin' which work together on a functional and structural level to provide shelter. The skeleton, or bar system, acting as a primary load bearing structure, is called kinetic (or kinematic) when movement is introduced in the system by means of a mechanism, aiming at transforming the geometry. For the system to be able to act as a fully fledged architectural shelter, a skin - or membrane - is attached to the primary structure before or after the deployment.



Folded structure Unfolded structure
Figure 1: example of a kinetic membrane structure in folded and unfolded position as designed by partner VUB

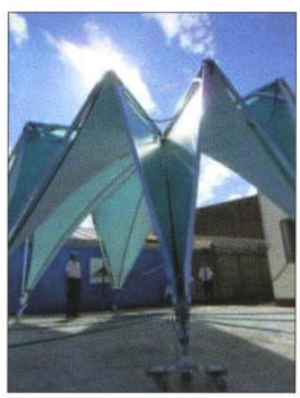


Figure 2: Contex-t demonstration of a foldable membrane construction. Involved partners: IASO – construction, Sioen – membranes, VUB - design.

Developments related specifically to the textile membranes
Easy to clean membranes

Because they are used outdoors, membranes are exposed to many different challenging environmental and weathering conditions. They quickly collect all types of dirt which is not easily removed. Finding an appropriate top coating which releases the dirt is therefore of paramount importance especially for PVC membranes as these membranes have a low surface tension. The requirements of a new membrane material should combine the good mechanical behaviour, flexibility and ductility of polyester yarns combined with the non-flammability and UV resistance of the glass fibres.

The coating should also be flexible, easy to be welded, should have a good adhesion to the yarns and should have the possibility of different translucency. The surface should be self cleaning even under urban environment and vehicle exhaust. The appearance should be more elegant, more like a cloth, soft and high strength and demonstrating the character of high sophisticated fabric.

Different routes for achieving an easy cleaning surface were studied:

- silicone top-coat on silicone rubber and UV-curing systems,
- topcoats based on acrylates, fluorocarbon and other polymeric species),
- new types of fluorinated top-coat,
- sol-gel based coatings.

The UV curable systems which were studied comprised different types of acrylates. Hardness, flexibility, abrasion resistance, adhesion and chemical resistance were criteria used to evaluate the different candidate solutions. Materials were extensively tested for soiling and cleaning behaviour using agreed laboratory test methods and outdoor exposure. Reproducibility, thermal and UV resistance and processability were also subject of study. This characterization has permitted to select promising material combinations which were then produced an industrial scale for demonstration.

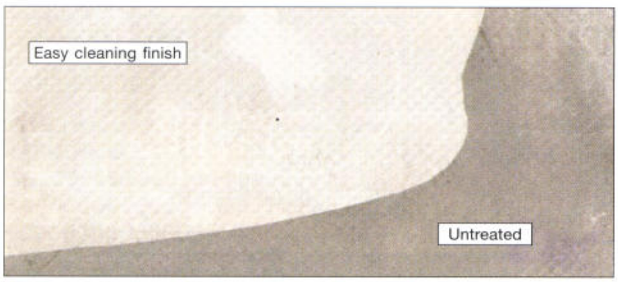


Figure 3: soiled and cleaned membrane which is partially treated with the new top coatings. The influence of the top coat can be clearly seen (partners: Sioen and Centexbel)

Fire safety

Fire behaviour of membranes was studied for a number of standard membranes with small-scale cone calorimeter tests, fire classification test methods prescribed by EN 13501-1, and large-scale fire tests as a reference. The tests were made in order to characterize the products and to relate the test results to the fire behaviour of the membranes in a building. For this a modified room corner test scenario was used according to ISO 13784 and ISO 9705. PVC-PES and silicone-glass type membranes were studied and clearly showed a fundamental difference in fire behaviour and room conditions during the fire. These differences are due to the fact that PVC-PES membranes break open when exposed to flames while glass fabrics stay intact. This results in higher temperature conditions in the room and in the door. Temperatures up to 350° C are observed for a long period in rooms covered with glass based membranes. It is important to note that all membrane products tested in the large-scale room scenario gave acceptable results when comparing with the same criteria as for normal building products.

Heat reflecting membranes

Membrane structures are passive optical barriers. In order to create a comfortable membrane it should permit the transmission of visual radiation but shield the enclosed environment from radiation carrying heat. In the following figure the transmission, reflection and absorption spectrum is presented for a PTFE-glass membrane.

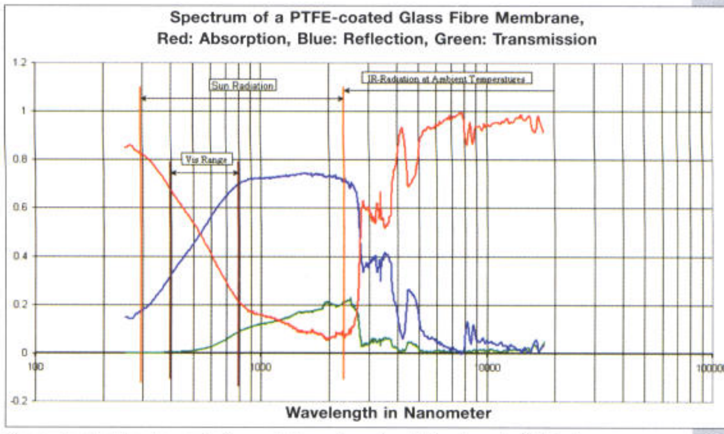


Figure 4: reflection, transmission and absorption of radiation through PTFE-glass membranes

The modification of the optical properties of membranes was studied by PVDF techniques with different metallic and metal oxide layers and by ITO nano-particle top layers on membranes. Different types of ITO nano-particles in combination with a suited lacquer composition and also suited stacking of layers was studied.

Energy generating membranes

The feasibility to integrate photovoltaic cells in membranes was also studied. Flexible solar cells are today on the market but it was unclear if these components could be integrated due to the high tension which was applied to the membranes. These high tensions can not be transferred to the solar cells as this would lead to destruction of the component. A solution was found in the way these solar cells were attached to the membrane. An intermitted layer was used in to prevent the transfer of forces from the membrane to the photovoltaic cell.

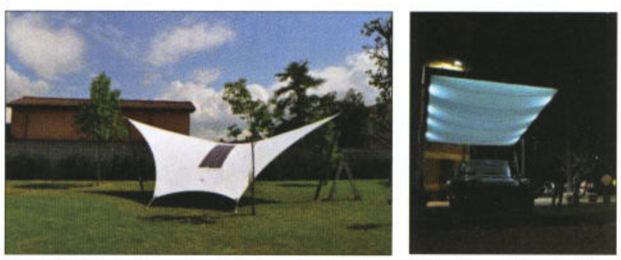


Figure 5: picture of two demonstrators showing the feasibility of combining textile membranes with energy harvesting via photovoltaic cells. Involved partners: Sioen, D'Appolonia, Canobbio.

Further information

More information about the project and about the involved partners be found on the project web site: http://contex-t.ditf-denkendorf.de/.

Acknowledgement

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