IMPACT

SUPPORTING NOVEL AND SUSTAINABLE URBAN ARCHITECTURE

NOVEL STRUCTURAL SKINS

VUB VRIJE UNIVERSITEIT BRUSSEL

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

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Impact Objectives

- Standardise the material and structural testing and analysis approaches within Europe to design safer and more efficient structures
- Harmonise the research on membrane and foil structural skins
- Collate harmonised data and tools on energy performance and life cycle analysis
- Stimulate and deliver innovation and development of new structural skin products, adaptable systems and durable applications in the urban environment

Innovations in the built environment

__Professors Marijke Mollaert__ and __Lars De Laet__ introduce __Novel Structural Skins__, an EU COST Action network of researchers striving to improve sustainability and efficiency using new structural textile materials and designs, and discuss the important societal implications of this work

Marijke Mollaert

Lars De Laet

Can you first introduce yourselves and your respective interests in tensile surface structures?

MM: I have been interested in this area since 1980, when I developed a graphical interactive form-finding tool based on the force density method for my Master's thesis. The domain of tensile surface structures is situated at the interface between architecture and civil engineering, making a synthesis of creation and structural analysis. The first numerical form-finding tools became available while making and testing physical models was still a powerful way of designing. Projects have ranged from art to high-tech civil constructions; aesthetically pleasing shapes have been inspired by nature; new materials have come onto the market; and new computer-aided design algorithms have been developed, all providing an exciting environment.

How did the Novel Structural Skins project come about?

LDL: The creation of a network for researchers to exchange concepts, reports and results, as well as to stimulate cooperation, was a logical next step after the TensiNet Association was established. TensiNet is a platform for all parties interested in tensioned membrane structures, a multidisciplinary association conforming to the initial objectives of the EU-funded thematic network (Growth, G1RT-CT-2000-05010 [2001–2004]). TensiNet promotes the quality of tensile surface structures and the dissemination of information about built projects. The domain still requires a lot of research to broaden and push the growth of applications.

What are the advantages of skins derived from textile architecture?

MM: Tensioned membrane structures have properties that other more conventional building elements often do not possess simultaneously, such as low self-weight, high flexibility, translucency, and the capability of forming architecturally expressive shapes that enhance the environment. In addition, membrane structures are known to be 'optimal' since they are only loaded in tension and adapt their shape to the flow of forces. Hence, they use a minimal amount of material to cover a space. Tensile surface structures can rapidly be deployed on site and easily be removed. Additional specific opportunities are linked to the fact that tensile surface structures can fit in any boundary, integrate easily in any type of environment (such as new or existing buildings, streets, gardens), improve the microclimate, facilitate rain water handling, urban gardening, etc. Adaptability is another key feature because they enable open spaces to be utilised in multiple ways.

What do you find most exciting about textile architecture?

LDL: These structures are fascinating due to their lightness and expressiveness. By 'just' using lightweight technical textile, these structures are able to create the most architecturally expressive coverings. In addition, it is fascinating how these structures are a true combination of architecture and civil engineering: their shape and structural behaviour are completely intertwined; changing the shape affects the structural behaviour and vice versa.

Can you discuss the anticipated benefits to society?

MM: More confident and creative use of tensile surface structures can definitely contribute to health and well-being in modern cities. It is a universal target that more people should live in more dense cities and, linked to that, urban spaces, commuting possibilities and green areas should be more attractive. Appropriate interventions can contribute to make working and living in cities more attractive.

Supporting novel and sustainable urban architecture

*The **Novel Structural Skins** EU COST Action network is constructing a pan-European collaborative platform to unite and harmonise research on membrane and foil structural skins, thereby furthering and enhancing sustainable innovations in the built environment*

Textiles and foils are increasingly present in the urban environment in temporary structures, architecture and building constructions in the form of small-scale canopies, facades and roof structures. A wide variety of materials have been used, such as open mesh materials, coated fabrics and foils; new types of membranes, however, have additional functionalities, such as photovoltaic properties and insulation.

Founded on the belief that applying textile architecture in the built environment can provide a response to modern needs and global challenges, Novel Structural Skins is an EU COST Action that is seeking to harmonise research on membrane and foil structural skins and standardise testing and analysis approaches within Europe. It is hoped that this work will stimulate and deliver innovation in the architecture and building sectors and develop new and energy-efficient structural skin products and applications in the urban environment. To do this, Novel Structural Skins is facilitating networking between partners and encouraging researcher mobility.

FILLING A GAP

Chair of the Action Professor Marijke Mollaert is based in the research laboratory of the Department of Architectural Engineering at Vrije Universiteit Brussel in Belgium. The project arose to fulfil a gap in the market, says Mollaert, and responded to 'a need to synthesise existing innovations and technologies and, from this, establish a platform on which the development of new advancements, projects and applications can be simulated and produced'. Novel Structural Skins establishes a solid network of researchers, academics, architects, engineers, contractors, asset owners and policymakers. It achieves this by sharing expertise, techniques, facilities and data, and establishes technical consensus and develops European standardisation for the analysis, design, and realisation of multifunctional building skins.

Mollaert explains that one of the challenges the project faces is a lack of awareness of the strengths of such materials, which they are working hard to overcome: 'Urban developers, traffic engineers and policymakers are not aware of the potential of tensile surface structures, and not all stakeholders have full confidence in tensile surface structures, which are sometimes still considered as "tents".'

PAN-EUROPEAN SHARING OF EXPERTISE

Working closely alongside Mollaert is Professor Lars De Laet, also based at Vrije Universiteit Brussel, who is Co-Chair of the COST Action, and Professor Peter Gosling from Newcastle University, UK, who is Vice Chair. The researchers collaborate with peers across Europe, and involve target groups including researchers, academics, engineers, fabricators, construction firms and standardisation working groups, making this a truly collaborative effort.

Bus Terminal Aarau, © Nikkaus Spoerri

For Mollaert, 'once you are passionate about textile architecture, you remain passionate. The most beautiful realisations are made by a team, where material fabricators, architects, engineers, designers and constructors work together to realise the best they can, respecting each other's expertise and trying to go as far as possible within the given constraints.' From her perspective, the value of this work lies in the creation of new ways to solve challenges: 'The creative interaction; the idea to do more than solving a problem; the integration of beauty – these are what make it extraordinary. So many realisations are jewels.'

The project is divided into five Working Groups (WGs): New applications of structural skins and new concepts (WG1), led by Lars De Laet and Tim Ibell;

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Sustainability and life cycle analysis (LCA) of structural skins (WG2), led by Alessandra Zanelli and Jan Cremers; Building physics and energy performance of structural skins (WG3), led by Monika Rychtarikova and John Chilton; Materials and analysis (WG4), led by Natalie Stranghöner and Peter Gosling; and From material to structure and limit states: Codes and standardisation (WG5), led by Marijke Mollaert and Jean-Christophe Thomas. De Laet outlines that the activities that fall under the WG1 umbrella involve presentations by early stage researchers, writing common papers, and the exchange of ideas about research project proposals. ‘Additionally, we share knowledge on built projects, discuss approaches for the design and analysis of new ideas and concepts, discuss design principles and guidelines of new structural systems, and networking,’ he says.

ENHANCING EUROPEAN STANDARDS

The researchers involved in the network hope that the work will provide a solid contribution to the ongoing development of European standards in this field, and also lead to the development of innovative products. The efforts are expected to contribute to a reduction in material, embodied energy and energy consumption of buildings in use, with sustainability, energy performance and LCA of structural skins at the heart of the project. Furthermore, the network hopes to expand opportunities for new collaborative projects. Mollaert explains some of the advantages of harmonising and standardising research on membrane and foil structural skins: ‘The benefits include improved confidence in the use of structural membranes as a building material, improving the safety and robustness of tensile surface structures, and even lighter surface structures and primary supporting elements. Less weight also means less waste after the structure is dismantled.’

SUCCESSFUL OUTCOMES

The impact that the team hopes the COST Action will have on the built environment is broad. For example, the researchers believe the membrane building concept has huge potential, including being used for a wide range of functions such as open canopies to protect and revitalise public spaces, cover shopping streets, parking lots for bicycles or waiting areas for public transport, and roofs for playgrounds in schools or sports facilities. ‘It could also enable covered zones between buildings which could be seasonal or retractable or lightweight second skins on facades to improve the energy performance of existing buildings (reuse of buildings), as well as membranes for large span roofs, which could be more frequently built,’ adds Mollaert. Tensile architecture has the added advantage that it is sustainable and eco-efficient because structures are lightweight, their lifetime is considered during the design phase, membranes are recyclable, and less artificial lighting is needed in spaces covered by translucent membranes.

One of the project’s outputs was a symposium, held in October 2016, with presentations organised into five main topics relating to the WGs of the COST Action, along with an extra sixth topic, built projects, which was the theme of the open session. The network is already making progress in its endeavours, as Mollaert observes: ‘One of the most striking realisations is using modern automated knitting combined with advanced structural design. A super lightweight tower, realised by Novel Structural Skin members, was first built in Copenhagen, Denmark, and later in Guimarães, Portugal.’ Another important milestone for the team is that the Science and Policy Report *Prospect for European Guidance for the Structural Design of Tensile Membrane Structures* has been published and distributed. Although the team is aware that uptake of innovations can be slow, it hopes to support the delivery of innovation in the form of new and energy-efficient structural skin products and applications in the urban environment.

Project Insights

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Professor Marijke Mollaert started her professional career in the Department of Structural Analysis, Vrije Universiteit Brussel, Belgium in 1978. She became a full professor in the Department of Architectural Engineering of the same institution in 1993. Her research interest lies in the field of tensile surface structures. Mollaert is Executive Secretary of the TensiNet Association and participated in the EU projects Contex-T (2006–2010), S(P)EEDKITS (2012–2016) and Smartblind (2012–2015).