The “4th Latin American Symposium of Tensile Structures” was held in Montevideo in April 2011. It was organized by the Faculty of Architecture of the University of the Republic, Uruguay, and chaired by the architect R. Santomauro. It was the fourth in a series of symposiums that began in São Paulo in 2002, followed by Caracas in 2005 and Mexico D.F. in 2008.

Over three days, 11 lectures and 31 presentations were given to 278 participants from 19 countries and three continents. The main topics focused on recent projects, as well as new applications, basic concepts, features, materials, design, software, testing, installation and education.

Main Lectures

Following the welcome address by the Dean of the Faculty and the introduction to the Symposium by R. Santomauro, N. Goldsmith presented “Skin. Biomembranes in buildings”. After discussing natural skins, he went on to talk about building skins as holistic solutions in which the body and skin perform together, integrating structure and environmental design concepts. He used a series of case studies on the work of FTL Design Engineering Studio (Future Tents LTD) to discuss several applications related to structure, form, acoustics, shading, lighting surface, energy generation, insulation and water collection that transform the notion of building facades into a porous multifunctional membrane reflecting the natural world. Special emphasis was placed on two textile roofs: the Sun Valley Pavilion (Fig. 1) for its dialogue between fabric and stone, and the Skysong at ASU Campus, Scottsdale, AZ (Fig. 2) for its dynamic rotational symmetry.

Figure 1. Sun Valley Pavilion, Idaho, USA

Figure 2. Skysong, ASU Campus, Scottsdale, AZ, USA

G. Schmid reminded the audience of the advantages of “ETFE” compared with glass in terms of cost and maintenance based on transparency, spectral transmission, lightweight, stiffness, vapour barrier behaviour and thermal coefficients. He also referred to the particularities of cutting patterning, production and assembly and emphasized the printing, colouring, lighting and
self-cleaning capabilities together with recent applications in many fields that allow forward-looking architects to design their self-marketing envelopes (Fig. 3).

The most frequently mentioned realization, with two main lectures and two presentations, was *"La Plata Stadium"* in Argentina (G. Castro, R. Ferreira, F. García Zúñiga, H. Larrotonda, M. Levy and T. Birdair), a derivative of the tensegrity Georgia Dome. Several speakers outlined the construction engineering, planning and procedures for the roof assembly, detailing the cable net lifting, jacking system and membrane installation (Fig. 4).

In *“Ejemplos en y desde Uruguay. Metodología de trabajo”*, P. Pinto and R. Santomauro presented the Uruguayan state of the art with a wealth of examples and a detailed description of the entire process, from a simple primary idea to the exact definition of the project, including all of the structural elements and their details, the membrane, its patterns and its installation on site (Fig. 5).
In “Lightweight structures and membranes for stadiums”, K. Stockhunsen from SBP insisted on the design and installation of roofs for large-span applications. Worldwide developments in recent decades culminate in the designs of the sports venues for the World Cup 2010 in South Africa and the future icons of the Brazilian World Cup in 2014. Other impressive realizations were presented from the Berlin Olympic Stadium 2010 to the Warsaw National Stadium 2012 and Rio de Janeiro Maracana Stadium 2014 (Fig. 6).

C. Bauer from Mehler Tex—nologies began his presentation “Tensile architecture. Principles of feasibility, sustainability and reliability in the practice” with the Vitruvius principles (durability, utility and beauty) and summarized a chronological development and possible future evolutions. He described several aspects of tensile architecture as advantageous and mentioned large spans, light conditions, economy (of time, energy and materials), efficiency, eye-catching forms, versatility, fire performance, uniqueness and cost (Fig. 7). A special reference was made to sustainability, recycling systems and the need to rely on the right consultancy, specialist industry and practical support. The Mehler TensileDraw available at www.mehler-technologies.com was recommended.

F. M'Cormick (Buro Happold) displayed in some detail the installation of the environmentally friendly 22,000m$^2$ roof for the 80,000 seat “2012 London Olympic Stadium”. To provide more potential for world records, complex CFD was used to analyse the wind regime on the track and field, which revealed that a roof covering will attenuate wind speeds. In addition, the 28m high lighting towers were lifted on top of the inner ring in order to avoid disturbing photographers. These are new requirements for contemporary stadiums that have to be added to the FIFA demands for visibility of the advertising strip around the field and may invalidate most contemporary designs (Fig. 8).
A. Capasso presented “Membrane architecture: from research to teaching and realizations 40 years between the sails”, based on the research, teaching activities and realizations of light structures that the author has carried out at the University of Naples’ Faculty of Architecture. Highlights of his career include the sails of the Triennale di Milano in 1973; Le tensostrutture a membrana per l’architettura, the first handbook on membrane structures in Europe in 1993; the international conference “Architettura e leggerezza”; and the Laboratorio di Tecnologie leggere per l’ambiente costruito at the University of Naples, established in 2000. His current work involves university theses and research into developing various functional and environmental possibilities for textile technology (Fig. 9).

J. Llorens lectured on “Detailing tensile structures”, which form a substantial part of the design process and influence the final result, but do not yet form a well-known and well-documented discipline. He presented a design methodology for detailing tensile structures based on the principles governing their behaviour and a prior recognition of the requirements to be met, taking into account the characteristics of the project to which they belong. A typology was also illustrated by specific examples placed in context that are available at http://sites.upc.es/~www-ca1/cat/recerca/tensilestruc/portada.html.

S. Delano and T. Dreyfus (Ferrari) in “Sustainable development strategy in textile composites” went into the material properties that are specially suited for permanent installations, such as lightness, translucency and longevity. They furnished data on weight/m², residual tensile strength (80% to 100%), exposition to severe climatic conditions, energy savings by protecting façades (more than 60% under the Latin American climate!), cost of recycling (~450 €/T) and life cycle analysis (Fig. 10).
In “Tensoestructuras. Diseños peruanos para el mundo”, A. Pérez and G. Carella presented a wide variety of textile roofs designed or built by Cidelsa, a Peruvian company that specializes in architectural design and engineering, membrane transformation, high-frequency welding, manufacturing of steel structures and accessories, and assembly. The collection of projects included shopping centres, stadiums, museums, convention centres, beer gardens, squares, sports halls and stations (Fig. 11).

Current research
G. Filz from the Institute for Structure and Design (University of Innsbruck) presented in “Soft Spaces” his current research on anticlastic minimal surfaces that considers the infinite possibilities of membrane forms as new elements in architecture in combination with common building technologies that deliver new capabilities in designing and creating space.

“Climatic Criteria for the Design of Tensile-Structures in Regions of the Humid Tropics” by J.F. Flor dealt with the passive adaptation to the climatic conditions of the humid tropic to obtain architectonic spaces that reach the maximum hydrothermal comfort of users with the minimum resources.
In “Adaptable Structures”, R. Franco explored more than 20 mobile systems, aiming to apply the features of these systems to build and develop an adaptable architecture that satisfies the needs of the contemporary world.

P. von Krüger (Universidade Federal de Minas Gerais) returned to the application of the tensegrity principles to latticed domes with associated membranes as an active cover that stretches the structure.

C. Morales (Universidad Veracruzana) based his “Design of Structural Flexible Systems in the Architectural Space” on the understanding of organic forms to construct a design methodology aimed at flexibility.

L. Moreira (Universidade Federal de Minas Gerais), explored in “Form Finding of Tensile Structures Made of Bamboo” the integration of physical and mathematical models. Numerical methods were also present in “New Strategies in Form Finding for Tensile Structures” by F. Pantano (Uni Systems) and “The Natural Force Density Method for the Shape Finding of Membrane Structures” by R.M. Pauletti (Universidade de São Paulo).

Testing Methods
In “Structural behaviour of textile roofs under different climatic conditions”, C. Hernández (Instituto de Desarrollo Experimental de la Construcción) showed the design of a testing apparatus and procedure for measuring the influence of humidity, temperature and wind on the pretension of hypars.

J. Blessman (Laboratório de Aerodinâmica das Construções, Rio Grande do Sul) was in charge of the last presentation of the Symposium, which dealt with wind tunnel testing techniques.

Other presentations
Several Latin American countries were represented and the latest realizations in Argentina (W. Runza and P.C. Valenzuela), Brazil (P.A. Barroso), Chile (O. Sotomayor) and México (J.G. Oliva, M. Ontiveros, V.H. Roldán and E. Valdez) were shown.

J. Monjo, representing H.Bögner-Balz for TensiNet, summarised the aims, objectives and activities of the Association, which was particularly relevant because the Latin American Network meeting was held afterwards.

Education
Several proposals and experiences for education were presented by leading professors from Latin American institutions.

- J.G. Oliva Salinas: “Curso de Arquitectura Textil”, 17 to 21 October 2011 plus 2 months online, Universidad Nacional Autónoma de México. His experience was discussed by P. Villanueva in the presentation “Contemporary teaching of tension structures”, in which the online form finding of membrane structures “Membranes 24” is used (http://www.membranes24.com)

- J. Monjo: “Curso de Arquitectura Textil” 2011/2012 (15 + 30 + 60 ECTS), Universidad Politécnica de Madrid. He discussed his experience in the presentation “Teaching Tensile Structures”.

- Robert Wehedorn: “Membrane Lightweight Structures”, Master Engineering Program (90 ECTS), Vienna University of Technology (http://mls.tuwien.ac.at).

- Unfortunately, Robert Off didn’t attend the Symposium to present his “Archineer and Master of Engineering in Membrane Structures”, Anhalt University of Applied Sciences, Dessau (http://www.membranestructures.de).
Software demonstrations (Fig. 12)
In sessions parallel to the lectures and presentations, demonstrations of specific software for designing tensile surface structures were led by: Gerry d’Anza “ixForten 4000” (www.forten32.com); Dieter Ströbel “technet GmbH” (www.technet-gmbh.com) and Robert Wehdorn “Formfinder” (www.formfinder.at).

Exhibitors (Fig. 13)
Student competition
The competition for design projects that make use of textile, cable or tensegrity structures, which was open to architecture and engineering students, received 10 proposals. The jury, composed of J. Monjo, N. Goldsmith and G. D’Anza, awarded R. Vivar and J. Tataje for “Tensowrap: signals – protection – security” (Fig. 14).

![Tensowrap](image1)

Figure 14. Tensowrap™ - Winner of the student competition

Other activities
T. Birdair offered the Welcome Cocktail, during which music was provided by a sax quartet. The “criolla” Symposium dinner was the opportunity to enjoy a Uruguayan meal. The city of Montevideo was also worth visiting, particularly the double-curved thin-walled shell in single-thickness reinforced bricks by Eladio Dieste (Fig. 15).

![Eladio Dieste Chapel](image2)

Figure 15. Eladio Dieste Chapel

Latin American Network of Tensile Structures
The 4th Symposium was also the occasion to meet the Latin American Network of Tensile Structures. It assembled 60 participants with an interest in regional activities and envisaged the collaboration or association with TensiNet. They decided to hold the next Latin American Symposia in Santiago de Chile in 2012 and in São Paulo in 2014.

Conclusion
The Symposium ended with a panel discussion on tensile structures in Latin American countries, during which we learnt that Latin American countries are not only fully involved in the development of tensile structures, but that they will also be very active in the coming years and constitute a key scenario for the future.

Josep I. de Llorens
ignasi.llorens@upc.edu
www.tens-mvd2011.org