TensileArchitecture & Engineering

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Tensys

Tensile architecture depends on the most advanced technological systems used in engineering and architecture today. Its basis is the materials and design techniques which have only become available in the last few decades and its future development will be dependent on continued technological scientific development, particularly in the field of materials which still need to be improved before they fully meet the requirement of designers and manufacturers.

Because of its lightweight and efficient nature tensile architecture also has a sound economic basis, able to enclose the largest area with impressive column free spans and the minimum of material. The possibilities of tensile architecture have expanded greatly since the development of computer modelling techniques.

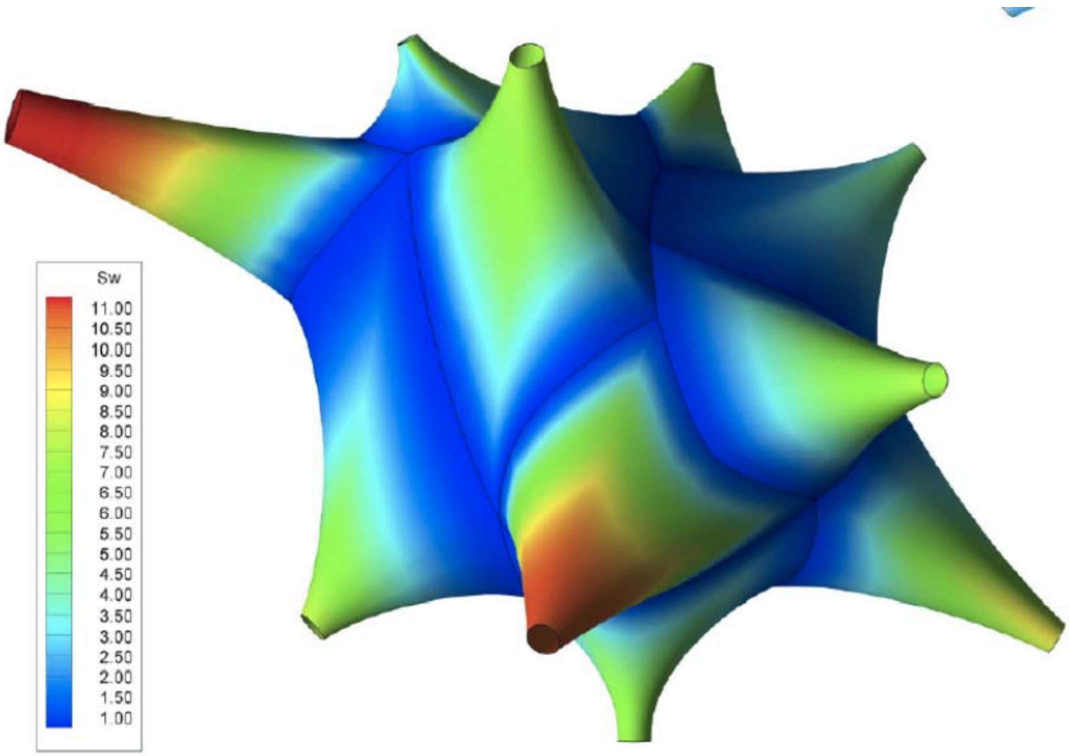
In his book, *An Engineer Imagines*, Peter Rice believed that the limits of what can be designed and built are the limitation of materials and the limitations of the designer's inventiveness, not the case of limitation of analysis and specification methods.

The engineer experiences interactive information response with the computer as manipulating the shape of the building is instantly shown on the screen together with the resultant stresses. Computer analysis software programs have developed to the point of not only creating a structural model of the building form but also the cutting patterns of the fabric and the cable layout of the net structure.

In stating the above, one must not lose sight of the important role played by physical models. They help us to understand how the forms can be manipulated and changed. They are also a key component in wind tunnel modelling

The engineer uses drawings and models in the early stage of the design in a complex subjective synthesis process of practical and aesthetic considerations that is not easily duplicated on the computer. These design methods mean that the designer has a direct tactile response in the development of these sophisticated structures and can maintain direct control over the formal development of the design.

Creating the organic form of these building is like shaping sculpture rather than assembling components, a direct response to the nature of form and space, the internal volume directly related to the external form and the division between outside and inside being the structural skin (acting both as cladding and structural support and synonymous with the structure)



The main problem for architects and engineers using this form of construction and continuing to exploit the development (which is undoubtedly still taking place), is to respond to the opportunities of the materials with appropriate detailing.

The beauty of tensile membrane architecture is in the few components required to create such a structure. These elements include the primary structure and specific components related to the structure, the fittings and hardware used to tension the tensile membrane and the membrane itself.

Mast or Compression Members
Most tensile membrane structures require a compression member (mast or arch) to form a complex shape. The component usually has welded “cleats” or “struts” which enable it to support the membrane, cable or other structural components.

Base Plate
The base plate forms the connection between the tensile membrane structure and the ground, wall, building or adjacent structural system. The base plate is usually welded to the bottom of a compression member or separated from the mast and connected to the mast with a pin connection.

Membrane Plate
Membrane plates are the most time consuming components to design and the key to successful tensile membrane structures. Membrane plates provide a "link" from the membrane to the structural masts. These plates are installed to accept tensile membrane catenary cables and pin connection hardware.

Bale Rings / Ring Beams
Bale Rings / Ring beams are compression rings which are used at the top of conical shaped structures that are used to erect and support the tensile membrane at the top of a mast. The tensile membrane is normally clamped to the ring and the entire structure is tensioned at the top by "lifting" the ring. Bale rings vary in shape and size depending on the complexity of the design. They can be left opened, covered by a metal, membrane or glass top, to name a few.

Catenary Cables
"Catenaries" are formed along the tensile membrane perimeter stretching from mast to mast. Catenary cables are installed inside a pocket in the tensile membrane or supported along the edge with cable straps and usually terminated with a threaded end stub or forked clevis that is connected to the tensile membrane plates.

Tie downs
Each perimeter mast requires either a large moment connection or a series of cable tie downs to withstand the loads. Tie down cables are generally attached to cleats on the top of a mast and connected to anchors installed in the ground with turnbuckles.

Specialized Hardware
Tensile membrane Structure hardware consists mostly of parts made for yacht racing, bridge building, rigging and mountain climbing industries. Shackles, turnbuckles, "toggles" and carabineers are just a few of the hardware choices available. These components are the link between the tensile membrane and the primary structural support.

Clamp Plates
Clamp plates are normally used to provide a watertight seal along a frame, beam or adjacent structure. The material most often used is aluminium or steel. The clamp can be extruded or cast to have a distinct profile.

The tensile fabric patterns not only need to reflect efficient cutting of material and exact matching of the structural profile but to express the nature and the direction of the stresses they contain. In a subtle medium of white on white, the material joints are especially important. The possibilities of harmonising the different layers of translucency must be understood. The inclusion of conventional materials makes transparency and light even more important.

The jointing and supporting components where cables and fabric are connected to each other and compressive elements need to be carefully designed so that they do not appear crude standing adjacent to such elegant forms.

Tensile architecture exhibits the environment problems of all large volume buildings in terms of air movement and heating.

Large movement under wind loads and noise considerations (from rain and wind) must be taken into consideration. The challenge is therefore to create appropriate new form of detailing and environmental control that not only solve these problems but express their dynamic quality in their form and operation.

Wind loading on tensile membrane structures consists of a random and varying set of surface pressures in which uplift generally dominates. The downward pressures are taken by the sagging set of tendons and the uplift pressures by the hogging tendons. The tension along any particular tendons remains sensibly constant so local high pressures are taken by the surface deflecting.

The same principle applies for down loads. Snow tends to slide down the steep slops and remain on the flatter slopes. This results in high local patch loading on horizontal areas. These high local load produces large local deflections. When these loads overcome the tensile membrane prestress level, ponding has occurred and potential failure is imminent.

The physical relationship between architecture and the user is not just a formal and spatial one, it is also environmental and tactile. Tensile architecture is a relatively new form of building based on precedence, examples in nature and technology transfer. The opportunities it possesses are a gift to the engineer and architect in that they make possible the generation of seductive forms and spaces.

However they also have the concerns of contemporary building technological innovation, ecology, buildability and economy. The designer who wishes to utilise tensile solutions must therefore accept the responsibility to understand the special environment conditions of lighting, acoustic and thermal performance and the necessity to take control of the structure and constructional detailing to convey the same message of balance and harmony that has been achieved in the purity of the overall form.