Tensile Facades – Realizing the Living Machine

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The concept of “the building as a living machine” has laid foundation to designs from some of our most prominent architects - Le Corbusier to Renzo Piano, Richard Rogers and more locally Sean Godsell. But for the majority of us, engaging the principles of the building façade as a mimic of the human skin has been difficult to sell and even harder to execute.

While the theory is well acknowledged, only recently have advances in lightweight tensile architecture provided realistic solutions to effect a true semi-permeable building façade or skin – one that allows the building to breathe, but also keeps out the elements at the same time. Advances in cable technology, an improved understanding of specific cable behavior, an intimate knowledge of tension and mechanical concepts, and improved modelling and analysis techniques, have all combined to realize light and dynamic building skins that do not restrict the building form. These lightweight tensile skins or facades, with their small mass relative to their span, use pre-stressed elements to resist deformation and provide stability over large areas. At the same time they provide identity, reflecting the context and experiences of the building owners.

Individuality

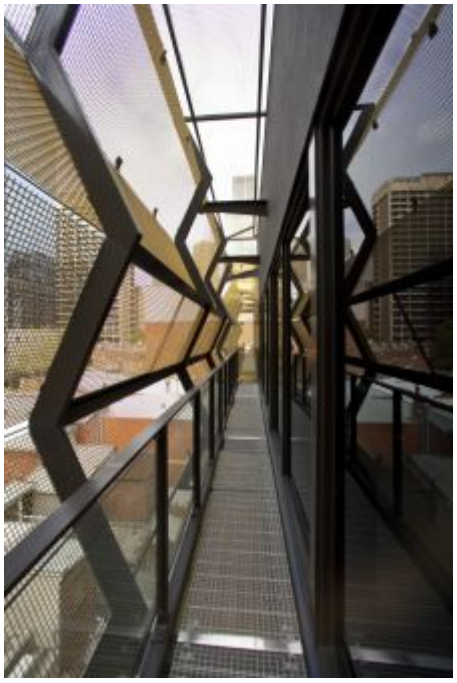
One of the great qualities of skin is its ability to define the individual. Shape and colour, for example, are two identifying factors that attract people to each other, and with buildings this is just the same. When someone says they like the appearance of a building, they refer to an appreciation of its façade, the primary building element that conveys individuality and interacts with the surrounding environment. Peddle Thorpe’s rejuvenation of the Whitten Oval Grandstand in Melbourne’s inner west provides a perfect example. It called for a feature façade that would respond to its context displaying the colours of the local Western Bulldogs AFL team, form an identifiable entry, and provide an environmental benefit in the form of shading for the west facing glazed façade behind. A conventional steel framed structure, used to support the façade panels, would have dominated the building, its bulky steel members limiting the view of the forecourt from within, and the internal spaces from outside. The solution was a tensile net of lightweight panels and cables that allow a unique and transparent view from inside and out.

The Whitten solution with its cable grid of 8mm stainless cables and cross clamps is truly individual. Like most tensile structures in glass, metal panels, timber or tensioned fabric, the integrity of the lightweight solution relies upon geometry and pre-stress in the cables to reduce deflection and

deformation in the absence of heavy members. At Whitten, the curvature of the façade and the pre-stressed cables are shaped into an elegant geometric form that effectively resists the imposed forces and provides the stiffness required to readily maintain the structure's stability. The design preserves the transparency of the system to clearly articulate the geometry of the structure and to realize the brief for shelter and branding with minimal support. Like all tensile structures that rely on optimized design processes and minimized materials to achieve their "lightness" and form, a tensile facade will often have a two or three dimensional element to its design for greater structural efficiency. This form provides essential stiffness.

Wrapping & Folding

Unlike human skin, which masks the structure underneath, few facades really break from the rigid form and structure imposed by the building proper. Gehry's "Guggenheim Museum" and Lab+Bates Smart's "Federation Square" are two very successful examples of wrapped or folded almost "origami-like" facades that do achieve this, but they rely at least in part upon deep steel structure beneath to support this skin. The application of tensile façade elements in cable or rod allows buildings to be wrapped, or façade materials to be folded around minimal structure, independent of the primary building construction. Less weight, less mass and lower cost can all be realized in a tensile cable supported skin. Installation programs are shortened and maintenance cost reduced as small diameter pre-stressed cables replace heavy painted beams. The efficiency of these tensile elements makes these facades a reality. Without them costly and cumbersome secondary structures would be used to connect the "fluid" façade with the rigid structural form of the building's beams, columns and slabs. At 103-105 Lonsdale Street in Melbourne's CBD, SJB Architects designed a two storey addition for the top of a 4 storey heritage listed building that today expounds the benefits of tensile façade solutions.



Conceived to respect the contextual challenge posed by the buildings heritage listing and close proximity to Chinatown, the 103 -105 Lonsdale Street façade uses vibrant colour and dramatic shape to shroud two additional stories in a façade representative of a Chinese lantern. The lantern hovers ethereally above the existing heritage building; its cable supported woven aluminium panels folded in chiselled lines around horizontal cables to create a unique architectural icon in the area. For the lantern illusion to succeed the façade element needed to appear as light as possible. Cables pre-tensioned between cranked beams replaced heavy horizontal steel members and provided the essential structure onto which mesh panels were clamped. More efficient, lighter, horizontal cable members facilitated a substantial reduction in the number of vertical cranked steel beams, minimizing structural bulk and opening the aspect from within for occupants; a strong feature of the design brief. The result is a façade of unique "lightness" and transparency. The woven mesh filter cleverly hides

the regular form of the building, which is wrapped in a second skin to provide protection and uniquely identify with the surrounding area.

Shelter and Filtering

Aside from our skin's ability to convey identity, to promote interaction and provide the body with sensation, as a membrane it also provides basic shelter, controls incoming and outgoing substances and regulates the body's temperature. These skin functions rely upon a membrane's ability to be selectively permeable. Today's building facades are the same and much like the process of osmosis in cells, they filter elements selectively, allowing some elements through the membrane, whilst blocking others in accordance with ESD principles - if sustainable design is at all a factor. Facades must protect against wind and rain, while filtering sun, which at times is welcomed providing essential warming. At other times sun needs to be controlled to regulate temperature.

Traditional curtain wall solutions have struggled in this area. They provide effective shelter, but isolate the occupant from the outside environment at the same time, forcing an over-reliance on artificial environments or air conditioning. Tensile facades, with their minimized structure, provide effective shelter more efficiently, and can increase an occupant's opportunity for interaction with the surrounding environs through the provision of structural support with less disruptive visual bulk and mass. Above all, the introduction of tensile elements strikes a better balance between amenity and the provision of shelter, temperature regulation, and the ever increasing demand for more sustainable design. Pre-stressed cables or rods and geometric form can facilitate the utilization of meshes, plants, battens, and timber or metal louvers with minimal disturbance to the building behind.

Melbourne's CH2 Building illustrates this perfectly, successfully addressing the challenges of shelter and filtering without detrimental effect on amenity. The green facades of CH2's Northern Terraces span 9 floors of the building bringing lush flora to the north facing balconies. These "living screens", as they are sometimes called, not only provide shelter from the low angle morning and afternoon sun, aiding thermal control and limiting heat gain, but they also help restore ecological balance and greatly add to the amenity for building occupants with improved natural light and ventilation. Like so many tensile structures before them, the simple form of the Northern Terrace screens harbours a hidden complexity, which in this case plays an integral role in the realization of CH2's ESD philosophies.

The green facades were first modelled and analysized for minimization of the structural elements, before the plant's requirements for support were overlaid. These have a significant bearing on the density of foliage achievable and therefore the plant's ability to shade. The process resulted in a tensile cable net comprised of 1.5mm diameter stainless steel cable mesh, which was bordered by larger cables to facilitate the transfer of wind, plant and other loads back to the main building structure. With planter boxes at each level, these tensile green façade structures provide plants with an optimal and secure growing environment. Like human skin they shelter and filter effectively and allow the passage of elements in both directions. On the Northern Terraces this means providing occupants with the opportunity to experience the surrounding environment as well.

Protection and Strength

One of the remaining functions of skin is to provide protection. Its ability to regenerate and repair, and its inherent immune qualities, are difficult to replicate, but the façade fulfils the protective role as a physical barrier for our buildings. Few façade materials are truly homogeneous, their integrity as a barrier compromised by the need to mate panels and surfaces requiring jointing, lapping and the use of sealants or other compounds. Tensile membranes of textile or metal mesh fabric absolve this need and are tensioned into place as one single impervious span. These new materials offer degrees of "imperviousness" on a cascading scale from the full blockade of some textile solutions, to open metal fabrics that provide security with full ventilation and transparency. All allow façade designers to play with light and shadow, opacity and identity, while ensuring effective breathing and climatic control. When tensioned into place these supple and fluid materials become robust and strong providing almost "skin-like" qualities.

At Sydney International Airport Carpark, Design Inc used a single tensioned cable mesh fabric of 1500m² span to provide fall protection for the 11 storey carpark. The 95% open area of the tensile cable net solution achieved a minimum air flow rate that traditional façade solutions with heavy sub-structure couldn't. This ensured classification of the carpark as an open deck realizing substantial cost benefits and liberating the building of the cost burden associated with mechanical ventilation and fire sprinkler systems.

A growing understanding of tensile architecture and what it means to facades is definitely providing designers with a range of new and exciting façade options. To the purist, the utopian representation of a façade that truly mimics skin and its ability to provide protection, immunity, temperature regulation, sensation and social interaction is far from realization, but tensile architecture brings us closer than ever before. New materials and the ability to carry forces within the surface, either by membrane stress or cable tension, provides façade solutions of unique depth and openness, with large spans made possible by balancing the need for reduced self weight with the application of minimalist and efficient high tensile cable tendons.