Stretching the Boundaries of Membrane and Film: Robina Skilled Stadium and Clarke Quay

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In many ways the fabric structures industry has matured. The use of structural membranes is now more commonly seen as just another building option rather than something exotic and different. There is now a very wide range of projects in locations across the world.

The form and detailing of tensile structures is deceptively clear and simple. However these are still complex systems that require care in design, detailing, fabrication and installation.

The continuing development of fabric clad stadia roofs has provided structures where not only the cladding but also the supporting system has been optimised for both efficiency and aesthetics. The new Robina Skilled Stadium in Australia features not only a tension fabric roof structure but it is further enhanced by a translucent tensile membrane façade wall structure.

Some buildings continue to push the envelope of form and function. Conceived by SMC Alsop are the sculptural shade elements for the streetscape of the renovated Clarke Quay riverside area in Singapore. These use a mixture of PTFE coated glass and ETFE.

The growth of use and architectural interest in ETFE foil as a cladding material is probably one of the strongest phenomena in Europe at present, and this effect is spreading towards Asia.

New applications and materials continue to challenge the designers and builders of stressed membrane structures. This presentation is intended to stimulate further possibilities.

Robina Skilled Stadium and Clarke Quay are presented in a little more detail on the following pages.

Project **Robina Skilled Stadium, Gold Coast Australia**

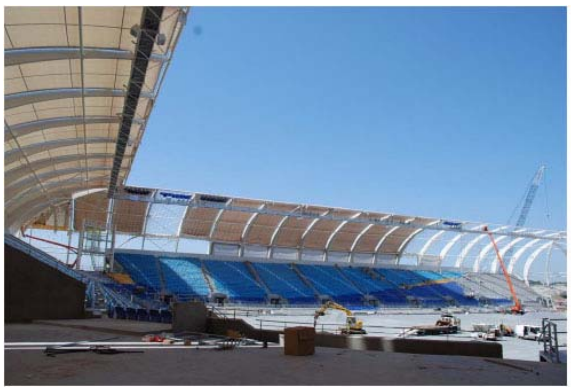
Description — Robina Skilled Stadium (under construction) is to be the new 25,000 seat rectangular (in plan) home of the ARL team Gold Coast Titans. The stadium terraces are covered with a roof constructed from curved steel box section rafters interlinked with CHS purlins and clad with PTFE glass tensioned fabric panels. The playing surface is open to the elements.

Steelwork — The roof steelwork is formed from fabricated steel plate box section ribs or rafters. The rafters are spaced at 10m centres forming a regular grid along each of the four sides of the stadium. The rafters truncate and mitre into diagonal rafters at each corner.

The curved rafters span from pinned connections at entry terrace level curving out and away from the grandstands and then up and over the seating area. The rafters are tied into the terrace structures approximately 14m above entry terrace level and then cantilever 28m beyond this point.

The rafters are 350mm wide and vary in depth from 620mm at the base pin to 2340mm at the prop and back down to 360mm at the tip. This is the situation along the North, South and East wings.

Along the West Wing is the main entry structure that projects out through what would be the lower roof area and so upper roof rafters' cantilever from the top of the entrance structure.



Fabric

The rafters form the boundaries dividing up fabric panels that are attached and tensioned to the faces of the rafters. Each bay between the rafters is divided into two regions; an upper "roof" panel and a lower "wall" panel.

The edges of these regions are defined by purlins spanning between the rafters. The fabric is also attached and tensioned to these edge defining purlins.

There are also some internal purlins spanning between rafters to help brace the rafters. The fabric is intended to sit clear of the internal purlins under all conditions. The upper roof panel of fabric is fabricated from conventional PTFE coated glass weave fabric.

Along the South and East Wings lower wall panels the architects have proposed that the conventional fabric makes way for a fabric of much higher translucency. This panel is offset inwards towards the stadium from the line of the roof panels; the architects intent is as if the conventional roof panel has been torn away to expose the interior workings of the grandstand behind. A PTFE laminated glass weave mesh fabric with approximately 50% light transmission compared with 10% for the conventional material was adopted.

Wall Panels in the North and West and at all corners are fabricated from the conventional fabric.

Roof panels are subject to high uplift forces. The roof panels are reinforced with a valley cable system that acts to stiffen the panels and reduce fabric stresses under the uplift load cases. It is intended that the valley cables are only notionally prestressed at installation and so they have little effect at resisting downwards wind pressures. The fabric works on its own under these conditions.

Wall panels on the other hand are subject to high inwards pressure wind loads. In particular, the South West corner panels are heavily loaded. The original intention was for the wall panels to also have valley cables, however these had no practical function in resisting the high inward pressure loads and were deleted.

Installation

Hightex have brought their novel approach to installation that is a variation on their proven methodology used to install fabric panels at Bangkok Airport and Berlin Stadium. The use of expensive conventional access equipment and fixed scaffolds are minimised. This methodology was approved by the local workplace health and safety authorities following a stringent review of the procedures.

At time of publication, many of the conventional fabric roof and wall panels have been installed and the first laminated mesh wall panels have gone smoothly into position.

Contributors		
	Client	Major Sports Facility Authority Queensland Government
	Architect	HOK Sports Architecture
	Engineer	SKM
	Main Contractor	Watpac Limited
	Specialist Contractor	Hightex
	Membrane Engineering	Tensys

Project **Clarke Quay, Singapore**

Description

The current redevelopment of the riverfront at Clarke Quay brings new shopping and dining facilities whilst trying to maintain some of the ambience of the old fishing village that had become a hub of trade and industry.

SMC Alsop was engaged by Capitaland to create a new Singaporean landmark with the redevelopment of Clarke Quay in Singapore. Local Singaporean architectural firm RSP Architects worked as the local documentation and project architect.

Clarke Quay is a riverfront neighbourhood composed of 100 year old Chinese dockside shop fronts and rice godowns. This area was redeveloped in the late 1970s, but over the years it is looking tired prompting Capitaland to redevelop it as a major tourist precinct with cafes, restaurants and nightclubs.

There are two distinct areas to the development. Alongside the Singapore River the promenade has been extended by ”Lily Pads” that are 0.5m above ground level and and extend by up to 1.5m out over the river. Continuing the botanical theme, the waterfront is covered by a series of over 100 ”Bluebells”, 4m and 5m diameter PTFE glass canopies with a form resembling the flower.

The second area comprises of canopies providing shelter for the 4 main internal streets and the central courtyard of Clarke Quay. Approximately 7500m2 of double layer ETFE and 3800 m2 of single layer ETFE are supported by steel ’angels’ towering over the adjacent buildings at 16m above ground level.Along the Riverfront is a strip of outdoor dining areas with Riverfront Canopies.

Stylish street furniture has been created by the architect to provide not only shade and shelter, but also strong visual interest by day and night.

Bluebells

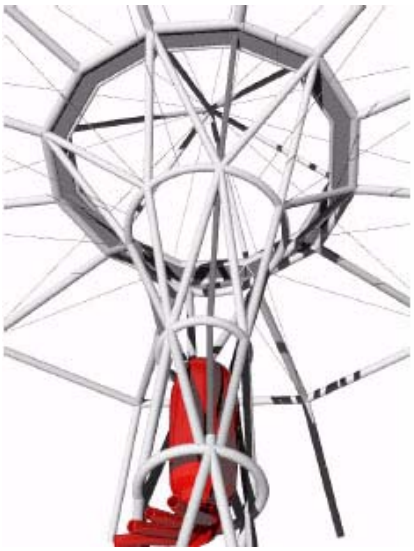
The Bluebells are dome shape structures that are fabricated with an exterior steel skeleton frame (a series of hoops and ribs). The frames are clad with tensioned PTFE glass fabric that is tensioned and attached to the interior of the frame. There are two different modules; a 4m and a 5m diameter dome that are seemingly suspended from curved steel masts.

The structures are challengingly intricate for PTFE structures with great accuracy required in detailing, patterning and fabrication.

The irregular interstices between the Bluebells are filled with a tensioned PTFE glass fabric panel ribbons that flow over arches linking the Bluebell frames. The ribbons also flow around trees growing up between Bluebells.

Providing weatherproof coverage from the Shopfront facades to the Riverfront Canopies are a series of Link structures.

The Links structures are shallow PTFE cone structures with catenary cable edges with external steel frames attached to slab level at the facades (slab levels vary from one building to the next). The structures cantilever over the quayside street and overhang the Riverfront Canopies. The Link structures can be raised by a retractable arm with the canopy pivoting at the building face to allow clearance for transit of emergency vehicles.



Angels

These structures are the first use of ETFE in Singapore and so there was much work required to satisfy regulatory authorities for it use on this project. Hightex and Tensys worked closely with the architects to get the concepts approved. Tensys also worked closely with the architect to develop a suitable rational geometry and structural system to support the canopy.

The structural system is a series of spiral truss columns that zigzag from side to side along each of the four legs along streets leading to the central crossroad area. The zigzag helps to provide some stability and also decreases the uniformity that the architect was trying to avoid.

At the head of each truss column is a series of twelve radial arms that crank in elevation and overhang the shopfront buildings along the sides of the streets. The arms are stayed with tension rods both above and below.

At the central cross road area there are four tall spiral truss columns interlinked with rod stayed radial arms that also crank and cantilever over the street canopies and corner shop front buildings.

Each of the four street canopies and central canopy are structurally independent of each other.

Each spiral truss column is capped with a large polygonal ETFE cushion and each of the radial arm frames are clad with ETFE cushion structures. The ETFE has an intricate organic frit pattern printed on its surface to provide some shading.

At the ends of each radial arm, the arm cranks down to provide some weather protection as the structures cantilever over underlying shop fronts. The cranked regions are clad with tensioned single layer ETFE skins.

Rain on the ETFE cushion structures drain into box gutters at the head of each truss and thence into downpipes that are hidden inside structural members. A siphonic drainage system was adopted to minimise downpipe size.

Contributors		
	Client	Capitaland Commercial Limited
	Architect	SMC Alsop
	Engineer	Tensys
	Main Contractor	Kajima
	Specialist Contractor	Hightex (Angels) & Rightech (Bluebells)
	Membrane Engineering	Tensys