

LSAA Conference – 2009 - Lightweight Structures

Catching the Next Wave

Advancing new technologies are no longer a surprise to architects and engineers, but expected opportunities within an ever advancing learning society. New ideas embodied in nanotechnology, industrial and other chemical processes are dramatically altering strength/weight ratios; affording lighter elements to provide shelter, particularly where large spans are required.

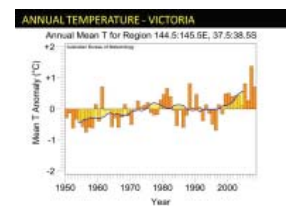
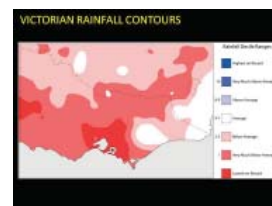
The paper reviews a number of such projects, defining the architectural relevance of “light weight” aesthetics, the characteristics of which may well be a tradition we inherit from the **tent cities of the Australian gold fields** and the Country Showgrounds; even the gas filled dirigibles of World War I or the **light sailing racers** we see cruising around for leisure or competition in dynamic circumstances: the uncertain, even indeterminate conditions of wind and tide, the interplanetary rotation around the sun and the constellations beyond.

One of the engineering by-products is a need to keep things in place.

I am thinking here of **lightweight cable stayed cantilevers** on the MCG northern stand and on the **Gabba fabric parasols which shelter the patrons.**

Other recent projects of significance are those seen on **Southern Cross Station in Melbourne**, a range of new stadia in China; the fabric structures for the Royal Melbourne Showgrounds and, earlier on the **celebratory mobile exhibition for the Australian Bi-centenary in 1988.**

A second observation I wish to make, returns to the first point. We are now seeking **further “energy” understanding of our world**; going beyond the tectonics of physical structure only, to embrace an advanced thermodynamic paradigm, whereby energy use and waste, (carbon in particular), and principles of sustainability are new found **aspects of belief, self-expression and identity** as humankind brings a better understanding to built form, energy consumption, and ecological planning into **another new alignment for survival.**



This means further conservation of the existing landscape, a process of recycling water, the idea of building additions and transformations of valued existing buildings, as well as new completions; all critical areas for relevant engineering and architectural exploration.

The accompanying diagram illustrates the coming together of these elements of design, not exclusive to “light weight” engineering or architecture, but pertinent now to consider in all our respective tasks.

So, what constitutes the designation ‘lightweight’ as an adjective for a structure?

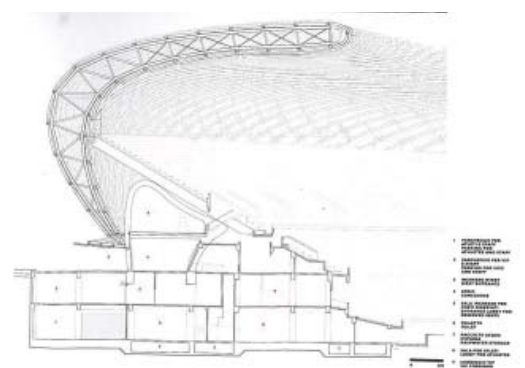
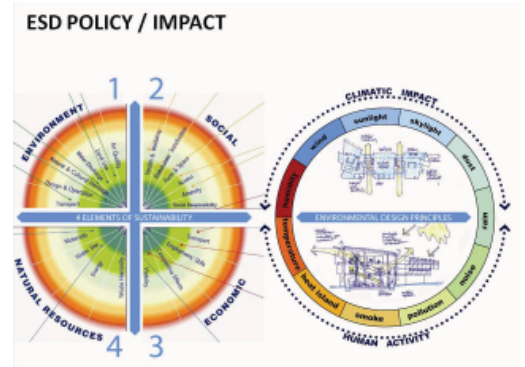
There are several answers and they relate to building typology, to fire rating, to climatic envelopes and above all to materials assembly. One size does not fit all, and there are conscious demands created by function or purpose that establish a reasoned “sense of fit”.

One definition of architecture I use is “*the thoughtful making of space to encompass human activity*”. And the paradigms of utilisation, **life cycle costing** and **environmental sustainability** all need to be brought together: **problem solving in Century 21**.

This year, a **new stadium for the World Games in Taiwan** met many of the relevant criteria; the project was designed by the Japanese master architect Toyo Ito.

The key point of difference to other stadia is not only the elegance and fluidity of the ellipsoidal embrace of the arena, but in the use of a solar panel roof ... **the first stadium to draw most of its energy from the sun**. The design is defined by a crescent shaped web of skeletal steel ribs supported by a sculpted concrete beam/column arrangement, which in turn form the sloping base for a single tier of upper arrangement of seats suspended above an in-ground lower bowl. There are 40,000 seats wrapping around the field of play.

This configuration enables a **double upper form to result**, without the complexity of the three tier bowls we design in Australia for spectator numbers of 50,000 to 100,000, complete with an array of sponsor suites, and a range of public dining areas, bars and merchandise facilities which need to be shoe-horned in, to provide further amenity beyond one’s seat.



Apart from Ito's lightness of touch there are three other aspects to which I wish to draw your attention, just to recognise one example of the new found design syntheses currently demanded of engineers and architects, contractors and material suppliers. The Taiwan Stadium evidences:

1. A lightness and openness of form, a "sprung steel" curve in the section which establishes the roof/wall enclosure and cantilever. The roof purlins are tubular and spiral diagonally across the primary structure. These expressive elements are akin to, but in no way resemble, the "tensioned up lightness" of the Munich Stadium first seen in Frei Otto's tent forms for the 1976 Olympics.



2. Solar energy is the second critical ingredient beyond "lightness". In engineering terms, the roof assembly is a "receiver of light", with energy from the sun an embodied condition required by the client. In the Taiwan climate, one other primary environmental condition is to achieve 'natural ventilation' and 'sun protection' for patrons. The 9,000 photovoltaic roof panels provide 80% of the electricity during game time, and save 650 tons of CO₂ emissions each year. When not in use, the stadium is a generator of power returning some \$5 million (National Taiwan) to the city government.



3. My third point resides in the Stadium's feeling of lightness, the expressive power of constructed engineering forces which cause us to admire the project's elegance of translucent fusion of form, allowing the exterior and the interior to come together; and for the serpentine unravelling of the roof 'opening out' to embrace the park, and provide an emotive sense of welcome.



In my opinion Century 21 is about "meaning", about effective behaviours; not just the "economically convenient" lower order of measuring human existence. As we now know, the planet has its own DNA and so does every species upon it.

Remember Charles Darwin? His paper on evolution was publicised in 1859; the same year Tom Wills and others invented and wrote the rules for AFL. They too have **evolved**.

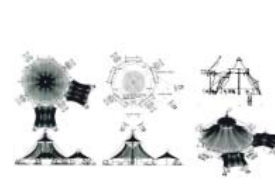
Our role as designers is to determine our own conscious role within the new spectrum of resource limitation, of conserving what we can, and renewing our cities with even greater care built into human desires, as an indelible part of our species DNA: just like championing a team.

To that extent a **lightweight structure conference has much to offer on every frontier**, as suggested in this paper.

1. The following examples of our work over the last few years commences with a light weight fabric marquee for **Melbourne's Agricultural Showgrounds**. It measures 80 metres by 90 metres and cost \$1 million; used intermittently for events, conventions and the Show.



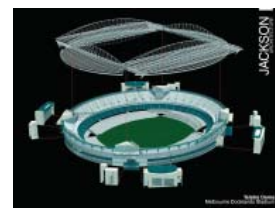
2. The precursor of such a structure was designed for the **Bicentenary travelling exhibition** ... 35 cities in 12 months; a 20th century circus where the elephants were replaced by the **low loaders front element to erect and then anchor the structures** before moving them on to the next location.



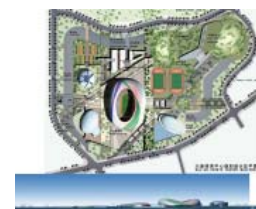
3. A cable stayed roof cantilever above the MCG Northern Stand is lightweight, **only the concrete filling of the hollow steel girders was deliberately heavy to prevent uplift**.



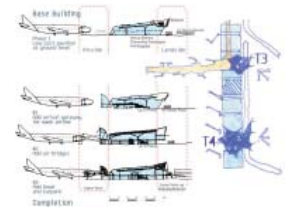
4. **Etihad Stadium** has been operative for almost 10 years, with **one of the world's largest sliding roofs**. Each sliding plate measures 50 metres across with a span of 170 metres for the curving bowed form upper truss. The roof membrane is an acoustic diaphragm, so fabric was not an option. The roof opens and closes in 7 minutes: **stopping it in the middle as each plate meets** was the exciting engineering exercise.



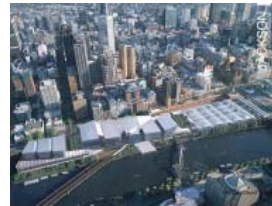
5. Several stadia designs were proposed for competitions in **China**. They were not successful, except for the design quality. **Winning such projects always has other complexities, some unaccountable.**



6. An **aircraft maintenance hangar in Canberra** is a reality, a stable arched form with sloping side walls as bracing frames. A mooted **low cost terminal for Melbourne** seeks to achieve the same “lightness of touch” but has yet to emerge from the studio to get lift off: the diagrams represent an evolutionary resolution to a staged existence.



7. Finally a conceptual design study for a final **completion of Flinders Street Station**; glazed bookend arched lightweight roof vaults designed by us to provide an envelope to the platform and a bookend to our work with Grimshaws on the naturally breathing **Southern Cross Station**, at the other end of the city.



Here the **“Spirit of Progress”** still pulls into Platform No 1; an icon of 1930’s rail travel as an emblem for a future we know we have to create for another era.



The **art of life in Century 21** is to **“catch the next wave”** ... progress and passion are demanded for:

1. researching
2. comprehending
3. initiating
4. testing
5. implementation.

There are five accompanying behaviours:

1. peak experience
2. heightened expectations
3. revolutionary enterprise and evolutionary existence
4. convergence, communications information systems
5. relativity and duality.

