David McCready is a director of **Spacetech Pty. Ltd.,** a company dedicated to all aspects of design and construction of geometric surfaces including space frames and tensioned membrane structures.

Their period of time actively building these structures (14 years), allied with their dedication to the highest quality detailing, has made them field leaders in the industry.

THE PERFORMANCE OF NINE FABRIC STRUCTURES IN AUSTRALIA OVER THE LAST DECADE

This paper looks at some of Spacetech's membrane structures dating back to the infancy of the industry in Australia. It includes some of Australia's oldest structures, ones which predate the M.S.A.A.

Where these lacked technological refinement, they were supplemented by an extraordinary enthusiasm for the developing medium, an aspect which is largely retained by exponents in the industry today.

The earliest works in membrane structures were inspired by pictures in books and magazines, usually the work of Frei Otto and his group.

Information on detail and design elements was largely gleaned from hours of close study of the new picture models available and from reading scarce design texts. Much extrapolation was obviously needed to realize a structure from such a birth place.

The antipodean information vacuum, while it somewhat delayed the field's development in Australia, left a legacy of keen minds with a thirst for information and designers who could and would tackle projects beyond their experience base.

On occasion this lead to disaster, but one must reflect on the fact that the field largely developed from a craft base here as elsewhere and that the move into a more science based approach has been the product of firstly an established and maturing industry and secondly, the professional impetus the Membrane Structures Association of Australasia as an organization has had on its members.

PROJECT: Art house roof
CLIENT: Ivanhoe Girls' Grammar School, Victoria

ARCHITECTS: Bryan Dowling & Associates
ENGINEERS: Detail design - In-house
Membrane & Structure - Peter Kneen Pty. Ltd.
Foundations - B.J. O'Neill & Partners Pty. Ltd.

FABRIC: Polymar PVC/Polyester 650gm/square metre
COMPLETION: April 1978 (Oldest existing tension structure in Australia)

DESCRIPTION: 10m x 10m steel frame supporting 4 hyperbolic paraboloid surfaces defined by straight steel edges. Structure is laced at perimeter and tensioned by elevating the centre. Contract for membrane and steelwork erection.

CLIENT'S COMMENTS: Very happy with the structure's performance. The art room is flooded with light in winter and is not cold. There is one rarely used light in the room. No condensation except when the school is closed over the winter holidays. It is a little warm in summer, but there is an extractor fan. Teachers like working in the art room because of the atmosphere

MAINTENANCE: Cleaned every 12-18 months. One pin-hole puncture about 5 years ago, otherwise, no leaks or problems.

CONDITION: The structure exhibits good surface appearance and is apparently of a similar translucency to that when new. It is still white. The PVC surface has degraded to expose fibres at weld lines and the surface is somewhat brittle.

PROJECT: Half Olympic swimming pool pneumatic roof
CLIENT: Parade College, Bundoora, Victoria

ARCHITECTS: In-house design
ENGINEERS: Patterns & details - In-house
Foundations - B.J. O'Neill & Partners
Mech/Electrical - Connell Group

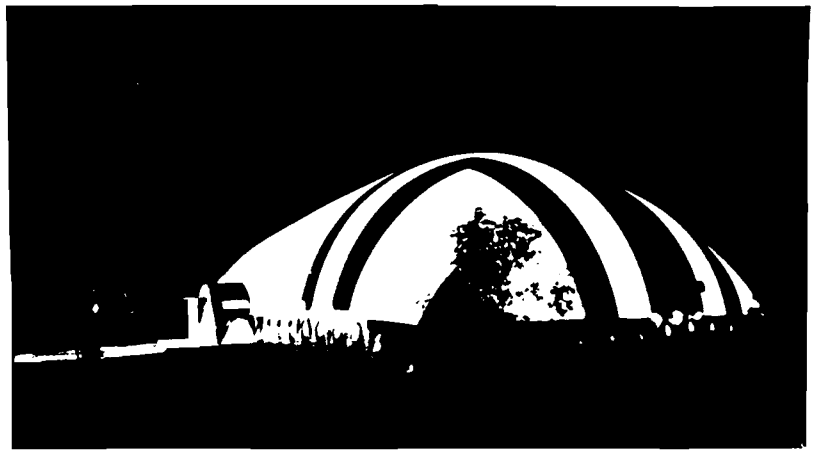
FABRIC: Polymar PVC/Polyester Type I
COMPLETION: November 1978

DESCRIPTION: 35m x 21m pneumatic structure with one entry/exit station. Contract included structure plus concourse, foundations, refurbishment to services, heating water and air, all mechanical and electrical works.

CLIENT'S COMMENTS: Brother Wright commented that it was the answer to everything they needed for the pool. It also was used extensively by community groups. While they worried about vandalism, it did not eventuate.

MAINTENANCE: The structure had an emergency fan installed after construction. The surface was cleaned once during its life.

CONDITION: During Christmas of 1985 a fire in the main school destroyed the electricity supply to the entire school. The pneumatic structure was maintained by its auxiliary diesel powered fan.The mains supply was not restored nor was the fuel tank refilled so the structure rested, deflated, upon the light support poles. Eventually a storm caused wind damage with substantial tearing and final loss.



PROJECT: Dean Park Sound Stage Roof
CLIENT: Council of the city of Townsville, Queensland

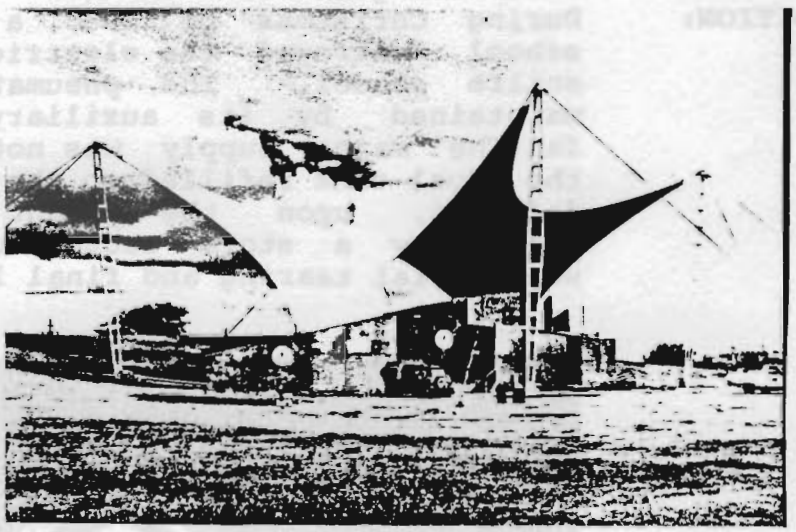
ARCHITECTS: In-house design
ENGINEERS: Peter Kneen Pty. Ltd.

FABRIC: Polymar Type IV PVC/Polyester 1400gm/square metre with carbon black substrate
COMPLETION: August 1980

DESCRIPTION: Tension structure utilizing 4 masts, 15 metres in height and 2 tie-downs. The area is 800 square metres. Contract covered all elements from top of footing up.

CLIENT'S COMMENTS The structure has performed well during its life. It has withstood significant winds from cyclones and has not suffered structural damage from wind forces.

MAINTENANCE: Cleaned annually in March
CONDITION: From ground level the fabric appears as good as the day it was built - no deleterious effects.



Condensation problem !
in humid environments

PROJECT: Sports hall pneumatic roof
CLIENT: Melbourne University Sports Union, Victoria

ARCHITECTS In-house design
ENGINEERS: Patterns - P. Kneen Pty. Ltd.
Structurals - B.J.O'Neill & Partners

FABRIC: Polymar PVC/Polyester Type I
COMPLETION: October 1980

DESCRIPTION: 40m x 19m air supported structure on first floor level attaching to existing concrete slab. Contract involved removal of existing deck, penetration into adjoining building and construction of two sets of access/exit stairs. Mech/elec. works were in the contract.

CLIENT'S COMMENTS A budget dilemma prompted construction of a low cost solution for indoor sports activities. The structure was successful for tennis, netball, basketball, aerobics etc. during its life, enhancing the existing facilities. Its only problems were that it was hot in summer and occasional vandalism.

MAINTENANCE: A series of minor vandalism incidents required repair works. Surface cleaned once.

CONDITION The structure was severely damaged after a person exited the structure through an emergency exit (breaking the glass over the door release handle) causing depressurization during a severe storm. Early in the morning, staff were warned by an alarm system which registered the loss of pressure. However the membrane was torn in several places as a result of contact with light supports and repressurization was not possible when staff arrived at the building. The damage to the membrane was severe, resulting in total loss.

PROJECT: Pair of pneumatic structures for touring performance group.

CLIENT: Command Performances, Sydney N.S.W.

ARCHITECTS: In-house design

ENGINEERS: Peter Kneen Pty. Ltd.

FABRIC: Polymar PVC/Polyester Type II with carbon black substrate

COMPLETION: December 1980

DESCRIPTION: Pair of 27 metre diameter pneumatic structures to seat 600, with 8 exits and 1 revolving entry door. Structures were transportable and utilized driven ground anchors for foundations and modular electric powered axial fan with diesel driven back up fan for emergency.

CLIENT'S COMMENTS: The structures were a great success. They were used for six years with over one hundred uses each.

MAINTENANCE: Ground anchor replacement, door repairs and significant cleaning and mould removal program. Some vandalism rectification.

CONDITION: After a successful life of six years, the company ceased using the structures - current status not known.

PROJECT: Amphitheatre roof
CLIENT: Seven Creeks Run Trust, Euroa, Victoria

ARCHITECTS: In-house design
Roy Grounds & Partners Pty. Ltd.
ENGINEERS: Peter Kneen Pty. Ltd.

FABRIC: Nylex Airflex PVC/Polyester Type II
COMPLETION: July 1982

DESCRIPTION: Centre mast supported conic form with catenary edges restrained by masts and guys. The structure adjoined the historic Woolshed building with a flashing panel. Contract involved all works from top of footings up.

CLIENT'S COMMENTS: The structure was a successful roof to the ill fated project which ceased operation not long after opening.

MAINTENANCE: Since the venue has been closed for much of its life, the structure has not been maintained.
CONDITION: The surface is soiled from dust (it is in a rural setting), but otherwise performing well. No other problems are known.

PROJECT: Temporary structure over display apartments
CLIENT: Lend Lease, Queensland.

ARCHITECTS In-house design
ENGINEERS: Peter Kneen Pty. Ltd.

FABRIC: Nylex Airflex PVC/Polyester Type I
COMPLETION: October 1982

DESCRIPTION: Octagonal tension structure using four high/four low points and catenary edges. Masts were aluminium CHS with four outrigger braces each. Contract works were top of footings up.

CLIENT'S COMMENTS: The structure performs well as an attraction to the real estate development. Its shape evokes the nautical theme of the development.

MAINTENANCE: Nil
CONDITION: The structure is located in an area where seasonal cane field burn off causes a big deposition of carbon material and the region has been the centre of large scale earth moving activity. As the structure has never been cleaned it is very dirty, but is still in place though not used to shelter display units at present.

PROJECT: Sound stage roof, Tolosa Street Reserve
CLIENT: Shire of Glenorchy, Tasmania

ARCHITECTS: In-house design
ENGINEERS: Connell Group
Connell Barrow McCready Pty. Ltd.

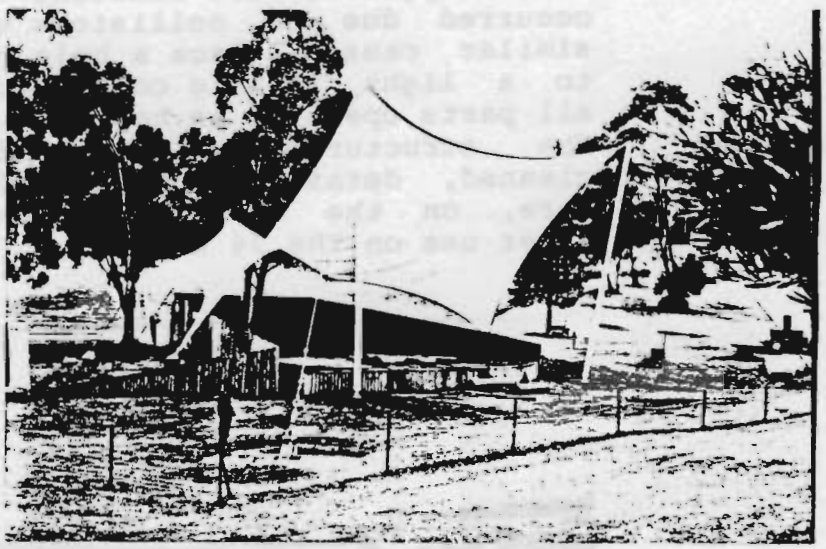
FABRIC: Polymar PVC/Polyester Type II
COMPLETION: August 1986

DESCRIPTION: Tension structure supported by varying height perimeter masts and having catenary edges. Project included all works from top of footing up.

CLIENT'S COMMENTS: The sound shell performs marvellously. Its acoustics are extremely good for all manner of performance. Client has had excellent feedback from orchestras and choral groups who have used the sound shell.

MAINTENANCE: Has not been cleaned as yet - left to the elements.

CONDITION: Looks good. No deterioration.



PROJECT: Australian Bicentennial Travelling Exhibition
CLIENT: Australian Bicentennial Authority, Sydney, NSW

ARCHITECTS: Daryl Jackson Pty. Ltd.
ENGINEERS: Connell Group
Connell Barrow McCready Pty. Ltd.

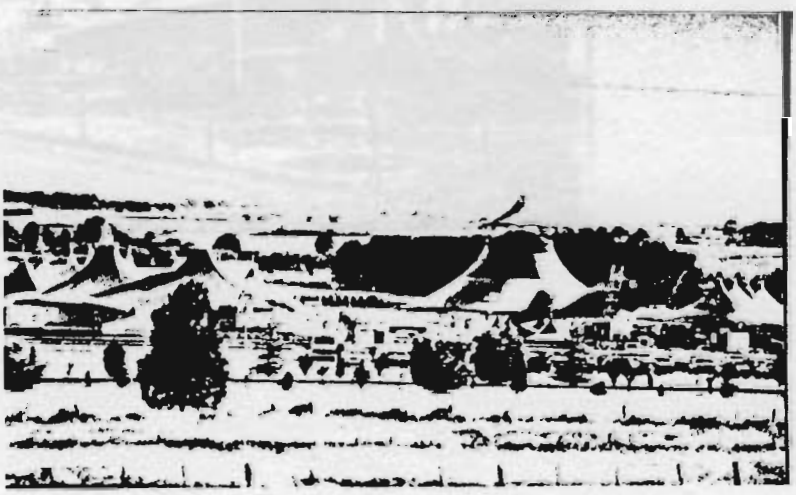
FABRIC: Polymar PVC/Polyester Type II/III

DESCRIPTION: Series of transportable tension structures built to house national exhibition on tour throughout Australia. Structures were conic variations with major structural supports being gained from use of transporter pantechnicons and prime movers. Project involved intensive and detailed design of all aspects of construction, fabrication, transport, maintenance, erection and crew training.

CLIENT'S COMMENTS: This was one of the truly great activities of the bicentennial year. The structures surpassed all hopes in their performance in robustness, effectiveness and ease of handling.

MAINTENANCE: Cleaning was carried out continually with a major clean every five sites. Painting and other upgrades were constant. Several ruptures occurred due to collisions with forklifts and similar causes. Once a hole burned through due to a light falling on the surface. Generally all parts operated as hoped.

CONDITION: The structures, at the end of 1988, were cleaned, detailed and packed for sale. They were, on the whole, in excellent condition after use on the 34 sites.



CONCLUSIONS:

Structures have been built from PVC coated polyester material in diverse locations from tropical north Queensland to temperate Victoria covering a range in UV bombardment and climate generally. The indications taken from the oldest of these structures shows that throughout most of Australia, the material survives very well and it can be considered an appropriate material for this kind of construction.

From all reports, maintenance is sadly lacking in most cases. Certainly an organized program of ongoing maintenance either by the owner or by the constructor, should be implemented for the safety and longevity of the structures.

Cleaning programs, where these have been operating, have largely maintained the original appearance and presumably lengthened the life of the structure.

Pneumatic structures have been shown to have a propensity for more problems than other forms of structure and it is obvious that they have a definite window of vulnerability to vandalism.

The incidence of vandalism in the pneumatic structures in this study shows 100% occurrence, although the extent of this varied. The recently erected olympic pool roof at Kilsyth in Victoria was up for three days when it had its first instance of vandalism.

Pneumatic structures have also shown a propensity for problems resulting from poor maintenance of their mechanical systems and one can draw the conclusion that these structures are more living, breathing structures than others in that they require a constant attention by a maintenance crew who are skilled and tireless in their diligence with regard to the mechanical elements of the structure.

This study is the beginning of a greater work which will incorporate statistics related to the cost of the structures for ongoing reference.