"FAST FOOD, FAST CARS, AND FINE LEARNING"

An overview of three recent projects.

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This paper discusses three recent projects designed by Tattersall Engineering Consultants. The three projects are quite different, ranging from a permanent structure for sun and rain protection to a playground at a restaurant in Tasmania, to a 500 sq. m. relocatable restaurant set up at the 1996 Melbourne Formula 1 Grand Prix, to a permanent multi–purpose area at a primary school in Melbourne.

Discussion of the three projects is based around the client brief for each project, and the manner in which the designs responded to and met the client requirements.

All of the projects were designed by Tattersall Engineering Consultants Pty. Ltd., with specialist assistance on membrane analysis by Wade Lester Consultants.

1.0 MCDONALD'S RESTAURANT, ROSNY, TASMANIA – PLAYGROUND STRUCTURE

1.1 THE BRIEF

The client's brief was to provide shade and weather protection to a playground, outdoor eating area, and a restored tram set up as a party room, at his McDonald's restaurant in Rosny, Tasmania. In addition, the structure was required to provide an aesthetically appealing point of differentiation and recognition for the restaurant. The tension structure had to be built between the existing restaurant and a restored tram located about 10 metres away from the restaurant. For weather protection, it was required to overlap the roof of the restaurant and the tram. Supports had to be compatible with the layout of the playground equipment, and cause minimal obstruction.

1.2 THE SOLUTION

The solution utilises five frames to create a membrane shape best described as eight combined hyperbolic paraboloids. The plan area of the structure is approximately 22 by 9.5 metres, with five frames at 5.5 m centres. The frames are supported on posts which provide stability to the structure by use of a fixed base connection to pad footings. The membrane has a mechanical clamped joint at the centre frame, and the perimeter of the membranes have catenary edge cables. Cable tensions along the sides are carried by compression struts parallel to the long axis of the structure, at the ends of the rafters. Cable tensions at the ends are carried in the end rafters in compression. The rafters cantilever 1.75 m from the position of the columns. The highest points of the structure occur at the centre of the first frame in from each end, and are at approximately 6m. height. The lowest points occur at the outside edges of the first frame in from each end, and at the centre of the end frames, and are at approximately 3.0 m. height.

To ensure clearance and coverage over the restaurant roof, the structure is assymetrical about its long axis, with the end of the rafters on the restaurant side being higher than the other side. A photograph of the project is shown on page 2.

McDonald's Restaurant, Rosny Park – Photo not available (May 2006)

1.3 PROJECT SPECIFICATIONS

Project Name	McDonald's Restaurant, Rosny Park
Project Address	Ross Avenue, Rosny Park, Tasmania 7018
Consulting Engineer	Tattersall Engineering Consultants Pty. Ltd. 1283 Malvern Road, Malvern 3144
Contractor	Tecraft Pty. Ltd.
Membrane Type	Precontraint 502 Fluotop S, 670 gsm
Date of Installation	29th September 1995
Type of Structure	8 combined hyperbolic paraboloids.
General Description	The structure is covering a play area and party tram on the north side of the restaurant. The plan area is approximately 22m by 9.5 m. The structure has four bays, with five rafters spanning the 9.5 m direction, supported on 10 cantilever columns.
Area of structure	Approximately 200 square metres in plan.
Area of fabric used	Approximately 312 square metres.

2.0 MCDONALD'S RELOCATABLE RESTAURANT, 1996 MELBOURNE GRAND PRIX

2.1 INTRODUCTION

The 1996 Formula One Grand Prix, held in Melbourne in March of 1996, was a spectacular event. It succeeded in gaining world–wide recognition and exposure for Melbourne, Victoria, and Australia, and was generally regarded as a huge success.

A Grand Prix is a major event, and the logistics involved are quite staggering. One of the myriad factors that the organisers have to consider is the provision of catering facilities. Whilst those fortunate enough to be invited to corporate boxes are well looked after, the provision of more affordable catering is also a necessity. For the majority of people attending the Grand Prix, there had to be available catering of high standards of nutritional value and hygiene, at reasonable prices. It also had to be able to be provided in large volumes, with significant peaks in demand. This concern led to McDonald's Australia Limited being invited to set up a temporary restaurant at the event. McDonald's has built its' reputation on the provision of affordable food of high and consistent quality, with excellent standards of service and hygiene.

A temporary restaurant at the Grand Prix provided many challenges to overcome. Five relocatable buildings were constructed to house $1 million worth of specialised kitchen equipment, providing food at 30 service counters. Extensive timber decking was provided around these buildings to elevate queuing and seating areas from dust and mud. The most visually significant feature of the whole design was a vast "sail" or tensioned membrane roof, serving both to provide shelter from sun and rain, create a unique sense of identity for the facility, and to demonstrate McDonald's commitment to quality of design, product and service.

Once the concept of a tensioned membrane structure was raised, Tattersall Engineering Consultants Pty. Ltd. were invited to design and oversee the construction of the tensioned membrane and the other major structural aspects of the project. The result is shown in the photograph on page 4.

McDonald's Relocatable Restaurant – Photo not available

2.2 THE BRIEF

There were stringent requirements placed on the design, to meet a number of important criteria relating not only specifically to the installation at the 1996 Grand Prix, but also to other uses. The facility is not only intended to be used for the Grand Prix, but also to be fully relocatable to anywhere in the world.

Specific criteria of the design brief were

It was to be erected on a fairway at Albert Park Golf Course, and so had to cause minimal damage during erection, and have minimal impact on removal.

There was a short period of time available for the erection and dismantling of the project, to minimise the time when the Golf Course was unavailable for use. Specifically, the steelwork and tensioned membrane structure had to be erected in two days, and dismantled in one day.

The structure was to be designed for erection at any location, and hence to resist wind loads at the most exposed locations.

The whole structure as erected at the Grand Prix, also has to be able to be split into two smaller structures which can be independently erected at different locations.

Protection from sun and rain had to be provided to the queuing and seating areas around the perimeter, and to service areas at the rear

The structure had to be transportable on standard semi–trailers, and be efficient with its use of storage and transport space.

No permanent footings or restraints were allowed within 500 mm below the ground surface.

2.3 THE SOLUTION

2.3.1 Tensioned Membranes

The project uses a PVC–Coated polyester material for the main membranes. The specific material is Polymar 6505, which is imported from Germany (no suitable fabrics are made in Australia). The fabric has an acrylic lacquer on the top side to assist UV resistance and aid cleaning. It is a strong, durable, and fire retardant material, weighing 850 grammes per square metre, and with a tensile strength of 3000 N/50mm (60 kN/m).

The full structure comprises four separate membranes, two upper and two lower ones, covering about 500 square metres. The upper membranes are over the queuing areas, and the membrane shape for these is best described as a distorted barrel vault. The two lower membranes are sections of a conic, with catenary cable lower edges. The lower membranes have a mechanical field splice on their axis of symmetry, which allows the structure to be split into two when required. The edges of the membranes have a hem with galvanised steel cables running around the perimeter between the connection points.

Rainwater runoff from the upper membranes falls on to the lower membranes, and then is shed away to the perimeter of the structure. The perimeter connections are generally the lowest points of the membrane for maximum protection against sun and rain.

2.3.2 Support Steelwork

Over the temporary buildings housing the kitchens, there are steel masts supported on trusses just above the roof of the temporary buildings. These trusses transfer vertical reactions from the base of the masts to points in the buildings below where supports are built in. They also transfer horizontal reactions from the base of masts from one side to the other. This steelwork also provides support for plant above the roof of the relocatable buildings. At the upper points on the masts where the membranes connect, the structure is braced and allows forces to be transferred from one side to the other with a series of perimeter steel struts, and diagonal stainless steel cables. Around the perimeter, connections are made either to steel lattice frames, or to individual steel masts. The lattice frames have two lattice columns and latticed beams across the top. They provide for connection of the membranes at points where individual masts would not be suitable, and provide supports for signage.

2.3.3 Foundation System

Since the tensioned membranes develop significant reactions at the outer supports, the bases of the individual masts and the lattice frames must be secured with supports of significant capacity. The critical loads to the perimeter membrane supports are in a generally horizontal plane, at between 3 and 4 metres above the ground. Therefore the supports must develop both overturning and horizontal resistance. This was achieved by a base with timber distribution pads at the inner side, and connection to screw–in foundations at the rear.

The screw–in foundations comprised galvanised steel circular hollow sections, with helix plates at the base. They were founded at 4.0 metres depth, and connected by chains to the base of the frame. They were set at the appropriate angle to develop the necessary horizontal and vertical load capacity. The screw–in foundations are removable and re–useable, although since the structure is intended to be at the original location for five years, these anchors have been left in the ground.

2.3.4 Membrane to Steelwork Connections

At the connection points to the support steelwork, the membrane is reinforced with additional layers of fabric, and bolted to steel clamping plates. These plates have a stainless steel pin passing through them, which is attached to a large "U–bolt" which then passes through cleats welded to the support structure. The edge cables on the fabric terminate with swaged stud ends, which pass through steel tubes welded to the clamping plates.

This connection detail allows the membrane to be pulled out and connected in an unstressed state, and then gradually tensioned using the U–bolts. Further adjustment of the stress state of the fabric is available through the cables. The pin and U–bolt detail allows the connection point to be able to rotate about three axes so as to ensure a direct load path under prestress and wind and live load conditions.

2.3.5 Ability to split the structure into two smaller structures.

Since not all the potential events at which the facility may be used are of the size of the Grand Prix, McDonald's required the facility to split the structure, and provide two separate ones.

This was achieved by forming a mechanical joint in the lower membranes at their axis of symmetry, and designing the steelwork so that it was modular and able to be disassembled and reassembled in other configurations. Additional perimeter masts and components are also needed, and these are designed to match the primary steelwork. The mechanical joint in the centre of the membrane allows a smaller edge piece, shaped to suit a catenary cable, to be clamped on to resolve the fabric stresses at the edge.

3.0 KEYSBOROUGH PARK PRIMARY SCHOOL – MULTIPURPOSE AREA

3.1 THE BRIEF

In this case, the client had limited funds with which to relocate four portable classroom buildings, and wished to set them up with an internal courtyard protected by a tensioned membrane structure. They required a light and airy space, well protected from sun and rain, and able to be used for classroom and physical activities at the school. Timing was tight, particularly for construction of footings, which had to be done very soon after the project was confirmed, so that the building relocation could be completed.

3.2 THE SOLUTION.

The structure designed is a rectangular–based conic, with a perimeter frame supported on ten perimeter columns inside the courtyard. At the top of these columns, connections cantilever out over the classroom roofs so that the perimeter frame provides protection from sun and rain by overlapping the surrounding roofs. This also allows rainwater to be directed on to the roofs and into the existing downpipes. A photograph is shown on page 8.

The peak of the conic has permanent ventilation, with a circular skirt to ensure weather protection is maintained. The permanent ventilation prevents stratification of air layers within the space, and ensures heat build–up is not a problem. The top of the cone is supported with a bail ring hung from a cross frame on top of a central column. There are radial struts from the perimeter columns to the central mast, to balance out forces from membrane stresses. The entire structure is independent of the surrounding buildings, with the posts acting as vertical cantilevers from bored pier footings, to resist overall wind loads.

3.3 PROJECT SPECIFICATIONS

Project Name	Tensioned Membrane Structures, Conic structure to Multi–purpose area,
Project Address	Keysborough Park Primary School, Loxwood Avenue, Keysborough Park, Victoria 3173
Consulting Engineer	Tattersall Engineering Consultants Pty. Ltd. 1283 Malvern Road, Malvern 3144
Contractor	Tecraft Pty. Ltd.
Membrane Type	Edselac 701SL, 800 gsm, lacquer and cleanguard finish to both sides
Date of Installation	31st March 1996
Type of Structure	Rectangular–based conic with central mast.
Area of structure	Approximately 200 square metres in plan.
Area of fabric used	Approximately 312 square metres

Photographs not available (May 2006)

Keysborough Park Primary School