An Air Supported Swimming Pool Cover

For The

Massey Park Olympic Pool Complex

Papakura

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ABSTRACT

In 1988 an air supported dome was constructed over an existing swimming pool complex in Papakura, South Auckland, New Zealand. The development also included the installation of a heating plant. Since that time the facility has operated as a covered, heated pool in the winter, and, by removal of the dome, as a heated, outdoor pool in the summer.

This paper discusses various aspects of design and implementation of the project.

Introduction

The Massey Park Swimming Pool Complex is situated on the edge of the Papakura Central Business District. The pool complex occupies a portion of the larger Massey Park which is also a home for rugby, athletics, a play ground, and passive recreational areas.

The Massey Park Swimming Pool was opened in 1963 providing a summer-only unheated outdoor swimming pool. The complex comprised a 50m x 17m olympic sized main pool and a 12m x 6m learners pool, together with their associated changing rooms, office, club rooms, and filtration plant. In 1975 a new office block and entry were constructed, together with a small toddlers pool.

The pool complex is owned and maintained by the Papakura District Council and administered by a contractor on Council's behalf.

The pool complex provides a pleasant outdoor swimming environment, and is also one of the few olympic sized pools (preferred by serious trainers) in the South Auckland area. The pool did however, suffer the combined drawbacks of being outdoor and unheated, which meant that the Labour Weekend (late October) to Easter swimming season was often in-effect shortened further by poor weather and cool water temperatures.

By the early 1980's Council was keen to see better use made of its swimming pool resource through a longer swimming season.

After visiting and inspecting a small swimming pool dome in Thames, Council were enthusiastic to investigate the concept of an inflated dome for Papakura, which promised the best of both worlds - a covered-heated pool in winter which was convertible to an outdoor pool in summer.

The Thames air supported dome was rectangular in plan and covered a 25m pool. It had been erected each winter since 1983. The basic design features ultimately adopted for the Papakura Dome are the same as, or are developments of the Thames Dome, which was the largest air-supported building in New Zealand up until that time.

Council staff also visited Australia to look at air supported buildings there.

Papakura Dome

Council ultimately resolved to proceed with construction of an air supported dome and heating plant for the Massey Park Pool Complex.

The dome itself was manufactured by the Auckland firm of Structurflex, who employed Geodome Spaceframes Pty Ltd of Victoria, as consultants for the design and patterning work.

The Papakura air supported dome is a single-skin PVC canopy held aloft by a small pressure differential (0.25kPa or 1.0025atm) between the inside air and the outside air. There is no rigid framework within the building at all (except for the steel door frames), nor are there any inflated ribs or tubes. The pressure differential, while small, is still sufficient to create an uplift of approximately 700 kg/m around the perimeter of the dome, and approximately nine tonnes each end of the main cable. Air pressure inside the dome is maintained by air-locks on the entrance/exit doors and by fans which operate continously to counter air loss.

Creating a new air supported structure over an existing pool complex presented a number of problems which might not be present in a virgin development. Existing buildings around the pool restricted the space available around the dome, limiting the walkways both inside and outside. Underground services were located in positions which interfered with the dome foundations.

The arrangement finally adopted was for an 'L' shaped dome covering the main 50m pool and also the 12m learners pool by means of a 'blister' at one end. The total floor area is 1,692m^2, and the total air volume enclosed by the dome which stands 9.6m high is approximately 10,600m^3. The 8.0m high side hall covering the learners pool is joined to one corner of the main dome. A steel cable arcs 6.7m high to form the junction of the two halls.

While building codes of the time did not prohibit air supported buildings, the concept was a little foreign to engineers and regulatory authorities. Typically engineers and building inspectors are comfortable with traditional "rigid" structures which resist external forces (such as wind) by internal stresses. Fabric structures on the other hand resist external forces by changing shape.

Design of the dome required sophisticated computer software, using non linear finite element analysis techniques. Design Consultant Geodome Space Frames Pty Ltd of Melbourne, used the state-of-the-art "Tensyl" programme leased from Minitec Ltd of Britain. The programme automatically generated the fabric surface, analysed the stresses, and produced the cutting patterns.

Design work for the five entrance/exit points was almost more extensive than for the dome itself. Local fire codes required an egress point within 20m of any point within the dome. Location of egress points were kept, where possible, to the axes of symmertry to minimise design effort, however no two were the same, and each required specific design. The interface between the rigid door frame and the flexible dome is by means of a fabric shroud, which because of its small radius is easily able to accommodate movement.

The designers considered that the dome fabric should meet the specification for a Type II architectural fabric. The chosen material was Polymar 6506, Grade II, comprising at 12/12 polyester base, PVC coated and acrylic lacquered to a weight of 900g/m^2. It has a tensile strength of approximately 88 and 76n/mm in the warp and weft directions respectively. 600 lineal metres (2m rolls) of base colour and 200 lineal metres of trim colour were imported from manufacturers Hammersteiner Kunstoffe of Germany.

Structurflex manufactured the dome itself in their Auckland factory. All seams were high-frequency welded. The dome is made in two portions, for ease of handling, the two portions being spliced together on site using bolts and aluminium splice plates.

Foundations

In its normally inflated condition the domes exerts an uplift force on its foundations. Wind effects tend to redistribute the uplift somewhat resulting in a maximum design uplift to be resisted by the foundations of 7kn/m (or 700 kg/m). The uplift force is resisted by a combination of dead weight and ground friction in the concrete strip footings which lie beneath the perimeter of the dome.

A 50mm steel base pipe is fitted through a fabric hem in the base of the dome. The base pipe is held to the foundations by steel saddles bolted down to masonry anchors.

All anchors are of the flush type to provide an unobstructed surface when the dome is removed in summer. A total of 378 16mm Dynaset anchors were required for the project.

One aspect of the project that would probably be modified if the project was repeated is the steel base pipe. It is felt that a base detail incorporating a steel cable would allow easier erection/removal.

Masonry anchors were chosen over cast-in-situ anchors for several reasons:

1. It was easier to accurately locate them than would be the case when pouring concrete around a large number of in-situ anchors.

2. Construction of the foundations was able to proceed a full swimming season ahead of the dome erection, and at a stage when exact anchor positions had not been finalised.

3. Where a few of the anchors have become damaged in service it has been a simple matter to grout them up and install new anchors close alongside.

Special foundation details were required to bridge the air supply ducts, and at either end of the main cable.

Air Handling System

The air handling plant is a critically important part of the pool enclosure. Its two functions are to supply an adequate quantity of fresh air for the comfort of pool users, and to supply sufficient air to counter losses and keep the dome inflated to its design pressure. In practice the inflation criteria is easily achieved and the comfort requirement governs.

Standard texts on swimming pool design suggest that six air changes per hour are necessary to maintain a comfortable pool environment. For the sake of economy this figure was lowered to four changes per hour at Massey Park. An air-flow of 12 m^3/sec was thus required, and is provided by two large centrifugal fans, working either singly or in tandem. One fan is a two-speed model which allows air-circulation to be minimised when the pool is not in use by selecting 'low' speed. A diesel motor is attached via a clutch and belts to the other fan to provide continuity of air supply in the event of an electricity cut.

Supplying an air flow of $12m^3$/sec required substantial sized ducts, and it quickly became apparent that it was impractical to construct them above ground level. The air entry point is far from any of the dome's points of symmetry, and is rather too close to an entry/exit point to allow for a simple shroud detail at the duct/dome connection.

Below ground ducts were constructed. Hindsight has proven this a sound decision.

Two air ducts were constructed, one for supply of fresh air, and one for the return of air for recycling or waste heat recovery. The supply air is distributed via a plenum with grilles designed to direct air flow toward the far end of the dome. The ducts are each 2.0m x 1.0m in area. They are lined with silencing liners and have vanes fitted to turn the air flows as required.

Air pressure in the dome is maintained by motorised dampers in the return air duct which regulate the amount of air which is spilled. The dampers are controlled by a programmable logic controller.

A basic alarm system has been installed incorporating an autodialler which rings a telepager when air pressure falls below a pre-set level. During the first year of operation the operator was plagued by a number of rogue alarms, which continued until condensation traps were installed on the pressure sensing tubes in the return air duct.

An over-pressure damper is fitted to the supply duct, comprising a weighted flap which lifts to spill excess air in the event of normal pressure systems failing.

Heating Plant

An integral part of the project to cover the pool and make it available for all year round swimming was to install a suitable heating plant.

Initially both natural gas and heat pump systems were considered. While the capital cost of a heat pump system was greater, this was expected to be recouped in energy savings over four to five years.

The principal of the heat pump is very similar to that of the household refrigerator. They do not create heat, they only transfer existing heat from the one place to another. Whereas a refrigerator transfers heat from inside to outside, thus cooling its contents, the Massey Park Pool heat pump transfers heat from the outside air to the inside air and pool water, and thus warms them up. The process is very efficient, often transferring four or more units of heat for every unit of energy used.

An added benefit of the heat pump system is that in addition to heating the pool water and air supply it can be switched to cool the air supply in warm weather.

Although using atmospheric air is one of the least efficient air sources, regrettably there were no other viable heat sources available. Papakura's system employs roof mounted evaporators which extract up to 272 KW in summer or 172 KW in winter of heat from the surrounding air for use by the plant.

Several modes of operation are available as follows:

- pool water heating
- pool hall heating
- pool hall and water heating
- pool hall cooling and water heating

The plant was designed to heat the pool water to 26°C and the dome environment to 28°C. In practice it has been found more comfortable for patrons for the poolwater to be about 28.5°C, with a slightly cooler dome environment. Solar gains through the fabric are quite significant, and it is frequently necessary to cool the supply air.

Heat transfer to the pool water ranges from 172KW to 272KW (evaporator capacity governs). The pool hall heating/cooling coil has a heating capacity of 172KW (condensing) and a cooling capacity of 246KW (evaporating).

Return air from the dome can be either recirculated to save heat (typically at night time) or spilled over the evaporators in order that its heat can be reclaimed.

An integral part of the heating system is heat conservation by means of a floating thermal blanket which is used when the pool is not in use. The blanket insulates the pool, but equally importantly minimises evaporation (a major source of heat loss) and chlorine loss.

Severe financial constraints necessitated the down-sizing of the proposed heating plant in order to save costs, and provision was made for the addition of extra heating capacity in future if necessary.

This extra capacity may be provided in the near future, as the plant has difficulty maintaining pool temperature in frosty weather (a few days a year in Auckland). Council is considering a proposal for co-generation whereby a natural gas driven engine will generate electricity for use in the plant, while engine-cooling water is circulated through a heat exchanger in order to recover the heat for pool heating. Co-generation promises to provide the necessary additional heating capacity while at the same time providing an overall saving in pool energy costs.

Other Services

1. <u>Drainage</u>

   Because of the pressure differential between inside and outside the "bubble", all drains and service ducts between the two areas required sealing. This was achieved by installing half-siphons on internal drainage, and plugging other service ducts with polyurethane foam.

   Two separate and par allel drainage channels were necessary to provide for stormwater drainage outside of the "bubble" and for splashwater inside. These were complicated by the need for minimum depth to avoid compromising the integrity of the dome anchors, and to avoid creating a hazard when the dome was removed and the pool operating as an outdoor facility.

2. Lighting

Early morning swimming and night-time use by clubs necessitated suitable lighting. Floodlighting which was already in place outside the dome was found to be inadequate because of the poor light transmittance of the dome material. Internal lighting was obviously necessary, however the major obstacle was the slope of the dome canopy and the need to maintain 1.0m clearance from the fabric to accommodate movement, which made it difficult to achieve the necessary mounting height. Additionally the lights had to be demountable to allow removal of the dome.

A very neat solution was achieved using curved poles, and hinged pole bases which were offset 15° to allow the poles to be lowered onto dry ground without fouling the canopy.

Erection and Removal

The original erection of the dome in March 1988 occupied approximately 55 man days, owing largely to the amount of once-off cutting and fitting required on that occasion. With experience the operation has become more streamlined and occupies approximately 26 man days. The single biggest job is to stretch the cover out over the pool, which requires 30 - 50 people for a short time. Extra help is enlisted for this task from students of the local high school.

Bolting down the saddles on the inside of the dome is an awkward task. Providing weather conditions permit the fans are turned on low during this operation to partially lift the fabric to provide a working space.

Walking on the deflated dome fabric is prohibited in order to minimise scuffing. Obstructions within the dome which cannot be removed have their corners blunted with old car tyres.

The deflated dome can accumulate quite a lot of water, via rain and leakage of pool water through the main splice. This water has to be removed by pumping or baling out before full erection can take place.

Serviceability

The following are a number of comments gained from experience with operating the Massey Park Pool "bubble":

1. Noise

Noise is a significant problem owing to its reflection from the large concave dome surface. Hanging baffles were investigated but have not been proceeded with to date. In the meantime the pool contractor makes ear plugs available to his staff.

2. Solar Gain

Solar gain is very significant in warm weather. The Papakura dome has never remained up for a full summer, but it is the authors opinion that it would become uncomfortably hot, even with the air cooling in operation.

3. Fabric Colour

In hindsight the choice of a green and cream colour scheme was unfortunate from the point of view of lighting, and heat gain. It is suggested that white is best for the main colour with darker "trim" colours making up not more than about 20% of the total area.

4. Fabric Cleaning

After more than five winters of service, five summers of storage and the consequent erection/dismantling, the dome is looking a little grubby. The only cleaning agents that the manufacturers approve has been found to be rather ineffective. Water blasting has achieved slightly better results, however safe access to the canopy for cleaning operations is difficult.

5. Spectator Space

Large events involving significant numbers of spectators are generally programmed during summer months when the pool operates as an outdoor facility. Noise problems and lack of spectator space make large events inappropriate when the dome is in place.

6. Changing Facilities

The short dash between the changing sheds and the dome is proving uncomfortably cold for many in winter. The difficulty could be overcome by means of either rigid or flexible tunnels between dome and changing rooms, however no action has been taken to date. Instead pool management have provided some changing screens within the dome.

7. Vandalism

The Massey Park Pool Complex has always suffered significantly from vandalism problems, and no chances could be taken. The back two sides of the dome are fenced off to prevent public access during opening hours. At night time guard dogs roam within the pool complex around the outside of the dome.

Over the past six years no significant vandalism to the dome has occurred.

8. Pool Painting

The pools have required emptying and repainting twice since the dome was commissioned. The paint used contains MEK and the thinners MIBK and zylene. The fabric manufacturers advised that these fumes, if sufficiently concentrated, could harm the dome material, hence painting the pool while covered was not recommended. This factor considerably complicates the timing of such works which tend to be carried out together with erection or removal of the dome. The works are then subject to the vagaries of the weather at that time of the year.

9. Erection and Removal

Erection and removal are significant costs in terms of wear and tear on the dome, as well as in labour. The manufacturers suggest that the expected 15 year life of the canopy could well be halved by annual dismantling and re-erection.

In the authors opinion the size of the Papakura dome is such that it is nearing the practical limits for regular erection and removal.

The Future

The inflated bubble has successfully met Papakura's requirements for a cost-effective all year round swimming facility.

Council is already making plans for further upgrading of the heating plant as noted above, and for ultimate replacement of the membrane when it reaches the end of its life.

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MASSEY PARK
AIR SUPPORTED POOL DOME

Papakura, New Zealand
Completion Date: March 1988