SYDNEY SUPERDOME
HOMEBUSH MULTI USE ARENA

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GENERAL

The Multi Use Arena now known as the Sydney SuperDome was the last major building for the Olympics to be awarded by the Olympic Co-ordinating Authority. It is an indoor stadium which will seat during the Olympics 15.500 people for the Gymnastics and 18,500 people for Basketball. When not in Olympic retractable seating can be used to increase the number of seats to 21,000. Adjacent to the Arena is a carpark with 3,500 spaces.

The building has a foot print of 18,900m^2 with 7 levels. The event floor is 78 metres by 45 metres and has a minimum head room over the event floor of 38.75 metres. Refer to Figure 1.

The contract was won by The Millennium Consortium and is being constructed by The Abigroup Contractors Pty Ltd. The major consultants are:-

Architect	Cox Richardson Architects
Structural Engineer	Taylor Thomson Whitting
Mechanical, Electrical & Hydralic Engineers	Norman Disney and Young
Quantity Surveyor	Page Kirkland Partnership

The bowl has four levels of tiered seating totaling 8.5km in length. The two middle levels provide prestige seating for 3000 spectators on club level and 1200 seats in 56 private boxes on suite. Refer to Figure 1.

The shape of the dome has been generated by rotating the seating about the rectangular event floor using two different radii.

The main entry to the building is via the Main Foyer which has a floor area of 1200m^2 with a continuous glass wall 14 metres high and maximum clear span of 30 metres. The Main Concourse provides direct access to the bowl. Access to the upper levels can be achieved by escalators, lifts and stairs. The public levels will provide food and beverage facilities as well as public amenities.

The Event Floor can be used for a variety of functions including an ice rink. A video scoreboard incorporating 4 video boards and 4 scoreboards weighing up to 30 tonnes can be hung from the centre of the roof. The roof has also been designed to carry 70 tonnes of rigging loads over the central section of the floor and/or the stage end of the floor.

There is a Warm up Court which can also be used to gain truck access to the event floor. The Warm up Court is 46 metres by 30 metres.

The design, construction and operation of the arena has been undertaken to provide the most environmentally advanced building through the application of ecologically sustained development. There is an array of solar panels on the Warm up Court roof. This will be the largest roof mounted array in Australia.

FOUNDATIONS

Prior to 1992 the site uses included holding yards for the State Abattoir, a railway embankment for a railway loop and corridor. A large sediment pond was subsequently established on the site for the construction of the Sydney International Aquatic Centre and Athletic Centre. With the completion of these projects this sediment pond was no longer required and was being utilised to stockpile surplus excavated material from other projects. This site was cleared, the sediment control pond drained and a site formation developed to enable simultaneous construction of the Multi Use Arena and adjacent Carpark.

The ground conditions necessitated the piling the secondary parts of the building down to Class 5 shale approximately 6 to 7 metres below the event floor level. The main building is supported on bored insitu piers founded at 14 metres on Class 2 shale. The event floor is a suspended floor poured on ground. This was required due to large and variable expected settlements in the ground. The event floor level supports masonry walls up to 6 metres in height thus strict control on deflection was required. The need to have a level floor for the Ice Rink also influenced the decision.

TYPICAL SUSPENDED FLOOR STRUCTURE

The suspended floors for Main Concourse, Club, Suite, Upper Concourse and Plant levels uses a hybrid of 3.6 metres wide post tensioned concrete bands and infill Ultrafloor slabs. Ultrafloor consists of precast pretensioned beams spanning between post-tensioned bands. The Ultrafloor beams are placed at approximately 600 centres and a fibre-sheet board is placed between the beams. Finally a reinforced topping slab is placed which acts integrally with the beams providing an efficient T shaped structure. These systems enabled the structure to have large span capabilities of the order of 10m for the bands and 9m for the slabs to produce an open floor space below. The use of Ultrafloor enabled Abigroup to reduce the amount of formwork on the project with subsequent improvement in speed of erection and reduction in building material usage.

SEATING AND RAKERS

The bowl seating consists of reinforced and pre-tensioned precast concrete plats sitting on 800 deep welded raker beams. The seating plats span up to 12.6 metres and have been designed to minimize the effects of crowd induced vibrations. The raker beams span from floor to floor and provide support for the seating plats. Careful coordination was required to ensure that differential deflections did not occur between the concrete frame and the raker beam supports. The raker beams and seating plats will be required to be positioned prior to the installation of the roof structure.

FOYER STRUCTURE

The structure of the Foyer has been designed as an integrated structure to support the roof system, the glazed wall, the external canopy and the shading system. The perimeter structure consists of partially braced, triangular towers 14 metre high and with a five metre base, at 13 metre centres. The front column of the tower becomes a tree at the top to support the roof external canopy. All members are tubular. At the widest part of the foyer roof, the southern foyer, the roof spans 30 metres. Refer to Figure 2.

The roof structure consists of triangular trusses which are strutted off the Club Level. The triangular trusses consist of two planar trusses which can be fabricated and transported to site, which combined together to make the triangular trusses. Where the roof is not exposed and the spans reduced the structure is a conventional beam and purlin system. In the northern foyer the span is 17 metres. The 'truss' consists of two tubular beams that are strutted by a central system of tensioned rods and a pyramid of struts.

The glass wall/metal cladding is hung from a beam that runs along the top of the facade and spans between the two back columns of the towers. The facade is stabilised at the club and suite level. This is done in a number of different ways. Where there is a slab behind the facade it is propped off the slab. Where there is no slab, such as on the southern foyer, a horizontal, external, bracing system between the towers is used. At suite level this bracing also supports the external sun shading. At the northern foyer the glazing is laterally supported by an internal truss that is incorporated into the bulk head over the entry doors.

MAIN STADIUM ROOF

The span of the main roof is 140 metres by 100 metres and has a roof area of 12,500m^2. It is an arch structure which is assisted by a system of suspended cables. There are 18 perimeter columns at typically 20 metre centres but up to 32 metre centres around the corners. The centre of the roof over the event floor, an area 40 metres by 70 metres, consists of a trussed space frame 5 metres deep.

Radiating from the centre space frame are 36 trusses at 20 metre centres which span the 30 metres to the perimeter of the building. Between these trusses is a conventional beam and purlin system. There is a horizontal truss around the perimeter of the roof which distributes the thrust from the radial trusses and radial beams into the base of the columns. The thrusts from the dome are resisted by ring action in the plant room slab. Because the plant room level has ring action the ultra floor was used only as a formwork system for a 200 thick reinforced slab. Refer to Figure 5.

The roof has acoustic requirements and consists of metal deck several layers of plywood with insulation, and a metal ceiling. The total weight is 55kg/m^2 and the built up depth is 500mm.

CABLES

The cables are generally made up of bundles of individual corrosion protected strands. The short cables at the base of the mast (CS5) are macalloy bars. All cables will have a jack incorporated into their base during the erection to enable the force in the cable to be monitored during stressing. The rear cables (CS1) will be stressed using four 100 tonne jacks with four 36mm diameter macalloy bars. A similar system will be used to monitor the loads in CS3 and CS4 and if necessary to jack the loads in these cables. The macalloy bars (CS5) will be jacked and the forces monitored using a Tecno Tensioner which has recently been developed in the United Kingdom.

COMPUTER ANALYSES

The complete structural steel roof has been modelled in Space Gass version 8. A geometric non-linear analysis was performed to obtain member forces. The Space Gass roof model was imported into Strand 6, and the concrete frame added to model the entire structure. This model combined plate elements to model concrete walls and slabs, and beam elements for the steel and concrete beams and columns. The model was used to analyse the effects of wind and earthquake loadings and the interaction between the roof and concrete structure. The computer program analysis of the plant room slab was done using finite elements that determine the stress pattern in the slab as the ring tension is effected by the large penetrations in the slab for the ducts, lifts and stairs. Refer to Figure 3.
The computer analysis was used to look at the dynamics of the roof and the effect of the temperature on the roof. A geometric non-linear analysis was performed on the structure. This model was also used to verify the forces from Space Gass.

The steel foyer structure has been modelled in Space Gass version 8, and analysed for design. The reactions from the foyer mode analysis were included in the Strand 6 model.

WIND MODEL

A 1:500 scale pressure-tapped mode of the Multi-Use Arena and its surroundings was tested in the Wind Tunnel at the Department of Civil Engineering of Sydney University to determine the wind pressure distributions on the roofs, and facades of the structure. The pressure measurement system used in the tests was based on a leak tube system. The model of the Multi-Use Arena was fitted with 360 pressure taps, each of which was connected to a 'Scanivale' pressure-scanning switch via a 1m length of flexible vinyl tube. Wind pressures were measured at the pressure taps around the model for wind directions from 0 to 350 degrees at 10 degree intervals.

The highest recorded minimum pressure was -0.94kPa on the edge of the concourse roof above the side wall. The greatest recorded maximum (positive) pressure was 0.70kPa on the small wall between the two roofs.

For the structural loading the pressures were averaged over 28 panels, each with 9-12 taps.

CONSTRUCTION OF THE ROOF

The roof is to be constructed in 9 large segments, refer to Figure 4. Each is to be lifted into place complete. The heaviest lift is approximately 350 tonnes. The perimeter segments will be erected first and supported an temporary towers. The joint between the perimeter segments and the centre segment is one bay into the centre space frame. The roof segments will have the roof cladding in place when they are lifted into position. The four large fans and their acoustic attenuators will be either in place at the time of erection or in the case of the furthest lift will be installed prior to the placing of the centre segment. The infill sections between each perimeter segment will be erected insitu.

The centre segment will be lifted into place and held by the crane until the connections of the top and bottom chords are made good. The next step in the erection will be the masts and cables which will be positioned and the drape taken out of the cables.

The initial stress in the centres will then be applied. The analysis of the cable stressing has shown that the external cables (CS1) can be stressed to 75 percent of their final load without overstressing the roof. Also the stressing of a set of two CS1 cables at any mast does not have a significant effect on the forces of the adjoining set of cables. This means there is no restriction on the number of sets of cables that need to be stressed together nor the stressing sequence. After the cables are stressed to 75 percent of the load, the temporary support system of the roof will be lowered. This will increase the force in the cables. The cables will then be rejacked to their full force and the force in all cables checked.

CONSTRUCTION CALCULATION

The results of the theoretical computer model of the final structure are not the actual forces in the member as the actual forces are dependant on the construction sequence. If the roof had been supported at close centres prior to jacking of the cables and releasing the structure, the theoretical analysis would be a true representative of the actual forces in the members due to the dead load.

The analysis of the member must follow the actual construction sequence. Each segment of roof must be analysed for the member forces while the segment is being lifted. The next step is to calculate the forces in the members while the segments of roof are being supported on the towers. The forces due to the dead load remain in the members. The dead weight includes the cladding, the fans and the catwalks.

The reason why the joint between the roof segments was made partly through the space frame was to reduce the unrecovered construction force, in particular the compression forces in the top chords of the radiating trusses.

The next step is to analyze the force when the centre roof section is in place. This further reduces the compression in the top chords. The connections to the top and bottom chords of the space frame are made while the centre section is on the crane so that the continuity in the final structure is also there at this stage of the erection.

The roof can than be modelled for the stage stressing of the cables to check the interaction between the cables being jacked and the other cable loads and the member forces. The next stage in the calculation is to lower the temporary towers and calculate the forces in all the members.

SUBCONTRACTORS

The concrete structure is being constructed by De Martin and Gasparini and Ultrafloor, the rakers by Transfield, the plats by Rescrete, the main roof by ABB, the stressing by Austress and the foundations by Frankipile.

CONSTRUCTION

In mid July the concrete frame is approaching completion. The fabrication of the roof has commenced and is anticipated that the main roof will be completed by the end of the year. The foyer structure will follow. The completion date for the project is August 1999.

TAYLOR THOMSON WHITTING TEAM

Director In Charge	Don MacLeod
Assisting Director - Roof Structure and Foyer	Richard Green
Project Engineer - Concrete	Andrew Sutton
Project Engineer - Roof	Duncan Duff
Computer Manager	Glenn Barton

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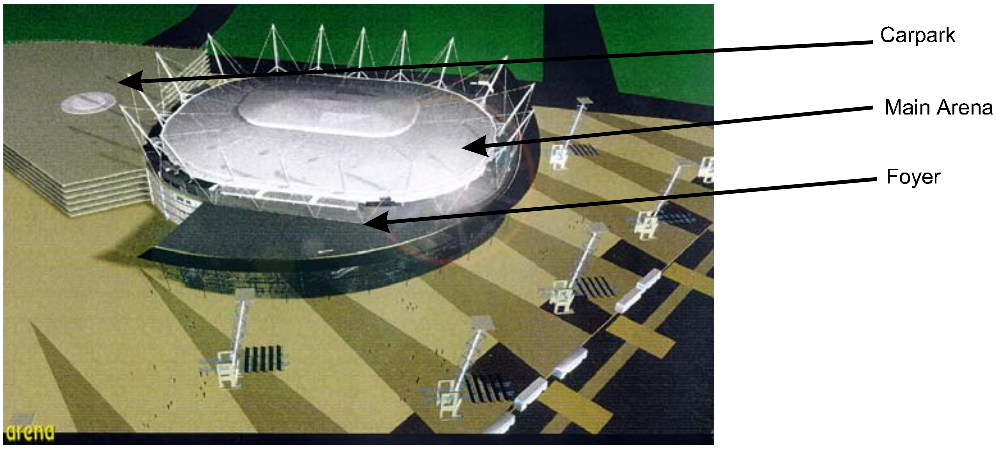
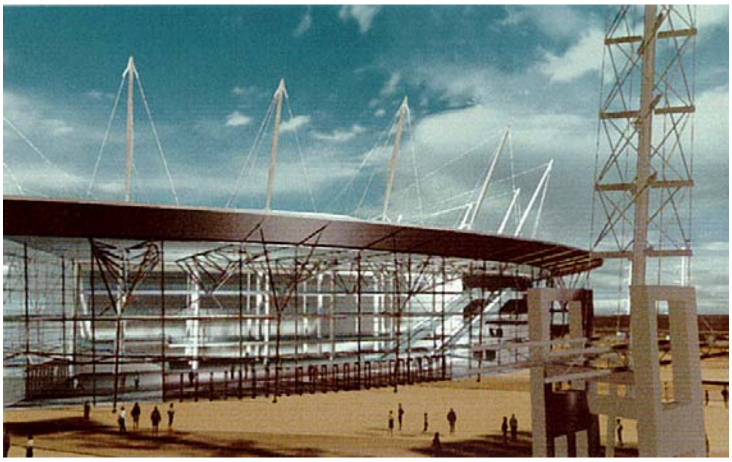
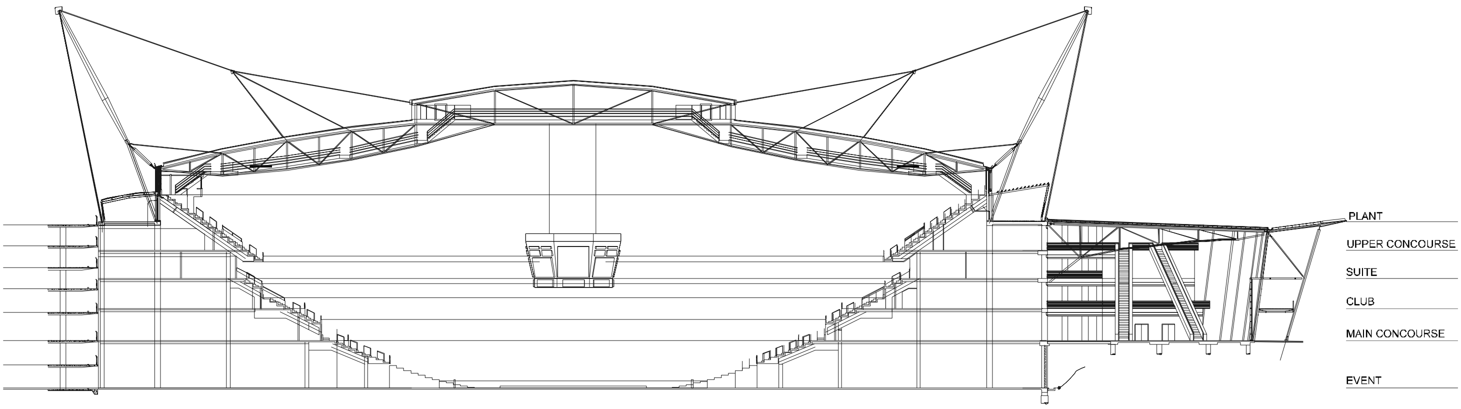


Arial View of Sydney Superdome, with Carpark

Internal View of Sydney Superdome

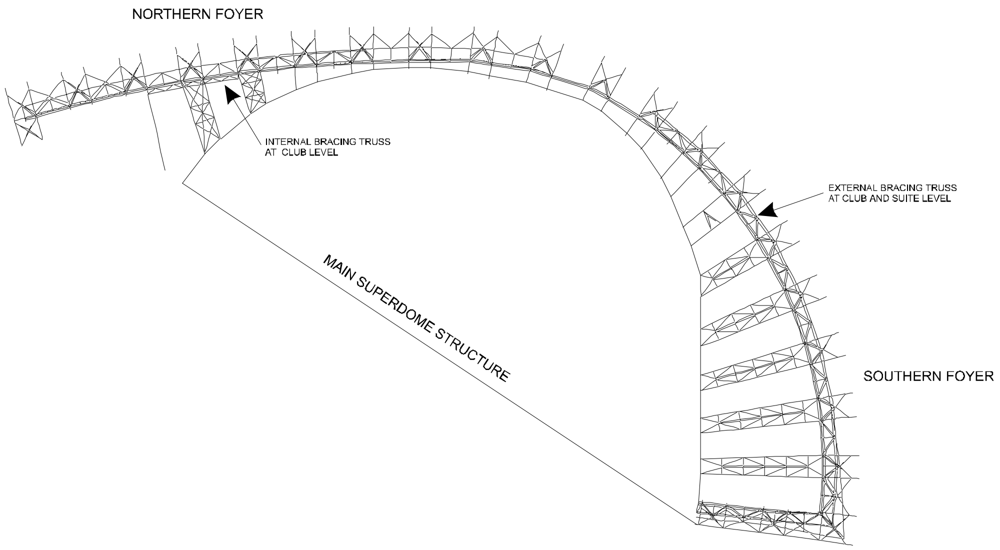


External View of Entry Foyer

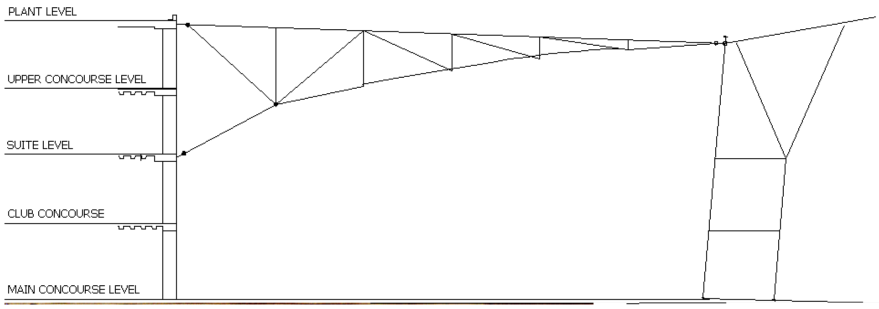


Typical Architectural Section

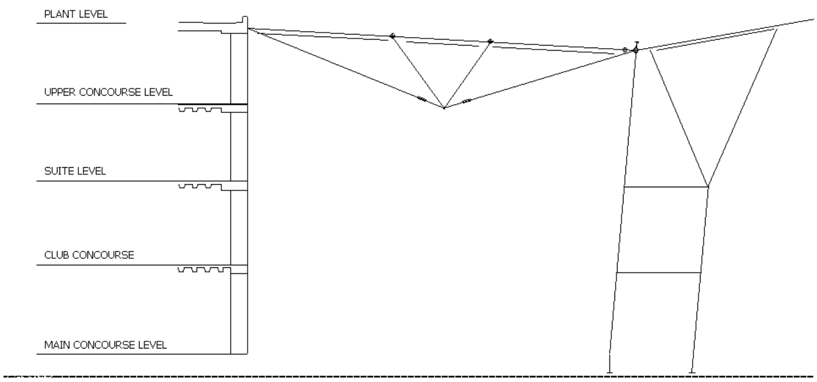
FIGURE 1



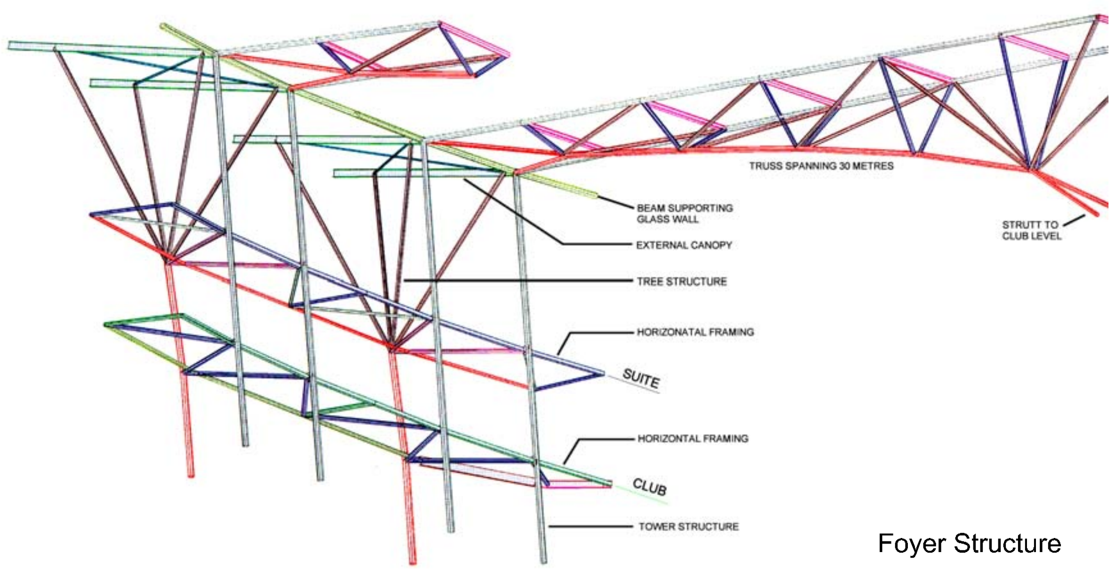
Entry Foyer Strucutre Plan



Southern Foyer Truss



Northern Foyer Truss



Foyer Structure

FIGURE 2

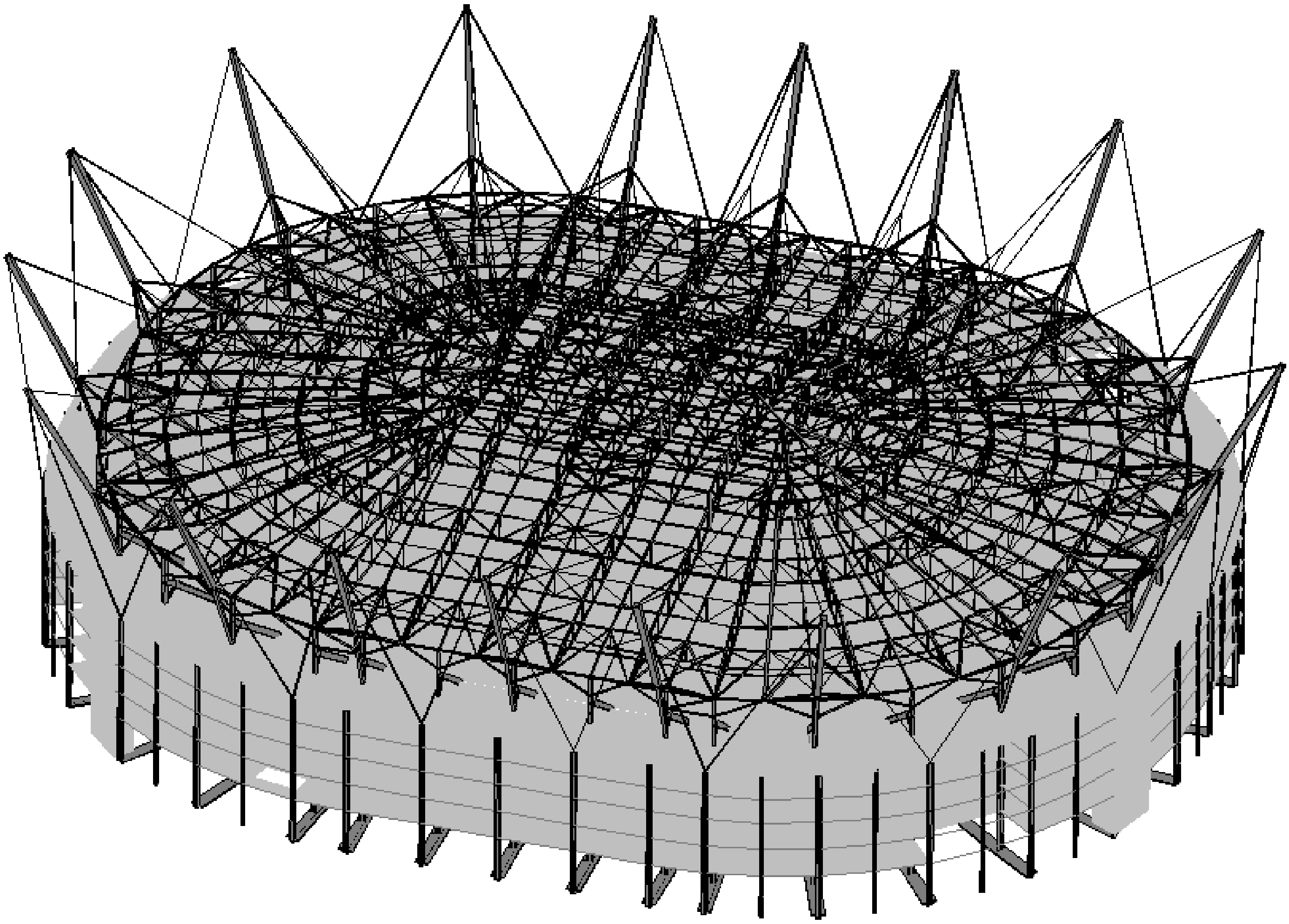
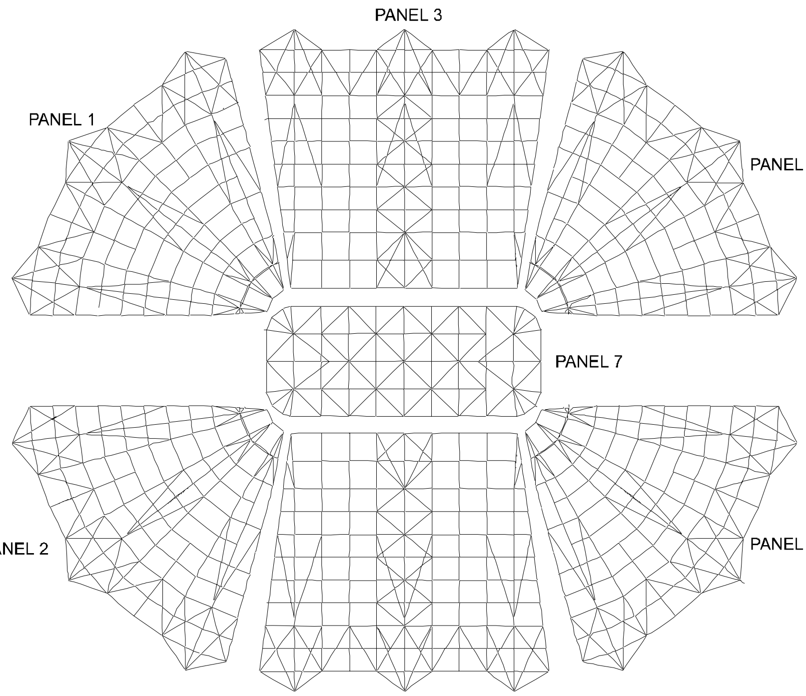
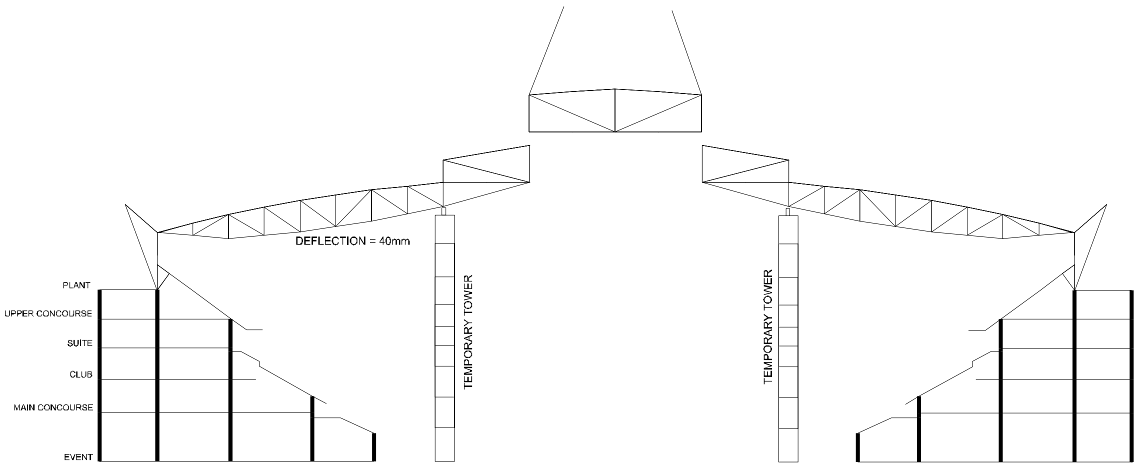


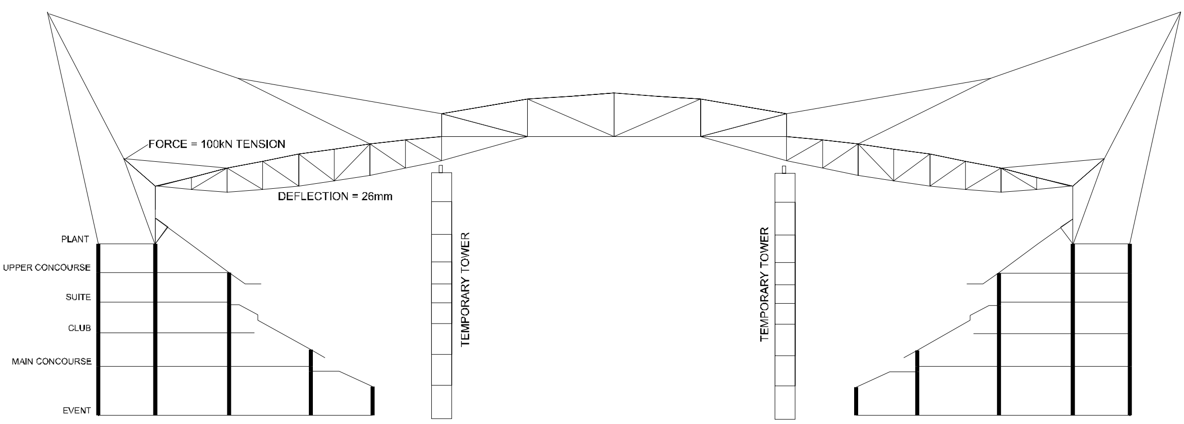
FIGURE 3
COMPUTER MODEL



Roof Construction Sequence



Stage 1



Stage 2

FIGURE 4
CONSTRUCTION SEQUENCE