1.3.G
Oriole Park, Camden Yard, Baltimore

that followed, that number rose 408 percent to 1,374 units.

- In 1996, the 945 rental units built downtown were more than in the previous four years combined.
- Residential sales prices jumped from $100 to $220 per square foot.

Entertainment

- More than 25 restaurants opened in LoDo between 1993 and 2000.
- From 1993 to 1996, the number of restaurants in the area increased 140 percent.
- Food and beverage sales in LoDo jumped 651 percent from 1991 to 1998. Microbreweries increased from four to 10.
- Food and beverage sales tax collections for LoDo increased 651% from 1991 to 1998 
- Sixty-one liquor licenses were issued within seven blocks of Coors Field between 1991 and 1997.


1.3.H
Coors Field, Denver

# 2.0 Development of the Awatea Street Site

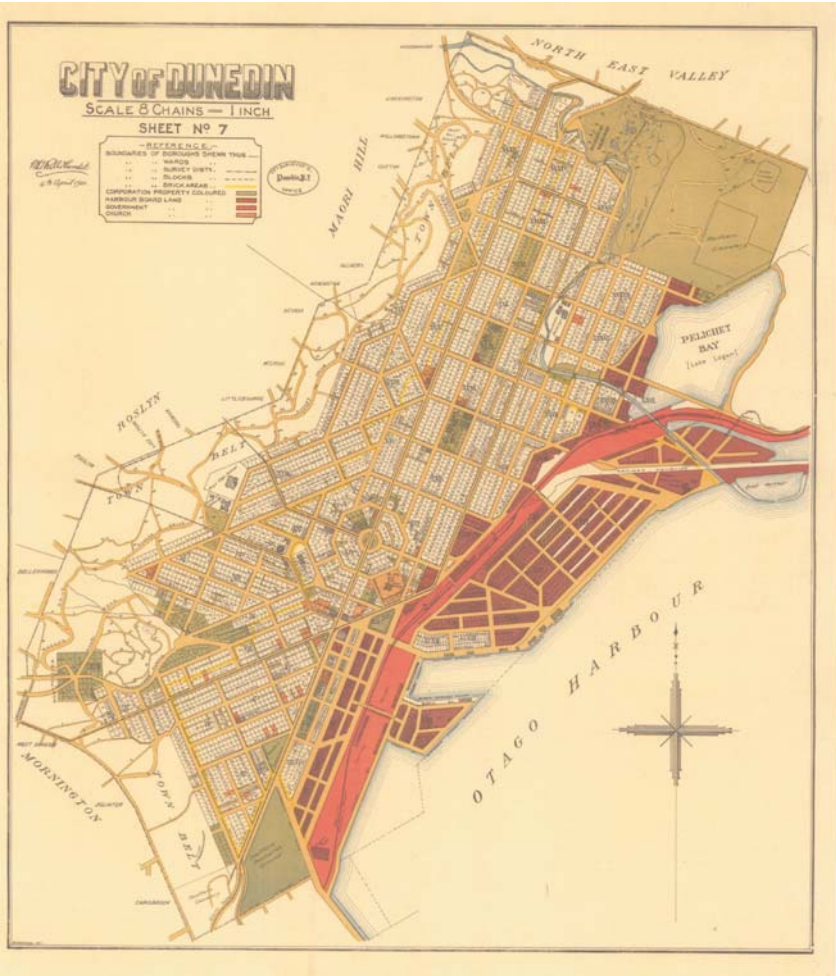


Figure 2.1.A

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Figure 2.1.B

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Figure 2.1.C

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## 2.1 Site Location and Context within the City

### Location

The Awatea Street site is located to the north east of the Octagon, the centre of Dunedin. In addition to this close proximity to the city centre, the site is located adjacent to the existing eastern end of the University of Otago; Logan Park is just across the road to the north of the site and the harbour edge flanks close by to the south.

The site is bounded by Anzac Avenue to the north west and Ravensbourne Road to the north. These roads form the western part of SH 88 from Dunedin to Port Chalmers. Proposals are currently underway to relocate SH 88 to the south east adjacent to the existing rail corridor. A land reserve has been allocated to facilitate this relocation. The proposed relocation of this major road forms the south east boundary of the proposed site. The southern boundary of the site is defined by the Waters of Leith.

### Land Formation and Use

The site was created in the 19th century through the process of land reclamation that generated the port, Logan Park and the waterfront that is seen in Dunedin today. Prior to reclamation the site consisted of low laying tidal marshes along the mouth of the Water of Leith as it discharges into the harbour.

Since reclamation, the site has been developed as light/medium industrial land with a variety of uses occurring in various facilities throughout the 20th century. The site currently accommodates commercial and industrial businesses.

### Surrounding Topography

The topography of Dunedin is characterized by hills that contain the city along its western and northern flanks and include the hills east of the city across Otago Harbour. To the west the hills rise up gradually from the flat lands beside the harbour and then more steeply to the elevated residential areas of Mornington, Roslyn and Maori Hill. Beyond these residential areas the topography continues to slope up to the ridge line running through Kaikorai Hill and Mount Cargill further north. The topography within the immediate vicinity of the Awatea Street site is essentially flat with the exception of Logan Point to the north which contains the quarry. Here the hill formation which originally defined the harbour edge overshadows the site and rises up to the north towards Signal Hill. Beyond this point the flat land extends out towards the harbour edge and west towards George Street where the transition occurs between the flat land and Maori Hill.

The Awatea Street site is prominent within the context of Dunedin and due to its topography is visible from many vantage points around the city. In particular the stadium design will be overlooked by the elevated residential areas to the west and from Waverly on the eastern side of the harbour. In addition to being prominent from an elevated perspective, the stadium will be a landmark when viewed from the foreshore along the eastern side of the harbour.

### Opportunities for Dunedin

Locating such a major community facility at Awatea Street provides a unique opportunity for Dunedin to expand upon a vision for growth within the city centre. Stadia located in these types of locations have been great catalysts for the regeneration of surrounding city areas. In this manner this vision ties in with Dunedin City's present vision to allow regeneration of the harbour area to tie the city back into the waters edge.

The proposed location provides a number of benefits for how central Dunedin works as a city:

- It provides a strong built civic identity for the revitalisation of the north eastern city quarter (Refer to Section 1.3 Stadia and Urban Regeneration)
- It extends and provides an eastern gateway to the University of Otago Campus and reinforces the University developments along the Water of Leith (refer Figure 2.1.B).
- It provides a catalyst for the re–establishment of a city connection to the waters edge
- It responds sensitively and creatively to the local natural environment
- It integrates the sporting and cultural identity of Dunedin within the built fabric
- Within walking distance from the city centre, stadium and University activities will act as a catalyst for regeneration of the city precinct between the Octagon and the new stadium precinct (refer Figure 2.1.A).
- The proposed site lies at the culmination point of existing green space and identifies new opportunities for new green spaces (refer Figure 2.1.C).

## 2.2 Land (Geotech and contamination)

### 2.2.1 Site Geology

The site is located in an estuarial position and as such its geology is potentially complex. It lies in the centre of a wedge shaped area of flood plain that extends to the waters edge and is bounded in the east by areas of modern reclamation and on the west by rock headlands and further areas of reclamation.
It is likely that over a period of tens of thousands of years the Leith stream has meandered across the flood plain depositing alluvium to as yet unknown depths and that when the area was developed and the stream realigned material was tipped across the site to raise the general level. As the site is neighboured by a black basalt quarry it is possible that overburden material was deposited as fill to the site.
The profile of the rocky headland upon which the quarry is sited will dictate the ground conditions. If the rock profile is a shallow slope then it is expected to be encountered at relatively low levels under the north stand, increasing in depth as the south stand is approached. However if the rock profile is very steep then solid founding may be encountered at considerable depth across the entire site.
Geotechnical information contained in the Masterplan and Feasibility phase report was based on historical records, anecdotal evidence from local property owners, and surface and sub-surface investigations undertaken on neighbouring sites. From this, the simple, possibly conservative, foundation solution of extending piles to sound material (at an assumed boulder layer) was identified as feasible. However for the Concept Design phase a preliminary site investigation was undertaken, with a view to more clearly identifying the level of bedrock, the most obviously suitable founding for piles. This investigation indicated the rock to be generally deeper than anticipated, and piles to bedrock would therefore be longer than expected. A substantial gravel layer has also been identified through all the test bores and may provide an opportunity for an alternative foundation design (possibly combining friction piles and/or a raft foundation). Further testing will be undertaken as we acquire access to other areas of the site. Given the site has existing structures, the specific test locations have been selected to provide the best base data in order to extrapolate subsurface test findings. The current findings have been taken into design consideration.
Liquefaction has also been considered when developing a foundation strategy. Preliminary geotechnical data has indicated it unlikely that loss of pile lateral support will result from liquefaction, confirming that piled solutions are the most suitable for the founding of superstructures. However, the risk of lateral spreading from liquefaction is more critical, particularly considering the existing retention of the Leith Channel behind the South Stand. It is likely that, in order to prevent the South Stand foundations becoming overloaded due to lateral spreading, strengthening of the channel wall is required.

### 2.2.2 Contamination

It is understood the previous uses of the site includes that of a tannery and the activity associated with the processing of wool. The degree of contaminants arising from these processes is unlikely to be severe and in the case of residues arising from wool processing can be remediated by exposing the material to sunlight.
A full site investigation will be undertaken for the detailed design of the stadium and will include comprehensive contamination testing to ensure the material excavated and remoulded on site or disposed off site is managed in the most appropriate way. However, during the concept stage around 60 test pits and boreholes were excavated to undertake some initial intrusive testing. This testing confirms our initial thoughts of limited contamination issues. The full extent of this risk however will not be understood completely until we are well into the earthworks phase of the project. These potentially unforeseen contamination issues have been considered as part of our current design, cost and construction assumptions.

### 2.2.3 Foundation Solutions

Various solutions are being considered with practical investigation strategies forming a part of our current risk assumptions. These solutions include driven piles in conjunction with a raft slab. Bored piles were originally assumed at around 15m in depth, but could now be some 30m based on the current geotechnical findings, if this solution is pursued.
With the ground conditions better understood, we are confident of the foundation solutions we have developed to date satisfying the criteria of the brief and budget.

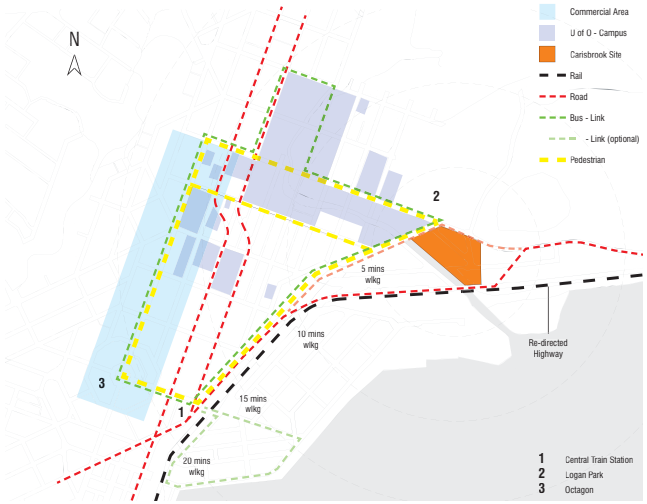



Figure 2.3.1.A

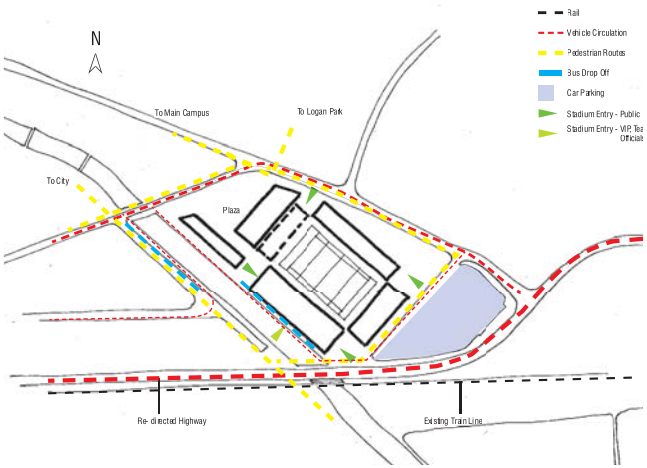



Figure 2.3.1.B

## 2.3 Facility Design

### 2.3.1 Connection to the City

Connections allow people choice and encourage sustainable modes of movement. Places that are well connected provide for healthy environments, encouraging people to walk and cycle. Enhancement of the movement network is a vital criterion of all good urban design solutions.

The transport strategy considers the movement of all modes – cars, taxis, service vehicles, trains, buses, shuttle buses, coaches, cycles and pedestrians (including those with disabilities). Public transport efficiencies and options will encourage people away from private car use. Refer Figure 2.3.1.A

This proposal considers movement patterns carefully and is a critical part of designing stadiums. It is important that people can move efficiently to and from the stadium. Consequently a comprehensive strategy allowing good access and circulation has been developed by the Consultant team. Refer Figure 2.3.1.B

By locating the stadium complex within approximately 1.5 km of the Octagon, it is anticipated that people will walk to and from events. This will create enhanced business opportunity within the central precinct area. This is likely to include increased opportunities for restaurants, cafes and pubs before and after events, retail opportunities provided by out of town visitors. The pedestrian route is likely to predominate along Anzac Avenue, Union Street East and Albany Street, allowing an opportunity to further enhance the landscape along these streets.

As part of Dunedin City Councils long term transport strategy SH 88 will be re-aligned to the eastern side of the new stadium and run parallel with the railway line. This will have the effect of re-directing large volumes of traffic around the south and east sides of the stadium. This in turn will significantly reduce the traffic flow along Anzac Avenue as well as improving traffic flow to Ravensbourne and Port Chalmers on the new State Highway. Anzac Avenue will become a more pedestrian friendly street enhancing connections between the existing University Campus and the University facilities included within the stadium complex. Pedestrian access can be along Union Street or along the edge of the Water of Leith. Beautification of the river and its edge will turn it from a storm water overflow into a major recreational asset for the city.

Currently the DCC are investigating various cycle path options in the vicinity of Awatea Street. These paths will be part of a much larger system of cycling routes throughout the region and will encourage cycling to and from the stadium and its integrated facilities further reinforcing connections and sustainable strategies.

Due to the quantum of University and activity within the precinct at all times, an opportunity exists for the provision of a 'link bus' loop that connects the central city, the University and the Stadium precinct. As the Harbourside precinct develops this loop can easily extend to service this area as well, providing the people of Dunedin with a great public transport amenity. The possibility exists for this loop to be enhanced further through a tram loop in lieu of a 'link bus'.

The existing railway line connecting Dunedin and Port Chalmers provides a future opportunity for a train station to be built nearby the Stadium Complex.

During major events it is proposed that the bus and taxi drop-off and pick-up area for the stadium be restricted to the area located along Anzac Avenue and Minerva Street south of the Water of Leith. Once on foot pedestrians will approach the stadium either via Anzac Ave or further east, via a pedestrian footpath attached to the new SH 88 bridge over the Water of Leith.

### 2.3.2 Traffic Management

While the Design Team in general has commented above on modes of transport, access and connections, Beca Traffic are currently finalizing a detailed Traffic Impact Assessment as part of the assessment of environmental effects for the District Plan Change. This report will cover in detail the issues associated with traffic and parking impacts of the development. Our understanding is that no major issues have arisen.

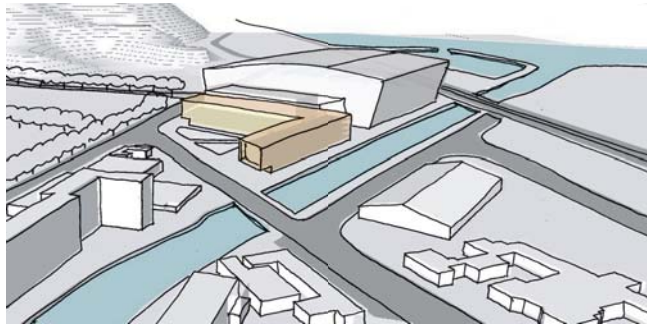


Figure 2.3.3.A

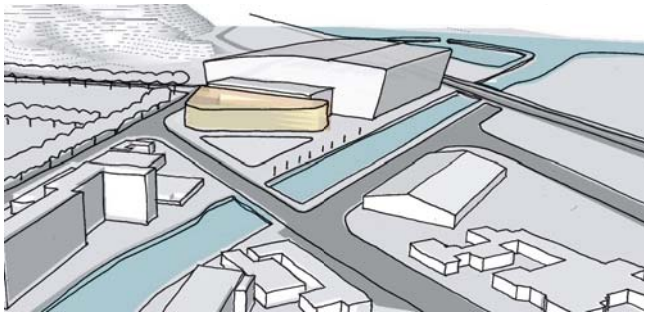


Figure 2.3.3.B

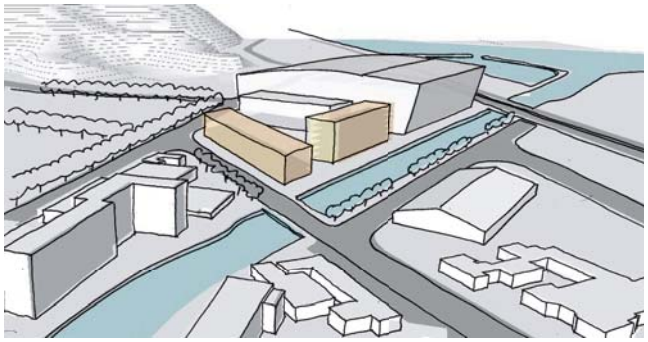


Figure 2.3.3.C

## 2.3.3 Master plan Design

HOK / Jasmax were asked by the Carisbrook Stadium Trust to further develop the Master Plan for the New Dunedin Multi-purpose Stadium Complex. The development was to review and test the assumptions made in the Masterplan + Feasibility Report. This has involved a number of workshops and regular meetings and close liaison with the design and project management teams. The main focus of the concept design has been on the stadium and its associated facilities. Further consultation with the University of Otago will be needed to progress the Master Plan. At this stage the University has been considered as a separate entity.

Design Objectives

The Master Plan has been developed for the following purpose:

- Establish a set of guidelines that allows for a staged development of the site and facilities
- Explore connections with the immediate context
- Reinforce connections with the University Campus
- Explore future development opportunities
- Establish clear linkages for all transport modes to the site and facilities
- Oversee the physical regeneration of the site
- Explore the relationship between of the Stadium and the University facilities

Master Plan Design Options

Three Master Plan concepts explore different configurations of the University Buildings as they relate to the Stadium and their perceived and physical connection to the immediate surroundings. Option 1 (refer to figure 2.3.3.A) + Option 2 (refer to figure 2.3.3.B) create an open space or plaza area that is contained within the university campus, reinforcing the idea of the university campus as a collection of buildings grouped around open campus spaces. Option 3 (refer to figure 2.3.3.C) places the plaza area between the university and the stadium creating the opportunity for further flexibility when staging events within the stadium environment.

At this stage only Option 1 is shown on the Master Plan. This option provides an outdoor plaza area that is effectively protected from the south west winds, opens out towards Logan Park and forms an interstitial space that effectively mediates between the public realm and the activities within the complex.

Master Plan Option 1

The site has been organized into three zones (refer fig 2.3.3.D):

- University zone
- Stadium zone
- Car parking zone.

The university zone occupies the western end and relates to the existing University Campus across Anzac Avenue. The stadium occupies the centre zone is orientated northwest – southeast and runs parallel with the River Leith along its long axis. A landscaped car parking zone occupies the eastern end of the site.

The layout of the site and its urban design has been configured around two main public spaces – an inward focused Stadium Quadrangle contained on all sides and an outward opening University Quadrangle contained on two sides (refer fig 2.3.3.E). This part is informed by the traditions of the University Quadrangle a common feature of many famous Universities with its traditions dating back to the original universities of medieval Europe which were often associated with the traditions of the Monastery and its cloisters. This sense of tradition allows the University and Stadium facilities to be merged as a single urban design element comprising of two adjoining quadrangles. The stadium itself is seen in this light as an enclosed cloister forming one of the many enclosed spaces of the University.

It is proposed that the University facilities will be located at the western end of the site, generating all week activity and providing a gateway to the eastern end of the University of Otago Campus. These buildings wrap around the quadrangle or public plaza on two sides to create the following conditions:

- Activated edges to encourage a lively environment through out the week
- A sheltered north orientated outdoor environment protected from the prevailing south westerly winds
- Reinforcing the connection to the University
- Safe environment

The height and scale of the University Buildings are designed to relate to the existing built fabric as it exists along Anzac Avenue. They also act as mediating masses reducing the perceived scale of the much larger stadium mass as approached from Anzac Ave and Union Street (refer figure 2.3.3.F). Similarly the hilly topography to the north of the stadium will have the effect of reducing the perceived mass of the stadium when viewed from elevated positions west of the city centre.

Open Spaces

On the western side of the site a major urban plaza is proposed. This space will function as the major pedestrian connection and arrival gateway to the Stadium from the centre of Dunedin. Major access points to the Stadium are located off this plaza. As well as providing a vibrant and dramatic entry for events, the plaza provides a major community and University asset at all times. As an urban landscaped space it will become

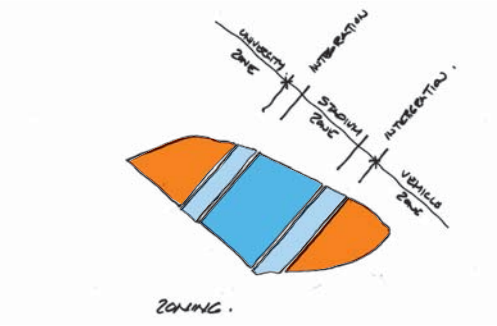



Figure 2.3.3.D

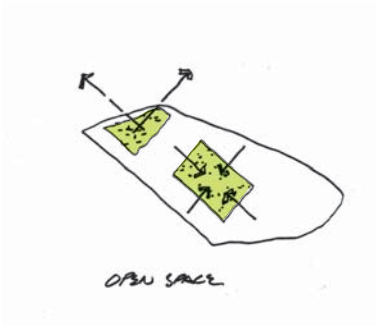



Figure 2.3.3.E

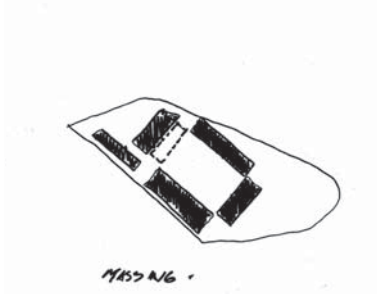


Figure 2.3.3.F

a focal and gathering point for the North eastern sector of central Dunedin.

The plaza (Quadrangle) is bounded by Anzac Avenue and Ravensbourne Road and is envisaged to be the main focal point of the new development, as entrance for both Stadium and University. The plaza is considered an opportunity for all year round activity including craft fairs, exhibitions, visiting shows etc. The design of the plaza also allows the development of an 'overlay' approach to be adopted for major events. The process of overlay would see the additional requirements of major events such as Rugby World Cup and Lions Tests being required both inside and outside the stadium. The plaza is envisaged to form a live site during such events where the activity of the stadium can engage with the city. During such major events it is envisaged that the plaza would be used as a centre for a live stage hosting community acts supporting the stadium event as well as a major video screen to allow people outside the stadium to partake in the activities going on inside.

A smaller pedestrian precinct is provided along the northern flank of the Stadium. Located across the road from Logan Park, the proposal allows for the provision of commercial spaces to be located along this edge, possibly with synergies to the provision of sport to the Otago Region. During large events it is proposed to temporarily extend the stadium secure zone to the footpath edge along Ravensbourne Road.

Connection + Entry

To facilitate the pedestrian access of crowds from the Central Business District and population areas to the west of the site it is proposed to enlarge the southern footpath of Anzac Avenue including the bridge where it crosses over the River Leith.

It is also anticipated that significant crowd numbers will arrive by shuttle bus or coach at the public transport node along Minerva Street. To facilitate access from this drop off zone to the eastern end of the stadium it is proposed that a generously proportioned footpath be provided as a part of the new SH 88 bridge across the Leith. Some consideration has been given to providing covered access from the transport node to the stadium. However for urban design reasons this is not considered desirable. It may be possible to provide rain shelters along Minerva Street adjacent to the Leith should this be deemed necessary or desirable although no allowance has been made for this at this stage.

The new University Quadrangle forms the main entrance to the stadium on event days as well as providing the main access to the proposed University facilities 365 days a year. The Quadrangle is envisaged as a hard landscape piazza with defined soft landscape areas containing arbours, raised lawns and parterres to create a sense of scale and intimacy as well as providing shade and shelter from the prevailing winds whilst maximising solar penetration into the entry areas of the University and stadium. The landscape has been specifically designed to ensure the safe, unhindered access into the ground by patrons as it is envisaged that up to 70% of patrons will be accessing the stadium from Anzac Avenue and the North-West corner of the site.

Traffic + Parking

Car parking for approximately 336 cars is located in the landscaped buffer between the East Stand and the realigned SH 88. As well as providing for VIP parking during major events, these car parks can be utilized through out the week by the university or by the stadium facilities for weekday functions such as wedding parties, large meetings and the like.

A restricted drop off zone along the south side of the stadium has been designated for team buses and VIP and service vehicles. Provision has been made to allow these vehicles to circulate through the site with an exit onto Anzac Avenue south of the plaza area.

The major event public transport node is located along Minerva Street beside the River Leith. This node gives access to both shuttle buses and coaches with taxi drop off and pick up restricted to Anzac Ave south of the River Leith.

It should be noted that issues mentioned above that relate to traffic infrastructure will be dependent upon the outcome of the Traffic Impact Assessment (TIA).

Future Development Opportunities

The opportunity exists within the precinct for future commercial development at both the western and eastern ends of the stadium. At the western end the opportunity exists for smaller scale commercial interests such as retail and gastronomic services, to be carefully integrated with the university facilities. Facing onto the plaza at ground level would be an ideal location to attract abundant potential clients both during an event and during the university week.

At the eastern end of the precinct there exists another opportunity for larger scale commercial development. This could host a development less dependent on walk-in customers and benefit from the realignment of State Highway 88 and the prominent corner created at the intersection with Ravensbourne Road. This location would have very good accessibility by car with plenty of parking. Any future development could potentially be built over the car parks, framing the side and diminishing noise exposure for the pedestrian zone around the stadium by doing so.

## 2.3.4 Stadium Design

Design Objectives

The major design objectives that the consultant team have addressed during the concept design stages following the original feasibility and masterplan report (dated February 2007) are as follows:

- The primary objective of the stadium development has been to create a high class multipurpose public assembly facility configured around a rectangular sport field, with a roof covering the stands and pitch area. Whilst moving roof stadia have been developed in the past it is believed that this proposal will be the first fixed roof stadium with a natural grass playing surface.
- The stadium is designed as a multipurpose venue capable of hosting a range of events such as rugby union, rugby league, soccer, American Rules Football (Grid Iron), horse trials, highland games, concerts and other mass assembly events as deemed appropriate.
- With modifications to the natural grass pitch and the introduction of alternative field of plays it could be possible to host in addition to the primary activities mentioned above the following; field hockey, ice hockey, tennis, basketball, netball, indoor athletics, exhibitions and motorcross.
- Design options for the roof over the pitch have investigated the ability to retrofit this feature, either as the entire roof structure or simply the envelope.
- The stadium accommodates a base case of approx 20,000 minimum permanent capacity with the flexibility to achieve approx 30,000 utilising additional 5,000 temporary seats and 5,000 standing. The north stand lower bleachers will also be able to provide for standing at times when the stadium is not in full capacity mode. Please refer to fig 1.2.A for capacity distribution.
- The consultant team will endeavour to design an internal environment within the seating bowl arena that provides conditions as close as possible to an external environment (light quality, ventilation, air quality) to allow a natural grass pitch to be incorporated within the covered/ enclosed environment. However the design team has undertaken extensive research (including the development of an external test rig) to test the proposal. While the design team believe that turf will grow successfully, research will continue through all subsequent stages of the design of the stadium to ensure the best quality turf surface can be achieved. A separate report on the outcome of the turf testing has been produced.
- Careful consideration has been given to the bowl geometry, seat spacing, and access to amenities to provide optimum levels of comfort and viewing standards for all patrons.
- The stadium layout has been designed to develop a single main stand (South Stand) which incorporates all the major functional spaces of the stadium including;

    -Team Facilities

    -Administration Facilities

    -Lounges and dining rooms

    -Corporate and VIP facilities

    -Loading docks

    -Public Amenities

    -Food and Beverage concessions

    -Retail outlets

    -First aid facilities

    -Grounds keeping facilities
- The stadium massing and roof design has been developed to minimise shading on the pitch, maximise solar penetration onto the playing surface and allowing the maximum natural ventilation at pitch level.
- The Stadium is to be a facility with the flexibility and durability to meet the brief requirements over a primary structural design life of 50 years.
- The composition of the external envelope incorporates issues of context, transparency, climate and durability into the design as well as maximising natural light penetration and ventilation.
- The public concourse areas of the Stadium are designed to be as open as possible whilst retaining a sense of shelter and security. These areas are designed to be naturally lit and ventilated.
- The proposed South Stand of the Stadium is to be unified by a new façade structure forming an envelope wrap. The emphasis will be placed upon simplicity of the structure and slenderness of the edges.
- The Stadium shall indicate a strong and impressive architectural form reflecting its function with the roof angled towards the northern sun to maximise solar penetration through the roof.
- The seating bowl, concourses and stairs shall be designed in accordance with the Guide to Safety at Sports Grounds (The Green Guide).

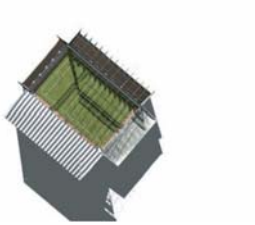


Figure 2.3.4.A
East-West Orientation at 12-noon

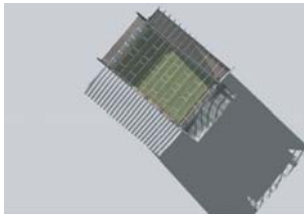


Figure 2.3.4.B
East-West Orientation at 3pm

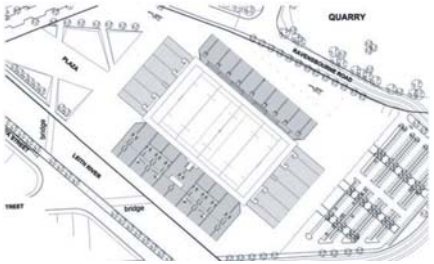



Figure 2.3.4.C
Stadium on an East-West Orientation

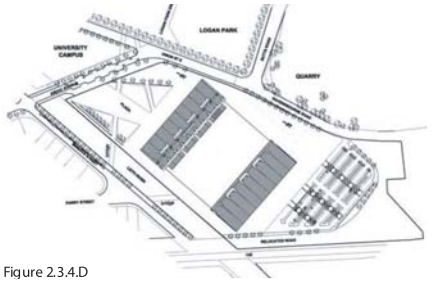



Figure 2.3.4.D
Stadium on North-South Orientation

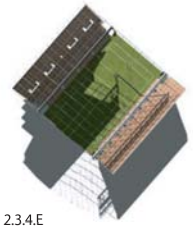


Figure 2.3.4.E
North-South Orientation at 12-noon

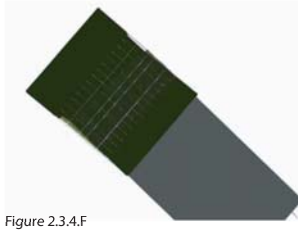


*Figure 2.3.4.F*
North-South Orientation at 3pm

- The design shall achieve regulatory standards of the NZBC through alternative accepted solutions (The Green Guide and Football Safety Advisory Design Council Guides as well as a Fire Engineered solution in relation to access and egress under normal and emergency conditions.
- A variety of hospitality spaces have been designed to be available to members, sponsors, public and corporate patrons including dining, lounges and bars in the new stand. The exact configuration and extent of these spaces will be determined by the Business Plan developed by the Client and will be developed further in the next stages of the design development.
- Both the external and internal concourses shall facilitate continuous circulation around the South stand and allow for future expansion around the Stadium to the appropriate entry/ exits. During match day events the CST members and ORFU members' areas of the ground are accessible only to those members.

Seating Bowl

Orientation

The field of play is orientated on an east – west axis which has been determined by the site constraints. This orientation, whilst not following the normal standard orientation for a professional rugby field (ref: Stadia – A Design Guide) is in keeping with other New Zealand grounds (Eden Park, Carisbrook). The traditional orientation was focused on the development of professional sport in the early 20th Century in the days before television when live sports matches were played on a winters Saturday afternoon. The traditional north south orientation ensured that no team had an unfair advantage by playing into the setting sun.

In the modern era of televised sports this issue is less of a consideration with the majority of games now played at night to suit television audiences as well as the development of stands on all sides of a sports field reducing the impact of the setting sun.

The consultant team have established that an east-west orientation is the preferred orientation based on the site constraints, shading on the field of play and required maximum capacity. It was necessary to test the principles established in the design objectives against different orientations.

East-West Bowl Orientation

In this option, which follows the masterplan and feasibility proposal, aligned with the River Leith the North Stand is significantly lower than the South Stand, which allows greater sunlight to get to the field of play. Based on sun path studies progressed by the consultant team the perceived shadow on and across the pitch in the east-west oriented bowl option was approximately in the order of an average 30% average coverage over the whole day (during 21st June). The design of the envelope has progressed and been informed by these studies. Refer to Fig 2.3.4.A and 2.3.4.B.

The orientation of the site, being East-West also facilitates the areas to locate the large (approximately 35m in depth) temporary and standing seating tiers as well as the 5,000 temporary standing tier at the other end when developing the east-west oriented bowl. Refer to Fig 2.3.4.C.

North-South Bowl Orientation

In assessing this orientation it became apparent that this would become a two stand option, with very little room for the flexibility required by the client, being a base case 20,000 capacity with the ability to increase to 30,000. This is due to the fact that on a north-south orientation the East and West Stands straddle the entire site. Refer to Fig 2.3.4.D

As the stands end up being significantly more massive, with the 30,000 capacity evenly distributed between them the shadow on the field of play was assessed at nearly 50% average coverage over the whole day (during 21st June). Refer to Fig 2.3.4.E and 2.3.4.F.

The shadows across the field of play for the options appear to be non-contentious with the NZRFU when consulted, but they need to be assessed against the relevant television production company requirements. This consultation is currently underway with the broadcast stakeholders. The shadows across the field of play need further assessment with regards the type of support structure and its impact with regards the weight and complexity of shadow produced; the varying of the translucency of the ETFE pillows and the possible impact on the turf growth; and the use of operable mitigating mechanisms such as the inclusion of strategically located blinds, such as at Allianz Arena in Munich (Refer to Fig 2.3.4g) or triple layer ETFE pillows which enable to the operator to modify the transparency of the pillow and would also aid the internal conditioning of the seating bowl.

Sightline Standards and Proximity

The design of the seating bowl places all patrons as close as possible to the field of play side lines and end areas whilst maintaining the minimum safety distances as prescribed by the relevant rectangular sports codes – refer also to sect 2.3.6 Stadium Uses. In addition the majority of patrons are located within 90m of the centre spot of the field, making the proposed stadium one of the most intimate in New Zealand.

The seating bowl is designed around the most onerous viewing criteria of potential events in the stadium, this being rugby due to the nature of the game and the importance of being able to have an unrestricted view of the sidelines and try line. The design adopts a sectional profile based on a parabolic curve responding to the optimum sightline calculations. The focal point utilised for the sightlines corresponds to the near side line of the South and North Stands and the dead ball line where the try zone is 10m deep to the proposed East and West Stands. When compared to Eden Park and Westpac Stadium in Wellington, this provides better sightlines (Refer to Fig 2.3.4.H). The new seating tiers adopt a minimum sightline criteria of c60 value to the focal point previously mentioned. The term 'c60' refers to a dimension of 60mm above the eye level of a person seated one row in front of any spectator.

Figure 2.3.4.G
Allianz Arena Operable Blinds

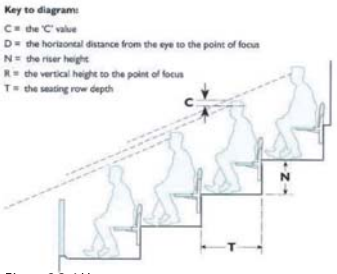



Figure 2.3.4.H
Sightline Diagram

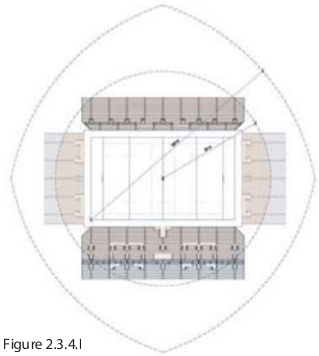


Figure 2.3.4.I
Viewing Cone Diagram

All new permanent seats are within 190m of the corner flag viewing arcs with a majority of the premium viewing seats within 90m radius of the centre of the field (Refer to Fig 2.3.4.I). These viewing criteria are established for rugby based on the size of the ball used in the sport and are in keeping with international standards for large stadia. A high ball viewing criteria of 18m at the centre of the ground has also been adopted.

The cantilevered upper tier of the new stand reinforces the amphitheatre of the stadium while bringing the patrons on the upper tiers as close as possible to the action. A maximum rake of 32 degrees has been utilised to the upper tier to further enhance the sightline quality of these seats, making patrons feel 'on top of the action'.

The corporate box seating at the top of the lower tier allows for a c90 sightline value and an elevated position to enhance their viewing pleasure. The media lounge and viewing positions are also established on the box level.

The middle lower tier arrangement of seating for the lounges and OCR's will be thoroughly investigated in the preliminary design stage to ensure that these seats are optimised with the hospitality spaces housed behind them.

The ground bearing lower tier in the North Stand is designed to facilitate modification from a seating tier to a standing tier by way of an additional 400mm wide step being added to subdivide the width and height between the seating bleachers. This will accommodate approximately 1600 seats and approximately 3000 standing capacity if required (Refer to Figs 2.3.4.J and 2.3.4.K).

As part of the concept the design team have allowed for the inclusion of temporary seating and standing to the West and East to take the capacity from the base of 20,000 to 30,000 for category B status tests or provincial Lions tour matches.

The north stand is made up of a small ground bearing tier and a large suspended tier, which provides for a 2m viewing and ventilation opening so that when one is on the concourse one can clearly see the field of play.

The east stand is a permanent standing tier bearing on the ground in front and supported on columns at the rear.

Spectators should have a clear, unobstructed view of the whole pitch or area of activity. However it is recognised that guardrails and barriers which meet safety code height requirements may obstruct sightlines. Therefore careful consideration will be given to the design and construction of barriers forming part of the seating deck in order to try and minimise seats affected by these obstructions.

An important aspect in the experience of attending live events at the stadium will be the quality of the video replay board and its location. The design currently proposes to locate the video board and build a structure that houses the associated facilities in the south-west and north-east corners of the stadium. The location will be defined during the preliminary design stage. Specific imaging or data requirements of the client/potential sponsor need to be provided and assessed in the preliminary design stage of the project. While two video boards could be provided, only one has been provided for in the current cost plan.

Composition

The stadium massing is defined by the site constraints, the seating bowl requirements and minimum clearances above the playing field. The seating bowl is organised into four stands: the north, south, east stands having a permanent seating capacity for 20,000 people: the west stand having temporary seating for 5,000. and the east providing for 5,000 standing. The playing field is orientated on a south east-north west axis in keeping with other New Zealand grounds (Eden Park, Carisbrook and the AMI Stadium). Unlike any other stadia in New Zealand a transparent roof over the entire playing field is provided, making this an all weather facility suitable for a broad range of large scale events. Stadium facilities such as changing rooms, corporate facilities, lounges and the like are contained within the larger south stand structure.

The north and south stands and the playing field are all enclosed within a single architectural form that sits against the harbour, the park and the quarry. This mass is broken down by the transparent ETFE pillow veil that forms a 'wrap' enveloping the various functional requirements of the stadium, blurring the boundaries between solid building and the environment from the north, east and western sides. The use of the transparent pillows reduces the apparent size and bulk of the building mass in relation to the surrounding residential / light industrial neighbourhoods

The dominant southern stand rises with an inclined, overhanging façade above the Water of Leith facing the city centre, providing a termination of the eastern view corridor from the city towards the quarry. The north stand also incorporates an inclined, overhanging façade rising over Logan Park. This façade, however, is transparent and provides a veil for the stadium when viewed from the sensitive setting of Logan Park. The structure will only be visible behind the ETFE envelope line on the north elevation and hidden entirely by the strategically perforated profiled metal cladding on the southern elevation. The cladding on all elevations of the stadium follows the structural lines and accentuates the honest structural language.

The massing of the south stand from an internal pitch side point of view is defined by the strong stepped form of the two seating tiers enclosing the field in a classic amphitheatre format along the south side with further enhancement by the lowering of the north stand. The East and West stands flank both ends to complete the stadium enclosure on all sides of the pitch. The roof increases this sense of pressure and intensity as it sweeps down from the high point over the south stand to the low point over the north stand. This intensifies the view from the south stand on the field of play as all the structural and architectural elements fall towards the north side. The east and west stands have presented to them the game and atmosphere as though through a proscenium arch.

Figure 2.3.4.J Seating Configuration

Figure 2.3.4.K Standing Configuration

ETFE Cladding Profiled Aluminium ETFE Cladding

Figure 2.3.4.L
Material palette
Refer to section 3 for elevational details

Architectural Character

The architectural character of the proposed multi-purpose stadium is inspired by both the local culture and its physical context, referencing the industrial and nautical heritage of the City as well as the region's Maori and Scottish forefathers. Set against the harbour and the surrounding hills the large angled roof form is the defining moment of the architecture. Exterior materials are in harmony with the surrounding landscape: they generally are naturally finished, sourced locally and relate to local building traditions. The highlight is the dramatic semi-transparent ETFE roof and cladding that encloses a significant part of the main stadium.

The façade and roof float over the stadium and are designed to diffuse scale by being a lightweight counterpoint to the mass of the stands. The façade is designed to be translucent which will mitigate the scale of the stands along the northern side and create the impression from a distance of the façade merging with the sky. The veil allows the building to take on a chameleon character with the skin responding to the changing moods of the day and night. During the day the translucent façade will shimmer in the changing environment from dawn to dusk with the sky contrast subtly altering the appearance of the façade. The daytime view would allow glimpses of the activity within yet provide a veil to the mass and bulk of the building.

The adoption of the transparent veil surrounding three sides of the stadium and the roof has been developed to soften the building mass and provide a screening device to the facility that can provide security yet allow natural daylight to penetrate the majority of the pitch. The hovering ETFE pillows create an ethereal quality counterpointing the metal shroud which envelopes the south stand.

Along the outside elevation of the south and east stand the envelope is proposed to be a sleek profiled metal cladding sliced and perforated. In the case of the south stand this allows for views and ventilation in and out from the functional areas within. Vertical cores containing stairs and service areas contrast with the open lounges behind the perforated metal cladding, creating subtle changes in the apparent massing and articulation of the building.

Key differences between the Master Plan and Feasibility Stage and the Concept Design Stage as they relate to the Stadium are:

- Under the MP + F Design the clear height over the field to the lowest structural element was 25m at the northern touchline. This has been raised to 30m following assessment by independent assessors.
- Under the MP + F Design there were proposed 4 no. stairs in the south stand, which were traditional stairs on a north south orientation angled to follow the angle of the southern facade. Under the Concept Design it is proposed that the stairs should now be scissor stairs on an east west orientation, which create vertical circulation that puncture the southern elevation.
- Under the MP + F Design there was proposed 2 no. stairs and 2 no. lifts at the west and east ends of the south stand, which provided access from the adjacent west and east stands and created a 360 degree access route within the stadium. Under the concept design these have been removed and access around the stand is proposed to be external between the stands.
- Under the MP + F Design the west and east stands were proposed to be fully integrated with University and Unipol facilities. Under Concept Design these are now stand alone elements, therefore require 3 sides of cladding and a roof each stand.
- Under the MP + F Design it was proposed that the temporary seating (5000 capacity) would be located in the east stand and that permanent standing/seating (approx. 5000 capacity) would be located in the west stand. Under Concept Design currently, this has been reversed as an option so that the temporary capacity is now located in the west stand and standing in the east.
- Under the MP + F Design there was no standing provisions in the North Stand. Under Concept Design it is proposed that temporary standing can be located in the lower tier of the north stand, but that the plats should be configured in such a way as to be easlity converted to seating if necessary and vice versa.
- Under the MP + F Design three team/officials vomitories to the pitch were proposed. Under Concept Design this was reduced to 1.
- Under the MP + F Design 2no. maintenance access routes were proposed through the south stand at the east and west ends. Under Concept Design 4 access routes are proposed through the east and west stands.
- Under MP + F Design a single roof option was proposed, being a lens truss spanning over the north stand, south stand and field of play. Under Concept Design 3 options were included, being option1: the MP + F scheme, option 1A: a lens truss over the field supported by primary trusses running east-west and roofs over the north and south stands, and option 2B: a tied arch truss at 20m centres over the field of play supported as in option 1A above.
- GFA of the stadium reduced overall from MP + F Design to the Concept Design, especially with the removal of the internal circulation routes between the stands and also the university facilities to the west.
- Under MP + F Design access from all floors with the university and commercial facilities at the east and west of the south stand was proposed. Under Concept Design this was no longer required and was removed.
- Under MP + F Design office space at level 02 of the north stand and access to it with lobby was proposed for the ORFU and AoS. Under Concept Design this has been re-configured.
- Under MP + F Design access locations into stadium were to the west and east and south east through the University Facility to

Figure 2.3.4.M
Suncorp Stadium GA concourse

the west and the east stand and adjacent to the Leith. Under Concept Design the access points are through a fenceline at the NE, SE, NW and SW corners.

- Under MP + F Design pedestrian bridges across Leith were proposed. Under Concept Design these were removed.

### 2.3.5 Standards

Key aspects of the design to create a world class venue have been adopted from the above documents and based on the international experience of HOK Sport Architecture. These have established the following key design parameters:

The sightline from the eye level of every spectator shall not be inferior to the following criteria as defined below. The eye level at each spectator is defined as a point 1200mm above the floor level and 150mm forward of the rear of each seating plat, centred on the seat location.

– Minimum 'C' value to be 60mm.

– All sightline 'C' values listed for pitch sports are to be calculated from the focus point which is to be as a minimum the nearest point of the touchline at pitch level for rugby union and half way between the dead ball line and try line for seats behind the goal line.

The 'high ball' line shall be 18m at the centre of the field and behind the goals.

The seating bowl and standing terraces shall be designed in accordance with the recommendations of the "Green Guide" with 28 seats located between aisles and 14 seats located in a row where served by a single aisle.

All seats and standing terraces shall be within a viewing arc of 190m from the opposite corner flag from where viewed.

Disabled provision shall be based on the following:

0.25% of capacity for wheelchair positions

0.25% of capacity for enhanced amenity seats

Standards References

"Stadia: A Design and Development Guide" by Geraint John and Rod Sheard.

"Guide to Safety at Sports Grounds (the Green Guide)". Fourth edition – 1997.

NZRU Minimum Test Rugby Facility Requirements (as advised February 2007)

New Zealand Building Code (NZBC).

Australian / New Zealand Standard AS1428.1 and AS1428.2.

FIFA / UEFA Construction of Football Stadia – 1995.

"Toilet Facilities at Stadia – Planning, design and types of Installations" published by the Football Stadia Development Committee (FSADC) – 1993

Further detail for standards is provided in the Facilities Brief appended to this report

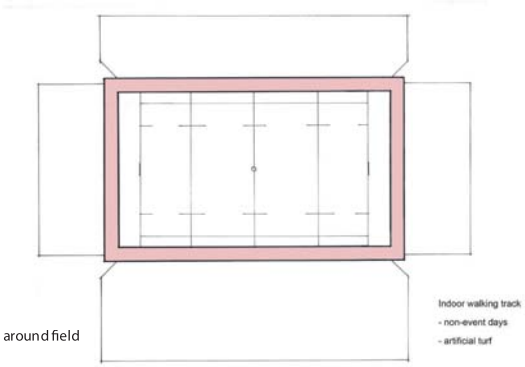



Fig 2.3.6.A
Safety Zone around field of play

## 2.3.6 Stadium Uses

The concept proposal is for a multi-purpose stadium and allows for a level of flexibility in how this stadium is used. This flexibility and multi-purpose scope includes:

In the South Stand the re-use of the corporate boxes, as breakout spaces for conferences, tutorial spaces for the University etc. The use of the dining lounges as conference facilities and seminar rooms was also in the initial design and this flexibility is retained into concept design.

In the West Stand (or East Stand depending on CST requirements) the removal of temporary seating and the re-use of this area as an exhibition or small concert venue. More intimate sporting events could be held, where only one court is required for a show match or international. This space could also be utilised by the university as an overflow gym or recreational space.

As part of the further studies into the multi-purpose activities within a covered/enclosed stadium the consultants looked at a number of sporting and leisure events that could be held within the bowl, being activities such as concerts where the stage is at the East or West end, at the North side or in the middle similar to the flexibility afforded within a covered stadium environment. Potentially basketball, netball and tennis competitions could be held in the stadium, but this would definitely require a palletised pitch, as the governing codes for these sports require a level playing field unachievable if the sports surface were laid directly on the turf pitch. The different sports surfaces could also damage the turf, dependant on the length of time the turf is covered. .

Listed below is a selection of possible sporting and entertainment events that could be held within a multi-purpose venue of this type. This list would need further verification through consultation with the operator and specialist consultants (such as the fire engineer) etc.

The following activities can occur on a natural turf playing field.

- International Rugby Tests
- Rugby Super 14
- NPC
- Regional rugby and soccer matches.
- Local School and Community Rugby and Soccer Finals
- All Weather elite sports training for national and professional teams.
- Concerts and major entertainment events such as Edinburgh Tattoo or Pipe Band Championships (with appropriate protection of the playing surface)
- Corporate Games.
- Indoor / Outdoor Cinema.
- Children's play area
- Extreme Games (Skateboarding, BMX etc)
- Equestrian Event
- International Polo Championships

Should the field of play be designed over a concrete tray with a palletised surface, additional activities could occur within the playing area. These could include the following:

- 11,000m2 exhibition hall
- Tennis
- Motor Cross
- Swimming
- Long Course Speed Skating
- Film Studio

Should the safety zone around the field of play be designed as an area of artificial turf for shading and maintenance (allowing vehicles to turn around off the natural grass playing area) reasons then potentially this area can be used as follows:

- Public walking track around the field of play within the safety zone. This use is dependant on the venue operator management and security strategy.
- A straight running track for the Academy of Sport or similar elite training centre within the northern safety zone.

Sketches indicating some of the multi-purpose possibilities within the new multi-purpose stadium bowl are contained in Section 3 (Architectural Drawings) Drawing No. ASK-122.

The ability to utilise as much of the building for non event day usage is an important part of generating income for the stadium. Non event day use will further enforce its presence within the city and region as a community asset exceeding that of simply a sporting venue.

When considering the flexibility of a space for alternative uses, it is important to firstly define what the prime use is, and then secondary and tertiary uses are. Identifying these uses will provide clarity when developing the design intent, as not all uses are compatible. The pursuit for total flexibility can mean that the facility itself does no one thing well.

Flexibility on a space will have an impact on the following attributes of the space:

- Additional requirements to support non event day usage
- Audio visual requirements.
- Brown out for conferencing.
- Column free space- conferencing.

Building services

Ability to zone air conditioning and power to particular areas in use.

Mechanical and fire systems which are designed to work within a subdivided room.

Additional services points located throughout the room- power/ voice/ data boxes in the floor and ceiling.

- Operation
- Closing off and securing discreet parts of the building
- Being able to service the function/ functions from the existing services
- Impact on the event schedule and turn- around times
- Furniture storage
- Signage
- Access from the kitchens to multiple function spaces.
- Access for guests from the central lobby on level 3 to multiple function spaces.
- Access to toilet facilities from multiple function spaces.

Whilst there is no doubt that it is critical that flexibility and opportunity be realised, these requirements should not impact on the core business or reduce the potential value of a given product.

Although it has been proposed that level 3 be left as one large shell space (refer fig 2.3.6.B). It will be sub divided into two 500 person corporate lounges, a premium lounge and the Founders Suite, located over the centre line (refer fig 2.3.6.C). Further separation of these spaces could be achieved through retractable walls or screens.

Retractable wall built into the base design. These are effective at providing a good level of physical and acoustic separation. They are however fixed in their location and expensive.

Screens which can be positioned anywhere. These are light weight and relatively inexpensive. However, they provide minimal acoustic separation and whilst they provide some form of physical segregation, the perception of temporary screens will diminish the overall ambience of the space. This would be of particular concern in the Founders Suite. Further research would be recommended to establish what, if any, impact this might have on potential revenue generation.

When considering the proposed uses for the space, they all fit within the existing main breakdown of spaces- two 500 person lounges, one 120 person lounge and the pre function space (refer fig 2.3.6.C). The only space which will require further consideration is the 225 person conference configuration. Whilst it easily fits within the space, the issue is the lack of column free space and sight lines to the speaker. Further investigation and a more detailed layout is required to ascertain what the maximum capacity for conferencing in this space is.

The existing break down of spaces on the floor lends itself well to non event day clients who may wish to host a medium to large scale event where multiple conferencing (500 person being the primary conference space, the Founders Suite a plenary facility) and then dining in the second 500 person lounge, with the pre function acting as the meet and greet area. The provision and location of the support facilities- kitchens, toilets and access to the floor, are all located well for this type of set up. From our visit to Waikato, a similar set up appeared to be in operation, although they did not have the facility for the smaller plenary conference space.

HOK sport and Jasmax will continue to develop the opportunities for level 3 and look forward to discussing in greater detail the operability of level 3.

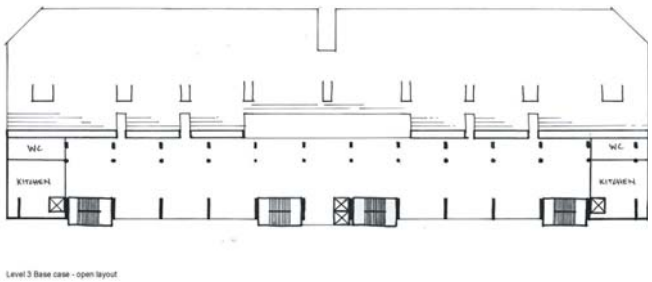



Fig 2.3.6.B – Level 3
open plan function space mode (indicative)

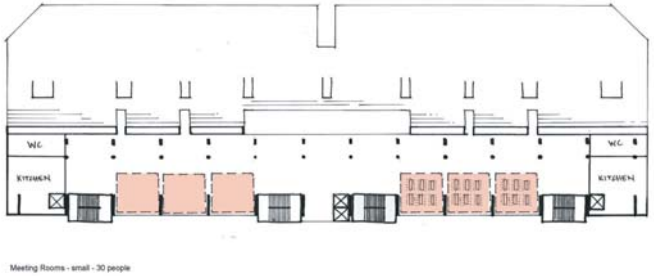



Fig 2.3.6.E – Level 3
30 person meeting space mode (indicative)

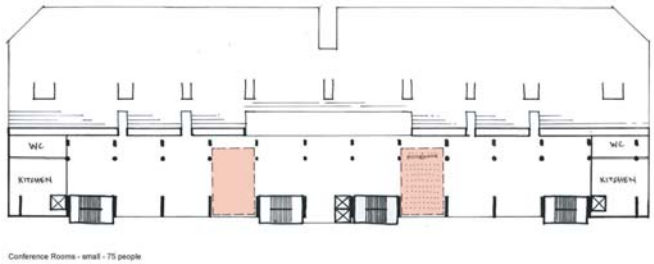



Fig 2.3.6.H– Level 3
75 person conference space mode (indicative)

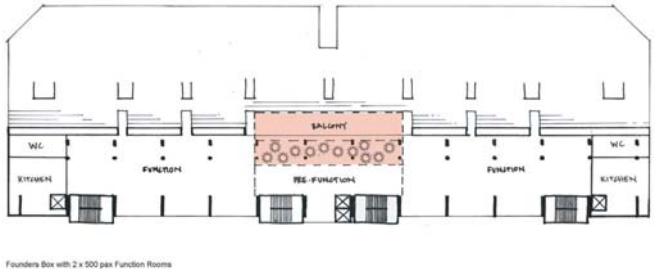



Fig 2.3.6.C – Level 3
Founders Box and 2 x 500 person function spaces mode (indicative)

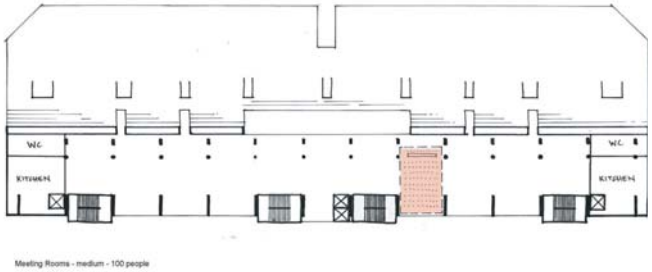



Fig 2.3.6.F –Level 3
100 person meeting space mode (indicative)

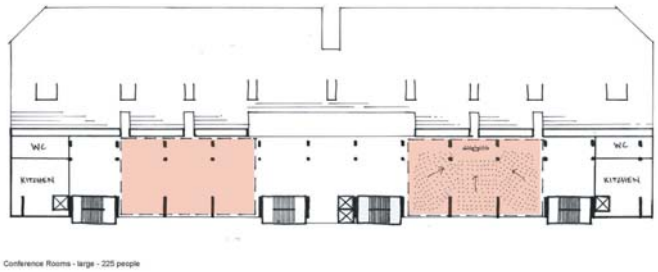



Fig 2.3.6.I – Level 3
180 - 225 person conference space mode (indicative)

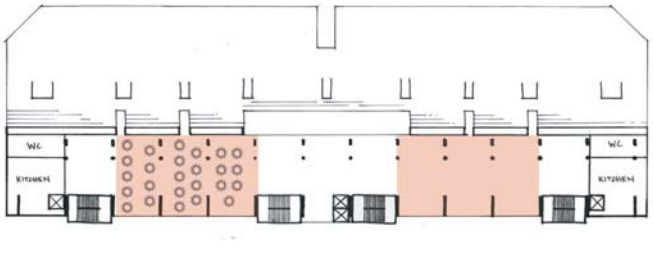



Fig 2.3.6.D – Level 3
250 person function spaces mode (indicative)


Fig 2.3.6.G –Level 3
150 person meeting space mode (indicative)

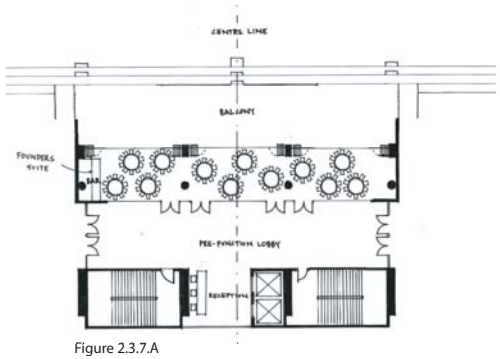



Figure 2.3.7.A

Founders Suite Indicative Layout for 120 person capacity

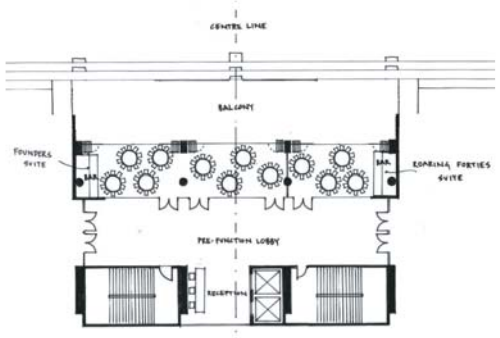



Figure 2.3.7.B

Founders Suite Indicative Layout for 70 person capacity

and Inclusion of the Roaring Forties Club Room

Figure 2.3.7.C

View from lounge in Suncorp Stadium

## 2.3.7 Functional Requirements

The functional requirements of the stadium have been set out, however it should be noted that no formal stakeholder workshops have been held with the design team, and therefore the facilities outlined are based on benchmarking other similar facilities, and that these are likely to change following stakeholder consultation.

Below are set out a level by level description of the facilities allowed for within the stadium at concept design.

LEVEL 1 (refer to ASK 101 in section 3 for drawn information)

This level exists in all stands. The level 1 accommodation provides concourse access from the lower tier in the North Stand to all the permanent toilets and areas for the temporary food and beverage concessions, merchandising outlets and satellite first aid stations. The stadium precinct is proposed to be dictated by the location of a fenceline, which will be relocatable when required for larger events. This is demonstrated in the masterplan section, which defines the location of the extended precinct. Level 1 in the South stand accommodates access stairs to all the levels in the South stand, the corporate, media and team entrance, security staff, catering staff and venue management, Also accommodated at level 1 in the South Stand is the main production kitchen, three changing areas (one home, one away and one auxiliary), a players lounge, media facilities, groundsman's offices, workshops and stores and plant areas.

The teams have direct access to the pitch via a centrally located vomitory, with interchange benches either side of it at pitch side. The facilities, as mentioned above, are divided into home and away changing rooms, team warm up facilities, medical facilities and entertainers changing rooms (included in the auxillary changing area). The two main team changing rooms are incorporated into the planning, each designed to accommodate 30 players and team officials. Access to the coaches boxes on level 4 is provided from each of the changing rooms.

The main production kitchen and commissary facilities are located so as to have direct access to the loading bay and waste storage area at the East end of the South Stand and to the shared service road at the South of the South Stand, running parallel to the Water of Leith. Catering staff offices are located adjacent to the kitchen facilities. Bulk goods stores are located adjacent to the loading dock and off the internal service route for ease of distribution.

An internal 4m wide route is provided at level 1 between the team changing areas and the main production kitchen, with secure access at each end of the South Stand. This is provided for ambulance access, VVIP secure drop off and pick up and also the transportation of goods and authorised people.

LEVEL 2 (refer to ASK 102 in section 3 for drawn information)

This level exists only in the South Stand. The level 2 accommodation provides direct access to the lower tier of seating via vomitories and forms the enclosed concourse for patrons on this level. The level 2 concourse provides access to food and beverage concessions, merchandise stalls, toilets, satellite first aid post and internal stairs and lifts providing access to the level 5 concourse and level 1 (being ground level). This level also accommodates the second corporate entrance lobby, centrally located it will be formed from a glazed screen off the concourse. The accommodation at this level is fully screened by the profiled metal cladding, although the level of perforation and openings have yet to be fully worked through and will be further progressed in preliminary design. All public concourses are envisaged to be naturally ventilated and therefore the screening needs to be further assessed with regards to this fact.

LEVEL 3 (refer to ASK 103 in section 3 for drawn information)

This level exists only in the South Stand. The level 3 accommodation provides 1no. 120 person founders box (Refer to Fig 2.3.7.A), located straddling the centre line, with direct access and views to the field of play and the pre-function lobby. The founders' box is proposed to include a bar. The box will be catered by the finishing kitchens in the dining lounges. It is also proposed that this box can be subdivided to accommodate the recently tabled Roaring Forties Club (Refer to Fig 2.3 7.B). This will impact on the 120 person capacity, but this will be further developed in preliminary design following continued client instruction and stakeholder consultation.

Either side of the pre-function lobby are proposed two 500 person dining lounges, each served by their own finishing kitchens and toilets (Refer to Fig 2.3.7.D). A bar may be set up within these spaces as well. These lounges have direct access to a dedicated area of seating in the upper section of the lower tier through glazed vomitories. Storage for tables and chairs is also located on this floor, and is supplemented with storage areas at level 1. This level is fully enclosed and conditioned similar to level 4. It is served by stairs and lifts with direct access to level 1 and 2 entrance lobbies.

Level 4 (refer to ASK 104 in section 3 for drawn information)

This level exists only in the South Stand. The level 4 accommodation provides 18no. corporate boxes that can accommodate between 18-24 persons each (Refer to Fig 2.3.7.F), 1no. 48 person hirers' box and an additional lounge area at the east end of this level. Each of the boxes includes a sink, countertop, fridge and storage. The media (Refer to Fig 2.3.7.G) and coaches facilities are also accommodated on this level, as is the security command post. This level is served by two pantry kitchens and communal toilets. The circulation corridor serving this level overlooks the dining lounge level below where a double height space is provided to accentuate the dining lounges, as well as giving a visual connection between the two corporate levels. These are the premium levels and they are proposed to feel that way. This level is fully enclosed and conditioned to protect the furnishings and provide a more controlled environment. It is served by stairs and lifts with direct access to level 1 and 2 entrance lobbies.

Level 5 (refer to ASK 105 in section 3 for drawn information)

This level exists only in the South Stand. The level 5 accommodation provides direct access to the upper tier of seating and forms the enclosed concourse for patrons on this level. The level 5 concourse provides access to food and beverage concessions, merchandise stalls, toilets, satellite

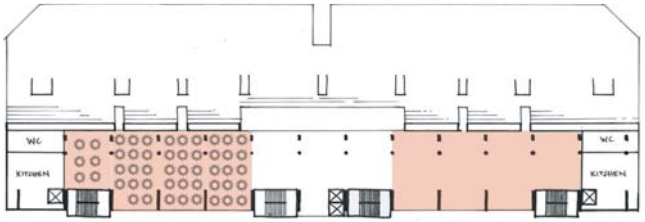



Figure 2.3.7.D

Dining Lounge Indicative Setting Out for 500 Capacity

Figure 2.3.7.E

Image of Dining Lounge at Suncorp Stadium

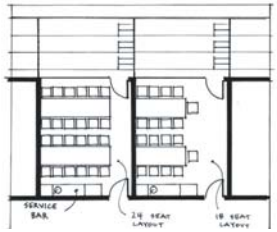



Figure 2.3.7.F

Corporate Suite Indicative Layouts for 18 person and 24 person capacity.

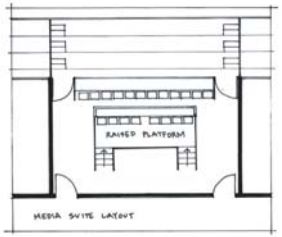



Figure 2.3.7.G

Media Suit Indicative Layout

first aid post and internal stairs and lifts providing access to the level 2 concourse and level 1 (being ground level). The accommodation at this level is fully screened by the profiled metal cladding, although the level of perforation and openings have yet to be fully worked through. All public concourses are envisaged to be naturally ventilated and therefore the screening needs to be further assessed with regards to this fact.

Roof (refer to ASK 106 in section 3 for drawn information)

The principles behind the roof height, angle and massing has been discussed earlier in this report. Two options have been developed being:

1) The envelope plane is over the supporting structure giving a clean external line devoid of structural penetrations, which is considered to be better for watertightness of the envelope. His option also closely follows the masterplan and feasibility aesthetic.

2) The ETFE envelope is supported beneath exposed structural arches, which potentially creates a more complex waterproofing detail and does not as closely follow the masterplan and feasibility structural aesthetic.

The main roof covers the North and South stands and the field of play and two smaller roofs cover the east and west stand areas. The roofing material over the South stand is proposed to be profiled metal sheeting, which presently extends from the Southern roof edge to the fifth row back from the pitch edge. It is proposed that the drainage will be hidden and that the roof edge is sharp. The material over the field of play and also the North stand is proposed to be ETFE pillows of between 5m-10m in width and 90m-120m long. The use of ETFE pillows or a similar approved system is considered necessary to allow for the maximum level of UV penetration through an envelope to theturf. More detail is provided in section 2.3.11

The sports lighting and speakers are located under the roof within the depth of the primary trusses with the lights at a minimum of 28m above the field of play, outside the 30m clear playing zone, with an angle of no less than 70 degrees to the far side of the field of play. The lights and the speakers will be accessed for maintenance via a gangway integral to the primary trusses. With the lights located within the stadium roof envelope and not on towers it will reduce light spill to neighbouring areas. As mentioned earlier, the material for the roof over the field of play and the Northern stand is proposed as ETFE pillows or similar. As a material, ETFE is considered to be acoustically transparent, providing negligible noise reduction. As a result, this will need to be allowed for when considering any noise restrictions imposed via the Plan Change.

Whilst the mechanical concept design has only just commenced, , the aim is to naturally ventilate the envelope, as opposed to mechanical ventilation. Therefore, it is anticipated that the roof envelope will also include environmental louvres to vent the built-up warm air at the roof level and also aid ventilation at bowl and pitch level by dragging the air entering at low level through the bowl space and across the grass sward. Air movement across the living grass is fundamental to pitch health and spectator comfort and requires further design input from the specialist pitch consultant, CFD testing, and concept design input from the mechanical engineers.

Sports and architectural lighting

The design of the new stands incorporates all sports lighting in the stadium under the roof plane on the North and South side of the pitch. A walkway under the roof provides access to the lights and auxiliary services.

The development of the profiled façade pillow veil and the profiled metal cladding allows event based architectural lighting and projection to be used on the façade on event days. This lighting would create event based experiences for the building utilising sequenced neon lighting, wash lighting to the walls behind the veil and projection onto the façade to create an artistic graphic on the façade. It should be noted that this system is designed only to operate on event days and as such would only occur at times when the sports lighting is used. The level of luminance required to achieve these effects is relatively low and will not cause additional light spill to the surrounding neighbourhoods; however this should be assessed within the Plan Change criteria.

Acoustics

The design of the new stands effectively encloses the activity zones, however ETFE pillows are to all intense and purposes acoustically transparent. This effect is being further assessed in terms of sound out of and sound into the facility. The location and type of public address speakers will need to be considered by a specialist consultant, however they should be facing into the spectator stands, therefore reducing the extent of the crowd and PA noise spill into the surrounding neighbourhood.

Fig 2.3.8.A
Eden Park Stadium, NZ

Fig 2.3.8.B Skilled Park, Australia
Heavy shadow to light zones can cause lens flare in transition.

Fig 2.3.8.C Westpactrust Stadium,NZ
Heavy shadow to light zones can cause lens flare in transition.

## 2.3.8 Benchmarking

The facilities have been initially developed based on the experience of HOK Sport Architecture in the development of various similar sized stadia they have completed in New Zealand, Australia and the UK. Particular reference in terms of functional and quality requirements associated with the stadium has been benchmarked against the following venues:

Eden Park South Stand, Auckland, New Zealand (refer to Fig. 2.3.8.A)

Skilled Park, Gold Coast, Australia (refer to Fig. 2.3.8.B)

Westpac Stadium, Wellington, New Zealand (refer to Fig. 2.3.8.C)

A key feature of the proposed stadium in Dunedin is the incorporation of a roof over the natural grass playing surface as well as the stands. This has resulted in specific brief requirements that define the height of the building as well as the structure, cladding and mechanical ventilation of the facility. In establishing the appropriate height of the roof enclosure over the playing field the following venues have been evaluated (refer to Fig 2.3.8.I):

Telstra Dome, Melbourne

Commerzbank Arena, Frankfurt, Germany

Millennium Stadium, Cardiff, Wales

Reliant Stadium, USA

Benchmarking of the proposed field orientation in New Zealand has been undertaken with the following findings:

| | |
|---|---|
| Palmerston North | SW-NE orientation |
| Westpac Stadium | N-S orientation |
| Hamilton Park | N-S orientation |
| AMI Stadium | N-S orientation |
| Ericsson Stadium | N-S orientation |
| Eden Park | E-W orientation |
| Carisbrook Stadium | NW-SE orientation |

The roof structure over the field of play casts shadows across the field of play with varying degrees of complexity and intensity dependant on the different support options being developed at this stage. Therefore it was felt prudent to carry out a desktop benchmark analysis of shadows on the pitches during game time at other stadia. In establishing benchmarking by which we can make an informed assessment of the potential impact of the shadows on the field of play at the new multi-purpose stadium the following venues have been evaluated:

Westpac Stadium, Wellington, New Zealand, (refer to Fig 2.3.8.C)

Commerzbank Arena, Frankfurt, Germany (refer to Fig 2.3.8.D)

Allianz Arena, Munich, Germany (refer to Fig 2.3.8.E)

Millennium Stadium, Cardiff, Wales (refer to Fig 2.3.8.F)

Schalke 04, Germany (refer to Fig 2.3.8.G)

Amsterdam Arena, Amsterdam, Netherlands (refer to Fig 2.3.8.H)

Braga Stadium, Portugal (refer to Fig 2.3.8.I)

Comparative sections were also developed against Westpac Stadium, Wellington, the Paul Kelly Stand, Christchurch and Waikato Stadium, Hamilton as part of the benchmarking exercise. The results can be seen in Section 3.0 (Architectural Drawings), Drawing No: ASK-310-ASK-313.

**Benchmark Heights to lowest structure above the Field of Play Comparisons**

| Space Type | Uses | Height of lowest structure above the field of play |
|---|---|---|
| Cardiff Millenium Stadium Cardiff, Wales | Rugby Union, Rugby League, Soccer, Concerts, Boxing | Approximately 33m |
| Telstra Dome Melbourne, Australia | AFL, Cricket (ODI), Rugby Union, Rugby League, Soccer, Concerts, Motor Cross | Approximately 24m |
| Veltins Arena Gelsenkirchen, Gemany | Soccer, Concerts | Approximately 25m |
| Commerzbank Arena Frankfurt, Germany | Soccer, Concerts | Approximately 25m |
| Reliant Stadium Houston, Texas | American Football, Concerts | Approximately 53m |
| Centre Court Wimbledon, England | Tennis | Approximately 17m |
| The New Stadium Dunedin, New Zealand | Rugby Union, Concerts | Approximately 30m |

Fig 2.3.8.I
Benchmark Heights

Fig 2.3.8.D Commerzbank Arena, DE

light shadows caused by the cables and strong shadows caused by the jumbotron and PTFE roof canopy. Heavy shadow to light zones can cause lens flare in transition.

Fig 2.3.8.E-Allianz Arena, DE

Complicate heavy shadow on the field of play. When blinds are closed then the transition between light and dark greatly increases and can cause lens flare.

Fig 2.3.8.F -Millenium Stadium, UK

Heavy shadow to light zones can cause lens flare in transition.

Fig 2.3.8G -Schalke 04, DE

Complicated heavy structural shadows transition between light and dark.

Fig 2.3.8.H -Amsterdam Arena, NL

Heavy shadow to light zones can cause lens flare in transition.

Fig 2.3.8.I -Braga Stadium, P

Soft, uncomplicated linear shadows on field of play produced by cables over

**Benchmark Comparisons**

| Space Type | Dunedin Stadium<br>Dunedin | Skilled Stadium<br>Gold Coast | Westpac Stadium<br>Wellington | Eden Park South Stand Redevelopment<br>Eden Park |
|---|---|---|---|---|
| Sports / Events | Rugby Union, Soccer, Rugby League, Concerts | Rugby Union, Rugby League, Soccer, Concerts | Rugby Union, Cricket | Rugby Union, Rugby League, Cricket |
| Construction Cost | TBC | NZ $138,000,000 | NZ $ 121,000,000 | |
| Capacity | 30,143<br>including approx.25,079 permanent capacity incl 5,060 standing and 5,064 temporary seats under cover | 25,465 | 34,500 | 22,000 |
| Number of Tiers | 2 in the South and North Stands, 1 in the East & West Stands | 1 with small corp suite tier on West side. | | 3 |
| Building Area (sqm) | tbc | 25,750 | 26,970 | 31,259 |
| Building Footprint (sqm) | tbc | 15,500 | | |
| Site Area (hectares) | 7.6 (incl. development spaces) | 4.8 | | 10.66 |
| Field Format | Rectangular | Rectangular | Oval | Variable (oval / rectangular) |
| Field Size | 132 x 81m | 138 x 83m | | 132m x 80m |
| Retractable Roof | No | No | No | No |
| Fixed Roof | Yes | | | |
| Roof Coverage | 100% with fixed roof over stands and field of play<br>90% with roof over stands only | 70% | 70% | 65% |
| **Spectator Group** | | | | |
| General Admission: | 23,084 | 22,643 | 31,900 | 16,695 |
| Club Seating: | 6,423 | 980 | 2,600 | 4,024 |
| Code Seating: | | n/a | | |
| Corporate Seating: | 480 | 1,360 | | 1,412 |
| Wheelchair Positions | 78 | 178 | 172 | incl. in above capacities |
| Companion Seats | 78 | 178 | 172 | incl. in above capacities |
| EAS | incl. in above capacities | 0 | | incl. in above capacities |
| Press | tbc | 36 | | tbc |
| Players / Officials / Team | tbc | 44 | | tbc |
| Total | 30,143 | 25,465 | 34,500 | 22,131 |
| **Seating Standards** | | | | |
| General Admission | *500 chair x 800 - 825 tread* | *500mm chair x 850mm tread* | *480mm chair* | *490mm chair x 825mm tread (lower and upper tier)* |
| Club Seating | *550mm x 850 mm tread* | *550mm x 900mm tread* | | *525mm chair x 850mm tread* |
| Code Seating | | | | *525mm chair x 850mm tread* |
| Corporate | *600 chair x 900 tread* | *550mm x 900mm tread* | *550mm chair* | *550mm chair x 900mm tread* |
| Written Press | *500m chair* | *550mm x 900mm tread* | *500m chair* | *550mm chair x 900mm tread* |
| Broadcast Commentators | | | | |
| Roof Coverage | 100% | 79% | | |
| **Corporate Facilities** | | | | |
| Suites | *18 x 18-24 capacity suites*<br>*1 x 48 capacity hirer's suite*<br>*1 X 120 capacity Founders Club*<br>*1 x 40 capacity Roaring Forties Club (could reduce capacity of Founders Club) tbc* | *18 x 12 seat suites*<br>*6 x 18 seat suites* | *55 x 16 seat suites (approx.)*<br>*12 x 9 seat suites (approx.)*<br>*1 x 242 seat lounge (approx.)*<br>*1 x 196 seat lounge (approx.)* | *48 x 18-20-seat suites*<br>*2 x 40-seat suites* |
| Total | *20-21* | 24 | | *52* |
| Open Carrel Boxes | *36 x10 person carrels* | *62 x 10 seat boxes*<br>18 x 8 seat boxes<br>*20 x 12 seat boxes* | 0 | *36 x 10-seat boxes* |
| Total | *360* | *100* | | 36 |
| Hospitality / Dining | *2 x 500 seat Function Rooms* | *1 x 500 seat Function Room* | *1 x 1000 seat Function Room*<br>*1 x 380 seat Function Room* | *2 x 350 lounges/restaurant*<br>*1 x 200 dining for OCRs* |
| Total Dining Spaces | *1,000* | *500* | 1,380 | *900* |
| Bars / Lounges | | *North West Member Bar - 400 standing*<br>*Function Room 2(no fit-out) 750 standing* | | *2 x 150 seat club lounge* |
| **Toilets** | | | | |
| Standards Used | FSADC | FSADC/BCA | FSADC | *FSADC* |
| Club/ Corp. | 60:40 male-to-female ratios | 60:40 male-to-female ratios | 50:50 male-to-female ratios | *60:40 male-to-female ratios* |
| Male | | | | |
| Urinals | | | 1:25 ratio | |
| WC's | | | 0-400 1 per 100p, 400+ 1 per 250p | |
| WHB's | | | 1 per wc, 1 per 5 urinals | |
| Female | | | | |
| WC's | | | 0-200 1 per 50p, 200+ 1 per 100p | |
| WHB's | | | 1 per 2 wc | |
| PWD | | | | |
| General Public | 70:30 male-to-female ratios | 70:30 male-to-female ratios | 70:30 male-to-female ratios | *70:30 male-to-female ratios* |
| Male | | | | |
| Female | | | | |
| PWD | | | 1 per 10 wheelchair spaces | |
| **Guest Services** | | | | |
| First Aid | | First Aid - *2 at 15sqm* | | First Aid - *1 at 21 sqm* |
| Customer Service Counter | one counter 'serving' space per 10,000 spectators | 0 | one counter 'serving' space per 10,000 spectators | Customer Service - *2 at 20 sqm each* |
| Creche / Kids | | Creche/Kids Play - *1 at 50 sqm* | | Creche/Kids Play - *no* |
| Mothering Stations | | Mothering Stations - *3 at 6.25 sqm* | | Mothering Stations - *In every PWD toilet* |
| TAB / Betting | | 0 | 1 TAB | Gaming Facilities - *no* |
| Merchandising | 1 permanent shop | ATM machines - *2* | | ATM machines - 1 *at 52 sqm on level 3 + 1 at 35 sqm on level 6* |
| | | Sports Store - *2 at 20 sqm* | | |
| | | 2 sales counters | | |
| | | | 5 permanent merchandising | |
| Food Stands | | | | |
| | | Sales Counters - *16* | | Sales Counters |
| Food Concessions | approx. 5m/1000 spectators | 5.0 m / 1,000 spectators | 12.5m/ 2500 spectators | 4.5 m / 1,000 spectators |
| Bars | approx. 2.5m/1000 spectators | 5.0 m / 1,000 spectators | 6.0m per 2500 spectators | 4.0 m / 1,000 spectators |
| Kitchen | | Kitchen/Commissary: *2,040 sqm* | | Kitchen/Commissary: *1,245 sqm* |
| Main Kitchen / Commissary | 780 sqm | 550sqm | | 1009 |
| Finishing Kitchens | 218 sqm | | | 239 |
| Suite Kitchens | 130 sqm | | | 111 |
| In-suite servery | | | | |
| **Team Facilities** | | | | |
| Home Lockers | 1 at 350 sqm(incl. warm-up, wet areas) | 1 at 350 sqm(incl. warm-up, wet areas) | | 1 at 367 sqm |
| Visitor Locker | 1 at 350 sqm(incl. warm-up, wet areas) | 1 at 350 sqm(incl. warm-up, wet areas) | | 1 at 346 sqm |
| Aux. Lockers | 2 at approx.175 sqm | 2 at 175 sqm | | 2 at 67 sqm each |
| Miscellaneous | Referee - *tbc* | Referee - *1 at 60 sqm* | | Referee - *1 at 57 sqm* |
| Lockers | Star Dressing - *tbc* | Star Dressing - *1 at 18 sqm* | | Star Dressing - *2 at 30 sqm each* |
| | Ballboys - *tbc* | Ballboys - *1 at 20 sqm* | | Ballboys - *1 at 17 sqm each* |
| | Cheerleader - *tbc* | Cheerleader - *1 at 150 sqm* | | Band - *1 at 28 sqm* |
| | Band Room - *tbc* | Band Room - *1 at 32sqm* | | Doping Control - *1 at 27 sqm* |
| Ticket Office | Doping Control - *tbc* | Doping Control - *1 at 25 sqm* | 1 window per 10,000 seats | 1 at 44 sqm |
| | Ticket Windows - tbc | Ticket Windows - 20 | | |
| | Administrative Offices - approx. 230 sqm | Administrative Offices - *180 sqm* | | |

## 2.3.9 Structure

### 2.3.9.1 Stands

The major stands located on the north, south and east faces of the site are to be constructed from reinforced concrete, although a solution with steel framing and concrete floors has been developed for the purpose of cost comparison. The longest stands will be 140 metres in length and a concrete structure of this scale (regardless of whether the primary frames are steel or note) will require specific detailing to overcome the shrinkage in the curing concrete. This can be accommodated either through the provision of movement joints provided midway along the stands or by strategic pour sequences with delayed-pour stitch zones.

Frames are to be located at 10 metre centres to reflect the framing to the roof structure. The frames will provide lateral stability to the structure in this direction through the provision of rigid connections between the beam and column elements. A significant feature of these frames which will dominate frame behaviour to some extent are inclined columns which spring from ground level and extend up to directly support the steel roof structure at the rear of the stands. As is normal for stadium structures the seating plats will be supported on raking beams. The treatment of these beams at each floor level is very dependant on the seismic philosophy adopted. For a ductile structure the raking beams will need a horizontal sliding joint at each level, whereas for an elastic approach the beams can be made continuous. This latter approach will also enhance their dynamic response to crowd excitation. Refer to Section 4.0 Structural Drawings, No. S007 for the concrete frame solution for the south stand.

In the longitudinal direction precast floor units span the 10 metre grid to form the floors to the concourses and the functional areas. The precast units are to be prestressed hollowcore units which have an insitu concrete topping applied to the top face to form diaphragms which assist in the transfer of lateral loads back to the lateral load resisting elements. Where the precast units bear onto the concrete frames the intersection will be detailed as to induce controlled cracks in the topping concrete to further alleviate shrinkage forces. Refer to Typical Beam/precast Floor Drawing, Section 4.0 Structurla Drawings, No. S008.

Similarly precast concrete seating units are to be employed in the upper face of the stands to support spectator seating. These will be designed to be of adequate mass and stiffness to avoid detrimental dynamic effects arising from crowd loading and excitation.

Lateral stability is provided in this longitudinal direction by the provision of braced bays in between the major inclined columns. The bracing will be formed from structural steelwork arranged as either cross or K bracing. It is expected that 4 bays of bracing will be required. These will be coordinated in both location and form to provide the required architectural aesthetic and to also ensure that the distribution of loads to the foundations is uniform. Careful consideration of the effects of differential settlement wil be required.

It must be noted that where prestressed roof forms have been considered the application of lateral loads to the stands structures significantly increase the demand and hence size of the structural elements. The most pronounced element is that of the rear raking columns which are 50% larger in prestressed roof options. In addition, for the south stand, a large diagonal strut is required to transfer horizontal prestressing loads from the roof to the foundations without overloading the frame system or causing excessive deflections.

With the prestressed roof option, it is likely that design of the transverse frame system will be governed by the prestressing loads, resulting in a relatively stiff structure. If seismic loading does not govern design there will be limited opportunity to introduce ductility into the system, and member sizes will subsequently remain relatively large.

If roof loads are predominantly gravity, as with non-prestressed roof options, the frames can be designed as having larger degrees of ductility. A ductile frame has to the capacity to dissipate the energy arising from seismic loading hence requiring smaller structural elements, albeit at the cost of more considered detailing.

### 2.9.3.2 Foundations

Currently documented are reinforced concrete cased, bored piles to a suitable founding layer (see Section 4.0 Structural drawings, No. S-007). As described previously, this solution was easily identified as feasible from the limited geotechnical information initially available. The depth to founding is yet to be determined, although bedrock is undoubtedly suitable. The preliminary site investigation undertaken during concept design indicated that founding on bedrock would require piles over 30m long in some areas. Clearly this has cost implications and has necessitated review of other foundation options. The suitability of founding on other material, and the location and depth of such material, is still being investigated, however preliminary advice from the geotechnical engineer is that bored piles would probably need to be taken to bedrock.

A possible alternative is a piled soil raft where close-spaced piles are driven to densify the soil and mobilise a large soil mass to act as a raft. A conventional foundation using strip footings is then constructed above this pile-soil raft.

Possible alternatives for piled solutions are:

- Precast concrete piles drivin to a founding layer that may not necessarily be the bedrock. Such piles would be considerably smaller than the currently detailed bored piles (eg: 600 x 600, however a great deal more will be required. The installation of such piles densifies the ground, and with consideration of this effect it may be found that suitable bearing is available from a layer of competent gravel. The preliminary boreholes indicate that such a layer is present across the site, varying in thickness and depth, but on average around 15m from the surface.
- Steel H-piles driven to the bedrock. This solution is similar to that described above, however the preliminary indication is that the gravel layer will not be suitable for bearing. These piles will herefore be longer than the precast version, although their numbers may be similar.

Both driven pile solutions will be severely affected if liquefaction is found to e a design consideration. If so, the lateral load capacity of the piles will be come significantly reduced, so much so that these solutions may become invalid. Because of their greater diameter, the effects on bored piles to bedrock, although also significant, may be more manageable.

A foundation solution that my not be as greatly affected by liquefaction is ground improvements by way of stone columns, similar to that used at the AMI stadium. As with the driven precast piles, the stone columns serve to densify the groundwater pressures that can result from seismic shaking, reducing the potential for liquefaction. The possible arrangement, geometry and depth of stone columns will be assessed during the geotechnical investigation.

AMI Stadium

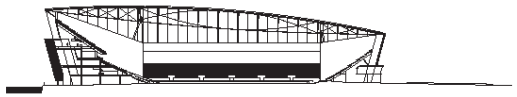
With 16,500 seats, the west stand of Christchurch's AMI stadium is considered an appropriate benchmark for the proposed south stand. A summary of th structural systems employed at AMI, and comment on their appropriateness for the DMS, is as follows:

- Foundations at AMI are bedded on a network of stone columns, each 600 x 600 and 8 to 10 metres deep, installed by vibrating holes in the soil and fillign with gravel. Such a solution, that consolidates the ground as well as providing drainage necessary to alleviate liquefaction potential, may be an option for the DMS, depending on the results of the geotechnica investigation.
- Seismic loads in the transverse direction are resisted by a hybrid system of large precast panel fin wall elements and a beam/ column frame. The fin elements are large, up to 400mm thick, around 1.8m deep, and with individual sectisn apparently requiring lifts of up to 55 tonnes. Columns vary between 750 and 1200mm, with the larger diameters also forming the longitudinal frame described below.
- The transverse wall/frame system supports prestressed seating bleachers that span a maximum of around 9m and a primarily L-shaped. For the upper tier there is a large cantilever of approximately 9m, stemming from the fin wall system.
- Concourse floors are Dycore with an insitu topping, similar to that proposed for DMS.
- In the longitudinal direction there appers to be a single, circumferential, internal frame formed from the 1200mm columns and deep slender precast beam elements.
- The transverse frame system utilised at AMI differs from the DMS concept in that the latter has a larger number of smaller frame elements, i.e., rectangular beams and columns in lieu of large fin walls. However, both systems can be consider frames, with the AMI structure acting in a similar, yet probably stiffer, manner under lateral loads. The tier cantilever for the DMS is smaller, therefore an element as large as that at AMI is not warranted.
- The fin wall system used at AMI could be considered an option for DMS, however the main drawback is the size and weight of the precast elements, and the subsequent need for mobile cranes. These are considerably slower that the tower crane solution made feasible for DMS by lighter lift requirements. The large fins are relatively obtrusive and therefore have obvious architectural implications.
- With a single line of lateral load resistance in the longitudinal directin, this aspect of the structural solution is similar to the DMS concept ,. The latter, however, employs a bracing system on the out wall, in lieu of a frame. For the DMS this saves on the complexity of creating two-way frame joints, however the location of the bracing line is architecturally limited.

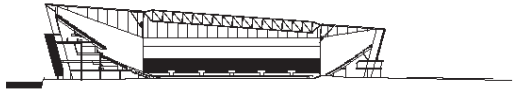
Waikato Stadium

Compared to the AMI stadium west stand, the north stand at the Waikato Stadium is closer in size to the proposed south stand at the DMS. The structural solution has fewer similarities however, with a comparison as follows:

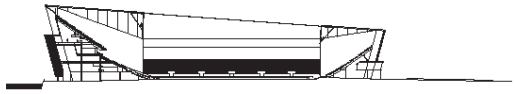
- The bulk of the Waikato Stadium appears to consist of concrete filled steel tubular columns and steel beams forming a system to carry vertical loads only. The joints are therefore relatively simple, with structural continuity not generally required.
- In the transverse direction it appers that lateral loads are carried by a core of shear walls.
- In the longitudinal direction three is an internal line of concentric steel bracing acting in conjunction with shear walls.
- The structural gird is closer together that AMI and DMS, with a spacing of around 6m.
- Exposed steel beams from rakers for support of precast concrete, L-shaped bleachers.
- There is a cantilever tier of approximately 5m, also supported by steel rakers.
- The primary differences to the proposed DMS therefore are:
- The lack of frame action in the transverse direction, with shear walls in lieu. This may be simple construction without complex joints, however the architectural flexibility appers compromised.
- The use of steel in lieu of concrete beams and rakers. This has been considered for the DMS, however the spans are larger and so, therefore, are the member sizes. When spans are large in steel framed stadiums, dynamics can become critical and spectator comfort effected. Increased maintenance costs are also a consideration for steel and corrosion was evident on a number of exposed steel elements at Waikato.



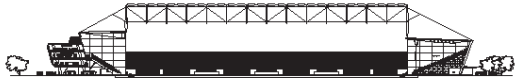
Short Section - Fully Enclosed Roof Option



Short Section - Retractable Roof Option



Short Section - Open Roof Option



Long Section - Fully Enclosed Roof Option

Long Section - Retractable Roof Option

Long Section - Open Roof Option

Fig 2.3.10

## 2.3.10 Roof

At the masterplan and feasibility stage the design team investigated a number of roof studies based on the vision of a fully enclosed stadium established by the CST. These studies included the following options:

- A fully enclosed stadium with a roof over the spectator accommodation and field of play.
- A retractable roofed stadium with the retractable roof located over the field of play.
- A traditional roofed stadium with the roof restricted to provide coverage to 100% of the seats and standing accommodation.

During the investigation of the above options it was realised that the best opportunity to develop a fully enclosed stadium within the budgetary constraints was to investigate the possibility to design a fully enclosed stadium with a natural grass playing field. This will be unique, not only in New Zealand but also in the world of stadium design, clearly placing Dunedin on the map in terms of unique venues and iconic landmarks.

A number of questions have been raised regarding the ETFE roof cladding during the concept design process and include the flowing:

- Integration with the roof structure
- Spacing of the foils
- Installation details
- Waterproofing

During the concept design stage the consultant team has progressed a number of options from the prestressed cable truss option to a cable net design based on a fully roofed stadium. These options have been assessed within a matrix based on complexity and buildability etc. From this matrix it was surmised that 3 options were viable. These are set out below:

Option 1

Prestressed cable or lens trusses over the stands and the pitch at 10m centres, stiffened by East-West primary trusses above the lower tiers in both the North and South Stands. In this option the lens truss needs to be installed early in the construction process. The roof cladding could be retrofitted over the pitch, however there are appreciable construction difficulties associated with this idea. The ETFE roof covering can be supported on the top chords of the lens trusses, which simplifies the waterproofing details. The lens trusses retain an elegance and simplicity, which proves itself in the reduction and simplicity of the shadows on the field of play. This option is consistent with the masterplan and feasibility scheme.

Option 1A

Lens trusses over the pitch at 10m centres, also supported by East-West primary trusses above the lower tiers in both the North and South Stands. The variance on option 1 is that the roofs over the North and South Stands are separately supported by steel trusses. In this option the lens trusses over the pitch can be retrofitted, as they are supported by the East-West primary trusses; however the size of the members of the trusses over the North stand are increased and therefore there is an increase in shading on the pitch compared to option 1. The ETFE envelope can be supported on the top chords of the lens trusses, which simplifies the waterproofing details. This option is consistent with the masterplan and feasibility scheme. Refer to Drawing S-001.

Option 2B

Tied arch trusses at 20m centres over the pitch, also supported by East-West primary trusses above the lower tiers in both the North and South Stands. The roofs over the North and South Stands are separately supported by steel trusses. Between the tied arches the ETFE envelope is supported on a 5m x 10m sub-grid, which potentially increases the density of the shadowing on the field of play. The ETFE needs to be supported above or below the structure of the tied arch and sub-grid which requires a greater attention to detail in waterproofing. This scheme differs from the original masterplan and feasibility scheme. Refer to Drawing S-004.

Further discussion of roof structural aspects is as follows.

The sizing of structural roof members has been based in part on preliminary advice provided by a specialist ETFE supplier, along with wind pressures extracted from the Building Code. With wind tunnel testing and integration of ETFE specialists into the design team, it may be possible to refine wind effects with subsequent refining of the structural system, however this cannot be guaranteed until the design process is further developed.

As outlined above, all of the structural roof options considered requires the incorporation of two main longitudinal trusses spanning 140 metres along the leading (internal) edges of the northern and southern stands. At the ends of these trusses are braced blade columns that, along with the trusses, form a large frame system that resists lateral loads in the east-west direction. Lateral loads in the north-south direction are transferred into the concrete stands. Lateral loads acting on the east and west ends of the enclosure are transferred through north-south oriented trusses into the braced blade columns at each end of the primary longitudinal trusses.

Options 1 and 1a – Prestressed Steel Trusses

For each of these, the lens trusses consist of steel cables, spanning continuously across the playing area. These cables have no inherent stiffness, therefore to prevent unacceptable sagging it is necessary to apply pretensioning, resulting in significant horizontal loads at cable ends. For option 1, the cables continue over the primary trusses and the north and south stand structures. The change in vertical orientation over the primary trusses, along with the pretension force, results in significant vertical loads in these trusses. The extent of these loads was found to be such that the primary truss system became impractically large. For this reason the structural team dismissed option 1 in favour of option 1A.

For option 1A, North and South stand roofs are steel frames trusses to which the centre cable system and roof can be retrofitted if required.

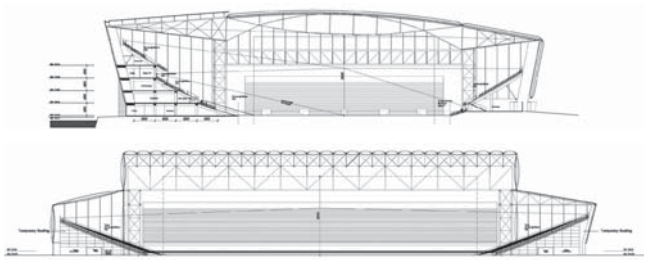
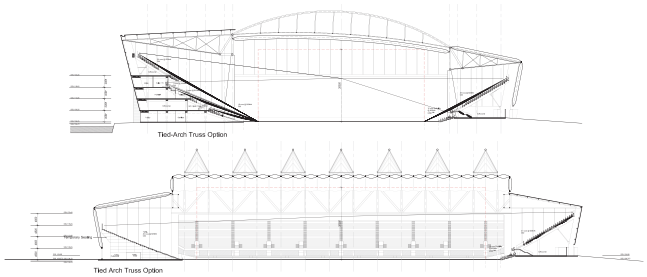


Fig 2.3.10.B



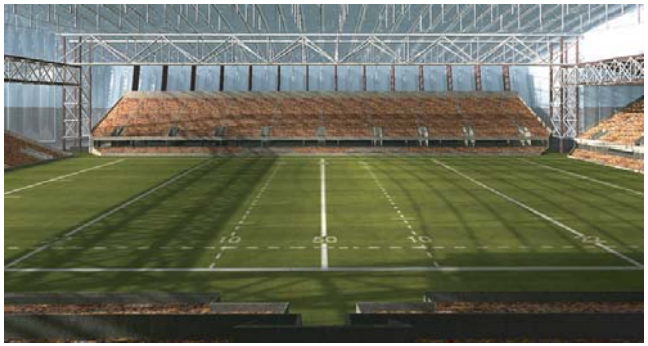



Fig 2.3.10.C

View from the camera position at the top of the lower tier on 15th September at 2:45pm

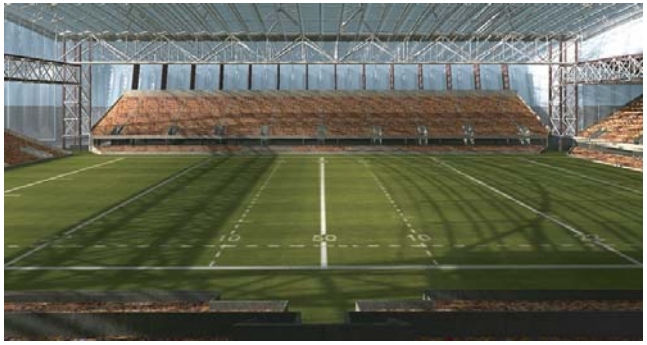


Fig 2.3.10.E

View from the camera position at the top of the lower tier on 15th September at 2:45pm

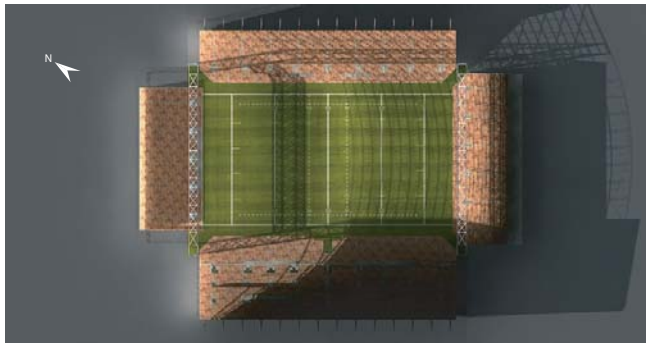



Fig 2.3.10.D

View from the blimp camera positioned over the field of stadium on 15th September at 2:45pm

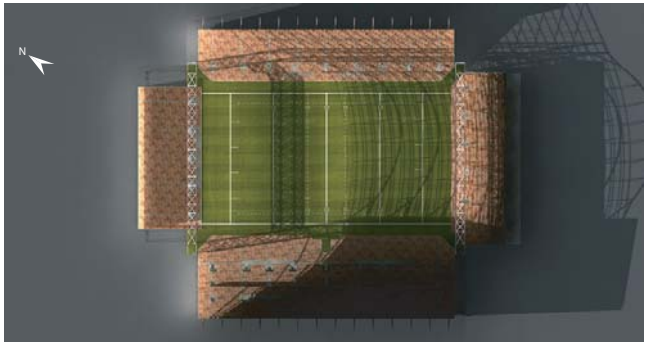



Fig 2.3.10.F

View from the blimp camera positioned over the field of stadium on 15th September at 2:45pm

Because the cables are terminated at the primary East-West trusses there is no change in the direction of pretension force and as such the vertical loads are more manageable.

The pretension forces required for options 1 and 1A are significant, and have consequences for design of the north and south stand structures that are explained in a later section.

Weights of steelwork included in option 1a are as follows.

| | |
|---|---|
| Lens Trusses | = 15 kg/m2 |
| Southern stand roof | = 40 kg/m2 |
| Northern stand roof | = 40 kg/m2 |
| Eastern stand roof | = 35 kg/m2 |
| Purlins & roof sheeting to northern & southern stands | = 15 kg/m2 |
| ETFE cladding and framing allowance | = 5 kg/m2 |
| Southern 140m truss (9m deep x 5.6 m wide) | = 3.6 Tonnes/m |
| Northern 140m truss (9m deep x 5.6 m wide) | = 3.5 Tonnes/m |
| Eastern 90m truss (varying dimensions) | = 1.6 Tonnes/m |
| Western 90m truss (varying dimensions) | = 1.6 Tonnes/m |

Option 2A – Steel Arch Trusses

As an alternative to pretensioned cables, this structural system provides over the playing area trusses with a curved top chord and a pair of flat bottom chords which forms a tied arch in elevation spanning 90 m. In section the trusses are triangular, and they are supported at their ends by the primary East-West longitudinal trusses. The arched truss option features ETFE cladding supported underneath the arches, therefore some structural elements are located externally to the cladding and are thus exposed to the elements. In this arrangement it is envisaged that 2 modules of ETFE cladding panels are located between the bottom chords of the truss and a pair of 5 metre wide modules span between arch trusses.

The key difference between the steel arch truss option and the lens truss options is the lack of pretensioning required. This results in a simpler structural system, and significantly reduces horizontal loads on the supporting north and south stands.

Respective weights for the Option 2A are

- Arch trusses = 46 kg/m2
- Southern stand roof = 40 kg/m2
- Northern stand roof = 42 kg/m2