

The City of Manchester Stadium

Martin Austin Stephen Burrows Colin Curtis Mike King Dipesh Patel Terry Raggett Marcel Ridyard Eugene Uys Andrew Woodhouse



1. The City of Manchester Stadium in its Eastlands setting.

BACKGROUND

History of the bids

The story of The City of Manchester Stadium, from initial sketch to first stone to final touch, has been long and complex - inevitably so, given the background of constantly changing circumstances. Nonetheless, the City Council throughout held to three fundamental principles:

- **Manchester deserved a new high-profile sports venue reflecting its status as a major sporting centre.**
- **The venue should be both a central component of urban regeneration and a catalyst for further renewal.**
- **The project needed a long-term, sustainable future.**

The idea of creating an international stadium dated back to the city's bid to stage the 1996 Olympics. Originally the Manchester Olympic Bid Committee, chaired by Bob Scott, planned an 80 000 capacity venue on a greenfield site in west Manchester. When in 1989 Atlanta secured the 1996 Games, however, Manchester re-evaluated its ambitions in anticipation of a second bid for 2000, and the focus shifted to east Manchester ('Eastlands'), 1.6km from the city centre, derelict and ripe for renewal, as an alternative stadium site. In 1992, Arup was brought in as design consultant for an 80 000 capacity stadium, as the firm had already helped in the selection of the Eastlands site.

At the same time, a working party was set up to review the implications of emerging government legislation on urban renewal, which promised vital support funding and had implications for the final site of the proposed venue. Government became involved in funding the purchase and clearance of the Eastlands site in 1992.

Manchester's bid for the 2000 Olympics was submitted in February 1993, but in October Sydney was declared the winner.

Shortly afterwards Manchester submitted the same scheme design to the Millennium Commission as a 'Millennium Stadium', only to have the proposal turned down.

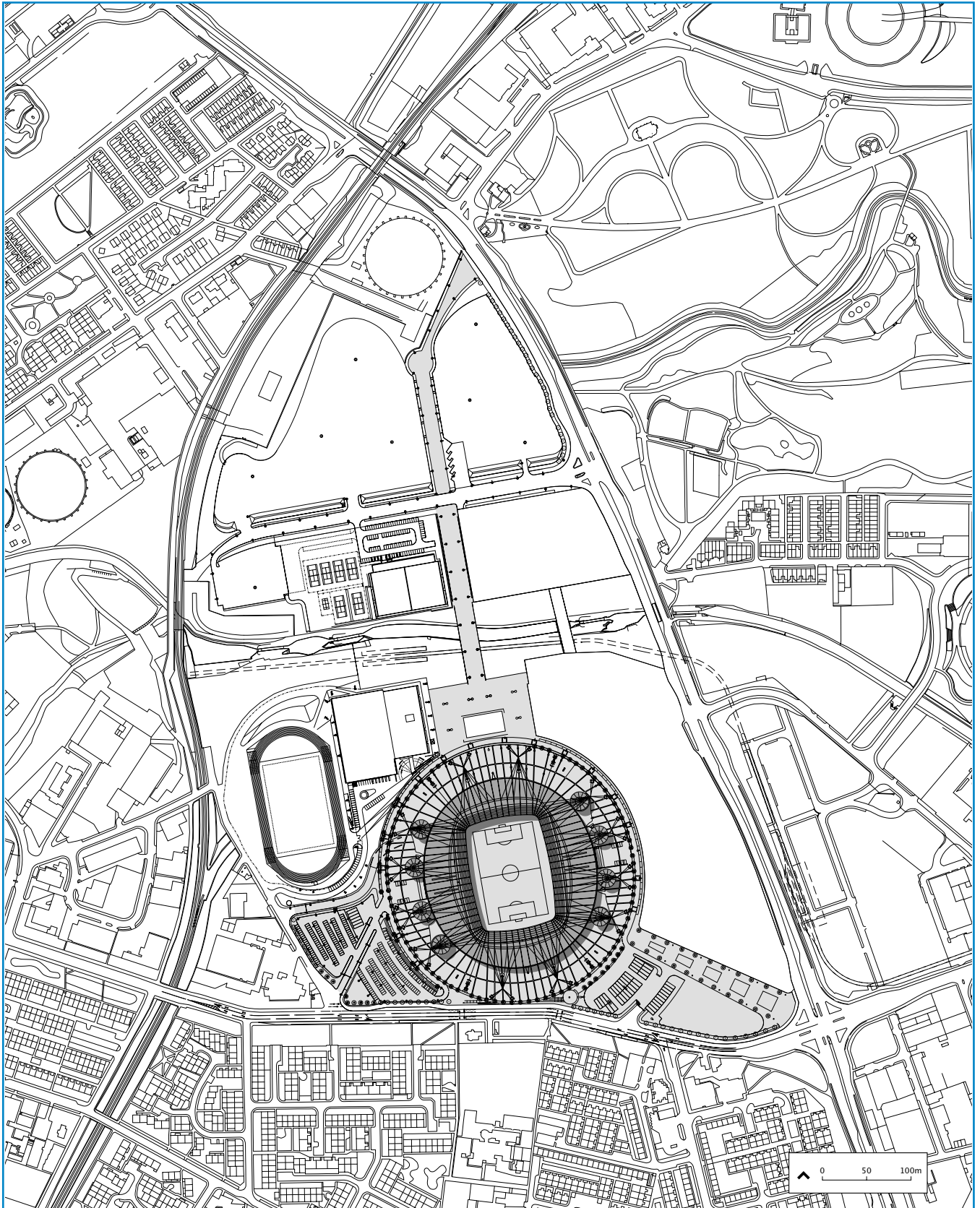
Undeterred by these disappointments, Manchester now looked towards a new target, the 2002 Commonwealth Games, whose Commissioners visited the city in January 1994. Manchester's bid went in shortly afterwards. By now the momentum established made it firm favourite, with a velodrome and the Manchester Evening News Arena¹ already built and the stadium site cleared with plans advanced. In 1995 Manchester duly won the bid to host the XVII Commonwealth Games.

For a time the Games became linked with Manchester's bid in autumn 1996 for the English National Stadium, the intention being that a stadium built for the Games could afterwards be reconfigured as a national football venue. Manchester saw itself as an ideal Northern home competing with or even replacing Wembley. But in 1997 Wembley beat off the Mancunian challenge to be confirmed as the home of the new National Stadium. The final incarnation of Manchester's stadium design was launched, with all energies now concentrated on the 'Friendly Games' of 2002, the biggest multi-sport event ever held in Britain.

One fundamental question remained, however: What would happen to the venue in the longer term?

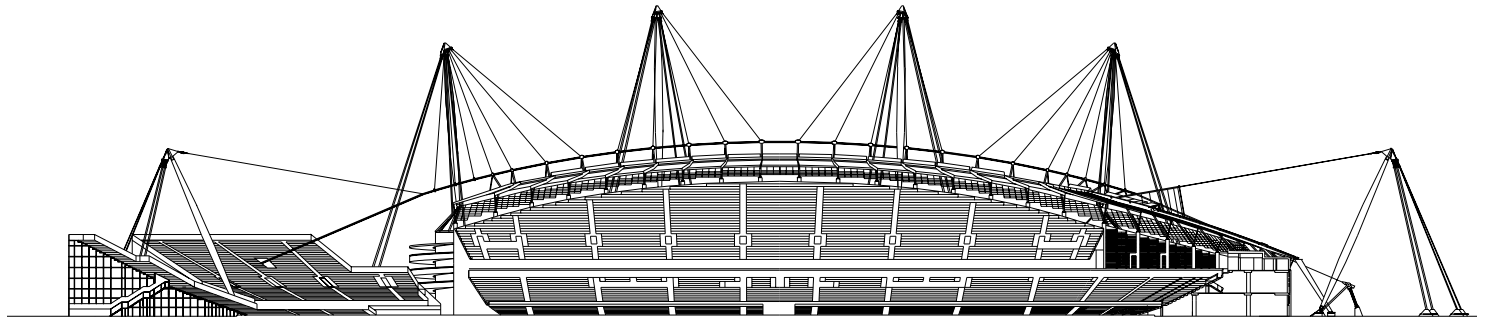
Long-term future

The question of what would happen to the Stadium after the Commonwealth Games was solved when a deal was struck between the City Council and Manchester City Football Club. The Council agreed to take over the Club's old Maine Road ground, with the Club moving to the new Stadium as tenants after the Games.

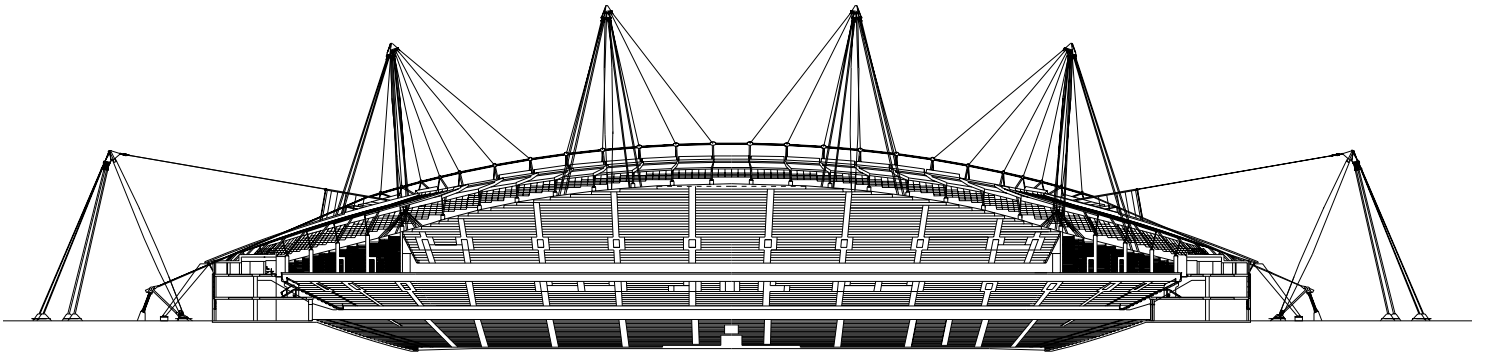


2. Site plan.

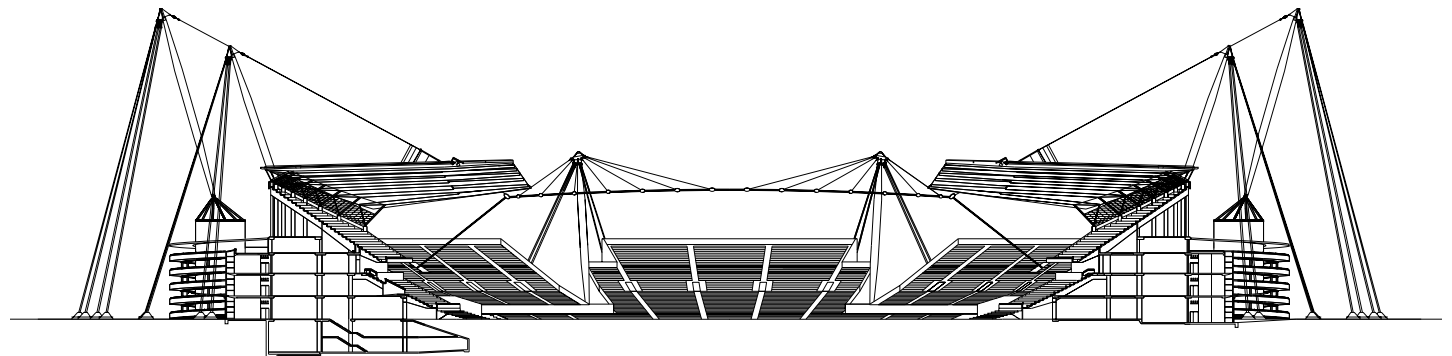
'Manchester deserves a new high-profile sports venue reflecting its status as a major sporting centre, which should be both a central component of urban regeneration and a catalyst for further renewal. It should also have a long-term, sustainable future.' Manchester City Council



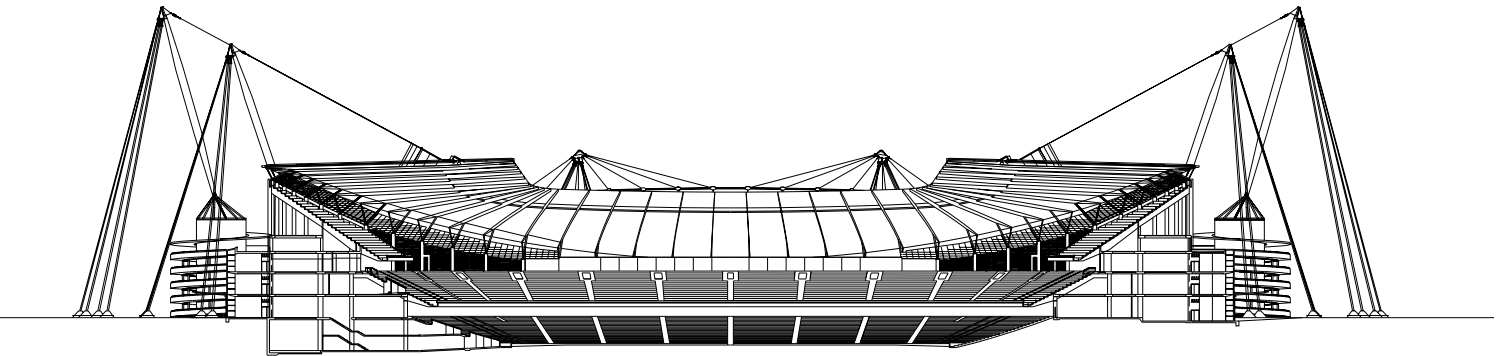
3. Stadium configuration for athletics: north-south section.



4. Stadium configuration for football: north-south section.



5. Stadium configuration for athletics: west-east section.



6. Stadium configuration for football: west-east section.

Manchester City Council, while sharing Sir Bob Scott and his team's commitment to winning the Games, always saw a wider picture. Simply bidding for the Olympics was in itself a statement of intent and self-confidence for Manchester and the North-West. It stimulated publicity for the city and its attempts both to transform its landscape and affirm its growing association with sporting excellence. The publicity, in turn, would attract outside the private and public funds needed for the city to attain its goals.

The concept emerged of the Stadium as centrepiece of a 'SportCity' complex that would transform the area and include a superstore, canalside homes, a hotel, restaurants and bars, plus an extended Metro rail link and pedestrian route along the Ashton Canal corridor north of the site that would link the once-blighted area to the hub of Manchester.

To underline the venue's viability, Manchester City FC was to be joined at SportCity by a branch of the English Institute of Sport and the National Squash Centre, as well as an indoor tennis centre and several other indoor and outdoor facilities, and with the existing and firmly-established velodrome, the National Cycling Centre, as a neighbour.

Alongside all this, other schemes - essentially unrelated but very much interdependent parts of the greater strategic picture - were being pushed ahead in the area by the New East Manchester Ltd urban regeneration company, formed in October 1999. Sport England, responsible for allocating National Sports Lottery Funds, contributed significantly, helping to free Manchester taxpayers from the spectre of a long-term financial burden, the fate of several cities that had staged major international sport events.

*'It means fun,
games and jobs,
jobs, jobs!':
Richard Leese,
Manchester City
Council leader
from 1996*

A final funding hiccup was overcome in 2001, with the help of Sport England, national government and the City Council. A few months before the Commonwealth Games began, a study commissioned by the City Council from Cambridge City Consultants forecast that the event would secure for the city over £600M in public and private investment. The Games themselves would generate the equivalent of 6100 full-time posts in and around Eastlands, whilst SportCity and the surrounding regeneration could lead to 300 000 extra visitors pa visiting the area. Nearly 30M people, the study also concluded, would look to Manchester as a possible business and visitor destination because of its booming image, broadcast via TV to a massive worldwide audience approaching a billion during the Games.

DESIGN DEVELOPMENT

Outline

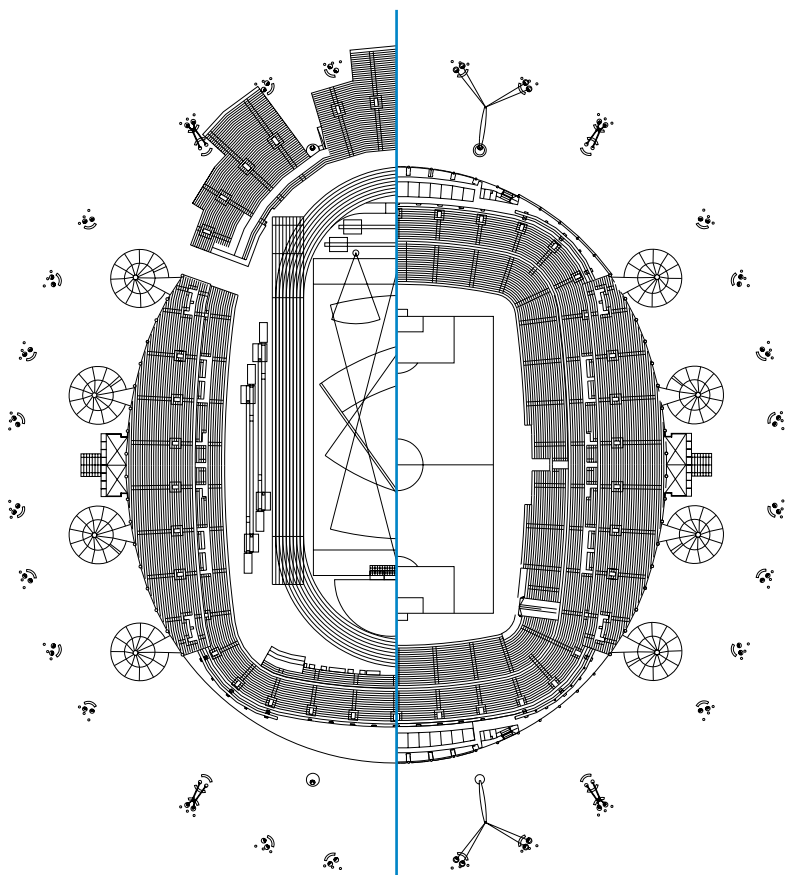
From the original 1992 design for an 80 000-seat athletics-only stadium developed the concept four years later for a 60,000 stadium eventually to accommodate national soccer games. The venue would also be adaptable for other sporting disciplines like rugby league internationals, and major non-sporting events such as pop concerts. Certain basic features like the swooping 'saddleback' roof and the spiral access ramps continued from the 1992 conception into this 1996 design, with the addition of a closing roof.

When the City Council came to its agreement with Manchester City FC, Arup again reworked the design so that the Stadium would be ready to stage athletics for the Commonwealth Games and then be converted for football. The Games capacity was to be 38 000, rising to 48 000 (50 000 gross) after conversion by removal of the athletics track and addition of extra seating (light blue, of course, to match City's colour). This would be made possible by excavating down one level. Almost 40 000m³ of fill would be removed, the pitch laid, and the temporary 13 000-seater stand erected on the north side of the venue for the Games replaced with permanent structure in time for the 2003–04 football season.

Athletics and football: needs and aspirations

When architects are commissioned to create large buildings likely to add significantly to a townscape, they naturally aspire for them to be iconic landmarks, and objects of civic pride. To satisfy such aspirations cost-effectively is particularly challenging when developing venues for one-off events like the Commonwealth Games. Manchester City Council's vision for this Stadium to have a viable long-term future after the Games, via its role as a new home for Manchester City FC, not only aided the project financially but also meant that it would become a permanent and momentous part of the city's civic infrastructure.

Generically, any stadium is a building for an audience to view a spectacle, the different forms of which dictate the shape of the viewing area. One of the earliest well-known examples, Rome's Coliseum, had a fully enclosed seating configuration enabling events to be viewed all over the display area. The behind-the-scenes organization was extremely intricate and yet functional, to enable the most stimulating and yet smooth-running show.



7a. Overall seating plan for athletics.

7b. Overall seating plan for football.

8. The Stadium in athletics configuration, ready for the XVII Commonwealth Games.



By contrast, the Greek theatre at Epidaurus focused the audience on a very specific viewing area. Current examples mimic the historic: to organize appropriate viewing systems for audiences to enjoy visual spectacles, with all necessary facilities to hand plus aspects like speedy evacuation for safety.

The principal events at The City of Manchester Stadium were to be athletics first and then football. Athletics has a seating bias skewed towards the home straight, with a particular emphasis on the finishing line. Football is best viewed from the sides, though many fans like to sit behind the goal. The west side is traditionally favoured because most clubs began with just one stand and disruption of the view of the game by low afternoon sun had to be avoided. This is less relevant for large stadia built from the outset with two or more stands, but the west stand is still regarded as superior and is in all cases the 'main' one even though it may be identical to the east stand.

Thus the two sports dictated two ideal seating bowls. Historically, the stature of the buildings housing them had very different origins. From its ancient Greek beginnings, athletics took place in celebrated venues and this tradition continued with the modern Olympics. Architecturally, athletics stadia have always been revered and much thought and effort has gone into their design. In contrast, most football clubs began with very small utilitarian stands, a building type largely ignored by the architectural profession. Most club stands to this day are a seating terrace served by a few toilets and vending areas clad like industrial buildings. Their appearance and building technology is akin to a warehouse, not a civic building.

Visual icon and user experience

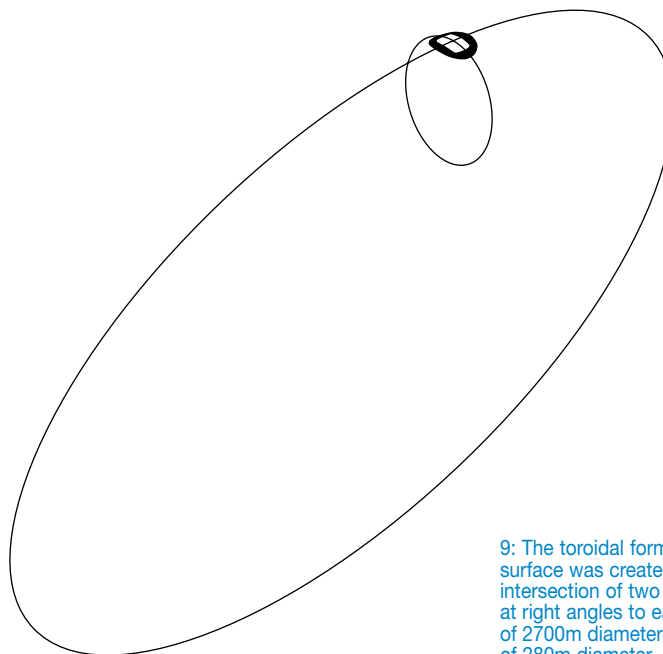
From the outset the objective of Arup Associates as architect was to approach The City of Manchester Stadium as a key civic building. This architectural stature, combined with the significant elements of structure and servicing, also made it a building type particularly suited to the firm's multi-disciplinary practice. Every element in the Stadium is designed to fulfil as many functions as possible, making the design very clear and maximizing use of the available funds.

Two specific goals lay behind the general aim to raise design standards for this building type: (a) to give Manchester a new icon, improving the city and in particular the surrounding deprived areas of Beswick, Chorlton, and Hardwick, and (b) to design a stadium that is a great experience in every way, not just for spectators viewing events. This may seem obvious, but to date no UK stadium has successfully addressed both types of issue. At the urban level many are 'bad neighbours', used only a few times a week at most. Otherwise they are empty shells sitting in a sea of empty car parking. Others are famed for their legendary 'atmosphere', but remain frustrating to get to and away from and become an unpleasant melee during half-time.

Unlike many of its historical predecessors, this Stadium was carefully designed with form, structure, and circulation in mind. The required seating bias dictated a bowl with high sides on the east and west and low ends north and south, allowing a single roof geometry to cover all seating and leaving large open areas in the corners for pitch ventilation and video screens.

This super-geometry comprises two circles, creating a toroidal form (the roof surface) over a circular plan (Fig 9). As oriented, this results in a building that addresses the local context, with the tallest parts in the middle of the site whilst the lower north and south aspects respectively address the sensitive Ashton Canal corridor and the housing area south of Ashton New Road.

Overlaid on this form are the spiral ramps and the masts, the central eight of which sit atop the ramps and together form the Stadium emblems: the distant view is of a low-lying curved form surmounted by 12 masts. These, with the ramps, terminate key view corridors for fans approaching the Stadium. Those coming to Manchester first glimpse these bold new landmarks from various points around the city and then find themselves heading directly towards them, a sequence completed on arrival when they climb up the ramps to enter the upper levels.



9: The toroidal form of the roof surface was created from the intersection of two vertical circles at right angles to each other, one of 2700m diameter and the other of 280m diameter.

'The City of Manchester Stadium is a national symbol of how major sporting facilities can contribute to the physical and social wellbeing of a city and country.'

Placing the ramps externally gives depth to the façades and makes the structure very distinctive, and most importantly adds to the drama of an event. Joining fellow supporters sweeping up the ramp in anticipation of the game ahead and descending afterwards, discussing it, is all part of the experience. The excitement of entering the Stadium is further heightened because fans can see each other and the surrounding city and moors until the very last moment.

This sense of connection begins in the external concourse, the circular public space around the Stadium visually delineated by a grid emanating from the external columns and terminating in a perimeter of trees. Surrounding this plaza will be the sports institute plus shops, leisure areas, and bars - when complete, a truly mixed-use area with the Stadium as centrepiece, and vibrant on both match and non-match days.

The first internal experience of the Stadium continues the human theme of spectator comfort. The space is akin to airport and railway station concourses, unlike other stadia where spectators make do with 'left-over space'.

An innovative fire strategy allowed the creation of continuous concourses - deliberately large, clean, uncluttered, and calm spaces designed to calm the typical half-time scramble for refreshment and relief. The main concourse serving the largest lower tier is also directly behind the last seat. Should UK law on consuming alcohol and viewing the game ever change, the dividing wall could be removed to bring the game's drama right into the very heart of the building.

Enabling works

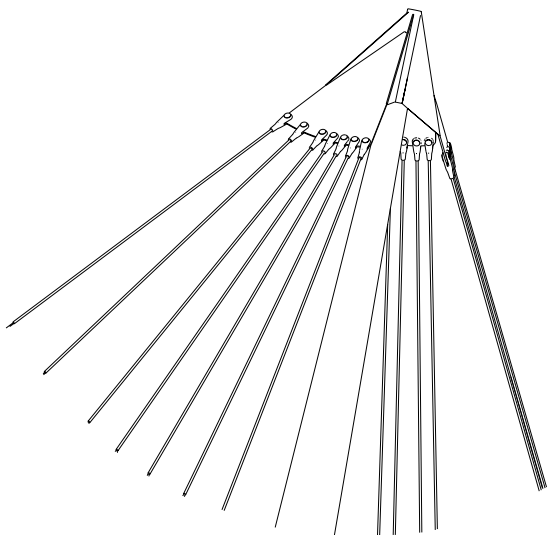
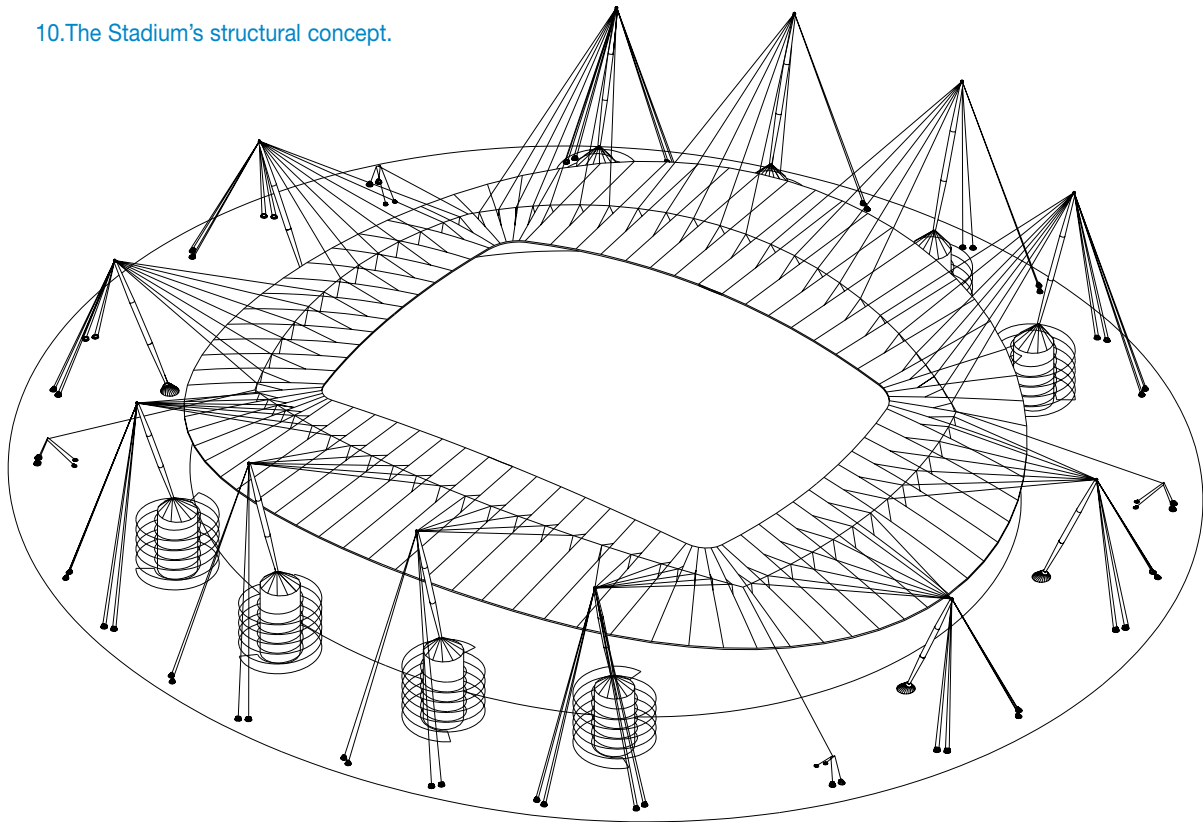
Site investigation and ground conditions

The derelict 11.5ha Eastlands site reflected the changing face of industrial Manchester. From the mid-18th century it housed coal seams and shafts, and from the 19th century the Ashton Canal, cotton and lead mills, railway lines, and iron and gasworks. It remained fully developed until the 1960s, but the colliery was closed in 1969 and the gasworks flattened to ground level a decade later. Further demolition and clearance work followed. With this history, and the hidden legacy of mine workings and shafts, some contamination was to be expected.

To overcome the shortcomings of previous investigations, boreholes up to 85m deep were sunk, together with trial pits and in situ testing. Landfill gas and groundwater installations were monitored, and samples tested for both geotechnical and chemical properties.

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10. The Stadium's structural concept.

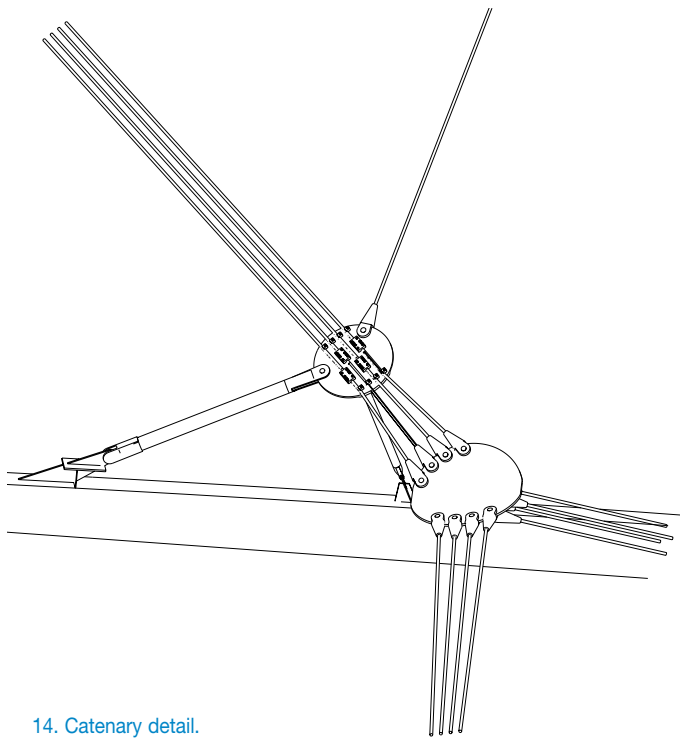


13. The City of Manchester Stadium illuminated at night.



Mast top detail: 11 above: as designed; 12 below: as built.





14. Catenary detail.

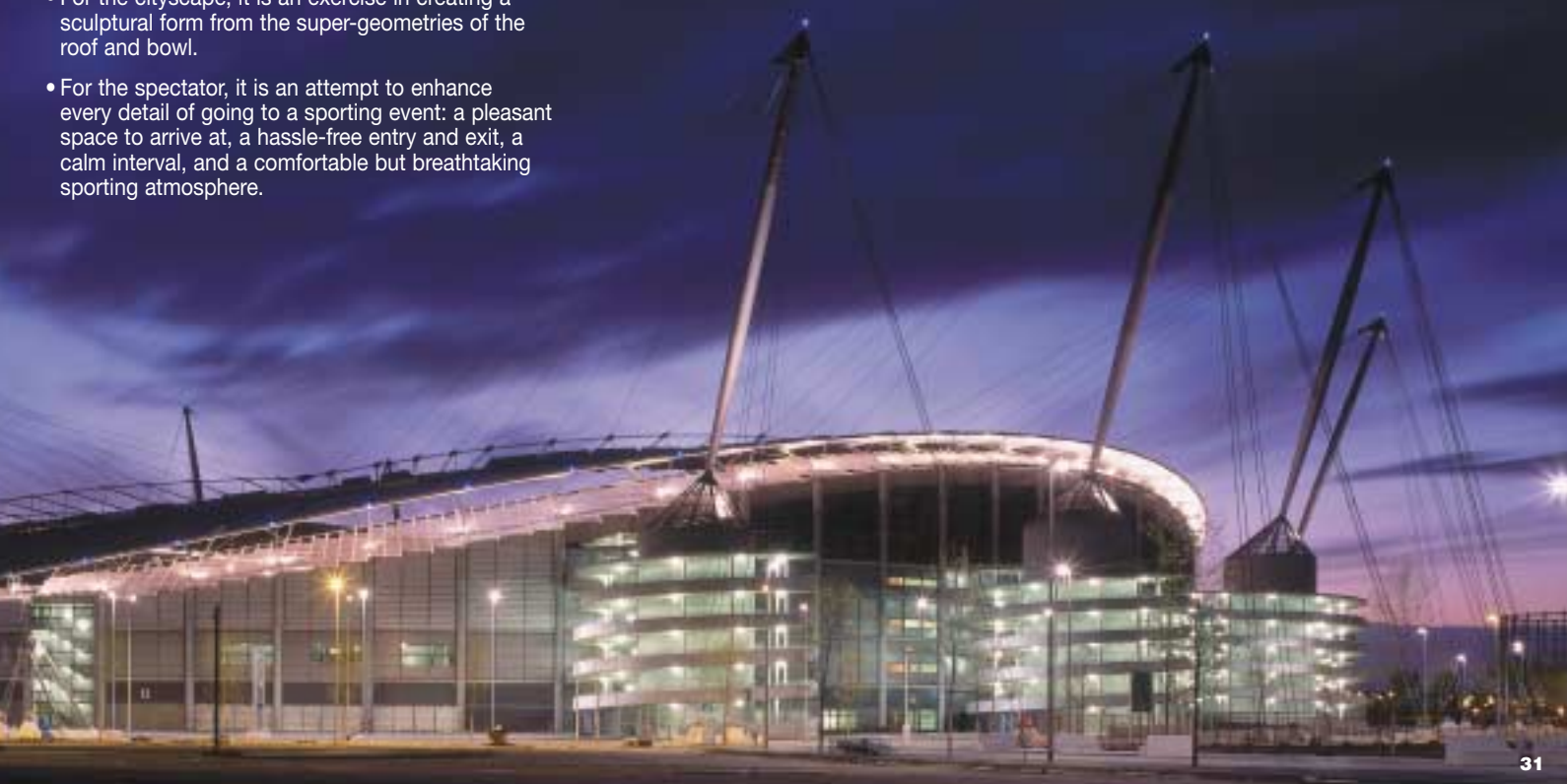
15 right: Façade detail showing louvres.



RAISING DESIGN STANDARDS

Ultimately Arup's main goal was to raise design standards in every way:

- At the urban design level, the Stadium and its plaza attract activities, making it a 'good neighbour' with civic character and purpose, the centrepiece of a regeneration initiative for an entire quarter of the city decimated by years of dwindling industry and social exclusion.
- As a building, visual depth and dynamism are created from its elements. Each is exposed to reveal its purpose and the activity within, and works with other elements to articulate clearly a technically very sophisticated building.
- For the cityscape, it is an exercise in creating a sculptural form from the super-geometries of the roof and bowl.
- For the spectator, it is an attempt to enhance every detail of going to a sporting event: a pleasant space to arrive at, a hassle-free entry and exit, a calm interval, and a comfortable but breathtaking sporting atmosphere.



Geotechnical and technical properties

The geological succession comprised 2-3m of made ground over 7-15m thick glacial clay deposits, in turn above coal measure rocks. The made ground was granular and cohesive, of variable density and strength, and included shallow groundwater. There were also minor water entries in the glacial deposits. As anticipated from the industrial history, the made ground was contaminated to varying degrees with hydrocarbons, heavy metals, and waste-containing obstructions from old foundations.

The coal measures comprised alternating mudstones, siltstones, sandstones, and thin coal seams, maximum 1.2m deep, dipping to the south-west. The coal workings were predominantly collapsed where encountered, probably from longwall mining beneath (in which a cutting head moves back and forth along a coal face). The site had several mineshafts, and in the masterplanning the Stadium was positioned to avoid them (though there was the possibility of old unrecorded shafts). Groundwater was encountered below rockhead. A geological model was prepared which differs from the map by the British Geological Survey, who are reviewing Arup's model for their new Manchester map.

Remedial works

These were designed to mitigate the effects of the abnormal features previously identified, and included large-scale earthworks to form the platform. The strategy was to limit the import of material and disposal offsite by maximizing re-use of excavated material. As for contamination, the levels of chemicals acceptable to be left with respect to end use were agreed with the regulators. Several 'hotspots', primarily hydrocarbons, were identified, excavated and disposed offsite. Of the total 250 000m³ of material excavated, however, only 10% left the site. The material was either used immediately as fill or processed, with concrete and brick crushed for capping and marginal material treated with lime to stabilize it. The team decided to excavate the made ground to its base under the Stadium footprint to remove obstructions to piling and check for unrecorded mineshafts. Three were found and grouted up.

There was an extensive network of both recorded and unrecorded services, the latter found during the earthworks. New services were constructed and others diverted, the most onerous work involving connections into existing very deep sewers.

Coal workings were treated by injecting grout into a grid of drillholes to different depths relative to each seam. The grout take varied, with more going into an uncollapsed seam than one partially collapsed. The takes also dictated the grid spacing. At the end of the treatment, test holes were drilled to check its adequacy.

Canal Bridge

For pedestrian and emergency vehicle access to the Stadium from the north, a 20m wide bridge was built over the Canal. Its deck was designed to be integral with the abutments, a combination of 1.2m diameter piles supporting the deck with faced reinforced earth infill walls. The bridge was designed to avoid any load being transferred to the Canal walls.

The playing area and seating bowl

Spatial concept

Once in their seats, fans experience the Stadium's principal space, the playing area and seating bowl. The toroidal geometry of the roof combines with the radial plan geometry to create a rising and falling perimeter, with the roof, visually separated from the seating, projecting overhead to create a dynamic space that draws the eye into the field of play.

When full of people this environment pulsates. All spectators are within 100m of the centre spot - as close to the field of play as possible.

For football it is ideal to maximize the number of spectators by the centreline, and to achieve this the 'saddle' bowl configuration was adopted: three overlapping seating tiers on the east and west sides, with two overlapping tiers on the north and south (the lower tier and permanent north end being completed post-Commonwealth Games).

'The City of Manchester Stadium story evolved over more than a decade of commitment and co-operation between the public and private sectors.'

The result is a dramatic sweeping bowl curving up to the highest points on the east and west and then swooping down to the north and south, forming the shape that encapsulates the identity and image of the Stadium.

Accommodation

All seats have world-class sightlines ('C' value), the quality of view being enhanced by curved terracing in plan and section, allowing people to look past each other without standing up. The various seat types allow price banding, which in turn enables income to be maximized. These include hospitality packages and corporate boxes, which bring proportionally more revenue into the business, through to the standard seat.

The bands are as follows:

- standard seats at 480-500mm centres, for the general public with season tickets or individual match day tickets
- executive seats at 550-600mm centres, in various price bands; most are upholstered with arms and on the second tier, mainly in line with the pitch centreline. All have access to hospitality suites, two of them with views onto the centre of the Stadium: one on the south and the other on the west stand (the premium restaurant and bar)
- box seats at 600mm centres: upholstered with arms, in front of glass-fronted boxes in a continuous tribune separated from the back of the middle tier by a parapet wall. The Stadium has 69 boxes, averaging 10 persons each.

All seat rows provide an appropriate minimum clearway between folded seats, equal to or more than required in stadium guidance. Generally seat rows vary between 780-800mm in depth. The box seating, a little more luxurious, is 900mm deep.



16. The spiral ramps and masts are key visual identifiers for the Stadium.



17. Executive seating in front of glazed hospitality suites.

The Games' gross seating capacity was 41 000 (a last-minute 3000 increase due to high ticket sales), while the net capacity for football will be 47 500. The Stadium can be used for concerts, and here the total stand + pitch capacity increases to 50 000 -60 000 (dependent on stage position and assuming up to 16 000 spectators on the pitch).

There is, of course, provision for people with disabilities. 226 wheelchair spaces are designed into the Stadium seating at all price bands and levels, each area including seating for those partnering the disabled. Ambulant disabled are also close to these areas so they have either flat or ramped access. Visually impaired spectators are provided with induction loops for match commentary via headsets, and hard-of-hearing spectators can also use these to improve hearing-aid amplification of public address announcements.

Bowl structure and form

The bowl has an in situ reinforced concrete primary structure, on bored pile foundations. Coffered slabs form the floors and precast concrete units create the terracing. A typical radial grid spacing of 7.6m was adopted as this is half the aisle spacing and allows relatively open floor areas below. The secondary circumferential grid, defined by the seating geometry, is translated into a 'faceted' grid for the whole structure. On the outside of the building, the supporting structure of the spiral access ramps also houses toilets, services, and plant, as well as supporting the roof masts.

The exposed structure of the terracing forms the ceilings of the three concourses, with the entrances or 'vomitories' to the seating expressed as ramped or stepped gangways. The concourses allow both mass evacuation and circulation areas to concession units and toilets, which are distributed throughout. Spectators are served speedily in comfortable and pleasant surroundings before returning to their seats, the maximum distance from a vomitory to any facility being just 40m.

Roof structure

Concept and structural systems

A central feature of The City of Manchester Stadium is its distinctive and dynamic form, key to which is the structural solution for supporting the roof. The roof structure essentially comprises two separate structural systems, the first providing primary structural support to the whole roof (the 'cable-net'), and the secondary being a more conventional arrangement of rafters propped from the rear of the concrete bowl and hung towards their leading edges from the cable-net. The mast and cable-net roof primary structure uses a 'grounded

tension ring' to create a prestress field against uplift wind loads. 12 cigar-shaped tubular steel masts up to 65m high support a total of 76 spiral strand forestay cables in fan-shaped groups of five or seven cables per mast. Each forestay supports an individual rafter. Just above the roof surface, all the forestay ends are connected by a system of four spiral strand cables that form the 'grounded tension ring' (also referred to as the 'catenary'). Prestress to the catenary and cable-net is provided by four corner-ties anchored to the ground. The top of each column is tied back to the ground by pairs of back-stays comprising groups of Macalloy high tensile steel rods. This mast and cable-net system not only provides a highly efficient structure but also is central to the drama of the building's architecture.

The roof plane structure comprises 300mm wide by maximum 900mm deep box section 'radial' rafters at approximately 7m centres, supporting UB section purlins at 4m centres. The rafters are supported at the rear of the Stadium bowl through integrated V-strut columns on the concrete bowl. The V-struts allow sufficient headroom between the rear seating terraces and roof structure as well as providing for transfer of horizontal thrust from the rafters to the bowl. Towards the inside of the Stadium the rafters cantilever by up to 14m beyond the support provided by the forestays.

Cladding

Most of the roof is clad with an innovative system that typifies how structure, services, and architecture are integrated in the Stadium's design and detailing. 150mm deep aluminium 'liner trays' span the 4m between purlins and rest on the purlin bottom flanges. The liner trays act structurally to support the aluminium standing seam roof sheeting as well as creating a hidden zone for acoustic insulation, wiring, and in-plane roof bracing. The trays also form a visually clean ceiling to the roof where a 'normal ceiling' would not usually be economical. The inside 10m of the roof on all four sides is clad in transparent polycarbonate sheeting, allowing sunlight onto the pitch to assist grass growth and also ample daylight into the seating bowl. Another advantage of this form of cladding at the leading edge is its more gradual transition from full daylight to shadow - particularly beneficial for television coverage.

The roof's geometrical form ensures that its surface always slopes down to the outside edge with an inclination varying from 1.5° to approximately 17°. Along this outer edge an aluminium-clad gutter defines the perimeter and carries all water runoff to two large sculpted downpipes at the northern and southern ends.

Details

A family of fabricated plate connections with a consistent architectural language has been adopted for major details such as the masthead and base, V-strut base, catenary nodes, and back-stay bases. These were developed in consultation with the successful first-stage roof steel tenderer who went on to secure the contract for the roof construction. Where axially loaded elements are visible, pin connections are used throughout except for the base of each mast, which utilizes a series of steel plates and a pot bearing. This detail enabled greater flexibility for rotation in any plane during erection whilst maintaining the capacity to transmit axial compression forces of up to 13 000kN in the final condition.

Back-stay and corner tie foundations

The back-stay rods and corner tie cables are anchored to the ground by an innovative foundation system comprising high strength steel multi-strand ground anchors which pre-compress concrete piles against the underlying rock strata. These anchors comprise 8-15 greased and sheathed 15.2mm diameter steel strands bundled and inserted into plastic ducts. The anchors are installed into bored holes up to 35m deep, with the lowest 10m of the anchor bonded to the surrounding bedrock by cement grout. Each anchor is prestressed so that it is in permanent tension whilst pre-compressing the concrete piles. This system was developed to deal with the local ground conditions where mining had left the underlying bedrock highly fractured. This bedrock can resist permanent tensile loads, but resistance to varying tensile loads is less reliable. The advantage of this anchor system is that the stress on the anchor/bedrock interface remains more or less constant and fluctuations in the back-stay or corner tie forces are accounted for by an increase or decrease in the compression in the concrete piles.

Servicing strategy

A 'clean' form

With some bad precedents in mind, the design team were determined that the public concourses should remain free of distribution services, satisfying the design concept of clear, coherent circulation and amenity spaces designed as 'streets'. The intent is that, unlike many stadiums across the UK, the experience away from the seating area is enjoyable too. Getting refreshments should not be an arduous scramble between events, but a more leisurely experience.

During the Games the main concourse level was the Stadium's key operational area and not open to the public. For football, by contrast, it becomes the main entry level and principal concourse, providing ground level access to the top of the lower tier seating and ramp access to all other levels.

The spiral ramp form for spectator access to and egress from the upper level concourses was chosen in preference to stairways for ease and safety of use and improved circulation. As well as being a key feature of the Stadium's image, the ramps are an integral part of the structural and servicing systems. The 10m diameter cores house all major shell and core primary plant, whilst the drum walls ultimately take the loads of mast and Stadium roof. To limit the number of openings through the walls, all ventilation intakes and terminals are at the tops of the towers; ducts thread through the towers to the plant area served. Depressed pile caps allow the piped and electrical main services to drop below ground level and connect into the 'raceway' that distributes services around the Stadium.

Electricity and lighting

An external raceway system was selected on a cost versus risk basis. It carries direct buried electrical communications to powerboards within the Stadium's water, gas, and heating services, linking the primary equipment from the ramp cores to the major building services cores within each stand. Electrical services break out from the towers at two levels, connecting to the Stadium via link bridges. Within the Stadium, cables are routed horizontally at high level and vertically within designated service risers. This enables service-free concourses with all major containment routes behind and beneath seating areas.

For spectators and TV cameras alike to view the action clearly, whatever the time of day, the event lighting needed serious consideration, and was designed to comply with FIFA (Fédération Internationale de Football Association) requirements. Some of the floodlights have hot restrike control gear, backed up by standby generators to maintain 800lux, which is the minimum for television to continue 'live' coverage in the event of a normal mains failure.

The Stadium's electricity needs are served by two 2MW substations, each in towers on the west and east stands. During an event the generators will be run to serve the hot restrike floodlights, but should a generator fail, the supply will automatically switch back to mains. If the mains are not available there is further back-up from the generator in the opposite stand.

Security and ventilation

Still further behind the scenes are the systems that back up the services. For security checks, a CCTV system gives image quality that complies with the required standards for identification and crowd monitoring. 15 fixed colour cameras and 57 fully functional dome cameras monitor the seating, public concourses, and access points. All cameras are run from the event control room where system recording takes place, with a secondary control position in the 24-hour security room.

The ventilation system consists of east and west accommodation air-handling plants at each floor level; outside air is filtered and mixed with recirculated air where appropriate. It is heated with low temperature hot water heating coils, then supplied to the appropriate space via insulated ductwork.

Extract air is drawn from occupied spaces through generally uninsulated ductwork to exhaust fans either at high level in the superstructure or back to the associated air-handling unit for recirculation or exhaust as appropriate. Exhaust ductwork is insulated where it passes through unheated spaces to prevent condensation within the duct and to minimize heat loss where the air may be recirculated. Supply and extract fans have variable speed drives. Exhaust air from general accommodation is discharged from the basement plantroom to the service road.



18. The public circulating - amongst the back-stay anchors - during the Games.



19. Opening ceremony for the XVII Commonwealth Games, 25 July 2002.

INNOVATORY DESIGN FEATURES

Wherever possible in the design of this building, the team went back to first principles to create the best systems economically possible rather than simply using tried and tested systems as in other stadia. This made for a unique building and enabled its success in both civic and financial terms.

Pitch ventilation

An inherent problem in designing large stadia is to create a roof that not only shelters (with 'drip-line' cover to all spectators) but also ventilates the pitch. Daylight, sunlight, and air movement over the pitch are essential for healthy grass growth but a wind-free and comfortable arena is also needed.

The dramatic roof form and corresponding stand configuration allowed movable louvre vents in the high-level corner voids. These vents can be adjusted to increase or decrease airflow through the Stadium, and thus benefit not only air movement over the pitch but also the spectator environment. Similar low-level vents are also incorporated in the corner exit gates.

Under most circumstances these precautions would have been adequate to ensure good grass growth, but Arup wanted to ensure the very best pitch possible. A further ventilation system was therefore added, this time beneath the pitch as for golf courses. At close centres perforated pipes were laid; these double for pitch drainage and through them air can be either pumped or sucked. Humidity detectors in the root zone of the turf show the groundsmen when the pitch is too humid and needs drying out, or is too dry and requires watering. Another benefit of the system is that air can be pumped direct to the base of the turf, thereby oxygenating the root zone and increasing turf growth.

Turnstiles

After the initial impact of the overall building form, spectators' next impressions of the Stadium are the entrance experience. The design of the turnstiles is a key component of this.

A turnstile capable of increased entry flow rates was desirable to alleviate the inevitable queues from the 20-minute rush before kick-off. To create a more open entry than many current systems, conventional 'off-the-peg' turnstiles were rejected as too unfriendly and unable to give the desired flow rate. Research showed that faster flow could only be achieved by replacing manual inspection of tickets with 'smart card' technology. Passive models - where gates are always open and only close when a 'bad' ticket enters - were looked at, but it was decided that the industry was not ready for such a turnstile yet (although the chosen system can be modified for this). An ergonomically designed turnstile, with increased space standards and a 120° rotor arm configuration, was developed with a turnstile contractor, ensuring comparable security to a conventional turnstile but with the above improvements.

As a result, queuing times and pre-match agitation are cut down and operational costs saved, as ticketing controllers are not required.

The system automatically counts and monitors the speed and location of spectator ingress, allowing stand-fill times to be based on current turnstile throughput.

Recessed gangway tread

Seats with restricted views have practical and financial implications in a stadium, but an unavoidable factor is the safety requirements for balustrades on the gangways of seating tiers, which give partially obstructed views to some seats in every stadium. At Manchester the design of the gangway steps around and above the vomitories was changed from the traditional 'planted-on step' to being recessed into the concrete seating tiers.

Also, there are hand holds on the seating side of the gangways for additional security while exiting the rows. As the height of the balustrade corresponds to its adjacent step, recessing the step results in a lower balustrade around the vomitory gangways, substantially reducing the number of restricted view seats and giving safer and more comfortable circulation around and into vomitories. Implementing this required a small cost increase, but fewer restricted view seats made for far greater added value.

Recessed floodlights and speakers

Floodlights and speakers are normally hung under the roof, with access walkways for maintenance. Additional structural framing and circuitous maintenance routes can create unsightly clutter under a roof; at Manchester this was solved by creating a 'kick-up' in the roof structure and cladding into which the floodlights and speakers are recessed. This integrated solution made for a neat and tidy soffit, free of clutter, with easy and convenient access for maintenance from the rooftop walkway.

Elegance is married with practicality, and both improved.

Fire and safety

Stadia are complicated buildings and do not always lend themselves to solutions based on prescriptive codes. In this Stadium the fire and safety aspects were developed in fire engineering terms in contrast to prescriptive codes. Fire engineering aims for high safety standards, and simultaneously to facilitate design innovation and limit costs.

No credible fire scenario would result in total building evacuation, so the Stadium construction was exploited and areas of fire risk separated so that, in many scenarios, stand occupants would not be immediately evacuated.

An excellent example of the lateral approach arose in the design of the concourse concessions. These areas not only form one of the most significant fire hazards in the building but their location could impact on the stand escape routes.

Awards

British
Construction
Industry BCI
Major Project
Award 2002:

High
Commendation

Manchester Civic
Society

Renaissance
Award 2002:
Joint Winner

City Life Awards
2002:

Building
of the Year

Institution of
Civil Engineers
2003:

North West Merit
Award

Institution of
Structural
Engineers
Structural Awards
2003:

Structural
Special Award

The standard solution is to suppress fire with sprinklers, and either extract smoke directly or allow it to enter the concourse area and extract from there at high level. The Manchester architectural concept was to maintain a clean soffit on the concourses, which ruled out concourse smoke extraction. Direct smoke extraction from the concessions was difficult, as it required large dedicated smoke extractor fans and fire-rated ductwork. Sprinklers were considered undesirable because of the cost and design complications. Faced with protecting the escape routes whilst keeping the architectural design intent, Arup Fire looked for an alternative solution.

The concept developed was the 'sweeper system'. Each concession unit has a double fire-rated roller shutter assembly with the inner (concession side) shutter reaching the floor and the outer (concourse side) shutter stopping short of the floor. An extractor duct connected at high level into the void between the shutters creates negative pressure and ensures that any smoke escaping through the concession shutter does not enter the public domain. 'Cool' concourse air is mixed with the smoke/heat to reduce the extract air temperature, and the smoke extract ducts are connected into the general toilet extract systems. The duct system did not have to be fire-rated, as calculations showed smoke temperatures to be sufficiently diluted by the ambient air drawn from the concourse.

With the aid of computer modelling, the fire engineered approach demonstrated to the statutory authorities that the Stadium is safe. At the same time, costs (both capital and lifetime) were reduced and design aspirations realized.

Structural fin cladding

A final, and fairly simple, innovation developed as a modernization of the standard composite panelling systems used on buildings throughout the world. Panels are usually formed from fabricated layers providing weatherproofing and insulation which are connected on mullions and transoms to create the complete panel, which in turn is hung on a structural framework. Again Arup went back to first principles and looked at extruding aluminium mullions into structural fins that would combine the tasks of fixing panels and being the framework.

This relatively simple invention contributed in several ways to the scheme development. Not only did the idea save money but it also gave an extra dimension of detail by producing relief lines to increase the interest on the façade.

CONCLUSION

These key innovations contributed to the Stadium's success and ensured not only its stature as an architectural landmark building for Manchester and the UK, but also its lead in integrating technology and architecture.

The City of Manchester Stadium story evolved over more than a decade of commitment and co-operation between the public and private sectors. The XVII Commonwealth Games was universally deemed a huge success, and that it coincided with HM The Queen's Golden Jubilee added an extra shine to a very successful event. The re-opening of the Stadium for football is scheduled for mid-August 2003.

Reference

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Credits

Client:
Manchester City Council

Design team:
Arup and Arup Associates Carolina Aivars, Martin Austin, Michael Beaven, Angela Bennett, Jane Bennisson, Polly Bentham, Helen Bladen, Gavin Blakemore, Mark Boyle, Tony Broomhead, Peter Brown, Mike Buckingham, Peter Budd, James Burland, Stephen Burrows, Peter Caller, Graham Campbell, Tristram Carfrae, Eddie Carmichael, Glen Carney, Richard Carroll, Jonathan Carver, Steven Clarke, Pat Clowry, Adrian Collings, Jane Collins, Kevin Connaughton, Peter Connell, Chris Cowell, Colin Curtis, Russell Cutts, Theo Devaney, Mike Devriendt, Anthony Dolan, John Edgar, Jeremy Edwards, Julie Ellis, Paul Entwistle, David Ferguson, Frank Ghaidan, Russell Grayson, Enamul Haque, Ben Hargreaves, Dennis Harrison, Peter Hartigan, Rob Hartshorne, Paul Holder, Rick Houghton, John House, Alastair Hughes, David Hughes, Paul Hughes, Ian Humphreys, Naushad Islam, Andrew Jefferson, David Johnson, Rich Johnson, Lindsay Johnston, Oliver Jones, Lee Jordan, Ulkem Karaca-Buckley, Mike King, Chris Lambell, Chris Lantsbury, Andrew Law, Simon Lay, Tim Leadbetter, James Leahy, Anna Liu, Peter Llewellyn, Carl Lowe, Charles MacDonald, Caroline Marklew, Mike Marr, Teresa Marshall, Dave Maunder, Sean Macintosh, Luke McAdam, Patrick McCafferty, Fergus McCormick, Vivien McCullough, John McDonald, Peter McDowell, Brian McLoney, Roger Milburn, John E Miles, Cathy Milligan, Mark Moppett, Richard Morris, Paul Murphy, Phygina Okoli, Donie O'Loughlin, Tsuyoshi Oya, Darren Paine, Ajay Parag, Richard Partridge, Raj Patel, Dipesh Patel, Steven Pearson, Neil Phipps, Rachel Pickford, Roger Pickwick, Duncan Platt, Adrian Popplewell, Judith Quinn, Terry Raggett, Reuben Ramelize, Stuart Redgard, Roland Reinardy, Marcel Ridyard, John T Roberts, Craig Robinson, Jon Sandford, Mark Scull, Stephen Setford, Gopi Shanmuganathan, Martin Simpson, Ben Slee, Caroline Sohie, Dave Spencer, Charles Stanton, Alexandra Stevens, Callum Stewart, Anthony Sumner, Craig Taylor, Jeffrey Teerlinck, Patricia Thorpe, Michael Tite, David Twiss, Eugene Uys, John Waite, Lisa Walker, James Ward, Trevor Wheatley, Gary White, Brian Wilcox, Tanis Williams, Darren Willis, Michelle Wilson, Michael Wilton, Joanne Wolbers, Colin Wood, Andrew Woodhouse, Jason Yi, Keith York

Design team collaborators:
AMEC Developments Ltd
Gillespies
HOK / Lobb Sports
Architecture
KSS Sports and
Leisure Design
Manchester Engineering
Design Consultancy
Sinclair Knight Merz
Sports Turf
Research Institute
Davis Langdon & Everest
Poole Stokes & Wood
Partnership

Main contractor:
Laing Construction Ltd
Steelwork subcontractor:
Watson Steel Ltd
Illustrations:
1, 8, 12, 13, 15-17:
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20. The Stadium in athletics configuration, ready for the XVII Commonwealth Games.

