Stadia

A design and development guide

by Geraint John, Rod Sheaard & Ben Vickery

Foreword by Jacques Rogge

Fourth edition

Architectural Press

STADIA

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The authors: Ben Vickery, Geraint John, and Rod Sheard.

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Fourth edition

Geraint John, Rod Sheard and Ben Vickery

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Foreword by Jacques Rogge, President of the International Olympic Committee

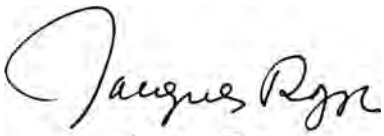
Olympic Stadia are the visual icons of any edition of the Olympic games. The design and development of sports stadia as explained and illustrated in this guide are an exciting challenge for all architects.

At the centre of their work has to be the athletes, and the guarantee that the stadium can provide the best competition conditions. This certainly has an impact on the concept, design and choice of material.

A sports stadium, however, also has to meet other expectations. It has to fulfill all the criteria for sustainable development. Its design and development have to be based on the latest economic, social and environmental standards. It has further to be part of an urban development plan which integrates the stadium into an overall concept. This underlines that neither stadia, nor sport, can live in isolation. They have to be part of everyone's life and society.

In the spirit of the Olympic Games, the stadia also combine culture, art and sport. Any architect who has the opportunity to design a new stadium will aspire to build a contemporary and highly symbolic building that reflects the mindset of his time. They therefore play a social and cultural role in all host cities.

Designing and developing sports stadia, which must take into account all the above-mentioned elements, is an extremely demanding task, and I am grateful to the authors of this guide for their valuable contribution to this endeavour.



Jacques Rogge

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Going to the Match, 1953, by L S Lowry (1887–1976).

Preface

This work first appeared in 1994 and was so well-received that a revised and updated edition was called for in 1997, and again in 2000. Since then the rate of change in the world of sport, and the viewing and marketing of sport, has been such that a fully revised fourth edition became essential.

For this purpose the original authors Geraint John and Rod Sheard have now been joined by Ben Vickery.

Geraint John was Chief Architect, and Head of the Technical Unit for Sport, of the Sports Council of Great Britain; a member of the Football Stadia Advisory Design Council in London; and Visiting Professor of Architecture: Sports Building Design at the University of Luton.

Rod Sheard was Chairman of the London architectural practice LOBB, and is now Senior Principal of HOK Sport Architecture. He has played a leading role in the design of some of the world's principal stadia including the Telstra Stadium in Sydney (previously known as the Sydney 2000 Olympic Stadium) in Australia, the Ascot Racecourse stadium in England, and the Emirates Stadium in London. His other recent books include 'Sports Architecture' and 'The Stadium: Architecture for the New Global Culture'.

Ben Vickery is a Senior Principal of HOK Sport Architecture in London. He has worked on a wide variety of sports buildings; was responsible for delivering Stadium Australia, the main venue for the Sydney 2000 Olympics; and led the team designing London's new Wembley stadium. In 2005 he served on the Football Licensing Authority committee that wrote the authoritative design guide on 'Concourses'.

The three authors have between them over sixty years' experience in designing, procuring, and reviewing sports stadia around the world. Their individual backgrounds cover private practice, public authorities and academia; all have spoken at numerous national and international events; and in addition to the many stadia with which they have been directly involved, they have studied most of the world's leading sports venues.

Their aim in this work is to share their hard-won expertise as openly as possible for the benefit of all who love sport, participate in sport, and produce sporting events. Like its predecessor volumes, this work is intended to be a comprehensive, authoritative, and practical guide that will assist designers, managers, owners, investors, users and other interested parties in understanding one of the most exciting and rewarding types of building today. They hope that this book will inspire the creation of venues that are practical, elegant, and a real asset to their communities.

Geraint John
Rod Sheard
Ben Vickery

Acknowledgments

The contents of this book represent the combined experience and views of the three authors, but they owe a great debt of gratitude to the many experts without whose help this work would have been much the poorer.

The International Association of Auditorium Managers (IAAM); the Sports and Play Consortium Association (SAPCA) and the International Association for Sports and Leisure Facilities (IAKS), in the person of Johannes Buhlbecker, are among the organisations which gave valuable assistance.

Andrew Szieradzki of Buro Happold provided information for Chapter 6, and Jeff Perris of STRI for Chapter 7. Michael Abbott Associates on behalf of SAPCA gave major assistance on Chapters 7 and 22, as did Jim Froggatt of the Football Licensing Authority on Chapters 10, 11, 12 and 15. Kelvin Austin of Abacus Lighting updated and made a large contribution to the section on lighting in chapter 21, as did Craig McLellan of Franklin Sports Business to the section on capital costs in Chapter 23. Terry Stevens provided information for Chapter 25.

Within HOK Sport Architecture, Javier Pinedo is responsible for the design of this book; and he and Simon Borg produced much of the artwork. Other assistance was provided by Helen Caswell, Michele Fleming, Dale Jennins; Tom Jones, Bill Odell, and Belinda Perkins. Phil Hofstra, Erin Hubert and Ed Roether gave assistance from HOK SVE in the USA.

Finally the authors wish to acknowledge the major contribution made by Maritz Vandenberg, who assisted them in producing each of the four editions of this work, and largely wrote chapter 10 of the present edition.

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Wimbledon Centre Court	HOK Sport Architecture, Patrick Bingham-Hall

1. The stadium as a building type

1.1 A venue for watching sport
1.2 History
1.3 Current requirements

1.1 A venue for watching sport

1.1.1 Architectural quality

A sports stadium is essentially a huge theatre for the presentation of heroic feats (Figure 1.1). From such a combination of dramatic function plus monumental scale ought to flow powerful civic architecture. The first great prototype, the Colosseum of Rome, did indeed achieve this ideal, but very few stadia since then have succeeded as well. The worst are sordid, uncomfortable places, casting a spell of depression on their surroundings for the long periods when they stand empty and unused, in sharp contrast with the short periods of extreme congestion on match days. The best are comfortable and safe, and offer their patrons an enjoyable afternoon's or evening's entertainment – but even these often fall short of architectural excellence.

Subduing the tiers of seating, the ramps or stairs, and the immense roof structures into a single harmonious and delightful architectural ideal is a challenge that seems almost beyond solution, so that sports stadia tend to be lumpy agglomerations of elements that are out of scale with their surroundings and in conflict with each other, and often harshly detailed and finished.

This book cannot show the reader how to create great architecture. By clarifying the technical requirements to the greatest possible degree, and showing how these problems have been solved in particular cases, it hopes at least to ease the designer's struggles with his brief and leave him better equipped for the really difficult task of thinking his solutions through to the point where they become a fine building.

1.1.2 Financial viability

In the 1950s sports grounds around the world were filled to bursting point at every match and watching live sport was a major pastime for millions. Now, only a few decades later, those same grounds are fighting for financial survival, and owners and managers search for solutions.

The truth is that it is now very difficult for a sports stadium to be financially viable without some degree of subsidy, whether open or covert. The most that

Figure 1.1 'Sport is theatre where the primal things are in play – courage, passion, perfidy, endeavour, fear; where grace and sometimes incredible gifts pass in front of us' (David Robson, former sports editor of *The Sunday Times*).

Photograph: Getty

can usually be done is to produce a facility that will satisfy a viable combination of the following three factors:

- The required subsidy is not impossibly large.
- The project is sufficiently attractive to public sources of finance to justify investment from the public purse ...
- and sufficiently attractive to private sponsors to persuade them to bridge any remaining financial gap.

Anyone who considers the above statements too pessimistic should ponder the American experience. The USA and Canada have highly affluent populations totalling 276 million, are keen on sport and have energetic leisure entrepreneurs and managers very skilled at extracting the customer's dollar. Of all countries the USA and Canada should be able to make their stadia pay, and they have seemingly explored every avenue – huge seating capacities, multi-use functions, adaptability of seating configurations, total enclosure to ensure comfort, retractable roofing to allow for different weather conditions and yet profitability remains elusive, particularly when the huge initial costs of development are taken into account. To take three leading examples:

- The beautifully situated 1968 Three Rivers Stadium at Pittsburgh (unroofed; seating capacity 47 971 for baseball; 59 000 for football) has been regularly sold out for every football match but is happy to limit its annual loss, we are told, to under two million dollars (US).
- The management of the 1988 Joe Robbie Stadium in Miami (unroofed; seating capacity 73 000) have optimistically suggested that they are among the first stadia in the USA to be 'turning the corner' thanks to new and aggressive financing arrangements, but observers in the industry are sceptical of this claim, particularly in view of rising interest rates.
- Construction of the famous 1989 Toronto Skydome in Canada (retractable roof; seating capacity 56 000) was funded by a unique system of private sponsorship and public funding, but after three years of use and huge publicity it was said to be struggling with heavy debt problems. As in many cases these were brought on partly by unforeseen interest rate rises – which merely demonstrates how vulnerable such huge projects are to uncontrollable factors.

Just as we cannot prescribe rules which will produce great architecture we cannot give formulae which will guarantee a profitable stadium. Teams of experts must analyse the costs and potential revenues for each individual case and evolve a solution that will be viable – or, at worst, leave a gap that can be bridged by private sponsors or public support.

This book identifies the factors that must be considered. But before getting into such technical details we must make the most important point of all: that

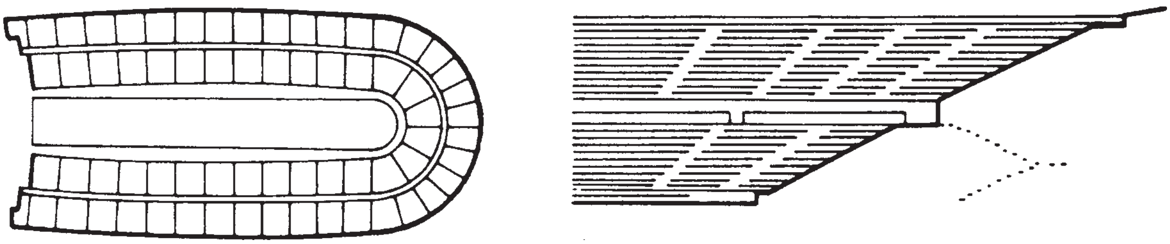


Figure 1.2 The U-shaped sunken stadium at Athens, first built in 331 BC for the staging of foot races, was restored and used for the first modern Olympics in 1896.

sports and leisure facilities are one of the great historic building types, representing some of the very earliest works of architecture (Greek stadia), some of the most pivotal (Roman amphitheatres and thermae), and some of the most beautiful (from the Colosseum in Rome to the Olympic Park in Munich twenty centuries later). Therefore we will start with a brief historic survey.

1.2 History

1.2.1 Greek

The ancestral prototypes for modern sports facilities of all kinds are the stadia and hippodromes of ancient Greece. Here Olympic and other sporting contests were staged, starting (as far as we can tell) in the eighth century BC.

Stadia

Greek stadia (foot racecourses) were laid out in a U-shape, with the straight end forming the start-line. These stadia varied somewhat in length, the one at Delphi being just under 183 m long and that at Olympia about 192 m. Such stadia were built in all cities where games were played. Some, following the pattern of Greek theatres, were cut out of a hillside so that banks of seats with good sightlines could be formed naturally, while others were constructed on flat ground. In the latter case the performance area was sometimes slightly excavated to allow for the formation of shallow seating tiers along the sides.

Stadia built on the flat existed at Ephesus, Delphi and Athens. The one at Delphi was almost 183 m long by 28 m wide, had a shallow bank of seats along one side and around the curved end, and the judges' seats were at the midpoint of the long side – very much as in a modern facility. The stadium at Athens was first built in 331 BC, reconstructed in AD 160 and reconstructed again in 1896 for the first modern Olympic games. In this form it can still be seen, accommodating up to 50 000 people in 46 rows (Figure 1.2).

Hillside stadia existed at Olympia, Thebes and Epidauros, and their kinship with the Greek theatre is unmistakable: these are essentially elongated theatres for the staging of spectacular physical feats, and from them runs a direct line of development firstly to the multi-tiered Roman amphitheatre and ultimately to the modern stadium.

The civic importance of such sporting facilities in Greek life is demonstrated particularly well at the ancient city of Olympia on the island of Peloponnesus. The site housed a great complex of temples and altars to various deities and, at the height of its development, was a rendezvous for the whole Greek world. There was a sports field situated adjacent to an enclosed training gymnasium, and along the edge of the field a colonnade with stone steppings to accommodate the spectators. As the track became more popular two stands were constructed, facing each other on opposite sides of the activity area. The fully developed stadium consisted of a track 192 m long and 32 m wide with rising tiers of seats on massive sloping earth banks along the sides, the latter ultimately accommodating up to 45 000 spectators. The stadium had two entrances, the Pompic and the Secret, the latter used only by the judges.

Adjacent to the stadium at Olympia was a much longer hippodrome for horse and chariot races, and in these twin facilities we may clearly discern the embryonic forms of modern athletic stadia and racing circuits. The stadium has been excavated and restored and can be studied, but the hippodrome has not survived.

While modern large capacity, roofed stadia can seldom have the simple forms used in ancient Greece, there are occasions when the quiet repose of these beautiful antecedents could be emulated. The essential points are unobtrusive form and use of natural materials which blend so closely with the surroundings that it is difficult to say where 'landscape' ends and 'building' begins.

Hippodromes

These courses for horse and chariot races were roughly 198 m to 228 m long and 37 m wide and were laid out, once again, in a U-shape. Like Greek theatres, hippodromes were usually made on the slope of a hill to give rising tiers of seating, and from them developed the later Roman circuses, although these were more elongated and much narrower.

1.2.2 Roman

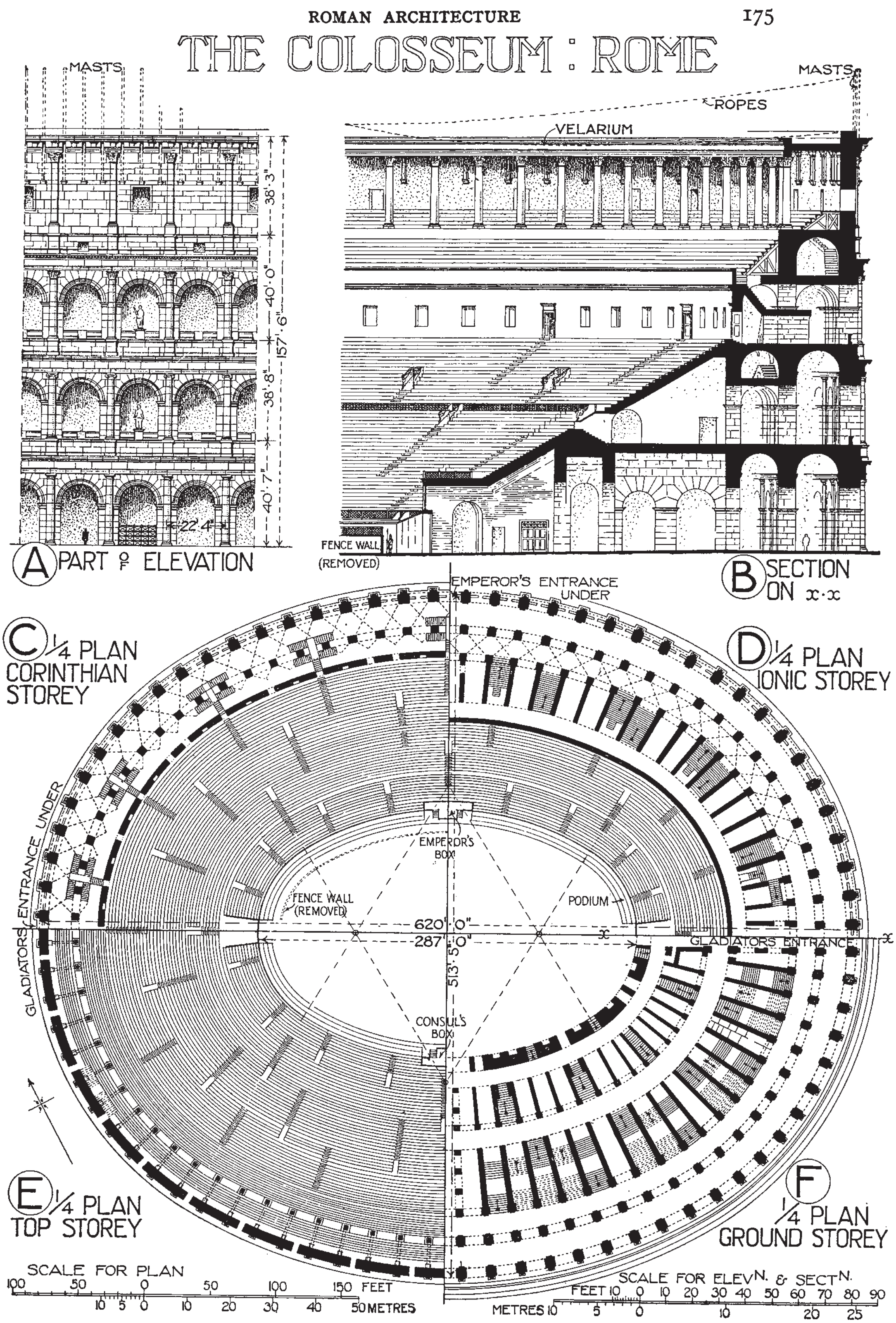
Amphitheatres

The militaristic Romans were more interested in public displays of mortal combat than in races and athletic events, and to accommodate this spectacle they developed a new amphitheatrical form: an elliptical arena surrounded on all sides by high-rising tiers of seats enabling the maximum number of spectators to have a clear view of the terrible events staged before them. The term 'arena' is derived from the Latin word for 'sand' or 'sandy land', referring to the layer of sand that was spread on the activity area to absorb spilled blood.

The overall form was, in effect, two Greek theatres joined together to form a complete ellipse. But the size of the later Roman amphitheatres ruled out any reliance on natural ground slopes to provide the necessary seating profile, therefore the Romans began to construct artificial slopes around the central arena – first in timber (these have not survived) and, starting in the first century AD, in stone and concrete. Magnificent examples of the latter may still be seen in Arles and Nimes (stone) and in Rome, Verona and Pula (stone and a form of concrete). The amphitheatre at Arles, constructed in around 46 BC, accommodated 21 000 spectators in three storeys and despite considerable damage, lacking for instance its third storey which held the posts supporting a tented roof, it is still used every year for bullfighting. The Nimes amphitheatre, dating from the second century AD, is smaller but in excellent condition and also in regular use as a bullring. The great amphitheatre in Verona, built in about 100 AD, is world famous as a venue for opera performances. Originally it measured 152 m by 123 m overall, but very little remains of the outer aisle and it currently seats about 22 000 people. The arena measures 73 m by 44 m.

The Flavian Amphitheatre in Rome (Figure 1.3), better known as the Colosseum from the eighth century onwards, is the greatest exemplar of this building type and has seldom been surpassed to this day as a rational fusion of engineering, theatre and art. Construction began in AD 70 and finished 12 years later. The structure formed a giant ellipse of 189 m by 155 m and rose to a height of four storeys, accommodating 48 000 people – a stadium capacity that would not be exceeded until the twentieth century. Spectators had good sightlines to the arena below, the latter being an ellipse of roughly 88 m by 55 m bounded by a 4.6 m high wall. There were 80 arched openings to each of the lower three storeys (with engaged columns and encircling entablatures applied to the outer wall surface as ornamentation), the openings at ground level giving entrance to the tiers of seats. The structural cross-section (Figure 1.3), broadening from the top down to the base, solved three problems at one stroke:

- First, it formed the artificial hillside required from the theatrical point of view.
- Second, it formed a stable structure. The tiers of seats were supported on a complex series of barrel-vaults and arches which distributed the immense loads via an ever-widening structure down to foundation level;
- Third it matched the volume of internal space to the numbers of people circulating at each level – fewest at the top, most at the base. The internal ambulatories and access passages formed by the structural arcades were so well-planned that the entire amphitheatre could, it is thought, have been evacuated in a matter of minutes.



'A History of Architecture', by Sir Banister Fletcher, published by Elsevier Press

Figure 1.3 The Colosseum of Rome (AD 82) was built for gladiatorial combat and not for races. It therefore took the form of a theatre in which rising tiers of seats, forming an artificial hillside, completely surrounded an arena. The great stone and concrete drum fused engineering, theatre and art more successfully than most modern stadia.

The arena was used for gladiatorial contests and other entertainments and could be flooded with water for naval and aquatic displays, thus anticipating modern mass entertainments. Beneath the arena was a warren of chambers and passageways to accommodate performers, gladiators and animals. The amphitheatre could be roofed by stretching canvas awnings across the open top.

All these diverse functions have been smoothly assimilated into a great drum that stands magnificently in the townscape – functional in layout, rational in appearance, yet rich and expressive in its surface modelling. Present-day designers could do worse than to spend some time contemplating the achievements of the Colosseum before tackling their own complex briefs.

Circuses

As the Greek theatre led to the Roman amphitheatre, so the Greek hippodrome led to the Roman circus. These circuses were U-shaped equestrian racecourses with the straight end forming the entrance and accommodating the stalls for horses and chariots. The starting and return courses were separated by a s*pina* – a low wall decorated with carvings and statues. Seats rose in tiers along the straight sides of the U and round the curved end, the lower seats being in stone and reserved for members of the upper classes, the upper seats made of wood.

A notable early example was the Circus Maximus in Rome (fourth century BC), followed in 46 BC by a successor of the same name. This was possibly the largest stadium ever built. It was about 660 m long and 210 m wide and offered all-seating accommodation for spectators in three tiers parallel to the track.

Other Roman examples include the Circus Flaminius (third century BC) and the Circus Maxentius (fourth century AD), the latter being the only Roman circus still extant today. Outside Rome were the Byzantium Hippodrome of the second century AD (based on the Circus Maximus) and the Pessimus Hippodrome which was unique at the time in consisting of a Greek theatre and a Roman hippodrome linked at the centre of the hippodrome via the theatre stage. Two events could be staged separately in theatre and hippodrome, or the latter could be used in combination for a single grand event. This building was an obvious ancestor of the modern multi-purpose stadium complex.

1.2.3 Mediaeval and after

As Christianity swept through Europe the emphasis of society shifted to religious salvation, and architectural effort was turned to the building of churches rather than places of recreation and entertainment. No major new sports stadia or amphitheatres would be built for the next fifteen centuries.

Sports buildings inherited from the Roman era became neglected. Some were converted to new uses as markets or tenement dwellings, the amphitheatre at Arles, for instance, being transformed into a citadel with about 200 houses and a church inside it (built partly with stone from the amphitheatre structure); many others were simply demolished.

During the Rennaisance and after, competitions on foot or horseback were held in open fields or town squares, sometimes with temporary stages and covered areas for important spectators rather along the lines of the first Greek hippodromes – but no permanent edifices were erected even though deep interest was taken in classicism and in the architecture of stadia and amphitheatres. The Colosseum was particularly closely studied, but only for its lessons in façade composition and modelling, which were then transferred to other building types.

1.2.4 The nineteenth century

The stadium as a building type saw a revival after the industrial revolution. There was a growing demand for mass spectator events from the public, there were entrepreneurs who wished to cater for this demand and there were new structural technologies to facilitate the construction of stadia or enclosed halls.

A particularly important impetus came from the revival of the Olympic tradition at the end of the nineteenth century. At the instigation of Baron Pierre de Coubertin a congress met in 1894, leading to the first modern Olympic games being staged at Athens in 1896. For this purpose the ancient stadium of 331 BC, which had been excavated and studied by a German architect/archeologist called Ziller, was rebuilt to the traditional Greek elongated U-pattern, its marble terraces accommodating about 50 000 spectators (Figure 1.2). Thereafter, Olympic games were held every four years, except when interrupted by war, and those which produced notable changes or advances in stadium design are noted below.

1.2.5 Twentieth-century Olympic stadia

In 1908 the games were held in London, where the White City stadium was built for the purpose, the architect being James Fulton. It was a functional building accommodating over 80 000 spectators, had a steel frame, and was the first purpose-designed modern Olympic stadium. The arena was gigantic by the standards of today (Figure 1.4), accommodating a multitude of individual sports and surrounded by a cycle track. It was subsequently decided to reduce the number of Olympic sports, partly to give a smaller arena. In later years White City stadium became increasingly neglected and was finally demolished in the 1980s.

Owing to the First World War the 1916 games did not take place, but a stadium with a capacity of 60 000 had been built in 1913 in Berlin in anticipation of these games. Its interest lies in its pleasantly natural form: like the theatres and stadia of ancient Greece it is shaped out of the earth, blending quietly into the surrounding landscape and making no monumental gestures. The architect was Otto March, and this stadium formed a prototype for the numerous Sport-parks built in Germany in the 1920s.

In 1936 the city of Berlin did finally host the Olympic games. The Nazis had recently assumed power and used the occasion to extend the stadium of 1913 to a great oval structure accommodating 110 000 spectators including 35 000 standees in 71 rows (Figure 1.5). The monumental stone-clad stadium was, unfortunately, used not only for sporting functions but also for mass political demonstrations. In spite of these unpleasant associations the Berlin stadium with its rational planning and powerful columniated façade is a highly impressive design. The architect was Werner March.

The 1948 Olympics returned to London, where the 24-year-old Wembley Stadium was renovated by its original designer Sir Owen Williams.

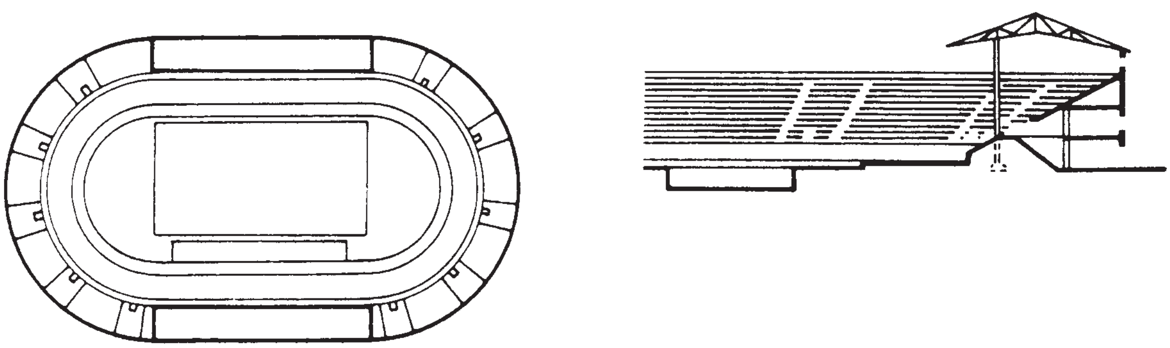


Figure 1.4 White City stadium in London (1908) was the first modern Olympic stadium and accommodated over 80 000 spectators. Its athletics field was encircled by a cycle racing track which made the arena larger than later examples.

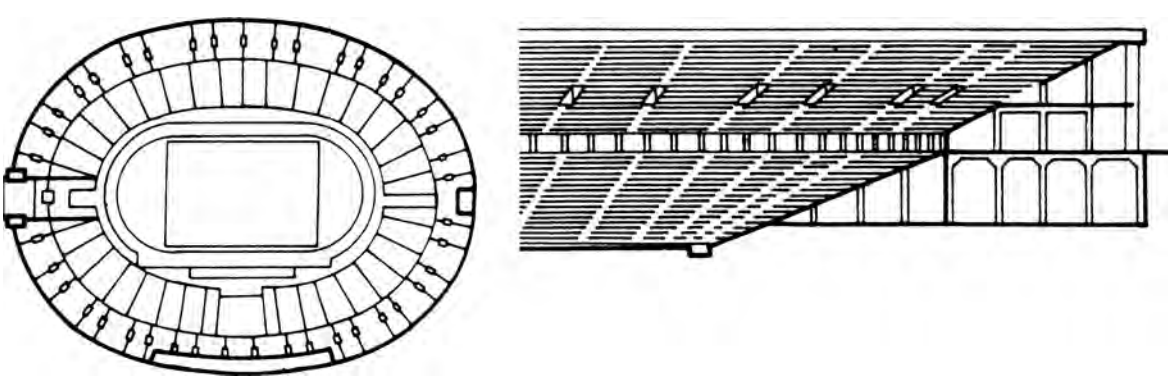


Figure 1.5 The Berlin Olympic stadium of 1936 accommodated over 100 000 people in a rationally planned elliptical layout.

The 1960 Olympiad in Rome marked a new departure. Instead of staging all events on a single site as before, a decentralized plan was decided upon, with the athletics stadium in one part of the city and other facilities some distance away on the urban outskirts, and this was to remain the preferred approach for decades to come. The main stadium, by architect Annibale Vitellozzi, was an uncovered three-storey structure (Figure 1.6) and bore some similarities to the Berlin stadium. It has an orderly and handsome limestone-clad façade wrapped round its oval shape, to which a roof was added in 1990 when Rome hosted the Soccer World Cup competition. Two of the fully enclosed smaller halls dating from 1960 are architecturally significant: the 16 000 capacity Palazzo dello Sport (Figure 1.7) and the 5000 capacity Palazzetto dello Sport. Both are circular, column-free halls which combine great visual elegance with functional efficiency. The architects were Marcello Piacentini for the Palazzo and Annibale Vitellozzi for the Palazzetto, and Pier Luigi Nervi was the structural engineer for both.

In 1964 the Olympics were held in Tokyo. The Jingu National Stadium, first built in 1958, was extended for the occasion (Figure 1.8) but, as in Rome, two smaller fully-enclosed halls caught international attention. These were Kenzo Tange's Swimming Arena and Sports Arena seating 4000 and 15 000 spectators respectively. The Swimming Arena building was justifiably called 'a cathedral for swimming' by Avery Brundage, the International Olympic Committee (IOC) President. Here, 4000 spectators could sit under one of the most dramatic roof structures ever devised: steel cables were draped from a single tall mast on the perimeter of the circular plan, and concrete panels hung from the cables to form a semi-rigid roof structure. As built the roof forms of the two gymnasia may look natural and inevitable, but both were the result of very extensive testing and tuning on large-scale models, not merely for structural efficiency but also for visual composition.

In 1968 Mexico City was the Olympic host and rose to the occasion with several notable stadia. The University Stadium, built in 1953 for a capacity of 70 000 spectators, was enlarged in 1968 to become the main Olympic stadium with 87 000 seats (Figure 1.9). Its low graceful form is notable: like the 1913 stadium in Berlin this is basically an 'earth stadium' which barely rises above the natural landscape and uses hardly any reinforced concrete, blending smoothly into its surroundings. It also uses splendid sculptural decoration to enhance its exterior form. More impressive in scale is the Aztec Stadium (architect Pedro Ramirez Vasquez) accommodating 107 000 seated spectators. Most viewers are under cover, and while some are a very long way from the pitch it is a wonderful experience to see this number of cheering fans gathered under one roof. This is said to be the largest covered stadium in the world. Finally, as at Rome in 1960 and Tokyo in 1964, there was a fully enclosed indoor arena also worthy of note.

In 1972 the Olympics returned to Germany. The site, formerly an expanse of nondescript land near Munich, was converted with exemplary skill to a delightful landscape of green hills, hollows, meadows and watercourses, and an existing heap of rubble

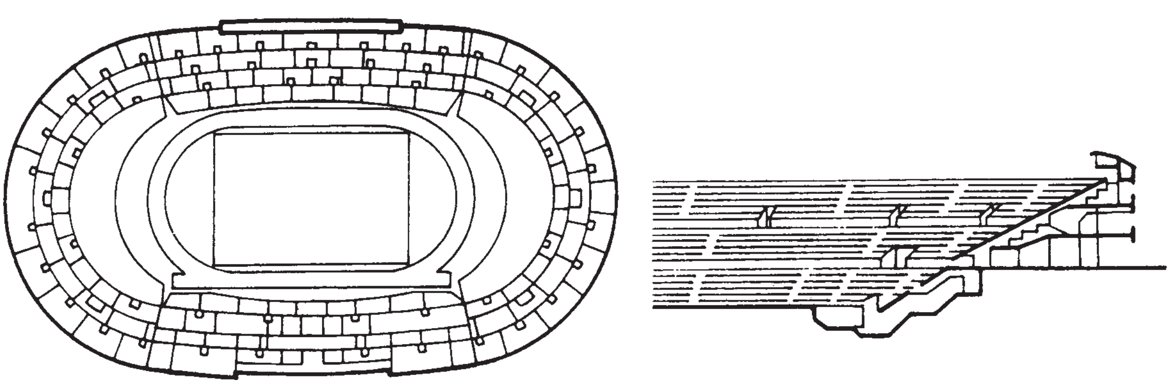


Figure 1.6 The Rome Olympic stadium of 1960, also a colonnaded oval bowl, bears a family resemblance to that of Berlin.

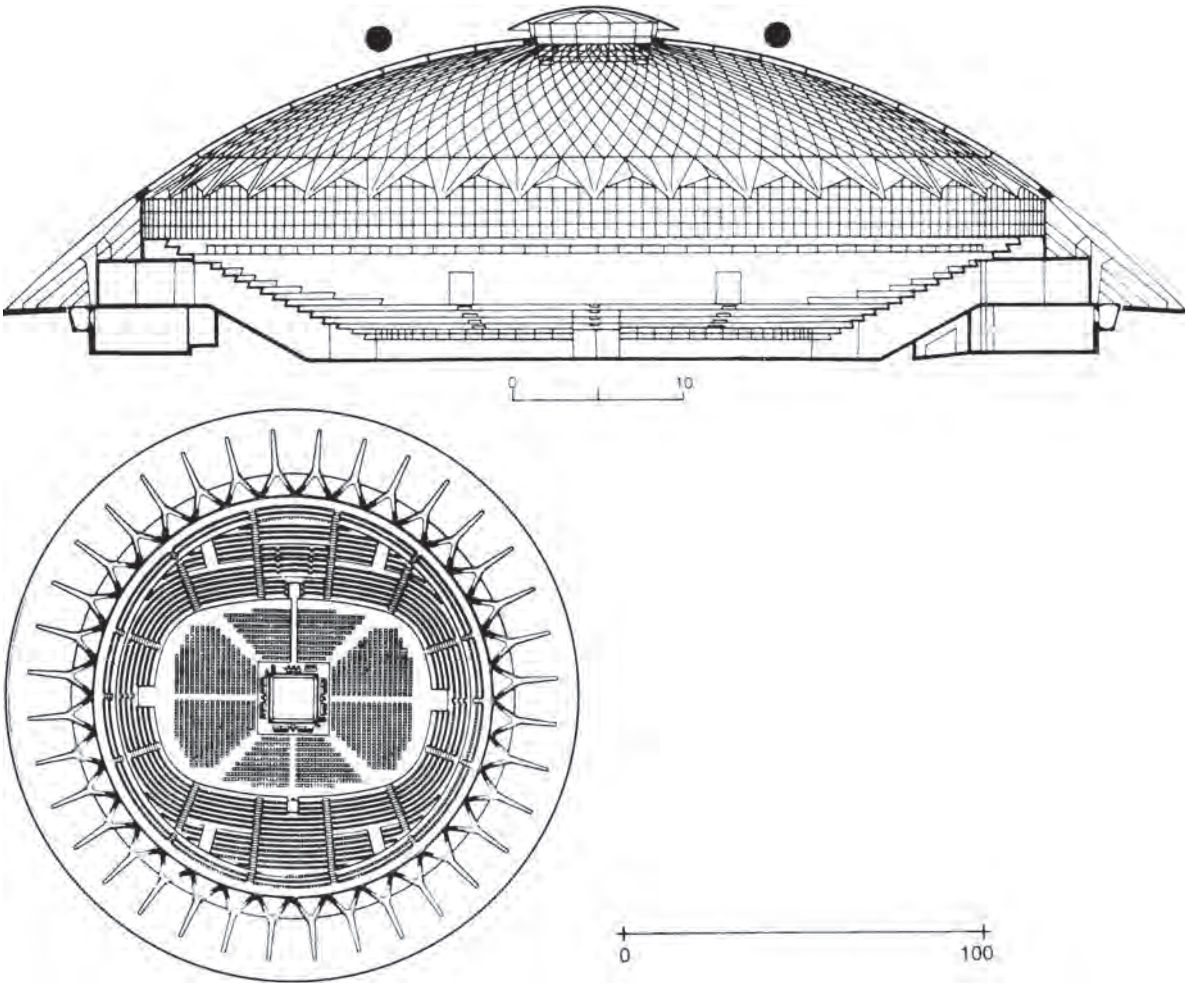


Figure 1.7 A smaller enclosed stadium with column-free interior and of exceptional architectural merit: the Palazzetto dello Sport for the Rome Olympics of 1960. It has a concrete shell roof resting on 36 pre-cast perimeter supports.

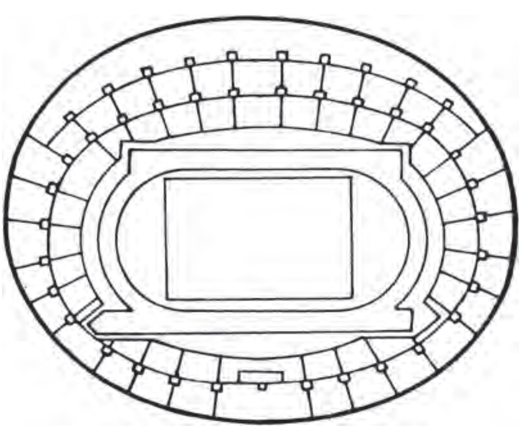


Figure 1.8 The Tokyo Olympic Stadium of 1964.

became a small green hill. Perhaps in a conscious attempt to erase memories of the heavy monumentality of the 1936 Berlin stadium, a very expensive but delightfully elegant lightweight roof was thrown over one side of the stadium (Figure 1.10) and extended to several other facilities, creating an airy structure that still holds its age well 30 years later. The arena is embedded in an artificially created hollow so that the roof, which consists of transparent acrylic panels on a steel net hung from a series of tapered masts, seems to float above the parkland, its gentle undulations mirroring those of the landscape below. It must be said that environmental problems have been experienced under the pool section of this

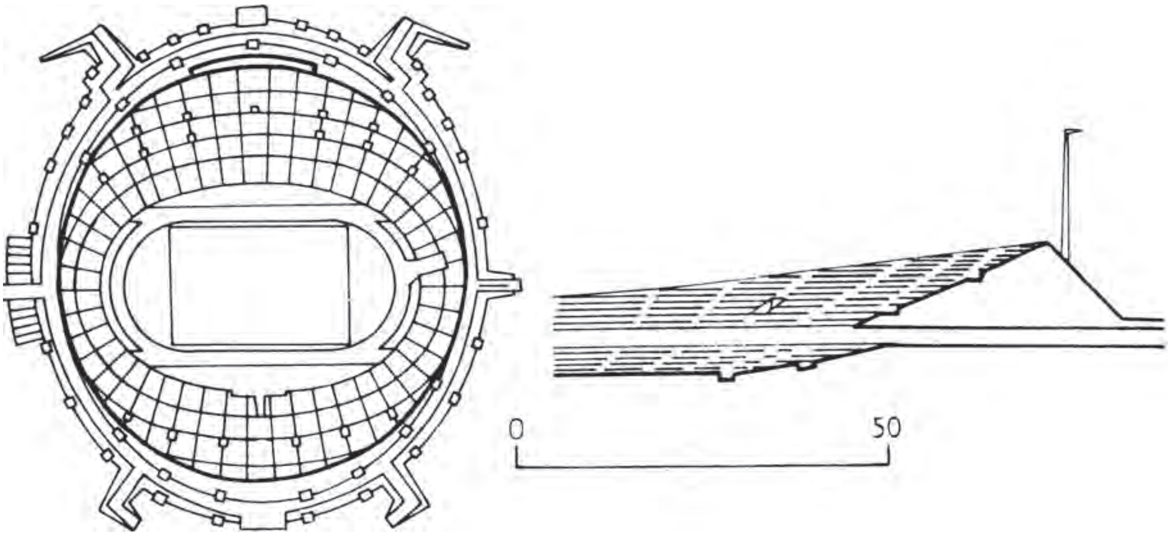


Figure 1.9 The Mexico City Olympic Stadium of 1968 seated spectators in a low, graceful shape sunk into the landscape.

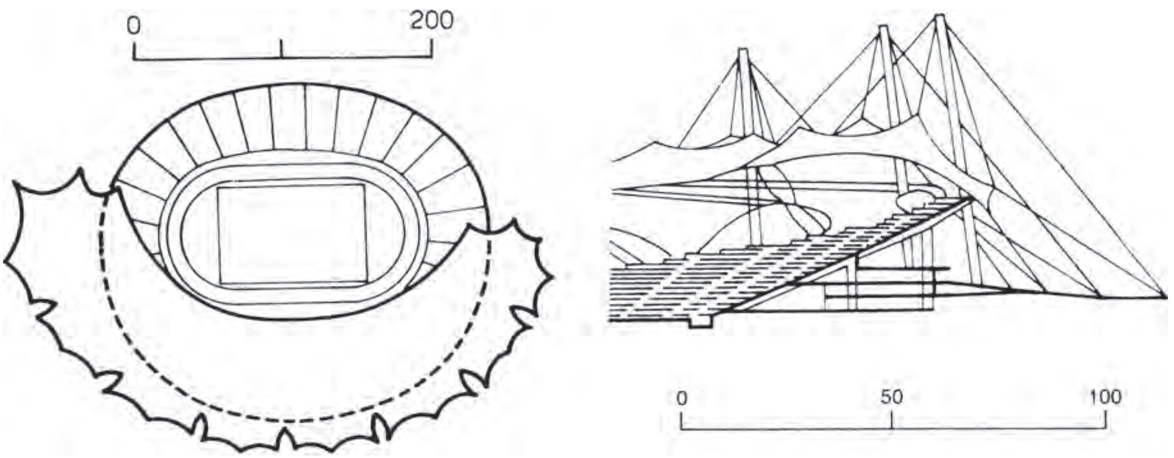


Figure 1.10 The Munich Olympic Stadium of 1972 brought the series of architecturally outstanding stadia of the preceding decades to a climax.

plexiglass canopy and that a PVC-coated polyester parasol was suspended under the arena section to shade the area below from the sun. Nevertheless the roof, which is further described in Section 4.8, remains an outstanding achievement: in addition to being beautiful it is the largest to date, covering 21 acres or 8.5 hectares. The stadium designers were architects Günter Behnisch and Partners, and engineers Frei Otto and Fritz Leonardt.

In 1992 Barcelona hosted the Olympics, and the 1929 Montjuic World's Fair stadium was extensively remodelled by architect Vittorio Gregotti, leaving virtually only the Romanesque façades intact, to cater for the majority of track, field and pitch sports. Everything inside the perimeter walls of the stadium was removed, the playing area was lowered to allow twice the previous seating capacity, and a new tunnel system was installed around the 9-lane running track so that members of the press could circulate freely without interfering with the events above. Outside the old gate to the stadium is a new piazza, from which access is gained to four other facilities: the 17 000-seat Palau Sant Jordi gymnasium (architect Arata Isozaki), the Picornell swimming complex, the University for Sport, and the International Media centre. The site is very compact compared to those of most other recent Olympic games.

Following concerns about the long-term viability of huge stadia built just for Olympic athletics events, most notably in the case of the Montreal stadium built for the games in 1976, later host cities have constructed stadia with their post-Olympic life in mind. The stadium at Atlanta for the 1996 Games was designed to be converted after the games into a baseball stadium, and that for the Sydney Olympics in 2000 by HOK Sport was designed with 30 000 temporary seats that were removed after the games so the building could be reduced in size to host an annual programme of games of rugby and Australian rules football.

The best of the above structures rise to the level of great architecture, most notably perhaps the Rome, Munich, and Tokyo buildings. Interesting stadia were built for the games of 1976 (Montreal), 1980 (Moscow), 1988 (Seoul), and 2000 (Sydney), but we do not have the space to show them here. Some information on the technically interesting but the problematic Montreal stadium is given in Section 4.4.

1.2.6 Twentieth-century single-sport stadia

As the above Olympic stadia were being created, increasingly ambitious facilities were also evolving for specific sports such as football (also called soccer in the UK and USA), rugby, American football, baseball, tennis and cricket.

Football

Football stadia predominate in Europe and much of South America, owing to the popularity of the game in these countries. But different traditions in these different regions have led to a variety of architectural types.

In the UK the typical pattern is for each stadium to be owned by a particular football club and to be used only by that club. This dedication to a single sport, combined with very limited income, has helped create a tradition of spectator 'closeness' which takes two forms:

- First, there is a tradition of standing terraces in which fans stand closely together. This is no longer acceptable at top division clubs on safety grounds and all standing terraces in the Premier and First Divisions in the UK have been converted to seats – see Chapters 7 and 13.
- Second, British football stadia have long been designed to accommodate spectators very close to the pitch. This allows intimate contact with the game but makes it difficult to incorporate an athletics track round the perimeter of the pitch. While this intimate social atmosphere is a much admired aspect of the British football stadium, and one which most clubs would wish to retain, it seems possible that major stadia will increasingly be designed for multi-purpose uses (including athletics in specialist cases).

In European football there is a very different pattern, with each stadium typically owned by the local municipality and used by a large number of sports clubs. The football clubs run their own lotteries, ploughing the profits back into the game; many stadia are also used for other sports, particularly athletics. For all these reasons European stadia have in the past tended to be better funded than British ones and somewhat better designed and built – examples are Düsseldorf, Cologne or the World Cup venue at Turin. Dual-use facilities have the drawback that the placement of an athletics track around the pitch pushes spectators away from the playing area, thus reducing spectator/player contact, but such loss of intimacy must be weighed against the advantage of better community use.

The most notable British football stadia are those of the Premier League clubs. Elsewhere there is, sad to say, a depressing tendency for clubs to settle for the cheapest and quickest solution, with little or none of the vision occasionally encountered on the continent of Europe. Exceptions in the UK are Huddersfield, Bolton, and the new Arsenal stadium in London.

Football is very popular in South America, where there is a liking for very large stadia. The largest in the world is the Maracana Municipal stadium in

Photograph: Action Images

Figure 1.11 When it opened in 1950 the Maracana Stadium in Rio de Janeiro, Brazil, accommodated around 200 000 people. In 1998 it was renovated and converted to an all-seater, and the capacity reduced to 70 000. *Architects: Rafael Galvão*, *Pedro Paulo Bernardes Bastos*, *Orlando Azevedo and Antônio Dias Carneiro*.

Rio de Janeiro, Brazil (Figure 1.11), which has a normal ground capacity of 103 000 spectators, of whom 77 000 may take a seat. It contains one of the first of the 'modern' versions of the dry moat to separate spectators from the field of play, the moat being 2.1 m wide and about 1.5 m deep. This is rather small by current standards (see Section 6.3) but it did establish a trend in player/spectator separation which has been used round the world including, for instance, the 100 000-capacity Seoul Olympic stadium of 1988.

The stadia built for the 1990 World Cup in Italy, and the 2002 World Cup in Japan and Korea, set very high design standards.

Rugby

One of the most important British examples is Twickenham Rugby Football Ground near London, dating back to 1907. The 10-acre site has undergone considerable development since then. The East, North, West and South stands are linked by a single 39 m-deep cantilevered roof sweeping round all four sides of the field and total ground capacity is 75 000, soon to be expanded to 82 000, all seated and all under cover. Because the stands shade the natural grass turf for part of the day they have translucent roofs to allow some transmission of sunlight, including ultraviolet radiation, to the pitch.

Other British rugby stadia worth studying are the Millennium Stadium at Cardiff Arms Park, Cardiff (which is successfully used for international rugby and soccer) and the Murrayfield Stadium in Edinburgh. The latter is an example, like Twickenham, of an entire stadium being rebuilt.

Other leading rugby stadia include the Sydney Football Stadium in Australia (Figure 1.12), the Stade de France in Paris, Lansdowne Road in Dublin, and Ellis Park in Johannesburg.

Rugby has moved increasingly towards stadia shared with football. Examples in the UK include Watford, Huddersfield, and Queens Park Rangers. Greater attention has to be paid to the grass pitch to permit joint use.

American football and baseball

After the First World War the USA broke new ground with a series of pioneering stadia built particularly for two burgeoning national sports – American football and baseball.

To cater for the growing popularity of American football there evolved a new type of single-tier elliptical bowl of vast capacity surrounding a rectangular football pitch. The first was the Yale Bowl at New Haven (1914, capacity 64 000). It was followed by

Figure 1.12 Sydney Football Stadium for AFL football and rugby is a design of fluidity and grace. *Architects: Philip Cox Richardson Taylor & Partners*.

Photograph: Cox Architects & Planners

the Rose Bowl at Pasadena, California (capacity 92 000), the Orange Bowl in Miami (1937, capacity 72 000), Ann Arbor stadium in Michigan (capacity 107 000) and others. Stands in the largest of these were up to 90 rows deep, the more distant spectators being so far from the pitch that they could not see the ball clearly.

Baseball became the second great popular sport. Because it requires a very differently shaped pitch and seating configuration than football a series of specialized baseball stadia were built, including the famous Yankee Stadium in New York (1924, capacity 57 000).

Typically the stadia for these two sports were urban stadia, built in the midst of the populations they served, and typically they were open or only partly roofed. After the Second World War there was a new wave of stadium building, but the typology shifted gradually towards multi-purpose facilities, often fully roofed, and often situated out of town, surrounded by acres of car parking. Between 1960 and 1977 over 30 such major stadia were built, the most impressive being the Oakland Coliseum, John Shea Stadium in New York (1964, baseball and football), and the Busch Stadium in St Louis (baseball). Recent examples are the Comiskey Park Baseball Stadium in Chicago (1991), seating 43 000 spectators on five levels, and the Minute Maid stadium in Houston seating 41 000 spectators, and with a closing roof.

The Louisiana Superdome in New Orleans, opened in 1975, is the largest of this generation of stadia. It has an area of 13 acres, is covered by one of the world's longest roof-spans with a diameter of 207 m, is 83 m tall and has a maximum capacity of 72 000 for football. One of its most interesting features is a gondola suspended from the centre of the roof, comprising six television screens of 8 m each, showing a range of information including instant action-replays.

Many of these great stadia catered for both American football and baseball (and usually other types of activity) in an attempt to maximize revenue. However, as already mentioned, the shapes of football and baseball pitches are so different that it is difficult to provide ideal seating configurations for both, even with movable seating systems as in the John Shea dual-purpose stadium of 1964. The Harry S Truman Sports Complex in Kansas of 1972 therefore separated the two sports: the Royals Stadium overlooks a baseball pitch (Figure 1.13), and its sister Arrowhead Stadium a football field (Figure 1.14), each of them being shaped to suit its particular sport. Each stadium has its own entertainment facilities, etc. for its particular group of patrons.

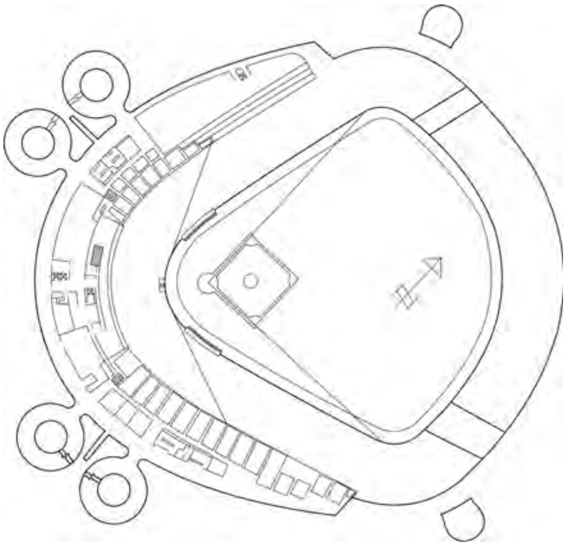


Figure 1.13 In the Harry S Truman complex in Kansas, the Kauffman (originally called the Royals) Stadium is designed specifically for baseball. *Architects: Howard Needles Tammen & Bergendoff (HNTB)*.

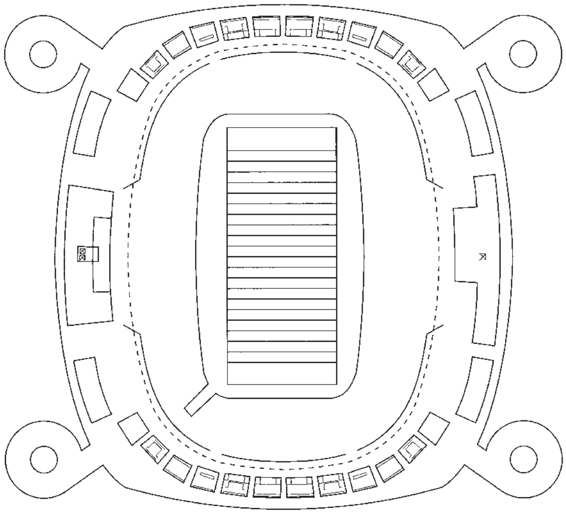


Figure 1.14 The Arrowhead Stadium for American football is a separate entity, in recognition of the very different seating geometries required for good viewing of the two games. *Architects: Charles Deaton, Golden in association with Kivett & Myers*.

Tennis

The world's most famous tennis venue is the All England Lawn Tennis and Croquet Club at Wimbledon in London, home since 1922 of The Championships. The Championship fortnight now attracts about 40 000 people each year. The tournament facilities comprise eighteen grass courts, five red shale courts, three clay courts, one artificial grass court and five indoor courts. In addition to these tournament facilities there are also 14 grass practice courts in the adjacent Aorangi Park.

To many people 'Wimbledon' means the Centre Court. The stadium surrounding this famous patch of grass was built in 1922 and has been gradually upgraded and renewed ever since. While it suffers from compromised sightlines from some seats, the stadium does in many ways give the most satisfying 'tennis experience' in the world: the tight clustering of spectators round the grass court, under a low roof which reflects the buzz of sound and applause from the fans beneath, creates an intimate theatrical atmosphere and an intensity of concentration which are missing from most other venues. To prepare the Club for the next century a comprehensive 20-year master plan for the entire site has been prepared and implemented. It includes a new No 1 court designed to replicate the intimate Centre Court atmosphere.

There are three other international Grand Slam tennis venues which are comparable in scale and complexity to Wimbledon: Flushing Meadows in the USA[1], Flinders Park in Australia, and Roland Garros in France. They all vary greatly in terms of atmosphere and tradition.

In North America the US Open Championship is played at Flushing Meadows in New York, where the spectators' attitude to viewing is much more casual than at Wimbledon. This is reflected in the design of the Principal Court where the spectators sit out in the open under a busy airport flightpath, with the outermost seats too distant to offer good viewing. The sense of detachment seen here is quite characteristic of US stadia which tend to be very large and to be patronized by spectators who are not averse to wandering around getting snacks and drinks while a game is in progress.

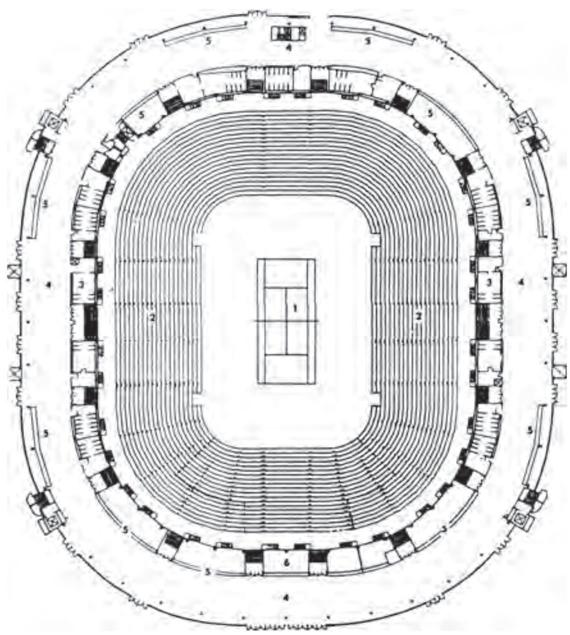
[1] Notable non-Grand Slam stadia in the US include the recently-built ATP Championship Stadia in Cincinnati and the Fitzgerald Tennis Centre in Washington, both designed by Browning Day Mullins Dierdorf Inc.

Photographs: Cox Architects & Planners

Figure 1.15a and b The Rod Laver Arena at the Melbourne and Olympic Parks, Australia (originally known as the Centre Court, Flinders Park), was a pioneering structure when built in the 1980s. *Architects: Peddle Thorp & Learmonth in association with Philip Cox & Partners*.

Australia's National Tennis Centre at Melbourne and Olympic Parks (originally known as Flinders Park, Melbourne) was constructed on derelict land in 1986–87. It can seat a total of around 29 000 spectators at 15 courts, which include the Rod Laver Arena (Figure 1.15). In addition to these there are five indoor practice courts, which are now thought to be too few.

The front rows of the Rod Laver Arena, also known as the Centre Court (Figure 1.16), are at a greater distance from the court than at Wimbledon or even Flushing Meadows on the theory that a ball travelling at 180 km/h cannot be seen properly by viewers who are too close to it. The validity of this approach is contested by those who hold that spectators want to be close to the action, even if that means



Cox Architects & Planners

Figure 1.16 Plan of the Rod Laver Arena (see Figure 1.15), which seats 15 000 spectators.

that the ball is only a blur at times. The 15 000 seats are fed by 20 entrances/vomitories, and the stadium has a sliding roof which takes 20 minutes to close. Unlike Wimbledon the court has a 'rebound ace' hard acrylic surface which has the advantage of allowing intensive multi-purpose year-round use for other sports and for pop concerts, etc. (around 120 events are staged per annum). However, it is thought by some to be visually 'dead' compared with the Wimbledon grass court.

Since completion of the Flinders Park venue there has been an increased demand, not foreseen at the time, on the hospitality, catering and press facilities in particular. An expansion plan is therefore being undertaken which would double the site area and include hotel facilities, a merchandising centre, a sports medical centre and more car parking.

In France the French Open venue is the Roland Garros stadium in the Bois de Boulogne in Paris, which was established in 1928 and has been gradually upgraded ever since. The 15-acre site contains 16 championship courts, all clay-surfaced. In atmosphere the Centre Court is closer to Flushing Meadows than Wimbledon, being open to the sky and with greater viewing distances than the tight clustering found at Wimbledon. As at Wimbledon and Flinders Park an expansion plan is underway.

Cricket

Lord's Cricket Ground in London has been the home of the Marylebone Cricket Club (MCC) since 1814 and is the symbolic centre of world cricket. The 12-acre site accommodates spectators in a variety of open and roofed stands which have gradually grown up round the playing field. The site development policy is to deliberately build on this pattern of individual buildings surrounding a green, instead of moving towards a unified stadium built to a single architectural style. The policy is clearly reflected in the 1987 Mound Stand (Figure 1.17), which cost approximately £4 million and replaced an earlier stand on the same spot, and the 1991 Compton and Edrich Stands which cost approximately £5 million. The Mound Stand seats 5400 spectators in two main tiers, 4500 at terrace (lower) level and 900 at promenade (upper) level, the upper seating level being sheltered by a translucent tented roof.

A new stand by Nicholas Grimshaw & Partners has been completed on the North side.

The Oval ground in South London, home of the Surrey County Cricket Club, is as well known as Lord's and the site has been master-planned for the future by HOK Sport Architecture. Also in Britain, a new cricket ground has been built for County Durham by architect Bill Ainsworth. In Australia the leading venue is Melbourne Cricket Stadium, which has recently been rebuilt.

1.3 Current requirements

1.3.1 The spectator

For all of these sports, stand design begins and ends with the spectator, and it is at this much-maligned figure that the planning team must look before anything else. At the outset of a project the first questions to be asked, and answered, must be: *who* are the spectators, *what* are they looking for in the facility, and *how* can their numbers be maximized? Only when these questions are answered will it be possible to examine the technical solutions which will satisfy those users and to do the necessary calculations. This simple methodology should be used for all sports projects.

It must be understood that different people have different motives, and that any crowd will contain a variety of subgroups with different reasons for

Photograph: Antony Devlin

Figure 1.17 Lord's Cricket Ground in London is the symbolic centre of world cricket. A variety of stands have been built round the field over many decades with no attempt at a unified style. The Mound Stand with a tent-style roof was added in 1987. *Architects: Michael Hopkins & Partners.*

attending. Some will have a primarily sporting interest, some a social reason for attending, and in some people the two interests are mixed.

The 'sports priority' spectator group is found in the stands and on the terraces for every game. For them 'live' sport at its highest level has an almost spiritual quality, an attitude aptly expressed in a statement once made by the great Liverpool football manager Bill Shankly: 'Football is not a matter of life and death; it is more important than that'. These fans are knowledgeable, respond instantly to every nuance of the action, offer advice to the players, and recognize the form, fitness and style of individual players and the effectiveness of strategies and tactics. Such issues form the basic topics of conversation before, during and after the game in the car, pub or train. The motivation and the behaviour of this group sometimes attract negative comment, but this may happen in respect of any group of people sharing some passionate interest – for instance evangelical churchgoers.

The 'social priority' group is found in the clubhouse, dining rooms and private boxes, entertaining or being entertained. The game is 'interesting' but interrupts the personal or business conversations and only briefly becomes the topic of interest. At the end of a game a short post-mortem takes place so that all parties can hint at the depth of their sporting knowledge before resuming the business conversation. This group is usually well dressed because its members will be interacting with other people to whom they must present themselves appropriately, whereas the 'sports priority' group dress casually because their interaction is with the event.

A third group contains elements of the previous two and tends to be fickle: these are the casual supporters who can be persuaded to attend if the conditions are right, but equally easily deterred, as everything depends on their perception of the event. When England was host to the World Cup football, attendances in the UK reached about 29 million per annum, but the figure has declined to around 20 million today. Clubs lose supporters when the team plays poorly, as this group of spectator only attends the game when standards of play are perceived to be high or when 'star' names are playing. These fans are also deterred by discomfort, a perceived risk of violence or lack of safety. Studies carried out well before the disaster at the Hillsborough Stadium in Sheffield (see below) found that football fans in the UK perceived violence from other fans as the most powerful threat to their safety, the risk of being crushed by crowds second and being crushed by mounted police third. All these perceptions will have their effect on attendances.

It should be noted that under the UK's Disability Discrimination Act around a fifth of the persons in each of the above groups may come within the legal definition of 'disabled people'. This definition is surprisingly wide, and goes far beyond the traditional concept of people in wheelchairs. By law all such people must be fully catered for in both the design and management of the venue, as outlined in Chapter 10.

1.3.2 The player or athlete

After the spectator the next most important person in the stadium is the player or athlete: without these people there is no game or event. Players' and athletes' needs are covered in Chapters 6 and 19, and as above the UK's Disability Discrimination Act (and similar Acts in Australia and the USA, etc) require full provision to be made for disabled players. This latter phrase is not a contradiction in terms, as the growth of events such as the Paralympics attests.

One matter must be mentioned at this stage because it will influence the proposed stadium in a fundamental way. If players require a natural grass pitch, but other design requirements (such as the need for a multi-use surface, or for a roofed stadium) make a grass surface unviable, then very difficult choices must be made about design priorities.

For some sports a natural grass surface is obligatory – for instance rugby and cricket. For others it may not be obligatory but is still very much the preferred option for players. In all these cases it is not merely the provision of the grass pitch that is important, but also its condition at time of play. The playing surface is a small ecosystem which actively responds to changes in the environment: it fluctuates in rebound resilience, stiffness and rolling resistance and can alter the trajectory of a bounce or roll so that players talk of the ball 'skidding through' or 'standing up'. All of these minute but critical variations can occur in a relatively short space of time, even during a game. Such uncertainties tend to widen the players' range of skills, both technically and tactically, because they must be sufficiently inventive and responsive to cope with changing conditions. In this way a natural surface may well raise the standard of play, giving a 'bigger stage' for the display of individual talent. But it may be almost impossible to provide a natural grass surface if the brief requires a fully roofed stadium or if the facility requires a multi-use pitch; and in these cases there will be tough decisions to be made.

Such problems are more pressing in Europe and Britain than in North America, partly because the traditional European games of football, rugby and cricket are based on a vigorous interaction between the ball and the playing surface, so that the latter becomes critical, whereas in American football and baseball the ball is kept off the ground at the critical stages of play thus allowing a more tolerant choice of playing surface. American players tend also to be well padded and less likely to suffer injury when falling on a relatively hard surface, whereas lightly clad European players are more vulnerable and have a preference for natural grass. But it is interesting that a preference for natural grass pitches seems to be returning in American football.

For athletics, a synthetic rubber track has become the normal surface with the centre field in grass.

1.3.3 The owner

Assuming players and spectators can be brought together, it falls to the stadium owner to ensure that the physical venue is a going concern – in other words, he must ensure the venue's continued financial viability. As stated in Section 1.1.2 very few stadia produce profits for their owners simply on their sporting functions. In most cases it will be necessary for the planning team to devise a development that will enable the owners to:

- Come as close as possible to profitability simply on sporting functions (i.e. 'gate income').
- Narrow the shortfall by exploiting non-sporting forms of market income ('non-gate income').
- Close any remaining gap by means of public funding or other forms of direct subsidy or grant.

Gate income

It will seldom be possible to recoup all costs from 'gate revenue', but this traditionally has been the most important single source of revenue and must be maximized. Investors will require a guaranteed target market of known size and characteristics, a guaranteed number of event days, and a guaranteed cashflow from these sources. To this end:

- An analysis of the market must be made as outlined in Section 1.3.1. It must be established who the stadium is catering for, how many of them there are, how much they will pay, how often they will attend, what are the factors that will attract them, and what are the factors that will deter them.
- Gate revenue can be enhanced by various forms of premium pricing – for instance sale or rental of private boxes at high prices. The availability of such opportunities should be part of the investigation of the previous item.
- It must be decided which sports types the stadium will cater for. This requires a careful balancing of factors. A facility catering for (say) both football and athletics events will offer the possibility of more 'event days' than one catering for a single sport; but, by trying to accommodate other functions, the facility may be less suitable for its major use, as discussed in Section 1.2.6 above and in Chapter 8. This is partly because different sports require different pitch sizes and layouts; partly because they require different seating configurations for good sight lines; and partly it is a matter of pitch surface: some sports (like football or rugby) demand a grass surface, but this may be too fragile to stand up to intense use for a variety of sports week after week.
- This question of pitch type also has a bearing on a stadium's overall construction. Just as natural grass is likely to be incompatible with multi-use, so is it also likely to be incompatible with a fully-roofed stadium. Experiments with natural grass under translucent roofs are proceeding, but at present this arrangement is expensive and technically difficult. Where incompatibilities arise and an 'either/or' decision must be taken, priorities will have to be very clear.

Non-gate income

Options for augmenting gate income include sale or rental of hospitality boxes, catering concessions, merchandising concessions, advertising and event sponsorship, media studio rentals, parking rentals and the like. While these can make a vital financial contribution, the planners must not lose their sense of priorities: such forms of income must always be 'supportive', never 'primary'. Increasingly such 'supportive' factors will have a direct influence on stadium design because, for instance, a game watched by 15 000 people from the stands may be watched by 15 million on television – with great cost implications for a sponsor – and these millions must be satisfied. But this influence should not be exerted to the point where the stadium loses its attraction to its primary patrons – those entering by the gate.

Subsidy

After all the above methods of revenue maximization have been built into the project there may still be a funding shortfall. A final element of support will probably be required from the local municipality, a national grant scheme or elsewhere to make the development viable.

Getting it all together

The key to a successful outcome is clarity of understanding between all concerned. If the stadium developers have a clear understanding of the spectators and players they are aiming for and how to attract them; if the various users have complete clarity about the uses to which the stadium might be put and their compatibility with the stadium design; if the potential providers of a public subsidy and the private developers share the same view of the purpose of the stadium and how it will benefit the local community – then the project may well become a long-term success. But if any of these matters are fudged or left unresolved, or if priorities are put in the wrong order, the stadium is likely to have a very clouded future. Chapters 8 and 23 deal with some of the above aspects in more detail.

1.3.4 Stadium safety

Safety is such a crucial aspect of the successful stadium that a few paragraphs must be devoted to this subject. Wherever crowds gather, particularly in a context of intense emotion as is the case with sport, mishaps are possible. The wooden stands of the Constantinople Stadium where Roman chariot races were staged were burned down by spectators in 491 AD, 498 AD, 507 AD and finally in 532 AD, when Justinian lost his patience and called in the army to restore order, leading to an estimated 30 000 deaths.

A partial list of recent disasters includes the following:

1996 – 83 people were killed and between 127 and 180 people were injured in a Stadium in Guatemala City when soccer fans stampeded before a World Cup qualifying match. Angry fans kicked down an entrance door, causing spectators inside to cascade down onto the lower levels.

1992 – 17 people were killed in Corsica when a temporary grandstand collapsed in a French Cup semi-final match between Bastia and Marseille.

1991 – 1 person died and 20 were taken to hospital after a stampede when 15 000 fans were allowed into the grounds without tickets just after kick off at Nairobi National Stadium, Kenya.

1991 – 40 people died and 50 were injured after a referee allowed an own goal at a friendly soccer match in Johannesburg, South Africa.

1989 – 95 people died and many were injured during a crowd surge into a restraining fence after kick-off at the Sheffield Hillsborough Stadium, England. (The Lord Justice Taylor Report followed, with a subsequent new edition of the Safety at Sports Grounds Act 1990 and additional tightening of the certification system under the Football Supporters Act 1989 which established the Football Licensing Authority. The football administrators also reacted by setting up the Football Stadia Advisory Design Council in 1991.)

1985 – 38 people died and 100 were injured in a crowd riot at the Heysel Stadium, Belgium.

1985 – 10 people died and 70 were injured in a crush when crowds tried to enter after kick-off through a tunnel which was locked at Mexico University Stadium, Mexico.

1985 – 56 people died and many were badly burnt in a fire at Valley Parade Stadium, Bradford, England. (The Popperwell Inquiry followed, with a subsequent increase in powers under the existing Safety at Sports Grounds Act.)

1982 – 340 people were reported to have died in a crush at Lenin Stadium, Russia.

1979 – 11 people died and many were injured from a ‘surge’ into a tunnel at a pop concert at Riverfront Stadium, Cincinnati, USA.

1971 – 66 people died after a soccer match at Ibrox Park Stadium, Glasgow, Scotland. (The Wheatley Report followed, with the subsequent Safety at Sports Grounds Act 1975 based upon its findings.)

1964 – 340 people died and 500 were injured after a referee disallowed a goal by the home team in a soccer match in Lima, Peru.

2. The future

2.1 The importance of the stadium
2.2 Economics
2.3 Technology
2.4 Ergonomics and the environment
2.5 What future for the stadium?

2.1 The importance of the stadium

Stadia are amazing buildings. They can help to shape our towns and cities more than almost any other building type in history, and at the same time put a community on the map. They have become an essential ingredient in the urban matrix that pulls our cities together and in so doing provide a focus for our aspirations. They are also probably the most 'viewed' building type in history thanks to the Olympics and other global sporting events. They change people's lives and may come to represent a nation's aspirations.

They can be very expensive buildings, but equally can generate substantial revenues. The global financial power of sport in general is increasing and the twenty-first century is gradually establishing sport as the world's first true global culture. Stadia, the buildings that accommodate sport, are becoming among the most important buildings any city of the future can build, partly because of their power as an urban planning tool – and also one of the most expensive.

In the last 150 years sport has been codified and professionalized and at the same time there has been a dramatic process of urbanization, with populations moving from the country to the city. With this social shift there has been an equally dramatic rise in the popularity of sport, perhaps as a consequence of this new urban society.

Stadia are also a key ingredient in the marketing of cities and even nations. They are often symbolic of the aspirations of a nation, which is not surprising considering that the tourist impact on Athens for the 2004 Olympic Games (see Figure 5.3) was reported to be around 1.9 million overnight stays during the two weeks of the event. They have evolved into a building type that contains all the elements required to achieve a critical mass capable of sustaining independent city life. Such a critical mass is composed of mixed elements including residential, commercial, retail and leisure, all working together with the other services and transport infrastructure that are required to make the 'stadium city' thrive.

2.2 Economics

But despite their huge public profile stadia are not without their problems. Owners and operators are very aware of the shortcomings of past generations

Photograph: Patrick Bingham Hall

Figure 2.1 Global events have helped to make stadia some of the most recognised buildings in the modern world. The Telstra Stadium Sydney (see also Appendix 3) was built for the Sydney 2000 Olympic Games and has become one of the iconic images of that city.

of stadia, how they have sometimes been difficult to manage without a huge workforce, and have at times been limited in their flexibility. Many of these issues have been resolved in more recent generations of these buildings, and there are few major stadia under development at the beginning of the twenty-first century which don't include in the design team people with proven experience of having solved these problems in the past.

Ownership issues over co-habitation of these buildings, thus spreading the burden of construction and maintenance costs across more than one sport or more than one club, have to some extent been addressed – sometimes very successfully, as in Huddersfield where football and rugby combine happily in the Galpharm Stadium (see Figures 5.8, 11.9, 19.2 and 21.1). Even the new Wembley Stadium (see Case Study, page 292) has been designed to be used for football, rugby and athletics as well as the ever-popular concert. The economics of huge stadia like Wembley with their extensive private suites, corporate boxes and large restaurants make the prospect of financially lucrative events more realistic.

In the USA the idea of 'multi-purpose stadia' as opposed to 'sport-specific stadia' is not very popular, mainly because the principal sports, NFL and Baseball, are so different in pitch form and layout that they are very difficult to combine in a single venue. There is also the economic factor, with sponsorship and naming rights revenue so high in the USA that it helps the business case to have different

Playing area		Support facilities		Additional facilities	
Primary	**Secondary**	**Primary**	**Secondary**	**Primary**	**Secondary**
Football	Concerts	Restaurant	Banquets	Health club	Offices
Tennis	Conventions	Bar	Parties	Other sports	Retail
Rugby	Exhibitions	Private box	Meetings	Hotel	Cinemas
Cricket	Other sports	Lounges	Conventions	Sports retail	Residential
Note: The above are only broad indications of options to be investigated. For actual design it will be necessary to undertake detailed studies using specialist advisers.					

Table 2.1 Possible multi-purpose uses of sports stadia

stadia for different sports. How else could a developer justify building a stadium for gridiron football that features only eight home games per season?

Another trend could be that clubs who wish to improve their grounds will begin to act more aggressively as developers, and will finance new facilities either by the sale of surplus land or by including explicitly 'commercial' uses. More recently the combination of a sport club and another key occupier has evolved, where sport is considered as an one element in a mix of activities in order to generate a critical mass of activity for the customer. Good management of these mixed venues can increase revenue by exploiting each part of the facility for more than one purpose, a strategy sometimes referred to as 'multi-use' but actually just a matter of maximizing the return from the investment. Table 2.1 shows some possible combinations of sports and commercial uses.

The key to all these approaches, if they are to be successful in the long term, will be good creative management. Stadia management is becoming recognized as a specialist field all over the world, and sporting venues are now beginning to attract the very best people to the job. This will start to change the form of stadia in the future. As a result of this expertise shift, ideas are emerging such as the concept of added-value tickets, where additional privileges are provided to encourage the whole family to attend. These privileges can include meals, bus rides from outer areas, and signed programmes. Family enclosures, which have gained popularity in the UK, are also a relatively new but important trend. Child-minding facilities, baby-changing rooms, family cinemas, museums, tea lounges, quality restaurants with high-chairs, and children's play areas are also important in encouraging family attendance and are gradually finding their way into the modern stadium.

The bottom line is that any facility which attracts a wider cross-section of the family, and keeps them entertained for longer, should eventually reap financial rewards. It is through a policy of inclusion not exclusion that the spectators of tomorrow will be created.

2.3 Technology

Television and the Internet have been with us for some time, but combined with the access that convenient global travel provides us with, their real impact is only now starting to be seen. There is a growing sense of 'the world' as a single entity, and sport is becoming the common social currency that, everyone, everywhere, can trade in and understand.

Technology is helping to revolutionize our societies and is also having a dramatic influence on the sporting world. We expect races to be timed to hundredths of a second, blood samples to be analysed down to particles per million, instant video playbacks, optional camera positions on television, and computer-generated images to determine if a ball was in or out.

However what we have seen so far is just the tip of the technological iceberg. Sport is benefiting from improved, faster, and safer construction techniques allowing light-weight opening roofs, moving seating tiers and playing fields, and replaceable cricket wickets. The dividing line between natural grass and synthetic playing surfaces is becoming blurred, and a hybrid of both is emerging with developments in plastic mesh root reinforcement, plastic turf support, and plastic granular growing mediums with computer-controlled nutrient injection. New hybrid grass types require less light, grow faster, and are far more robust; and the quality of synthetic grass is now such that it has been accepted under certain conditions for first class football. These advances allow a greater number of different types of events to take place on the same pitch, making the venue more financially viable and able to justify greater capital cost.

Sight lines, crowd flows, and environmental comfort for the twenty-first century stadium are all calculated and designed on computer, and the creation of three-dimensional virtual models of these buildings is critical. The latter are now an indispensable tool allowing the design team to communicate effectively with the owner and with future spectators who will be able to see the exact view they will enjoy from their seat at the time of booking.

Advances in communication and information technology not only allow the officials of an event to measure the winning action to extreme levels of accuracy and reliability, but also to communicate the result to the spectator in the stadium as quickly as to television viewers at home. There can be no guarantee that future generations will find live sport as attractive as the present generation, and the move to provide better information to the spectator is essential if attendance at live events is to be maintained. Ticket prices are increasing, and there is increasing competition for our leisure time while it is possible to sit at home and watch the event on television almost free of charge. The old argument that only the major events are televised is no longer true; cable and satellite television has changed that theory forever as more and more sport is televised. Sport is still a comparatively cheap television programme to produce and almost always finds an audience while the cost of developing dedicated ‘club’ channels is now a reality.

One answer for sport is to compete with television on equal terms and, as well as offering facilities at the stadium that are as comfortable, convenient and safe as spectators’ own homes, also offer information equal in range and quality to that provided by professional broadcasters. Replays and information about players and previous matches should be automatic but so should highlights of other events, statistics on the game, expert commentary, and perhaps even revenue-generating advertisements. This ‘narrowcasting’ is possible using the stadium’s closed-circuit television (CCTV) network, not just to large video screens but also to small personal receivers with screens a few inches across. These receivers may be embedded into the seat and be part of the ticket price, or could be linked to the spectator’s mobile phone using Bluetooth or the latest G3 technology (Figure 2.2). Press the button marked ‘statistics’, key in your favourite player’s name, and the career statistics will be displayed; press ‘action’, type in the date of the match, and see the highlights of his match winning performance two years ago. The horse racing industry around the world has moved forward using some of this thinking, possibly because of the large betting revenues which are at stake at racecourses. Pools revenue is also enormous, with the annual total in most developed countries being measured in billions.

Technology is also revolutionizing the management of stadia. Conventional turnstiles are evolving into more user-friendly control systems, but still have some way to go before they are likely to be considered welcoming. The ideal will be an ‘intelligent’ entrance linked to the stadium computer system, looking more like an airport X-ray machine. Details will be read from the spectator’s active ticket which will allow the person access to different areas of the grounds and entitle the holder to other predetermined benefits. The pass will be scanned by monitors at each access or sales point, and if the pass is invalid for any reason a warning will sound and the holder advised by synthesized voice of where to go to seek help. The automatic barriers in front, which are usually open, will close if the person attempts to proceed any further. In addition to this automatic access and sales control the stadium computer will store information on the spectators who attend each event including age, sex, address and event preferences. From this database of information the stadium management will be able to form a precise profile of who attends which events, allowing them to target that exact socio-economic group

Figure 2.2 We must aim to provide spectators with the same level of information as they would receive at home watching television. The integration of technology into the design of the seat is still in its infancy and may in due course be surpassed by personal mobile devices.

the next time a similar event is held. This knowledge of the spectator is essential for future marketing and critical for the economic survival of the venue.

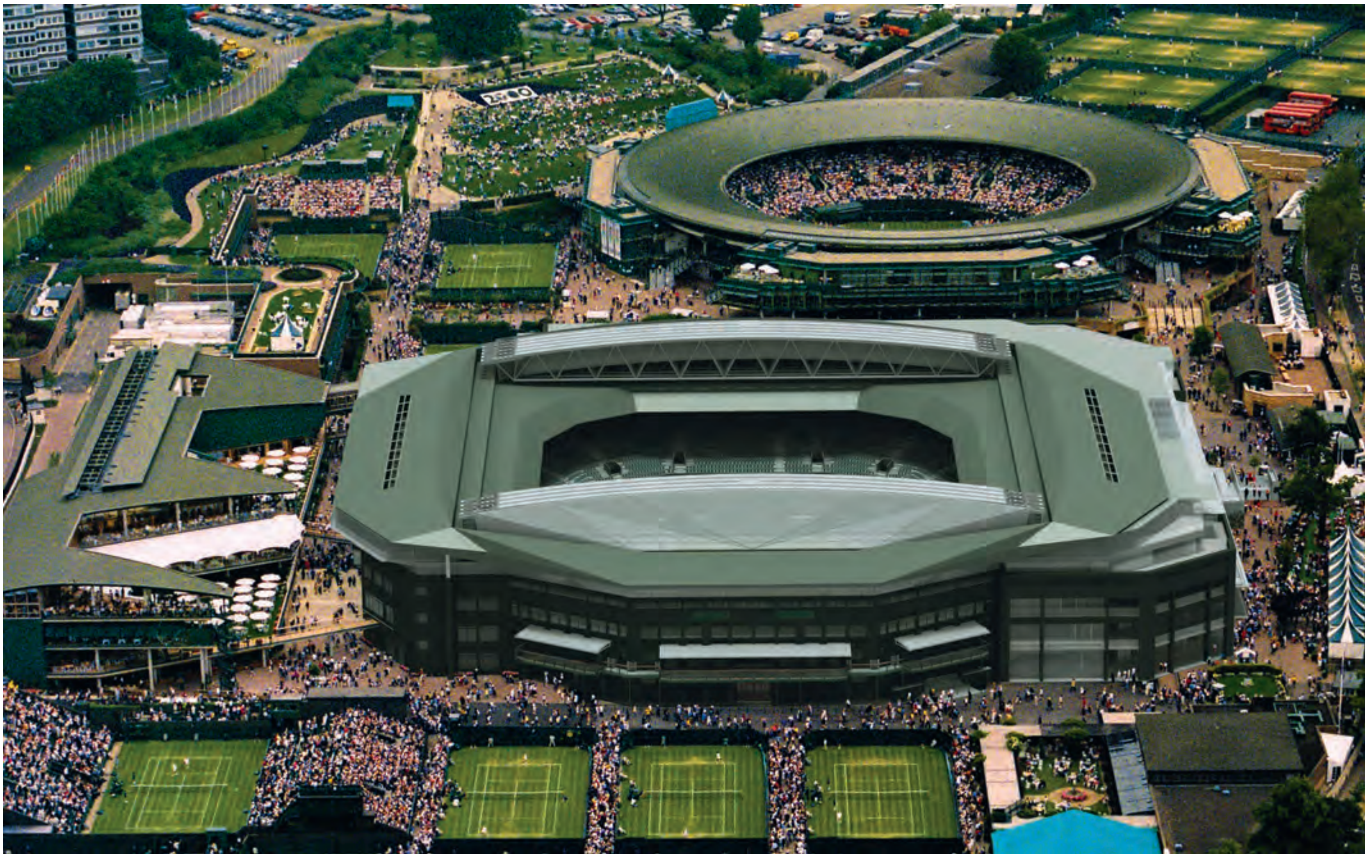
2.4 Ergonomics and the environment

Technology is being used to improve spectators' comfort levels when they are at the stadium, controlling aspects of the environment including temperature, humidity, and air movement more accurately. The increasing use of retractable roofs (see Section 5.8) forms part of this trend.

The design of the seats themselves is also more focused on the ergonomics of the spectators rather than simply the cheapness of producing a plastic bucket. Padded seats are becoming more common, and armrests to create the spectator's personal space are being considered. The size of the average spectator is also increasing and seat spacing is increasing to cope with larger people and more comfortable entry to, and exit from, the seat.

Support facilities will increasingly provide amenities for all the family to enjoy as well as other entertainment areas for those not committed to the game. They will eventually include every type of function from business centres to bowling alleys, similar to the range of facilities often found in international airports or shopping malls. Attractions will be designed to encourage spectators to arrive early and stay on afterwards – perhaps even sleeping overnight in the Stadium Hotel.

Tomorrow's stadia will be places of entertainment for the family where sport is the focus but not the complete picture. It will be possible for five members of



Photograph: Hok Sport Architecture

Figure 2.3 Control of the environment to improve spectator comfort is being considered even for sports that are traditionally 'outdoor' events, and this steady progress towards more comfortable stadia is having an influence on the sport itself. In 2007 a retractable roof was retro-fitted to the famous open-air Centre Court at Wimbledon, London (see also Appendix 3).

a family to arrive and leave together, but to experience in the intervening period five different activities. While the parents 'see' the live game, their children 'experience' the live game in the virtual reality studio where images from the 'in pitch' cameras provide close immediate action.

2.5 What future for the stadium?

The question arises of whether the stadium will be the ideal forum for sport in the future, or whether new sports might emerge that are better suited to other building forms. In recent years a number of sporting events have evolved that don't require a stadium, with a greater emphasis on outdoor activity – e.g. the range of extreme sports that are finding their way into established timetables and are ideal for television (Figure 2.4). There have been completely new events such as the Ironman Triathlon, which was created in 1978 resulting from a bar-room challenge issued in Hawaii and is now an Olympic event.

However for all the popularity of events that don't require a stadium, there is no indication that we are losing our commitment to watching sport and attending the live game. The majority of professional sports are continuing to grow, leading to a continued growth in investment in new venues of increasing comfort and sophistication.

Photograph: Getty

Figure 2.4 The ideal venue for watching any sport should capture something of the sport itself, reflecting the traditions and the atmosphere that spectators have come to expect of their sport.

Photograph: Team Macarie (Dan Macarie)

Figure 2.5 New stadium forms will evolve in response to changing social needs, and the opportunities generated by evolving technologies. This is an image of the new 50 000 seat Lansdowne Road Stadium in Dublin.

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3. Masterplanning

3.1 The need for a masterplan
3.2 Orientation
3.3 Zoning
3.4 Overlay
3.5 Security against terrorism
3.6 Conclusion

3.1 The need for a masterplan

3.1.1 Basic principles

Sports complexes are often constructed over a period of years (or even decades) for reasons of finance, natural growth or land availability. To help ensure that the ultimate development is consistent in terms of aesthetic quality and functional efficiency, and to avoid abortive work, a comprehensive plan for the entire development should be evolved at the very outset. This allows successive phases of the development to be carried out by different committees or boards over a period of time in the safe knowledge that their particular phase will be consistent with the whole (Figure 3.1).

As an example of a masterplan, Figure 3.2 shows in schematic form the masterplan for the new Milton Keynes stadium by HOK Sport Architects.

The art of planning large stadium sites hinges on the correct zoning of the available land and the separation of incompatible uses which must be accommodated within the site boundaries. These uses include not only the direct sporting functions but also very substantial parking areas, pedestrian and vehicular circulation routes, etc.

3.1.2 Sequence of decisions

All design must set out from the following determining factors.

Pitch/central area

The starting point of design is the central area or playing field. Its shape, dimensions and orientation must enable it to fulfil all the functions required of it (see Chapter 6).

Seating capacity

Next comes the seating capacity. If the pitch is to be of variable size to cater for very different activities then the design capacity should be stated as two figures: the number of seats around the *maximum* pitch size (perhaps football or athletics) and the maximum capacity around the *smallest* space user (perhaps the performers in a pop concert, or a boxing ring). The stadium owners will have very strong views on seating capacities as these form the basis of their profitability calculations.

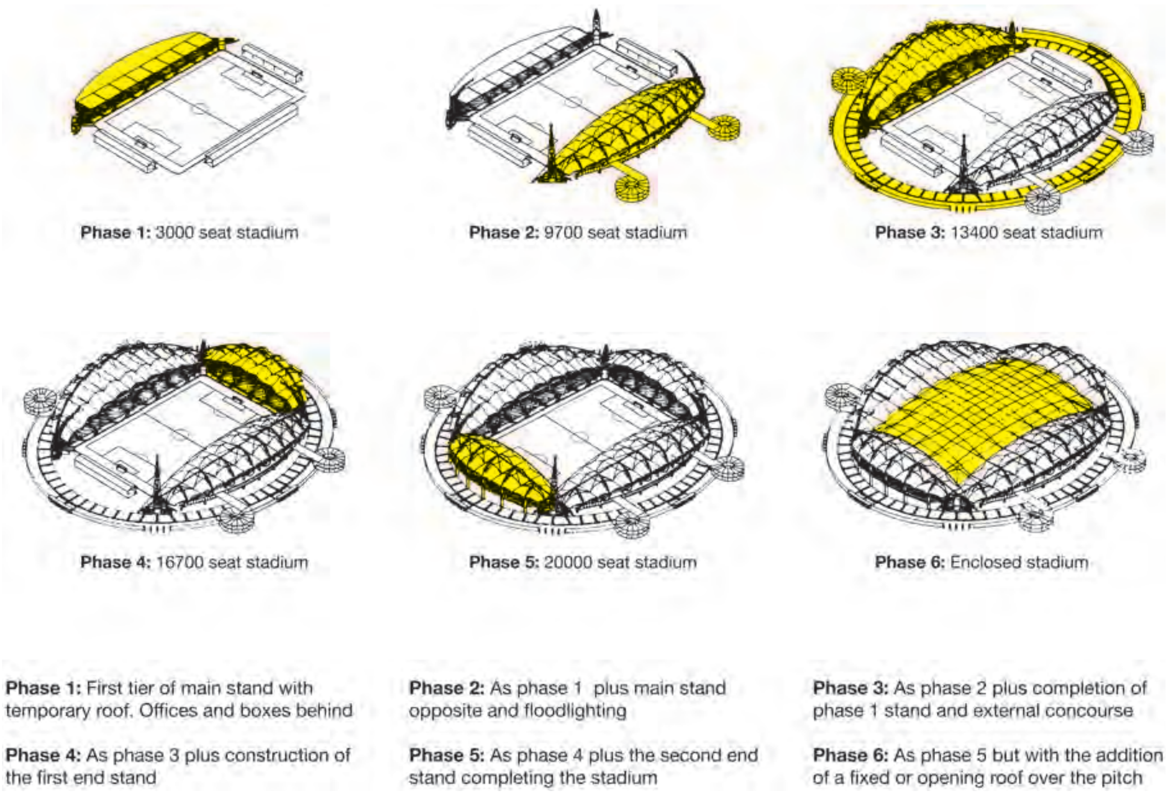


Figure 3.1 An example of a stadium planned for phased development. It is the British 'Stadium for the Nineties' proposal by the Lobb Partnership (now HOK Sport Architecture) in association with the Sports Council and the structural engineers YRM Anthony Hunt Associates.

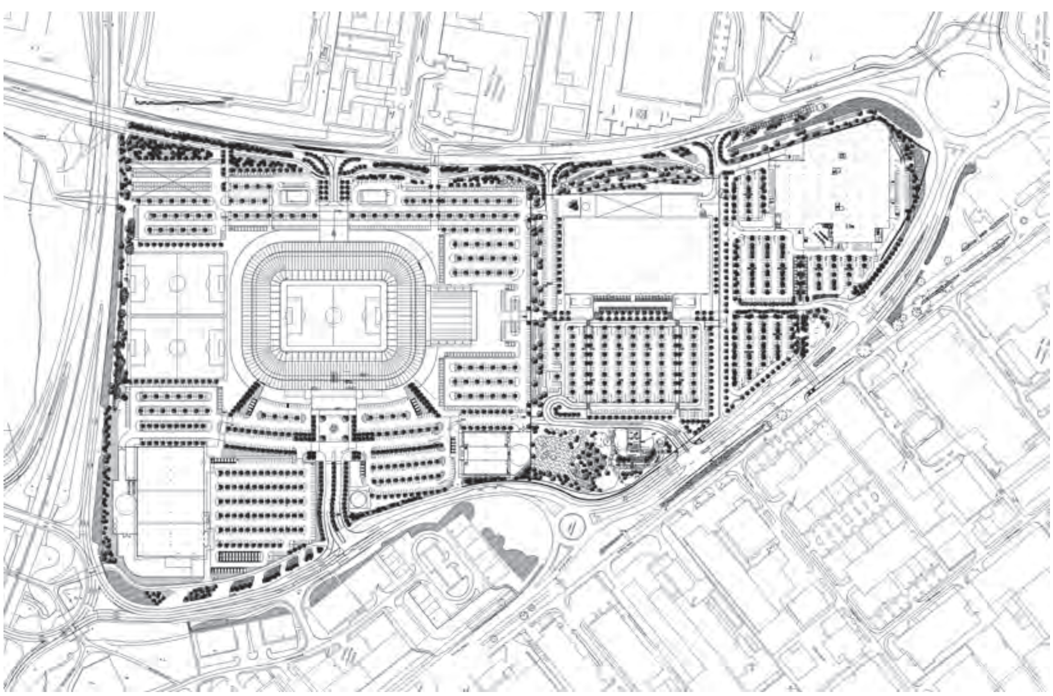


Figure 3.2 The masterplan for the new Milton Keynes stadium in the UK. *Architects: HOK Sport Architecture*.

Orientation
Pitch orientation must be suitable for the events to be staged (see Section 3.2 below), and the masterplan must be structured around this.

Zoning
Finally, a discipline for the arrangement of all the elements of the stadium, from the pitch at the centre to the parking spaces outside, is provided by the need for safety zoning as explained in Section 3.3 below.

3.2 Orientation

3.2.1 Design factors

The orientation of the playing field will depend on the uses to which it will be put, the main factors being:

- The hemisphere in which the stadium is located.
- The period of the year in which the designated sports will be played.
- The times of day these events will be played.
- Specific local environmental conditions such as wind direction.

All the advice below applies to open stadia in temperate zones in the northern hemisphere, and readers should make the necessary adjustments for stadia in other situations.

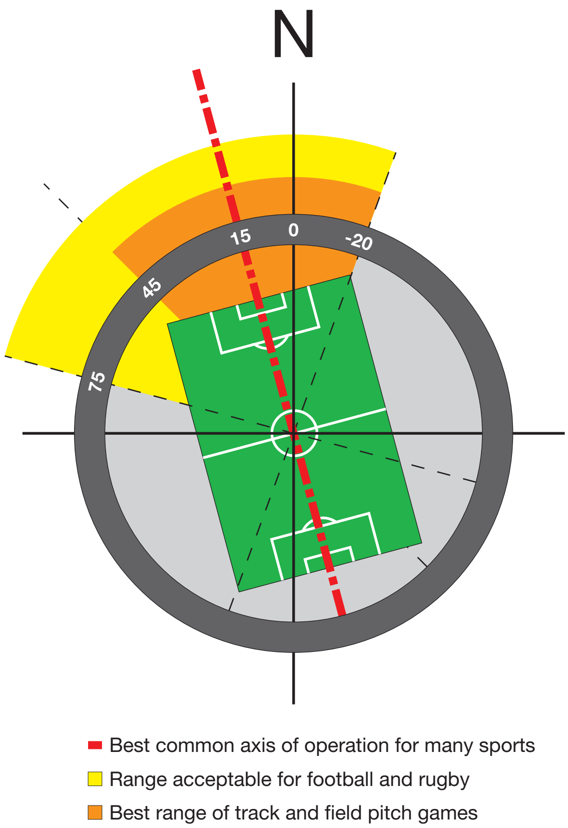


Figure 3.3 Recommended pitch orientations in northern Europe for principal sports. The underlying principle is that runners in athletics and sportsmen in ball games should never have the late afternoon sun in their eyes.

3.2.2 Football and rugby

Football and rugby in Europe are played during the autumn and winter months, in the early afternoon. This means that the sun is low in the sky and moving from south-south-west to west. An ideal orientation for the playing area is to have its longitudinal axis running north–south, or perhaps northwest–southeast. With these orientations the sun will be at the side of the stadium during play, and the early morning sun will fall on the greatest area of the pitch, thus helping any frost in the ground to thaw before play commences. Figure 3.3 summarizes the situation.

The sun should be at the side of the pitch during play. This suits the players, the spectators and the TV cameras.

3.2.3 Athletics

Field and track sports in Europe take place mostly during the summer and autumn months. Runners and hurdlers approaching the finishing line should not have the sun in their eyes and nor, ideally, should spectators. The ideal orientation in the northern hemisphere is for the longitudinal axis of the track to run 15 degrees west of north (Figure 3.3). The same applies to the stadium, which should be situated on the same side as the home straight and as close to the finish line as possible.

Sometimes it is difficult to achieve the above track orientations while also conforming with the requirements for wind direction. Where possible, alternative directions should be provided for running, jumping and throwing events.

3.2.4 Tennis

The longitudinal axis of the court should run north–south. Diverging by up to 22 or 23 degrees in either direction is acceptable, and diverging by 45 degrees is the limit. If matches are to be played in early morning or late evening the orientation becomes more critical.

3.3 Zoning

3.3.1 Planning for safety

Having set the orientation the next priority is to plan the position of the stadium on the site, and to start thinking about the interrelationship of its major parts; and this is best done by identifying the five zones which make up the safety plan (Figure 3.4). The size and location of these zones are critical to the performance of the stadium in an emergency, and they are:

Zone 1 The activity area (that is the central area and/or pitch on which the games take place).
Zone 2 The spectator terraces.
Zone 3 The concourses surrounding the activity area.
Zone 4 The circulation area surrounding the stadium structure and separating it from the perimeter fence.
Zone 5 The open space outside the perimeter fence and separating it from the car parks.

The purpose of such zoning is to allow spectators to escape from their seats, in an emergency, to a series of intermediate safety zones leading ultimately to a place of permanent safety outside. It provides a clear and helpful framework for design not only for new stadia but also for the refurbishment of existing facilities.

A tragic example is provided by the fire which killed 56 people at the Valley Parade Stadium in Bradford, UK in 1985. The stand was an old one, built of framing and timber steppings. On 11 May 1985 a fire started in the accumulated litter under the steppings and spread rapidly through the antiquated structure. Most spectators fled from the stands (Zone 2) to the open pitch (Zone 1) and were safe; but many made their way back through the stand towards the gates by which they had entered. Because there was no Zone 3 or 4 in the Valley Parade Stadium these gates formed the perimeter between the stadium and the outside world and management took the view that they needed to be secure – therefore the escaping spectators found them locked. Hundreds of people were trapped here, the fire and smoke soon caught up with them, and 56 people died.

Two lessons came out of this experience, one for managers and one for designers.

- Managers must ensure that gates offering escape from the spectator terraces to places of safety must be manned at all times when the stadium is in use, and easily openable to let spectators escape in case of emergency.
- Designers must recognize that management procedures such as the above can never be foolproof, and the stadium must be designed on the assumption of management failure. There should, where possible, be a Zone 4 *within* the outer perimeter to which spectators can escape and where they will be safe even if the perimeter gates are locked, cutting them off from the outside world.

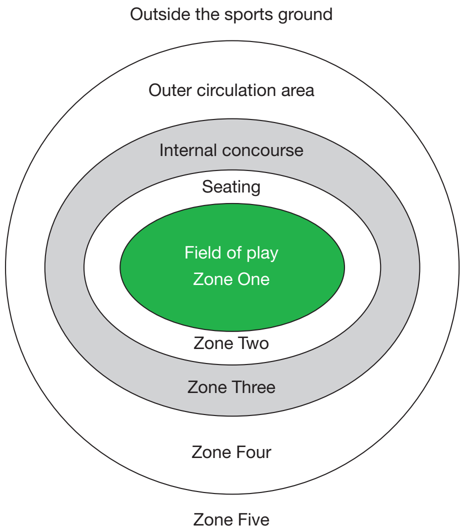
The arrangements whereby disabled spectators, particularly those in wheelchairs, are enabled to make their way to this area, and be safely accommodated within it, need particularly careful thought – see Chapter 10.

More detailed design notes follow below, starting with Zone 5 (the area of 'permanent safety') and proceeding to Zone 1 (a place of 'temporary safety').

3.3.2 Zone 5

The stadium should ideally be surrounded by car parks, bus parks and access to transport. The car park (well-designed, to avoid bleakness) should ideally surround the stadium on all sides so that spectators can park their cars on the same side of the stadium as their seats and then walk straight to an entrance gate and to their individual seats without having to circumnavigate.

Between this ring of parking areas and the stadium perimeter there should be a vehicle-free zone



Zone one: The playing field.

Zone two: The spectator seating and standing areas.

Zone three: The internal concourses, restaurants, bars, and other social areas.

Zone four: The circulation area between the stadium structure and the perimeter fence.

Zone five: The open space outside the perimeter fence

Figure 3.4 Zoning diagram showing the five 'safety zones' which form the basis for a safe stadium.

usually described as Zone 5, which can serve several useful purposes:

- From the point of view of safety, it is a so-called 'permanent' safety zone to which spectators can escape from the stands via Zones 3 and 4, and safely remain until the emergency has been dealt with. It should be possible to accommodate the whole of the stadium population here at a density of 4 to 6 people per square metre.
- From the point of view of everyday circulation, Zones 4 or 5 provide a belt of space in which spectators may circumnavigate the stadium to get from one entrance gate to another, assuming their first choice of gate was wrong (see Section 14.3.1). Every effort should be made to ensure that people are directed from their cars (or other points of arrival) to the appropriate gate for their particular seat, but mistakes will always be made and there should be an easy route round the stadium to allow for this.
- Retail points, meeting points and information boards can also very usefully be located in this zone of open space. To serve this social function the surface and its fittings (kiosks, information boards, etc) should be pleasantly designed, not left as a bleak band of tarmac.
- The above point can be taken further with Zone 5 serving as a pleasantly landscaped buffer zone between the 'event' and the outside world. Stadium performances (whether they be sport, music or general entertainment) are essentially escapist, and their enjoyment can be heightened by visually disconnecting the audience from the workaday outside environment.

3.3.3 Zone 4

The stadium perimeter will form the security line across which no one may pass without a valid ticket. Between this line of control and the actual stadium structure is Zone 4, which may have two functions:

- From the point of view of safety, it is a place of 'temporary safety' to which spectators may escape directly from the stadium, and from which they can then proceed to permanent safety in Zone 5. It is therefore a kind of reservoir between Zones 3 and 5. If the pitch (Zone 1) is *not* designated as a temporary safety zone, then Zone 4 should be large enough to accommodate the whole stadium population at a density of 4 to 6 people per square metre. But if Zone 1 is so designated Zone 4 may be reduced appropriately. In all cases the number of exit gates, and their dimensions, must allow the necessary ease and speed of egress from one zone to another (see Section 14.6).
- From the point of view of everyday circulation, Zone 4 is the main circumnavigation route for people inside the stadium perimeter (i.e. who have

surrendered their tickets and passed the control points).

The importance of Zone 4 can be seen from the Valley Parade fire. Because that stadium had no such zone, management felt that the link between Zones 2 and 5 had to be secure. The gates were therefore locked, inadequately supervised, and many people died horribly. Had there been a Zone 4 and good signposting many lives could have been saved even with the outer gates being locked.

3.3.4 Zone 3

This comprises the stadium's internal concourses and social areas (restaurants, bars, etc.) and is situated between Zones 2 and 4. Spectators must pass through this zone in order to reach a final place of safety (Zones 4 or 5). For this reason this zone, or the circulation areas within it, are often designed with a good level of fire safety so that large numbers of people can move through them at low risk in the short term.

Sometimes the main line of turnstiles is at the face of the stadium, at the outside of Zone 3. If the turnstiles are at the edge of Zone 4, the external precinct, then there may also be a secondary ticket check at the boundary between Zones 3 and 4 as people enter the main stadium.

3.3.5 Zone 2

This comprises the viewing terraces around the pitch. In many cases the greatest safety risk is thought to come from the building behind the terraces, so the seating terraces are seen as a place where spectators can stay in relative safety.

There may be a ticket check between Zones 2 and 3, where stewards guide people to their seat. There will often be a barrier at the edge of the arena (Zone 1) to prevent people entering the field of play, but this barrier must not impede people trying to flee from a fire or other emergency.

3.3.6 Zone 1

The pitch or event space forms the very centre of the stadium. Along with Zone 4 it can serve the additional purpose of being a place of temporary safety, on the following conditions:

- The escape routes from the seating areas to the pitch must be suitably designed – i.e. escape will not be an easy matter if there is a barrier separating pitch and seating terraces (see Chapter 9).
- The surface material of the pitch must be taken into account. The heat in the Valley Parade fire was so intense that clothing of the police and spectators standing on the grass pitch ignited: had the pitch been covered with a synthetic material that too might have ignited. These matters must be thoroughly discussed with the fire authorities at design stage and it must be ensured that management cannot take decisions many years later to change the pitch surfacing without being aware of the implications for safety.

3.3.7 Barriers between zones

In all cases the number of exit gates, and their dimensions, must allow the necessary ease and speed of egress from one zone to another. The principles involved are given in Section 14.6.

3.4 Overlay

At stadia there is normally a regular schedule of events through the year, and sometimes on top of this there are more infrequent, bigger events that are hosted there. For example a club football ground will hold the annual list of matches of the club, and then it might bid to hold an international cup final that will come to the stadium once every few years. Such a match will attract more spectators, more media and more sponsors for whom it is not worth constructing permanent accommodation, so temporary arrangements can be made, called an 'overlay' (see also Section 3.4).

In order for the overlay to be accounted for in the masterplan, some idea of the events to be hosted is required. In general an infrequent event at a stadium is likely to require more space, certainly outside the building and possibly also inside. Some of the temporary areas that might be needed are:

- Additional space for larger crowds to arrive at the stadium. This might be more car parking, wider access routes, more bus drop-off areas.

- Sponsors' advertising, additional catering, sales areas and visitor attractions. Some major events are even accompanied by activities for people who come along, but don't have a ticket for the event.
- Additional security. High-profile events often require greater security measures, for example everyone may be searched before they enter the ground, and this activity, along with the associated queuing, can take a great deal of space.
- Temporary media areas including space for television outside broadcast vehicles, rooms for sports writers to work, and associated dining, electrical generators and the like. Note that television satellite uplink vehicles will require a view of the sky where the satellite is located.
- Additional back-of-house areas. The need for extra offices, waste rooms, storage, ticketing, etc., should not be forgotten.

These areas will require space around the stadium and the best method is to keep the areas partly flexible and non-specific so that it does not constrain the layout of temporary accommodation, because, not only does every major event have different requirements, but the overlay for each event is likely to change over time.

3.5 Security against terrorism

Unfortunately in recent years it has become necessary to consider the possibility that high-profile sports activities might become the target of terrorists. The actual likelihood of a terrorist attack and the possible methods that such people might use are best known by the police, who should be consulted at an early stage. The security arrangements of the building should be tailored around their advice.

In general, lines for security cordons can be drawn around the sports building, firstly for vehicles further away from the stadium and secondly for people as they have their tickets checked. The cordons for staff and spectators are likely to require space for searching of people and their belongings.

For more detail on these matters see Chapter 6.

3.6 Conclusion

The matters above represent merely the first few decisions in a process that will ultimately involve hundreds of design judgements. But these are controlling decisions, and once they have been rationally made there should be regular checks to ensure that the evolving design never contradicts or moves away from them.

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4. External planning

4.1 Location
4.2 Transportation
4.3 Provision of parking
4.4 Stadium landscaping

4.1 Location

4.1.1 Past and current trends

Traditionally the sports stadium was a modest facility with a capacity of perhaps a few hundred, serving a small local community and forming part of the social fabric along with the church, town hall and drinking house.

As communities grew larger and more mobile, with ordinary people able and willing to travel great distances to follow their favourite sports, stadia became larger and much of the new capacity was needed specifically for visiting spectators. The presence of multitudes of 'away' supporters created problems in crowd control for which no one (whether the local communities, their police forces, or stadium managers) was adequately prepared. We tend to think of this as a recent problem, but it goes back many decades. Evidence can be found in any book of social history, or in an account such as this, made all the more astonishing by its source:

> *along the track . . . were returning coaches. We conscientiously demolished them with stones. We had broken everything breakable in our own train. The trains that followed, hastily pressed into service and waiting behind us in a straggling queue, were inspired by our methods. We also demolished the signals. Towards four o'clock the massed officials of the suburbs mobilised the firemen to intimidate us . . . the mob, one knows, generally becomes inspired when it is necessary to take action. As our train did not leave and other trains arrived in the night, filled with would-be spectators . . . we set to work to demolish the station. The station at Juvisy was a big one. The waiting rooms went first, then the station-master's office . . .*

The passage describes events at an aircraft show in France in 1933 and was written by the famous architectural visionary, le Corbusier.[1] Even allowing for the habitual hyperbole of the author it shows that the destructive impulse which may arise in crowds of otherwise civilized sporting fans is, alas, nothing new.

Crowd control proceeded on a 'trial and error' basis, and many mistakes were made; but we have finally begun to evolve a more systematic understanding which can be applied both to the design of stadia and their management. The lessons for stadium design are incorporated in the various chapters of

[1] *Aircraft*, Le Corbusier, Trefoil Publications, London.

Figure 4.1 The Arrowhead and Kauffman Stadia at the Truman Sports complex, in Kansas City, overcome the difficulty of providing good viewing for the contrasting configurations of baseball and football by giving each sport its own dedicated stadium.

Photograph: Barry Howe Photography

this book; but an additional response has been a locational one – to move major stadia away from town centres to open land on the town periphery.

Large out-of-town stadia

A major trend of the 1960s and 1970s was the building of large stadia on out-of-town locations where crowds, whether well or badly behaved, would create less disturbance to the everyday lives of people not attending events. Such locations would also reduce land costs and increase ease of access by private car. The largest developments of this kind are to be seen in Germany, where advantage was taken of post-war reconstruction opportunities, and in the USA, where high personal mobility and the availability of open land made it easier to locate stadia away from the communities they were meant to serve and provide the amount of car parking required. Leading examples of a cross-section of types include:

- The Astrodome at Houston, 1964, a dome stadium designed for both football and baseball.
- The Arrowhead and Royals Stadia at Kansas City (Figure 4.1), 1973, a complex which provides separate dedicated facilities for the two sports – the Arrowhead Stadium for baseball, and the Royals Stadium for football.
- The Giants Stadium at New Jersey, 1976, which is a dedicated stadium for football only.

These stadia tended to cater for a variety of activities to make them financially viable, had huge spectator capacities, and were surrounded by acres of car parking. They were built in a period when spectator sports were attracting markedly increased followings, probably owing to the influence of television; but even so they found it difficult to show a profit. Recovering their vast development costs would have been problematical anyway, but there were two aggravating factors. First, television coverage had improved to the point where people could stay at home and follow the action very satisfactorily in their living rooms; and second, the stadia of the late 1970s and early 1980s were all too often barren places with little by way of spectator comforts.

There was also a growing number of violent incidents in various parts of the world (resulting from crowd misbehaviour, fire or structural collapse) which probably reinforced people's growing preference to watch from the comfort and safety of their living rooms.

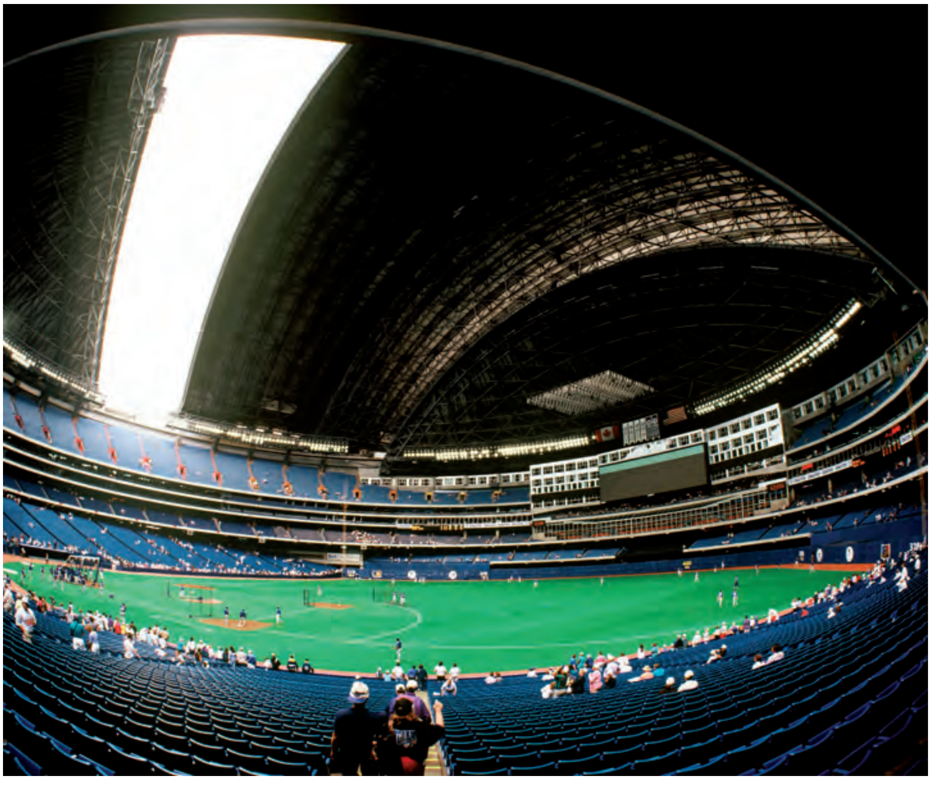


Figure 4.2 The Toronto Skydome (Rogers Centre), which opened in 1989, can be adapted by movable seating to several auditorium configurations to accommodate hockey, basketball, baseball, football, rock concerts and other entertainments. *Architect: Rob Robbie. Roof design engineers: Michael Allen.*

Photograph: Barry Howe Photography

Large in-town stadia

The next significant step in the development of the stadium occurred in 1989 with the opening of the Toronto Skydome in Ontario, Canada. The public authorities in Toronto had recognized the problems of out-of-town sites and decided to take a brave step by building their new stadium in the very centre of their lakeside city (Figure 4.2).

The stadium is within walking distance of most of the city centre and uses much of the transport and social infrastructure of Toronto. They had also learned the lesson of poorly serviced facilities and incorporated many spectator services designed to enhance comfort and security.

But in spite of all these efforts, and an ingenious funding arrangement, Skydome's financial viability has unfortunately proved no better than previous attempts – see Section 1.1.2.

Current trends

In Britain, following an inquiry by Lord Justice Taylor into the disaster at the Hillsborough Stadium in Sheffield (where 95 people died in a crowd surge) there has been a formal report recommending major changes to sports stadia to improve their safety. This document has caused many British clubs to question whether it would be best to redevelop their existing, mostly in-town grounds or to relocate to new sites out of town with all the transport and planning problems entailed. Existing in-town sites have the advantages of being steeped in tradition and being situated in the communities on whose support they depend, but the disadvantage of being so physically hemmed in is that it may be difficult or impossible to provide the safety, comfort and variety of facilities which are necessary. There are proving to be numerous town-planning difficulties in finding new sites.

The situation elsewhere in the world is equally ambiguous. Everywhere there is a preoccupation with the intractable problems of financial viability, everywhere there is pressure towards greater comfort and greater safety, and everywhere the refurbishment of old stadia is gaining ground . . . but these vague generalizations are about the only 'trends' that can currently be identified.

Figure 4.3 The Galgenwaard stadium in Utrecht combines shops and other commercial uses, located in the corners and on the street side, with the sports function. The stadium was first built as a velodrome in 1936; upgraded in 1981; and completely modernized in 2001–03.

FCU photo/Frank Zilver

4.1.2 Locational factors

Today it is technically feasible to build a safe, comfortable and functionally efficient stadium in any location (town centre, open countryside, or anywhere in between) provided that there is sufficient land and that the stadium's use is compatible with the surrounding environment. The deciding factors are itemized in the following paragraphs.

Client base

Any stadium must be easily accessible to its 'client base' – the people whose attendance will generate the projected revenues, and this is usually the primary motive for looking at a particular site. To test feasibility a careful analysis must be made of who the projected customers are, how many they are, where they live, and how they are to get to the stadium. All these criteria must be satisfied by the proposed stadium location.

Land availability

A new stadium can require around 15 acres of reasonably flat land just for the stadium and ancillary facilities, plus car parking space at 25 square metres per car (see Section 4.3.1). It may be difficult to find this amount of space.

Land cost

Land costs must be kept to a minimum and this is why sports facilities are frequently built on low-grade land such as refuse tips or reclaimed land that is too poor for residential or industrial use (but which may then lead to additional structural costs as noted in Section 5.5.1).

Land use regulations

Local or regional planning legislation must be checked to ensure that the proposed development will be allowed in that area.

4.1.3 The future

Taking all these factors together, wholly independent, stand-alone stadia may increasingly have to share their sites with commercial and retail complexes. Examples of such developments include:

- In the USA, the Hoosier Dome in Indianapolis of 1972.
- In Canada, the Skydome in Toronto (Figure 4.2) of 1989.
- In the Netherlands, the Galgenwaard Stadium in Utrecht (Figure 4.3).
- In Norway, the Ulleval Stadium of 1991.

- In the UK, the Galpharm (formerly the Sir Alfred McAlpine) Stadium in Huddersfield, West Yorkshire. This state-of-the-art 24 500-seat stadium will cater for both football and rugby and share its site with a hotel, a banqueting hall, a golf driving range and dry ski slope, and numerous shopping and eating facilities.

4.2 Transportation

4.2.1 Spectator requirements

If the journeys involved in getting to a sporting event seem excessively difficult or time-consuming, the potential spectator may well decide not to bother – particularly if alternative attractions are available, as tends to be the case nowadays. There may be a sequence of journeys involved, not necessarily just the journey from home on the morning of the match. This sequence may start from the moment when the decision is taken to buy a ticket, possibly weeks or months before the event, and involving pre-planning the actual match day with details such as:

- Will I be travelling with a friend or on my own?
- Will I be travelling by car, bus or train?
- Where will the transport leave from, and when?
- How do I get to and from the transport?
- What are the things which can go wrong with the above arrangements, and what alternatives do I have?

The transport infrastructure of a major stadium should offer ways of getting to (and away from) an event which are relatively quick, unconfused and trouble-free, otherwise attendance and revenues will undoubtedly suffer.

Pages 72 and 73 of *Accessible Stadia* (see Bibliography) give a useful checklist of matters that should be considered at this stage to ensure that all prospective spectators, able-bodied and disabled alike, are able to properly plan their visit to a sporting event.

4.2.2 Public transport

Any large stadium should be close to a well-served railway and/or metro station, preferably with paved and clearly defined access all the way to the stadium gate. If the stadium cannot be located near to an existing station, it may be possible to come to a financial arrangement with the transportation authorities whereby they open a dedicated station for the stadium. In the UK this is the case with the existing Watford and Arsenal football stadia, and a new railway station was constructed to serve the Olympic site at Homebush in Sydney.

The entire route, from the alighting point on the station platform to the seat in the stadium, should be easily usable by disabled people, including those in wheelchairs. Therefore it should be kept free of kerbs or steps that obstruct wheelchair users.

4.2.3 The road system

The road system must allow easy access into, around and out of a major stadium complex. There must not only be adequate roads, but also adequate electronic monitoring and control systems to ensure that any build-up of traffic congestion in the approach roads can be identified well in advance and dealt with by police and traffic authorities (see Section 20.2.1).

4.2.4 Information systems

Before major events, advice can be mailed to spectators with their tickets and car parking passes; some information can be printed on the tickets themselves. In the run-up to the event, information giving the choice of routes and the most convenient methods of transport should be thoroughly publicized via local, regional or national media (including radio, television and the press).

In the UK the Disability Discrimination Act places a legal obligation upon event managers to supply disabled persons – which includes people with impaired vision, impaired hearing, or impaired understanding – with information in formats that they can easily read, hear, and understand. This obligation applies to printed information, website information, telephone information services, and all other methods of information dissemination both before and during the match.

On the day of a major event every effort should be made to ensure an orderly traffic flow. Local radio and newspapers can be used to illustrate preferred routes and potential problem areas. Dedicated road signs, whether permanent or temporary, should start some distance away from the stadium and become increasingly frequent and detailed as the visitor approaches the venue. Near to the stadium information and directions should be particularly plentiful and clear with 'close-in' information indicating whether car parks are full, and identifying meeting points and train and bus stations. The same amount of effort should be made to ensure a smooth flow of people and cars away from the stadium after the event: it cannot be assumed that people will find their own way out, and a clear sequence of exit directions should be signposted.

4.3 Provision of parking

4.3.1 Types of provision

Parking is most convenient if located in the area immediately surrounding the stadium, and at the same level as the exits/entrances. But this tends to be an inefficient use of land – which is both scarce and expensive in urban areas – and the vast expanses of tarmac have a deadening effect on the surrounding environment unless extremely skilfully handled. Four alternative solutions follow.

Multi-level car parking

Building the stadium over a covered car park, as in Cincinatti in the USA or the Louis IV Stadium in Monte Carlo, helps to reduce the amount of land required and avoids the barren expanses of car park. But such a solution is very expensive and its viability may depend on the next option.

Shared parking with other facilities

A stadium may share parking space with adjacent offices or industrial buildings as at Utrecht, or even (as is the case with Aston Villa Football Club in Birmingham, UK) with superstores or shopping complexes. But problems will arise if both facilities need the parking space at the same time. This is quite likely in the case of shops and supermarkets which stay open in the evenings and at weekends. In the case of Aston Villa there is a condition in the agreement that the store cannot open during first team home matches. Therefore careful planning is required.

On-street parking

This is not encouraged by the authorities. However, stadium sites in green parkland can allow parking to be distributed over a large area.

Park and ride

This term refers to car parking provided at a distance from the venue, with some kind of shuttle service ferrying spectators between the parking area and the stadium. It is mainly used on the continent of Europe, especially in Germany. In the UK, Silverstone motor racing circuit and Cheltenham racecourse have helicopter park and ride services, both of which are usually fully booked.

Provision for disabled people

In the UK, pages 26 to 28 of *Accessible Stadia* and section 4 of *BS8300* (see Bibliography) give authoritative guidance on car parking provision for disabled people.

For the USA see section 502 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography).

4.3.2 Access roads

It is essential to provide the right number of parking spaces and to ensure that they are efficiently accessed, because nothing is more likely to deter visitors from returning than lengthy traffic jams before or after an event. There must be a clear system of routes all the way from the public highways via feeder roads into the parking area, and an equally clear way out. Arrivals will probably be fairly leisurely, possibly spread over a period of two hours or more before start time, whereas most spectators will try to get away as quickly as possible after the event. Such traffic patterns must be anticipated and planned for. It may also be possible to change these patterns of use. For instance, visitors can be enticed to stay longer and leave more gradually, thus reducing traffic congestion, by providing restaurants and other social facilities and by showing entertainment programmes on the video screens before and after the event (see Chapters 13 and 15 and Section 21.2.2).

Parking spaces, and the routes feeding them, must not encroach on areas required for emergency evacuation of the stadium, or for fire engines, ambulances, police vehicles, etc.

4.3.3 Spectator parking

Vehicular parking can account for more than half the total site, and the quantity and quality of parking provided will depend on the types of spectators attending. Data given for a variety of existing stadia – not as guidelines to be followed, but purely to give a 'feel' of provision that may be required in various situations.

In the USA, where the shift from public transportation to travel by private car has gone furthest, the trend has been towards stadia located out of town, not served by any significant public transportation network but surrounded by huge expanses of parking spaces.

In Europe, by contrast, most stadia are well served by public transport. Land is not easily available for large parking lots and it is quite common in European cities, where the majority of European stadia are still located, for only a handful of parking spaces to be provided for officials and for there to be no on-site parking for fans. A rural facility, such as the UK's Silverstone Circuit for motor racing, which caters for 98 000 spectators and provides parking for 50 000 cars, is definitely the exception.

In the design of a new stadium parking requirements for spectators should be estimated from an analysis of the following considerations.

Stadium seating capacity

It would be wasteful to provide car parking for every seat in the stadium as the maximum seating capacity will only rarely be achieved. A 'design capacity' should be calculated by assessing a typical programme of events over a season, and estimating a typical attendance for each event.

Programme and types of events

Each event type generates its own particular pattern of demand for parking. Some spectators will come by public transport, some by private car and some by specially hired fleets of coaches; the ratios between them will vary from one type of event to another (in the UK, for instance, national football club finals are likely to draw a higher proportion of coach travellers). The amount of parking space required will therefore be based upon:

- The ratios between the various categories.
- The occupancy rate of coaches and cars. It may be estimated, for example, that an average car carries 2.5 people and an average coach 50 or more.
- The amount of parking space needed per car or coach. As more fully described below, car parking may require about one hectare per 50 cars, and coach parking perhaps one hectare per 10 coaches.

By researching the above data for a particular stadium and multiplying the various factors a reasonable 'design capacity' and parking area may be deduced.

Rival demands for parking space

Some of the available parking spaces may occasionally be taken out for other uses, for instance by television service coaches, which must be parked immediately adjacent to the stadium (see Section 14.2.1). As many as ten vehicles, needing standing spaces of up to 12 m by 4 m each plus working space, may be needed for several days at a stretch. This may greatly reduce the planned car parking capacity near the stadium.

Cars: public parking

For preliminary estimation purposes, and subject to the computations suggested above, the following formulae may be helpful:

- A minimum of one parking space to every 10 to 15 spectators.
- If FIFA recommendations are to be followed, one space to every six spectators.
- If recent German recommendations are to be followed, one space to every four spectators. It must be said that this will very seldom be possible in European urban situations.

An area of about 25 square metres per car (including circulation space) may be assumed in the UK and Europe. Exact dimensions will depend on national codes of practice.

Cars: private parking

Private box holders and their guests, VIPs and similar private visitors should have special clearly identified parking areas, separate from the mass parking, and close to the entrances giving access to private hospitality suites (see Chapter 13).

Buses and coaches

FIFA suggests one bus space per 120 spectators, but this is quite an onerous standard and will in any case depend on other factors (for example number of cars expected and access to public transportation); we suggest that one bus per 240 spectators may be quite reasonable for preliminary estimation purposes.

An area of 60 square metres per bus (including circulation space) may be assumed in the UK and Europe.

Motorcycles and bicycles

Provision will depend very much on national and local characteristics and must be determined as part of the brief. The demand for bicycle parking is likely to be greatest in Asian countries, very much less in the UK and Europe, and least in North America and Australasia.

Spectators with disabilities

In the UK, page 27 of *Accessible Stadia* and para 4.1.2.3 of *BS8300* (see Bibliography) recommend that at least 6 per cent, but possibly more, of the total car parking capacity should be allocated to disabled people. In other countries local codes should be checked. In the absence of more specific requirements 1 per cent of car parking spaces may be an acceptable ratio. In all cases these should be the spaces closest to the stadium entrance gates, with easy access to ramped pedestrian routes.

4.3.4 Other parking

Players

Parking space for team buses should be provided for each team of players. Usually between two and six bus spaces may be required, but FIFA recommends at least two bus spaces plus ten car spaces: the specific figure will depend on the sport involved and should be researched. These spaces should always be secure and separate from other parking areas and from each other, and give direct access to the players' changing areas without coming into contact with the public (see Section 20.2).

Officials

Directors, sponsors and stadium staff should have parking in separate, clearly identified and secure areas, under close supervision and control, including closed circuit television (see Section 21.2.1). Sometimes this area is inside the perimeter fence of the grounds, which is acceptable if the zone inside the fence is large enough and out of reach of the circulation routes used by the public. Often this is not possible, when it is recommended that all official vehicles (except for emergency and essential service vehicles) be kept outside the main perimeter fence.

The media

Extensive areas must be provided for the increasing numbers of television and broadcast vehicles. As many as ten may be required for a single event, and factors to be taken into account are not merely their standings but also the widths of access roads and radii of turning circles required by these large vehicles. Their parking spaces may be incorporated into the general parking areas, provided they are adjacent to the cable access points provided (see Section 18.2) and able to bear the weight of the heavy technical support trucks. Provision must be made for catering, toilet and similar support vehicles adjacent to the technical vehicles, as media crews may spend long periods at the stadium before and after events. These areas must be fenced or protected.

Provisionally a space of 24 m by 4 m should be allowed per vehicle, and a level surface capable of supporting up to 15 tonnes.

Service and deliveries

A modern stadium complex requires heavy goods access to many delivery and service points (catering, cleaning, etc.) and these must be identified in the brief so that direct and unobstructed access can be built into the scheme at the earliest stages and not come as an afterthought.

4.3.5 Parking layout and services

Dimensions

Dimensions of parking bays should meet national standards, but for preliminary planning a bay length of 4.8 m, and a bay width of 2.4 m, would be reasonable. In the case of parking spaces for disabled people, bay length should be 6.0 m rather than 4.8 m, and each pair of bays should be separated by an access zone of 1.2 m, so that two bays have an aggregate width of 6.0 m rather than 4.8 m, as shown on figure 2 of *BS8300* – see Bibliography.

Zoning
All user groups should have independent and easily identifiable zones in the parking area, which should be divided into blocks of roughly 500 to 1000 cars. These blocks should be instantly recognizable by signs, numbering systems – devices such as colour-coded tickets coordinating with colour-coded signs – and by attractive landmark elements which can be seen and easily recognized from a distance. Varying surface treatments can also assist in partitioning the car park into separate zones.

When marking these decisions bear in mind that spectators may arrive during daylight hours but start looking for their car after dark when everything looks very different; that evening games under floodlights mean arrival and departure in darkness, requiring good lighting of all parking areas.

Pedestrian routes
On leaving their cars, spectators should be able to proceed directly to a safe pedestrian passage which feeds through the car park to the stadium entrance gates. This distance should preferably be no more than 500 metres, or an absolute maximum of 1500 metres. If distances become too great there should be an internal transport system of regular pick-up and drop-off buses, in which case waiting areas must be provided, and (as above) very clear signs provided so that spectators do not get confused.

Signage
The importance of signs has been raised in the preceding paragraphs and a summary of the main points might be useful.

At each entry point to the parking area there should be signs guiding visitors to their individual parking positions. When they have parked and left their cars or coaches there should be further boards telling them where they are, and guiding them towards their viewing positions. The correct perimeter access point must be clearly identified. Similar provision should be made for spectators leaving the stadium to guide them back to their vehicles quickly.

Public transport waiting areas
An efficient internal transport system around the car parks reduces overcrowding of the spaces close to the stadium, and allows visitors to leave the parking area more easily and quickly. There should be highly visible waiting areas, sheltered, provided with information boards and well lit. If possible communication links with the transport control centre should be installed.

Kiosks
The routes followed by visitors as they walk from their cars towards the stadium should be well provided with kiosks where food, beverages, programmes and perhaps even tickets may be bought well before the entrance gates are reached. Such decentralized sales points in the car parking area help reduce congestion at the entrance gates; they should be of an eye-catching design to ensure that they are noticed. Such kiosks, if well-designed, can add to the leisure atmosphere and even serve as 'markers' to help people memorize where their cars are parked.

Lighting
All parking areas should be uniformly lit, with no dark patches, to allow easy ingress and egress and to create a safe environment. High mast lighting is likely to be chosen for this purpose, provided it is aesthetically acceptable and does not cause annoying overspill into adjacent residential areas.

Separate pedestrian walkways, designed into the parking layout to provide clear walking routes between stadium gates and distant parking spaces, should be well lit, probably with low-level local luminaires chosen particularly for their suitability to this purpose.

Telephones
There should be a good provision of public telephones along the outer periphery of the car park in case of vehicular breakdown.

Overspill
If the site is unable to accommodate the total number of cars required, or if certain individual events demand a greater number of spaces, additional parking facilities should be identified in the locality. These can include fields, parks and play areas. The effects of cars parked on these surfaces should be considered, particularly in open-field conditions during the winter or in wet weather.

Figure 4.4 The Hong Kong Stadium, which was redeveloped from the old Government Stadium and opened in 1994, is an example of an urban stadium surrounded by greenery. Architects: HOK Sport Architecture.

Photograph: Kerun Ip

4.3.6 Parking landscape

Car parks can be barren-looking places casting a spell of bleakness on their surroundings and detracting from the spectators' enjoyment of their visit unless very great care is taken. A comprehensive landscaping plan must be devised to reduce the visual impact of these great expanses and to give them some humanity. At the same time, a well thought out scheme can help to define the parking zones and the vehicular and pedestrian routes which intersect them.

The key to success is mental attitude: stop seeing the car park as a piece of ground to be covered in asphalt, but see it rather as a great outdoor floor that must be planned and designed as carefully as the stadium itself. The following suggestions may help to achieve this:

- The paved surface could be subdivided into areas that would form a neat and attractive pattern as seen from above – perhaps a radial configuration centred on the stadium. One element in the formation of such a pattern could be a geometric layout of paved driveways and walkways set into the lower-cost general surface and contrasting with it, say, bricks or interlocking pavings set in an asphalt surface. Another might be the planting of regular rows of dense car-height shrubs or trees between adjacent blocks of car parking spaces to soften the space when observed from eye-height. A third might be rows of tall, slender trees lining the main radial access roads and marking their positions for drivers. Where climate allows, grass surfaces can with great advantage be incorporated in such a surface pattern.
- Each of the paved areas formed by such subdivision should be flat and true, separated (if the site contains substantial differences of level) by neat ramps and low retaining walls; it should not be a great undulating expanse of tarmac untidily following the natural ground contours, as is all too often seen.
- For rainwater run-off each paved area should be laid to fall to gulleys or drainage channels. The ridges and valleys should express the pattern established by the first suggestion above, instead of zigzagging across the site along the lines of least resistance.
- Changes of level should be designed to pedestrian rather than vehicle standards, and there should be no risk of tripping owing to uneven surfaces or sudden changes of level, particularly at danger points such as drainage gulleys and channels. Routes used by disabled people must avoid steps.
- Details at edges and verges should be particularly carefully designed, and formed in good quality materials.

Figure 4.5 The Oita Stadium (see also Figure 5.14 and Appendix 3), which opened in 2001, is a spectacular out-of-town venue set in open green landscape. Architects: Kisho Kurokawa and associates.

- The materials and construction methods should be selected to minimize maintenance, offer a good walking surface, and look attractive. Tarmac is commonly used and is cheap, but it will not give an acceptable result unless carefully subdivided, articulated and trimmed at the edges. Bricks and interlocking pavings offer a superior (but more expensive) finish but even they will not give an attractive result without careful design.
- Part-concrete, part-grass surfaces for vehicles combine the visual benefits of grass with the load-bearing strength of a road. One type uses pre-cast concrete units with large openings through which the grass grows, these units being laid like ordinary pavings. A second type is formed by lightweight, air-entrained concrete being cast *in situ* around polystyrene formers which are then burnt away leaving apertures for the grass to grow through. These surfaces are usually best where use is occasional (for example access roads) rather than continuous, because oil drips and heavy use may kill the grass.

4.4 Stadium landscaping

4.4.1 The stadium in its surroundings

Stadia are major developments which can enhance the surrounding environment or blight it. Attitudes to such environmental impact vary around the world, with the most protective approach found in Europe – partly no doubt because of its limited amount of green space.

Most countries now have environmental protection legislation for both town and country. They also have increasingly aware and assertive communities who will vociferously object to bulky-looking new buildings (particularly if these are likely to generate traffic and noise) perhaps even preventing their construction, or at least forcing expensive modifications to the design. Therefore, not only must very careful attention be given to the form of the stadium and the way it is blended into the landscape, but additionally, officials and community representatives should be consulted and involved from an early design stage and ‘carried along’ as the design develops, with the problems and the preferred solutions explained to them in jargon-free language. To do otherwise is to risk a refusal of planning permission entailing a heavy loss of time and money.

4.4.2 Planting

There are stadia, particularly in the USA, which have virtually no planting as a conscious part of the overall site philosophy. Pontiac Silverdome in Michigan is one. Another is the Three Rivers Stadium in Pittsburgh where the approach has been to allow the structure to be seen for miles around. The siting of the Three Rivers Stadium at the junction of the rivers which flow through Pittsburgh is certainly one of the most striking to be found anywhere, particularly when approached from across the river.

On the other hand, planting can greatly ameliorate the problems of scale and unfriendly-looking finishes sometimes associated with sports stadia and can make almost any stadium look better. The 35 000-capacity Cologne Stadium in Germany (now demolished) provided a particularly good example, being set inside a large sports park and surrounded by foliage so thick that it was possible to be beside the building and virtually not see it. As a more recent example, the stadium for the 2000 Olympics in Sydney is partly surrounded by an 'urban forest' of eucalyptus trees. Such measures can have a softening, and very pleasing, effect on what are often very large concrete buildings. The Hong Kong Stadium (Figure 4.4) is fortunate enough to be located in a lush green setting.

However, planting is expensive both in initial cost and in maintenance, particularly in places (such as sports stadia) where vandalistic behaviour may occur from time to time, and few stadia can afford large maintenance bills just for the care of plants. Possible precautions include:

- Planting mature trees and shrubs and protecting them for as long as possible with frames.
- Establishing a plant nursery on the site (assuming there is enough space) which is inaccessible to the public and where plants may grow unhindered until they are strong enough to risk the attention of the crowds.
- Concentrating the planting in those areas where it will be most effective, as discussed below.

Above all landscaping and planting should not be left as an afterthought at the last stages of a project, as happens all too often. They should be part of the masterplan, planned and adequately budgeted for from the very beginning. The ideal is a landscaping masterplan in which trees which will take several years to grow to maturity are planted immediately, protected during their vulnerable years, and are fully effective when the stadium comes into use. Mature trees can also be purchased from nurseries, transported to the site and planted, but this is expensive.

In summary, it is difficult to have too many trees on a stadium site, but we very frequently see too few. In some cases the planting becomes the focus of our attention: who would think of the Championships at Wimbledon, for example, without a mental image of the green virginia creepers covering the main elevations of the buildings? They are as much a part of Wimbledon as the singles finals, and the development plan which is to take this venue into the twenty-first century very consciously retains and builds on this image.

The following are particularly effective locations for plants.

Site boundary planting

Site boundary planting can soften the visual impact of a large stadium development on its environment, making the buildings seem smaller and perhaps less gaunt. Such planting can also help protect the stadium from the neighbours and the neighbours from the stadium, and form the transition between the outside world and the stadium precinct while also highlighting the positions of the entrances.

Car park planting

As drivers approach the car park, tall slender trees lining the main radial access routes can help them find their way in; and once they are inside and walking towards the stadium tall rows of trees can similarly help them locate the pedestrian routes. Lower, denser rows of planting can be used to separate adjoining blocks of parked cars from each other, softening the view as one looks across the acres of hard, bare landscape. These configurations of tall and low planting should add up to a functional and pleasing total design.

Buffer zone planting

The principal buffer zone is the transition between the stadium building and the car parking area – Zone 4, as described in Section 3.3.2. At least part of it should be hard paved or grassed to act as an assembly area if required, but the remainder can be trees, shrubs or even flowering plants, the latter particularly near the main entrances.

Concourse planting

Concourse planting is used inside the stadium perimeter to help define circulation patterns and to help screen the structure. Because these areas will be crowded with people we recommend planting that is hardy, with no foliage lower than about two metres. In addition to being less prone to damage, trees or shrubs with foliage only at higher levels do not obstruct vision, which is an advantage in circulation areas.

5. Form and structure

5.1 The stadium as architecture
5.2 Structure and form
5.3 Materials
5.4 The playing surface
5.5 Foundations
5.6 Seating tiers
5.7 Concourses, stairs and ramps
5.8 Roof

5.1 The stadium as architecture

5.1.1 The ideal

As suggested in the Introduction, sports stadia are essentially large theatres of entertainment which ought to be as pleasant to visit as a cinema, opera house or play theatre, whilst also being social and architectural landmarks in their towns and cities.

The designers of pre-modern stadia rose to this challenge with admirable skill. The Colosseum and the circuses of Rome, the amphitheatre in Verona, and similar buildings throughout the Roman empire played central roles in the civic lives of their communities. Based on the circle and the oval, they were also wonderfully successful in translating functional requirements and the known building technologies of the time into noble architectural form. The profile of the Colosseum (Figure 1.3) solves at a stroke the challenges of clear viewing, structural stability and efficient circulation, the latter allowing the building to be cleared of thousands of spectators in a matter of minutes; whilst the outer façade is related to the human scale by the colonnaded arcades of its composition. So powerful and inventive was this unprecedented façade that it became a primary source of inspiration for the architects of the Renaissance fourteen centuries later.

Whilst the basic form of the modern stadium remains very similar to those of antiquity (stepped tiers of seats facing a central arena) brick and stone have largely been replaced by concrete and steel, and it must be said that architectural standards have fallen: all too many current stadia are banal at best, anti-human at worst.

Design excellence is achieved in stadia when structure, enclosure and finishes express at all scales – from overall form right down to the smallest detail – a single concept which functions well, is rich and expressive, and avoids jarring conflicts. There are current examples of excellence, such as the Bari Stadium in Italy by the architect Renzo Piano, but complete success is rare: the first step towards higher architectural standards must be the identification of those particular problems which make it so difficult to achieve functional and beautiful stadium design nowadays.

5.1.2 The problems

Because sports stadia are so closely geared to onerous functional requirements (clear sightlines, efficient high-volume circulation, etc.) this is a building type where 'form' follows fairly directly from 'function'; unfortunately 'delight' is more elusive – for the reasons which follow.

Inward-looking form

Stadia naturally look inward towards the action, turning their backs on their surroundings. The elevation facing the street or surrounding landscape tends therefore to be unwelcoming, often made even more forbidding by security fences and other crowd control measures.

Car parking

They must often be surrounded by acres of car and bus parking which are not only unattractive in themselves but tend to cut off the stadium from its surroundings.

Gigantic scale

Whilst the huge physical scale of a major stadium may not create problems in an out-of-town environment it is more difficult to fit happily into a town setting. Reconciling the scales of stadia with those of their surroundings is a difficult challenge.

Inflexible elements

A stadium is composed of elements (seating tiers, stairs and ramps, entrances and roof forms) which are inflexible and sometimes difficult to assimilate into a traditional façade or compositional scheme. And even if traditional rules of composition are abandoned and innovatory architectural forms sought these stiff elements resist being bent or smoothed or tucked away to achieve the grace, harmony, and apparent effortlessness that makes good architecture. They tend to obstinately assert themselves, and the resultant form often simply does not 'look right'.

Tough finishes

Turning from form to finishes, stadia must have tough and highly resilient surfaces able to stand up, without much maintenance effort, to the worst that weather, uncaring crowds and deliberate vandalism can do to them. All too easily the requirement of 'resilience' tends to translate into finishes which are read as 'tough', 'brutal' and 'anti-human'.

Periods of disuse

Stadia tend to stand empty and unoccupied for weeks at a time, casting a spell of bleakness and lifelessness on their surroundings; then for short periods they are so intensively used as to overwhelm their environment. This pattern of use, almost unique among building types, inflicts upon the stadium and its surroundings the worst effects of both under-use and over-use.

5.2 Structure and form

5.2.1 Introduction

It is impossible to lay down a neat set of design rules which will guarantee good stadium architecture, but three suggestions may be helpful regarding architectural form:

- First, designers should think very hard indeed about each of the matters identified above, which are the key architectural problems.
- Second, they should look at existing stadia in which these (or other) problems have been solved with conspicuous success, and try to identify precedents relevant to their own case. There are very few entirely original building concepts in the history of architecture: much good design is an intelligent modification of an existing model that has been shown to work, and there is no shame in learning from the past.
- Third, the approaches outlined below may prove helpful. They are not intended as prescriptive rules but only as suggestions, intended to prompt designers into clarifying their own thoughts, and should be read in this spirit.

5.2.2 Low profile

Many stadia would look best with a profile kept as low as possible. Two techniques which help achieve this are dropping the pitch below ground level and raising the surrounding landscape by means of planted mounds.

There are in fact great financial benefits in lowering the pitch below existing ground level, so that a proportion of the terracing can be constructed as ground-bearing. This not only results in less steelwork but also in a reduced and less costly vertical circulation element – see chapter 23.

Photograph: *Action Images/Sporting Pictures/Nick Kidd*

Figure 5.1 Visual conflict between roof and façade can be resolved by eliminating the wall and reducing the building profile to a graceful roof hovering above the landscape. An excellent example is the 1972 Olympic Stadium at Munich. *Architect: Günter Behnisch. Structural engineers: Frei Otto and Fritz Leonardt*.

5.2.3 Roof and façade

In roofed stadia, which are becoming more common (particularly in Europe), the most important step towards a satisfying and harmonious architectural solution is to avoid having an assertive façade competing with an equally assertive roof. If one of these elements is dominant, with the other subdued or completely invisible, the composition may immediately become easier to handle.

Dominant roof

A successful example of a 'dominant roof' design is Gunter Behnisch's complex of sports buildings in the Olympiapark, Munich. In these buildings the wall has been virtually eliminated and the stadia reduced visually to a series of graceful roof forms hovering over green landscape (Figure 5.1). The playing surfaces are recessed below ground level.

Where the walls cannot be eliminated altogether it helps to reduce them to submissive, horizontal elements of 'built landscape' over which floats a separate graceful roof.

Dominant façade

A successful example of the 'dominant façade' approach is the Mound Stand at Lord's Cricket Ground in London by Michael Hopkins & Partners (Figure 5.2). This stadium façade can genuinely be called successful. It maintains an urban scale, follows the streetline, contains variety and grace; and there is a satisfying progression from the heavy, earth-bound basecourse to the light pavilion-like tent roof at the top.

Dominant structure

In large stadia there could be a third approach: to make the structure dominant. For instance, both façade and roof could be visually contained behind a dominant 'cage' of vertical structural ribs. Examples include the Chamsil Olympic Main Stadium at Seoul and the Parc des Princes in Paris. This may work best on large open sites where the building is mostly seen from a distance.

Kenzo Tange's twin gymnasia for the 1964 Tokyo Olympics provide supreme examples of structural expressionism of a different kind. Both have organically-shaped roofs suspended from cables which in turn are anchored to massive concrete buttresses. The horizontal sweep of the seating tiers and the upward-curving spirals of the suspended roofs obey few of the traditional canons of architectural composition and yet look magnificent – but it has to be said that few designers could handle such unorthodox forms so successfully.

An excellent recent example is provided by Santiago Calatrava's 2004 Olympic Stadium in Athens (Figure 5.3).

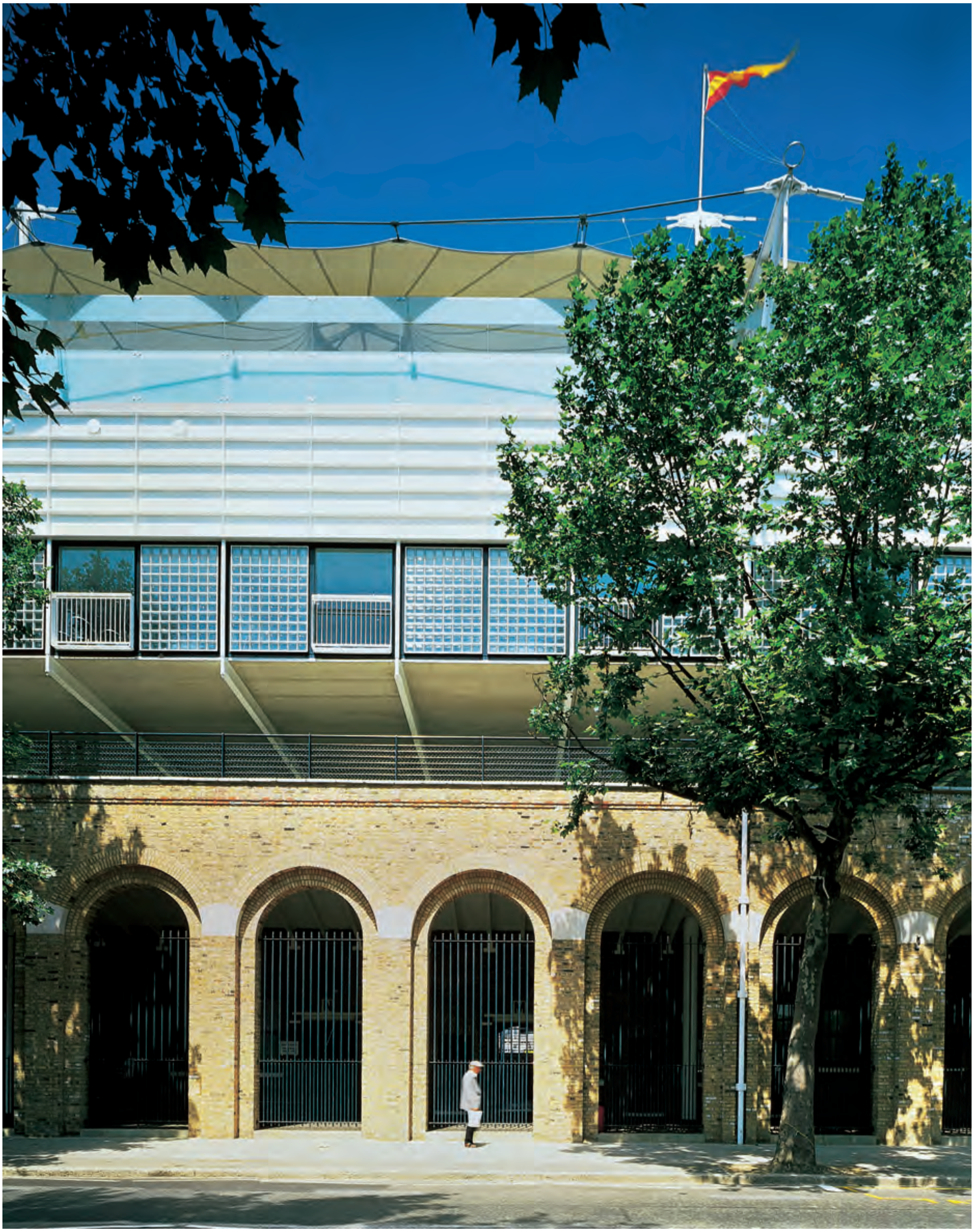


Figure 5.2 In urban contexts the most appropriate approach may be a dominant façade with the roof either hidden or subdued. The Mound Stand at Lord's Cricket Ground, London has a light roof floating above a dominant and well-composed façade. *Architects: Michael Hopkins & Partners*.

Photograph: Geraint John

Figure 5.3 In the 2004 Olympic Stadium in Athens the structure is visually dominant. *Architect: Santiago Calatrava.*

Appropriate choice: open sites

Stadia situated in open parkland can make a positive contribution to the environment if the form rising above the landscape is genuinely attractive and well-composed. If these qualities cannot be achieved, for whatever reason, then there is no shame in hiding the stadium completely behind landscaping; it is a perfectly valid strategy.

Achieving a form that blends with the surroundings is usually not too difficult in the case of an open stadium. Roofed stadia present a greater challenge. Sinking the playing field below ground level and/or surrounding the stadium with planted mounds to reduce the apparent height are useful devices, and could enable the stadium almost to melt away into the landscape.

Appropriate choice: urban sites

If a stadium is situated in a town or city the façades will probably be dominant, partly to allow the site to be exploited right up to its perimeter at all levels, and partly to maintain rather than disrupt the rows of façades which form the streetscape on either side of the stadium. It may then be desirable to subdue the huge stair ramps, and the backs of the seating tiers with their horizontal or sloping geometry, to blend with a surrounding streetscape of closely-spaced, vertically-accented building façades.

One approach, exemplified by the Mound Stand in London, is to adopt a structural pattern for the stadium that enables the rhythm, scale, materials and details to harmonize with the surroundings, and to ensure also that the façade smoothly follows the street line (Figure 5.2).

The other, exemplified by the Louis IV stadium in Monte Carlo, is to place a row of shops, restaurants, a hotel or some other 'orthodox' building type between stadium and street as part of a multi-purpose development. In addition to its architectural merits such a solution would help bring life to the street and could have economic benefits for the stadium as explained in Section 23.4.

5.2.4 Turning the corner

When stands are placed on three or four sides of a pitch the problem of gracefully 'turning the corner' where they join has defeated many designers, particularly with roofed stadia. Each individual seating terrace may be elegant in itself and be fitted with an equally elegant roof – but how to bend these stiff forms round the corners?

Some stadia, such as the one at Dortmund in Germany or Ibrox Park in the UK (Figure 5.4) simply dodge the problem: four rectangular 'sheds' are placed on the four sides of the pitch and the

Figure 5.4 At Ibrox Park stadium, Glasgow, four separate stands meet awkwardly at the corners. *Architects: Miller Partnership & Gareth Hutchinson*.

Photograph: Action Images

corners are left as gaps. This saves money and helps avoid awkward structural and planning problems, and in the case of natural grass pitches the ventilation provided by the open corners is very helpful; but nevertheless the effect is visually unhappy and the geometry sacrifices potentially revenue-earning corner seating, as pointed out in Section 11.3.4. One solution is to infill the corners with towers, with the side and end stands spanning between them. The stadium in Genoa (architect: Vittorio Gregotti), which is in tight urban surroundings, is an example of this approach. Such towers could accommodate offices or other functions depending on the local context.

Satisfying results have also been obtained by designs in which both the stands and roofs are swept round the pitch in some form. Examples include the Stadium of the Alps in Turin. This approach may be difficult on tight urban plots, partly because of insufficient space, partly because it may be desirable that the stadium façades follow the street line, and partly because swept forms may 'look wrong' in some contexts. But there is Philip Cox's elegant Sydney Football Stadium to prove it can be done (Figure 5.5). As in so many successful designs the playing area is submerged below ground (about 5 m in this case) which usefully lowers the stadium profile. The original design had the fluidly-shaped roof floating free above the seating structure – soaring high along the sides of the pitch, where most people want to sit and where the depth of seating extends back furthest and highest; and swooping down close to ground level at the pitch ends, where there are fewer and shallower seating tiers. This dip towards ground level also reduced the apparent scale where the stadium approached a residential area. But the gap between the roof and the rear of the spectator tiers proved too great and offered insufficient weather protection, a problem which had later to be rectified by a multi-million dollar contract to fill in the gaps.

The Manchester Commonwealth Games Stadium (now the Manchester City FC ground), designed by Arup Associates, with HOK Sport Architecture, is a further example of the same design theme – see Case Study, page 275.

5.2.5 Assimilating circulation ramps

Ramps are overtaking stairs as the preferred means of escape for the valid reasons given in Section 14.7.3, but their enormous scale (a circular ramp will probably have an internal diameter of around 12 m) makes them difficult to handle with elegance.

Photograph: Cox Architects & Planners

Figure 5.5 Sydney Football Stadium in Australia is a well-resolved overall design. The stands are deepest and highest where most people want to sit, and the roof sweeps gracefully round the field. *Architects: Philip Cox Richardson Taylor & Partners*.

Relatively successful examples include the San Siro stadium in Milan (Figure 5.6) and the Joe Robbie stadium in the USA.

5.2.6 Assimilating the structure

Lattice-like structures

Massive columns, beams and cantilevers are often difficult to assimilate into a coherent design concept, and a very useful trend in recent years has been the increasing use of more delicate lattice or tension structures to replace (wholly or in part) these assertive structural elements.

These concepts do not automatically solve all problems or guarantee aesthetic success, but they do offer help towards shapely and graceful structures which are related to the human scale. Good examples include:

- The roof of the Prater Stadium in Vienna.
- The Telstra (Sydney Olympic) Stadium by HOK Sport and Bligh Voller Nield.

Massive structures

The alternative 'brutalist' approach of powerfully expressed large-scale structural elements fascinates architects, but alas, for every masterpiece of sculptural concrete there are a dozen cruder examples, deeply disliked by the public. The sheer scale of a modern stadium is part of the problem. As an indication, the 110m-long girder spanning the North Stand at Ibrox Park stadium (Figure 5.4) is large enough to hold four double-decker buses.

If massive concrete forms are to be used they ought possibly to be softened by heavy planting which could consist of trees, shrubs, or smaller plants positioned around or on the building.

5.3 Materials

5.3.1 Visual aspects

Finishes

Unfinished concrete has many functional virtues and is widely used in stadium design. But it is disliked by the general public, tends to weather unattractively, and should be used with great caution. The following suggestions may be helpful.

- Exposed concrete finishes are best avoided in rainy climates, particularly in urban or industrial locations where the rainwater becomes contaminated by pollutants which then stain the concrete

Figure 5.6a The San Siro football stadium in Milan was built in 1939, but has since undergone several major alterations including the addition of eleven cylindrical access and escape ramps in preparation for the 1990 World Cup. The ramps serve a total capacity of 85 000 spectators.

Photograph: Fausto Bernasconi

Figure 5.6b Ramps at the Telstra Stadium Sydney (the Sydney 2000 Olympic stadium). See also Figure 14.5 and Appendix 3. *Architects: HOK Sport Architecture*.

Photograph: Patrick Bingham Hall

as the water runs down the surface. In theory the staining can be avoided by surface treatment, by well-designed drip mouldings and the like, but in practice these measures are seldom completely effective. Also, in theory, the staining of concrete can be positively exploited by carefully planning and guiding the patterns of water-flow to produce a pre-designed effect, but it is difficult to think of any examples where attractive results have been achieved.

- If exposed concrete must be used in these situations then expert advice should be sought and the greatest care taken (both in design and workmanship) to avoid surface staining. Aggregates, sand and cement should all be very carefully specified and be of high quality. The increasing use of pre-cast concrete, which can be manufactured under more controlled conditions than *in situ*, helps towards the achievement of higher quality finishes.
- Painting the concrete can also help, and several existing stadia (including the old Wembley Stadium in London and the Seoul Olympic stadium) have been treated in this way. But it poses a very great maintenance burden.

The above problems are reduced in locations with unpolluted air (where the rainwater is therefore cleaner and less liable to soil the concrete) and in dry climates with low or very intermittent rainfalls. An example of success is Renzo Piano's Bari Stadium in Italy.

Finally, concrete surfaces that are close to people should if possible be clad with brickwork, timber or some other 'friendly' material. This will do much to make for more popular sports stadia, though admittedly it will be expensive.

Colours

Tempted by the enormous range of colours now available for stadium seats, claddings and synthetic pitch surfaces, and trying to overcome the bleakness of the average stadium (particularly when it is half-empty, without crowds of people to give colour and variety to the terraces), designers may fall into the trap of producing gaudily coloured stadia. Imagination controlled by the strictest discipline may give the best results.

5.3.2 Technical aspects

Stadia have been built of every conceivable material. The ancient Romans built theirs in brick and stone, and modern Romans refurbished their existing Olympic stadium in concrete, steel, aluminium and plastic fabric roofing for the 1990 World Cup in football.

Cost is a major factor because structure, as discussed in Chapter 23 is a larger proportion of total cost in the case of stadia than in most other building types. Cost comparisons between all the alternative structural materials are therefore vital, with particular attention to the roof as discussed in Section 5.8 below.

Other performance characteristics such as durability, fire resistance, etc. must be just as thoroughly investigated – and then balanced against the less quantifiable but equally important qualities of user-friendliness, grace and beauty. Stadia can prosper only if they attract spectators, and increasingly people will stay away if the facility is rough or sordid-looking – no matter how technically correct the specifications.

5.3.3 Concrete

Reinforced concrete competes with steel as the most commonly-used structural material for stadia. It has the great advantage of being naturally fireproof and cheaper than steel in some countries, but it has the disadvantage of being unpopular if left unfinished (which is usually the case). By and large it is the only practical material for constructing the seating profiles of the stadium. Concrete may either be cast *in situ* or applied as pre-cast units, and both types are frequently used together.

***In situ* concrete**

The plastic properties of *in situ* concrete have been exploited to produce some very dramatic stadia, for instance the shell canopies of the Grandstand at Zarzuela racetrack near Madrid (Eduardo Torroja, 1935); in Rome the Palazzetto dello Sport (Annibale Vitellozzi and Pier Luigi Nervi, 1957) and the Palazzo dello Sport (Pier Luigi Nervi and Marcello Piacentini, 1960); and in the composite structures of the Hockey Rink at Yale University, Connecticut (Eero Saarinen, 1958) and the National Olympic Gymnasia in Tokyo. Recently such use has diminished in favour of more lightweight structures.

Pre-cast concrete

Pre-cast concrete, like steel, has the advantage over *in situ* concrete that structural members can be prefabricated away from the site well in advance of site possession, thus greatly reducing construction time. This is important when construction must be planned to minimize disruptions to the season's fixtures. Such is often the case with sports stadia in the UK, which must to be constructed in phases during the few months between one season and the next. This practice is not yet common in the USA where stadia tend to be constructed in one operation, but even here stadia owners are beginning to experience the difficulties Europe has had for decades, of clubs not wanting to move from the stadium while necessary redevelopment or upgrading work takes place.

Pre-stressed and post-tensioned concrete

Pre-cast concrete is widely used for the tread and riser units which form the seating platform. These stepping units are often pre-stressed so that they can be thin and light, but their jointing can cause problems. Choice of materials and detailing of junctions is as important here as for roof construction, particularly if the spaces below are to be as usable rooms. Waterproofing especially will be very important.

When using pre-cast framing, thought should also be given to the future uses of the stadium. If stadia are used for pop music concerts the spectators can set up rhythms in time to the music which may affect the structure, and some stadia in Germany have had to be temporarily propped for concert use to compensate for this phenomenon.

Both pre-stressing and post-tensioning are useful techniques in stadium construction – pre-stressing for reasons of lightness, and post-tensioning for offering a reduction (or even absence) of movement joints through the structure. This is an important advantage because many stadia are 100 m or more in extent, and normally such a length of concrete structure should be built as two independent units with a clear expansion gap between. In a post-tensioned structure the thermal movement still occurs but is greatly reduced by the enormous tension placed on the reinforcing rods. The entire structure is held together like a string of beads pulled together by a thread – the threads in this case being steel rods stressed to a hundred tons or more.

5.3.4 Steel

Steel is cheaper in some parts of the world than concrete and it allows prefabrication off-site, which can be a great advantage for the reasons given above.

It is of course lighter than concrete, both physically and aesthetically. This offers functional advantages, such as cheaper footings on bad soil, and the possibility of slender, graceful structures. Steel is an obvious choice for roof structures, two examples of excellence being the Olympic Stadium in Rome and the Prater Stadium in Vienna, both of which were given new steel roofs over the existing stadia.

Fire regulations will probably require steel members below the roof to be fire-proofed by encasing, spraying with mineral fibre or vermiculite cement, or by thin-film intumescent coating (which detracts least from the appearance of steel profiles). This could cause steel to lose its cost advantage over concrete. But fire safety regulations are changing as the emphasis shifts towards 'fire-engineered' solutions, and unprotected steel seems likely to become more widely acceptable provided certain additional measures are taken. These include:

- Ensuring that people can escape from the stadium within a defined time, as discussed in Section 14.6.2, and reach safety well before structural failure commences. This should not be a major problem because the main danger with fire in stadia is not that of structural collapse but of smoke suffocation. The Valley Parade stadium in Bradford, where 56 people died and many were badly injured in a fire in 1985, had an old pitched roof which effectively contained the smoke and flames.
- Installing a sprinkler system. New UK fire regulations do allow unprotected steelwork if sprinklers are installed, a concession that may in some cases tip the economic balance from concrete to steel in the UK. On the other hand the effects of a sprinkler downpour on an already panicking crowd have yet to be seen.

5.3.5 Brickwork

In a large stadium, brickwork is more likely to be used to clad a structure than to act as a structural material in itself. Its use would be particularly apt at 'people level' throughout the stadium to humanize otherwise brutal surfaces, or at street level to help the stadium blend in with the surrounding townscape.

5.4 The playing surface

5.4.1 Level

The level of the playing surface is often sunk below the ground line so that part of the front seating tier can be rested directly on the natural ground (Figure 5.1). This device may offer a saving in construction costs and give the aesthetic benefit of reducing the apparent height of the building. But constructing viewing terraces directly on the ground is not always as straightforward as it may sound: poor soil conditions (see Section 5.5.1 below) could create problems which cancel out the envisaged savings.

5.4.2 Surface

Chapter 7 deals in detail with playing surfaces: here we merely wish to point out that certain stadium forms will rule out (or at least have an adverse effect upon) certain playing surfaces.

Natural grass

Natural grass is the preferred surface for many sports, but the feasibility of installing it will depend on the degree to which the stadium is enclosed. The current situation is as follows.

Completely open stadia: these will accept any playing surface, including grass.

Partly roofed stadia: these may have natural grass playing surfaces, but a combination of shading from sunlight and reduced airflow at pitch level could damage the grass. Therefore expert guidance must be sought, computer modelling used to determine the shadow effects of the structure, and wind effects studied by means of models and wind tunnels – as there are, as yet, no reliable mathematical formulae for predicting wind conditions.

Totally permanently enclosed stadia: at present these cannot have natural grass pitches, and the use of synthetic turfs must be investigated as discussed in Chapter 7.

Experiments to make natural grass pitches feasible in enclosed stadia have so far either proved unsuccessful or very expensive, and cannot be wholeheartedly recommended. For the record, they include:

- Maintaining the grass surface in the open air outside, and then sliding it into the stadium when needed. An example is the Robbie/Allen Roll-in/Roll-out pitch proposed for Toronto's Skydome: in its 'outside' position this grass field can be used for open-air events seating up to 20 000 spectators. The stadium at Arnhem is a recent example.
- Raising the grass surface on jacks into the roof area between games. An example is the 'Turfdome' concept produced by Geiger Engineers in New York, which allows the grass pitch to be raised or lowered to various levels, each serving a different purpose. This is a technically expensive and difficult solution, as yet unbuilt.
- Supplementing a permanent translucent roof with artificial light. This system is currently used by some football clubs in Europe.
- Using an openable roof structure to provide sufficient light – see Section 5.8.4.

Synthetic surfaces

The chosen stadium form is unlikely to have any adverse effect on synthetic playing surfaces. Table 7.1 should be followed with regard to choice, and the advice in Sections 7.1.4 and 7.1.5 with regard to installation.

5.5 Foundations

5.5.1 Poor soil

The only foundation design factor applying specifically to stadia is that sports facilities are often sited on soil too poor to be used for any other kind of development – reclaimed land from disused refuse tips, old mine workings, drained marshland, etc. Much of the construction budget in these cases goes on ground improvement operations such as vibrocompaction, anti-methane treatment and garbage removal.

As soils of low or variable bearing capacity always carry the risk of expensive foundations, a full geotechnical report should be commissioned in all suspect cases before the final construction budget is agreed.

5.6 Seating tiers

5.6.1 Geometry

This is covered in detail in later sections. Here we merely wish to give the designer a clear picture of the key influences on overall stadium form and structure.

- Spectators should preferably not look into the sun while following a match: see Section 3.2 regarding orientation.
- Spectators should be close enough to the pitch to see the movement of the ball. For large-capacity stands this may be difficult or impossible, particularly if the ball is small and fast-moving (as in tennis), in which case compromises must be made; see Section 11.3.
- All spectators should be given a clear view of the pitch over the heads in front of them, which means that seating terraces must be 'raked' to angles which must be very carefully calculated; see Section 11.4.2.
- At the same time the stands must not be so steep as to be dangerous or induce vertigo: about 34 degrees will normally be the maximum; see Section 11.4.3.
- There must be no obstructions such as columns or excessively low roof edges to interfere with spectators' views of the pitch; see Section 11.5.

5.6.2 Construction

As stated in Section 5.3.3, seating tiers are most commonly constructed in pre-cast concrete. Steel as a material will be cheaper in some countries, but not necessarily after the members have been fire-proofed.

5.7 Concourses, stairs and ramps

5.7.1 Geometry

As with seating tiers this is covered in detail in later sections and we wish here only to give the designer a picture of the key influences on overall stadium form and structure.

- The pattern of concourses, stairs and ramps must allow for the smooth inflow of spectators, without people losing their way or getting confused, as outlined in Section 14.5; and a similarly smooth outflow after the end of the match, as outlined in Section 14.6.1.
- Most critically, the layout must allow for fast, safe emptying of the stadium in panic conditions; see Section 14.6.3.
- Planning must also facilitate easy access to toilets as discussed in Chapter 16 and catering facilities as discussed in Chapter 15. As a general rule no seat should be more than 60 m from a toilet, preferably on the same level.
- The circulation routes will probably be planned in a way that subdivides the total seating capacity of the stadium into sectors of about 2500 or 3000 spectators each, to allow for easier crowd control and a more even distribution of toilets, bars and restaurants; see Section 14.2.2.
- In each individual seating area the circulation routes will consist of vomitories fed by lateral gangways (running parallel with the side of the pitch), and radial gangways (which will be stepped). A pattern of few vomitories served by long gangways usually leaves less space for seats, while a larger number of vomitories fed by shorter gangways gives better space usage, and easier egress in panic conditions. A balanced solution should be aimed for.

5.7.2 Surface finishes

Stadia likely to be patronized by well-behaved crowds who will not abuse the building can be finished in the same way as any other public building, and no special notes are needed here. This is the trend in recent UK and North American stadia, where the areas for patrons paying more money may have polished marble concourse floors, toilets finished to hotel standard, and luxuriously appointed social areas.

In Britain a recent example of a stadium finished durably but elegantly is Richard Horden's 5000-capacity Queen's Stand at Epsom Downs racecourse, Surrey. This building, opened in 1992, is not so much a stand as a private box viewing area and therefore exceptional – but it shows what can be achieved. Another example in the UK is the mid tier at Arsenal Football Club, north London, completed in 2006. All seats are padded and with arms; and circulation, toilets and amenity features are finished to cinema standard.

But where crowds have a record of being boisterous and ill-behaved, and where large parts of the building are exposed to wind and weather, finishes must be tough enough to stand up to intense wear and tear, regular abrasive cleaning, and the effects of sun, rain and temperature change.

Concrete surfaces are widely used and relatively inexpensive, can be very durable if treated with additives and sealants, but are associated with precisely the image that the modern customer-winning stadium would like to avoid – of a rough, mean place where one would prefer not to linger. They are also less easy to keep clean than smoother surfaces, and this adds to their negative image. More positively, the colour and stain additives as used at places such as Euro Disney are likely to become popular in the future.

Natural concrete block surfaces with anti-graffiti coatings are serviceable; but for the public they have the same utilitarian image as unfinished concrete.

Natural brick walls promote a better image than concrete, and can be treated with anti-graffiti coatings.

Wall and floor tiles or mosaics in ceramics and terracotta are expensive initially but are hard-wearing and, if properly used, pleasing in feel and appearance.

Coated steel claddings have improved greatly in recent years and are now very durable. They are easily cleanable, the choice of colour and pattern is wide, and this cladding type offers the possibility of handsome yet eminently practical concourse wall-surfaces.

Studded rubber floor tiles and sheeting are available in improved forms and although relatively expensive initially they are hard-wearing and available in attractive colours. They have been successfully used in many stadia in Europe.

Liquid-applied coatings include finishes such as epoxy with grit in the top surface. They offer a tough, colourful, non-slip flooring. Many such coatings are now available.

5.7.3 Details

In all cases correct detailing is as important as correct choice of materials:

- Careful positioning of doors and openings reduces confusion and aids circulation.
- The use of rails along walls can protect the wall face from abuse by keeping people at a safe distance.
- Balustrades set back from the edges of landings and concourses help reduce the danger of objects being accidentally dropped on people below. Similarly, floor edges in these positions should be upturned to prevent objects rolling over the edge.
- Upper surfaces of rails and balustrades should be sloping to make it difficult for fans to stand on them, and to prevent objects which could fall onto people below being placed there.
- Corners can be protected from damage by catering trolleys and other service vehicles by fixing metal guards, or by having rounded profiles.
- High ceilings help to create an open, airy atmosphere and are beyond reach of deliberate damage.
- Toilets should have surfaces and edge details, etc. which allow the complete washing down of walls and floors.
- All dangerous projections and sharp edges should be avoided.

5.8 Roof

5.8.1 Degree of enclosure

Open or partially covered stands are still common in less wealthy regions such as Central and South America and Africa, and are found even in countries with relatively robust climates such as Canada and Russia. But spectators are increasingly demanding some form of protective cover and in colder climates (especially northern Europe, North America and Japan) where sporting events take place in winter roofs are becoming a standard requirement. The trend towards enclosure has gone furthest in the USA and Japan, where many new stadia are entirely covered. Designers should note that this decision, as pointed out in Section 5.4.2, has a dramatic effect on the playing surface.

Shading from the sun

For afternoon matches, which are the majority, the main stand should face east with a minimum of spectators having to look into the sun from a west-facing stand.

In all cases the efficacy of a roof in shading its occupants from the sun, and the extent of shadow it casts upon the pitch at different times of the day and year, must be studied by careful computer modelling. Such modelling should proceed in parallel with wind tunnel testing, especially if the playing surface is to be natural grass, because 'it is now generally accepted that a combination of shading from sunlight and reduced airflow at pitch level has an adverse effect on the durability and quality of grass', to quote Britain's Football Stadia Advisory Design Council.

Shelter from wind and rain

As far as plan shape is concerned, designers should note Rudolf Bergermann's advice that continuous roofs arranged in a circle or ellipse, as opposed to separate roofs with gaps between, normally have a calming effect on the air inside the stadium. This creates more comfortable conditions for spectators and performers – experience at the Don Valley Stadium in the UK actually suggests that such improved conditions can measurably enhance the performance of athletes. One disadvantage is that too little airflow in wet climates may give inadequate drying of a grass pitch after rain, which may argue in favour of open corners between the stands. A balance must be struck between such differing and possibly contradictory factors.

As far as cross-sectional shape is concerned, very approximate rules of thumb are given in Figure 5.7.

These simple parameters are only a starting point for design, and detailed studies should be made using scale models and wind tunnels. Factors to be included in the investigations are:

- Prevailing wind directions and velocities.
- Prevailing air temperatures, and whether winds at match times are likely to contain rain or snow.
- Local patterns of air turbulence caused by surrounding buildings and, of course, by the proposed stadium design itself.
- Conflict between the needs of spectators (wanting protection from wind and sun) and the desirability of a natural grass pitch.

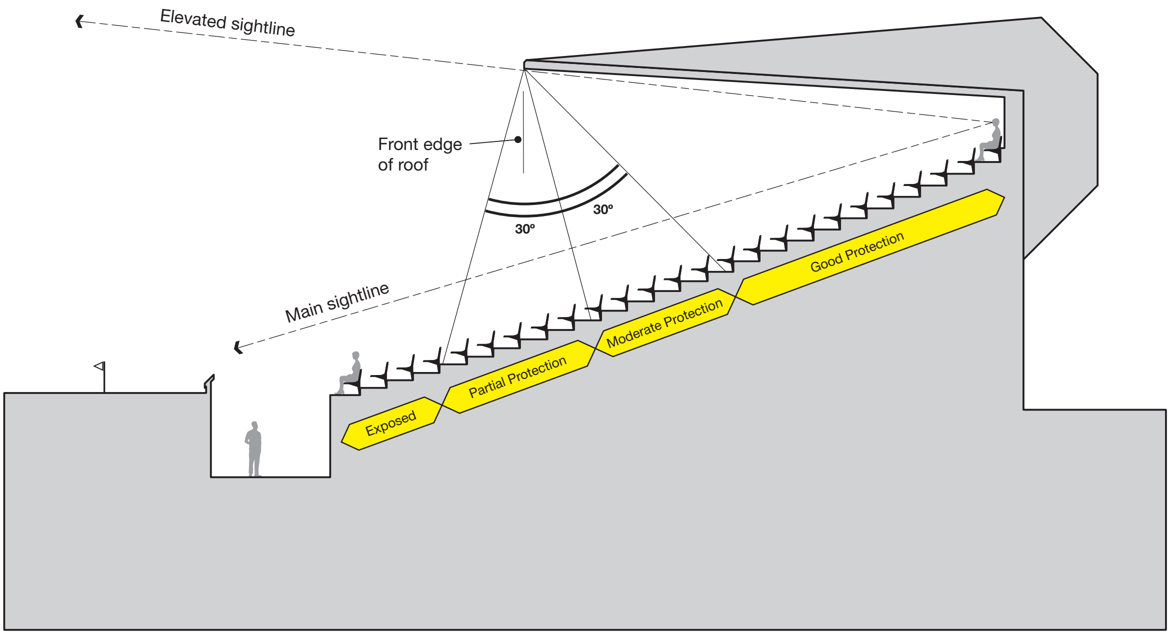


Figure 5.7 A simple model of the degree of protection offered by a stadium canopy. For actual design more detailed studies are needed taking into account factors such as orientation, prevailing wind direction and local patterns of turbulence.

Obstruction to viewing
The roof edge must be high enough that the majority of spectators keep sight of the ball when it rises high in the air, and spectators' views of the pitch should not be obstructed by roof support columns.

5.8.2 Design life

Different elements will have different design lives. The loadbearing structure (columns, beams and trusses) will always have the longest replacement cycle, usually 50 years unless otherwise decided; roof coverings 15–20 years or more depending on type; and finishes will have the shortest cycle, the actual length depending on the type and quality of finish and standard of maintenance. These periods must be discussed and decided with the cost consultants at briefing stage as part of the 'whole-life costing' of the stadium.

Elements which have shorter life cycles than the load-bearing structure, such as claddings, must be designed for reasonably easy replacement; and a definite maintenance cycle for the roof must be decided on and spelt out in an Owners' Manual as discussed in Section 21.1.1.

5.8.3 Designing for wind uplift

When considering alternative forms of roof structure it must be remembered that holding the roof up is not the only structural problem. Wind pressure under the roof may at times create a much more serious problem of holding the roof down – and it is worth noting that more grandstand roofs have failed from destructive uplift than from collapse. This uplift condition is often transitory and may introduce a further complication by setting up an oscillation in the roof beams which must be dampened by the structure.

The problem is particularly great in lightweight structures which have insufficient mass to naturally dampen the 'bounce'. Increasing the weight of the structure specifically to resist conditions of uplift is a possible solution, but an expensive one because these conditions may apply only occasionally. An alternative approach is to adequately stiffen the lightweight structure, partly with special braces and partly by deliberately enhancing the structural potential of elements which are normally non-load-bearing (cladding panels, fascia panels and the like), so that they are able to play a part in transferring loads to the more massive elements and help to control vibration.

The use of wind tunnel testing is recommended in these cases, even though this may require sophisticated models, take two to three months, and possibly cost a lot of money. To get maximum value for this expenditure, testing for structural stability can be combined with testing for environmental impact (for example deleterious effects of wind on a grass pitch, or the creation of unpleasant gusting conditions in surrounding properties). Environmental impact testing is becoming a standard requirement anyway.

5.8.4 Roof types

We summarize below eight principal structural forms which can be used to resolve the many forces acting upon a stadium roof, some of them working best as complete bowls, others as individual stands, as noted below. The list is not exclusive: there are other forms, and many variations and combinations of the basic options.

Throughout Section 5.8 we have drawn on the information contained in *Stadia Roofs* (see Bibliography).

i Post and beam structures
This structural system comprises a row of columns parallel to the pitch, supporting a series of beams or trusses which in turn carry the roof.

Advantages
The post and beam system is cheap and simple (though these attributes tend to be overrated: currently the cost of a column-free roof in a new stand is likely to increase total stadium costs by only about 2–4 per cent over the costs of a roof with columns).

Disadvantages
The row of columns along the pitch obstructs spectator viewing to an unacceptable degree. We believe that there are no circumstances in which this outdated form of roof construction can now be recommended.

If cases do arise where a post and beam roof is the only feasible option, owing perhaps to space constraints or the nature of the existing structure, then it is worth noting that the further back the columns are

Figure 5.8 Goal post and modified goal post structures are column-free and comparatively cheap. This is the Galpharm Stadium in Hudderfield, UK. *Architects: HOK Sport Architecture*.

Photograph: Patrick Bingham Hall

placed the less obstruction they cause. Seats behind such obstructions may have to be left unused or sold at reduced prices.

ii Goal post structures

This is like a post and beam roof with posts only at the two ends, and none between, the entire length of the roof being spanned by a single girder. A girder depth of about one twelfth of the length is normally economical (i.e. a beam that spans 120 m will be 10 m deep). Regular inspection and maintenance is especially important for this system because the entire roof structure depends upon a single girder.

A variant of this is to combine the post and beams into an arch along the front of the roof, examples of which include the Hong Kong stadium and the Galpharm Stadium in Huddersfield (Figure 5.8) both designed by HOK Sport Architecture.

Advantages

- Unobstructed viewing, particularly if the two uprights are situated at the ends of the playing field, with the entire length of the pitch left clear of columns.
- Moderate cost.

Disadvantages

- The system works best when little or no corner seating is required, thus placing a restraint on the seating layout as discussed in Section 10.3.
- The goal post system tends, from the visual point of view, to create a 'boxy shed' that cannot be coaxed round a curve or corner with any degree of grace, and is difficult to link smoothly with adjacent stands.

This system is therefore most likely to be appropriate where separate stands are required on the sides of a playing pitch, with no intention of extending the roof other than in a straight line.

Examples

The goal post system is widely used in the UK, and examples include Ibrox Park in Glasgow (Figure 5.4).

iii Cantilever structures

A cantilevered roof is held down by weight or otherwise securely fixed at one end while its other end, facing the playing field, hangs free and unsupported. A variation of the above is the propped Cantilever.

Advantages

- Such a structure can provide completely unobstructed viewing for virtually any length of stand

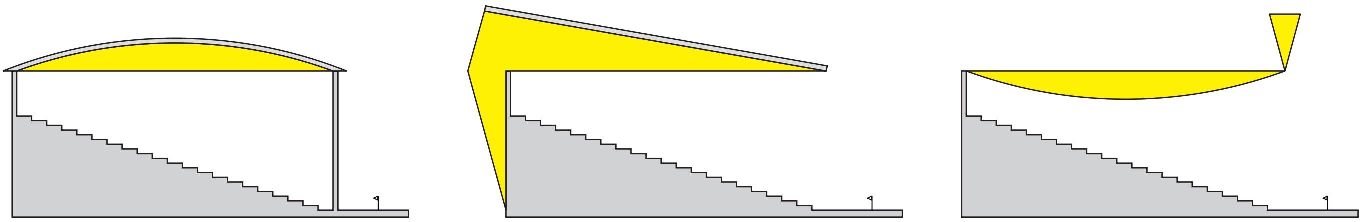


Figure 5.9 Three common forms of roof for stadia:
1 Roof spanning between columns at the front and rear of the stand. This system was used in the early twentieth century but is no longer favoured as the front columns obstruct spectators' view.
2 Roof cantilevered from the rear of the stand.
3 Roof spanning between the rear of the stand and a long-span beam at the front.

Photograph: Patrick Bingham Hall

Figure 5.10 The cantilevered roof at Selangor Turf Club, Malaysia, is mainly designed for protection from the sun. *Architects: T. R. Hamzah & Yeang Sdn. Bhd in association with HOK Sport Architects. Structural engineers: Tahir Wong*.

while spanning depths of 45 m or even more, the limiting factor being cost rather than technology. Examples include the stands at Twickenham Rugby Football Ground, London; the new north and south stands at Murrayfield Rugby Stadium, Edinburgh, which have a clear depth of 43 m; and the Husky Stadium, Seattle, with a clear depth of 48 m.

- Cantilever roofs can be very dramatic, exploiting the excitement engendered by structure with no apparent means of support (Figure 5.10).
- The cantilever is as suitable for continuous bowl-shaped roofs as for isolated stands. In bowl stadia the individual frames can be arranged as a closely-spaced series of vertical elements fluidly following a circular or elliptical plan form – as in the Parc des Princes in Paris – which is a great planning advantage.

Disadvantages

- Where the rear seating rows must be very distant from the playing field the cantilever becomes markedly expensive and it may be found that a roof of the goal post type, for instance, can be built more cheaply. Whether the cost factor will be enough to outweigh other considerations (such as aesthetics) is a matter for careful evaluation.

- The reversal of forces caused by wind uplift can be particularly destructive in the case of a cantilevered roof (though less so if it is a bowl stadium, where the curved plan provides a stiffening effect). If slender 'holding-down' stays were envisaged at the back of the cantilever, to create a light and graceful structure, it may be found that these must become more massive to cope with the compression forces set up when the roof is lifted, thus creating a heavy structure where the desire was for a light one.
- A cantilever roof rises to its highest point at the back of the stand – the 'street side' as it were – and may therefore appear taller and more intimidating to passers-by than alternative forms of structure enclosing a similar seating capacity. The East Stand at Stamford Bridge football stadium in London, while being an admirably heroic and exciting design, also demonstrates the colossal visual impact that a large cantilevered structure may have. Not every site can absorb such a dramatic intrusion, particularly on the street side, where the stadium must relate to the scale of much more ordinary buildings.
- Related to the above point, a cantilevered roof thrusting boldly out into space without any visible means of support provides not only an aesthetic opportunity but also a risk. Great care and some self-restraint is required if an obtrusive, out-of-scale result is to be avoided.

Examples

The East Stand at Stamford Bridge football stadium in London is not without problems: its construction costs were high, the upper seats seem a long way from the pitch, the lower seats are uncomfortably exposed to wind and rain, and there are difficulties with cleaning. Nevertheless its design has 'presence' and architectural power. Other examples include the Bari Stadium in Italy, Twickenham RFU and Seoul Olympic Stadium.

iv Concrete shell structures

Shells are thin surface structures which are curved in one or two directions, deriving their strength from the geometric shape rather than the thickness or firmness of the material (just as a flimsy sheet of paper may become capable of carrying a load if correctly curved). They include cylindrical, domed, conoid and hyperbolic shapes and offer the possibility of very elegant roof forms. A shell as thin as 75 mm or 100 mm may easily span 100 m.

Advantages

- Shell structures have the potential of great visual elegance. This does not, however, come automatically. Such innovative forms require very thorough testing of architectural character, using both computer modelling and physical scale models, if absolutely 'right-looking' results are to be obtained.
- If carefully detailed, shells can be self-finished both underneath and on the upper surface. The latter requires sufficiently steep drainage falls to ensure rapid and complete disposal of rainwater.

Disadvantages

- Specialist designers must be used, as the mathematics involved are advanced.
- If *in situ* concrete is used the formwork costs will be very high since a 'birdcage' or similar type of scaffold will be required. A pre-cast concrete solution should be considered, or a combination of pre-cast and *in situ* concrete.

Examples

The grandstand at Zarzuela racecourse near Madrid (1935) by Eduardo Torroja, the Palazzetto dello Sport in Rome (1957) by Annibale Vitellozzi and Pier Luigi Nervi, and the Palazzo dello Sport in Rome (1960) by Marcello Piacentini and Pier Luigi Nervi are the best-known examples of shell construction in sports buildings.

v Compression/tension ring

Such a roof consists of an inner tension ring and an outer compression ring, the two being connected by radial members which maintain the geometry of the overall doughnut-shaped structure and carry the roof covering.

Advantages

- Very great stand depths can be spanned with comparative ease: the new roof to the Vienna Prater Stadium spans a distance of 48 m between the inner and outer rings, and the recently added new roof to the Olympic Stadium in Rome a distance of 52 m.

- As can be seen from the above examples, this roof type lends itself both technically and aesthetically to the problem of retro-fitting a new roof to an existing bowl stadium.
- The inner perimeter is completely column-free, so that there are no obstructions whatever between spectators and pitch.
- The roof has a light, weightless appearance as seen from the stadium interior and is unobtrusive or even invisible when seen from the outside. The latter can be a particular advantage in many situations as discussed in Section 5.2.3.
- Both the overall roof form and the structural details have inherent qualities of harmony and grace, and do not resist the designer's attempts to produce beautiful architecture. This contrasts with some other structural types which are technically efficient but aesthetically difficult to handle.
- Transparent or translucent roof coverings are possible, as in the Olympic Stadium in Rome.
- Some types permit the addition of a permanent or temporary roof cover over the playing field.

Disadvantages

- This structural system can be used only with bowl stadia.

Examples

The Prater Stadium in Vienna was built in 1928–31 and extended in 1956, and the new roof retro-fitted in 1986 with no need for any additional reinforcement to the existing concrete structures. The pitch itself has been left open, while the surrounding stands seating 63 000 people are entirely covered by a continuous oval roof, the outer perimeter forming an ellipse of 270 m by 215 m. The roof covering consists of galvanized and plastic-coated corrugated steel sheets, while the structure comprises an inner tension ring and an external compression ring (both of these being box girders) with a connecting framework of steel tubes. The latter have a structural function and also support the steel covering plates. Special ties hold down the lightweight structure against wind uplift. Roof depth, front to back, is 48 m, and the overall roof area over 32 000 m^2. Floodlights are mounted on the inner ring and TV camera stands, public address systems and other services are integrated into the roof.

A more recent and even larger example is the open stadium in Rome which was used for the 1960 Olympic Games and then retro-fitted with a roof for the 1990 Soccer World Cup Competition. In this case roof depth is 52 m from front to back, and the roof covering consists of translucent Teflon, allowing some light to penetrate to the seats below.

vi Tension structures

These are roofs in which all the primary forces are taken by members acting in tension alone, such as cables. They are always more economical in material (though not necessarily in costs) than other forms of structure, but must be very carefully stabilized and restrained against any deformation which could cause parts of the system to go into compression. There are three principal forms – catenary cable, cable net and membrane.

Catenary cable structures

These consist of a compression arch (or arches) supporting one or more cables hanging in catenary shape, which in turn support a roof structure.

The beautifully shaped roof of Eero Saarinen's hockey rink at Yale University, New Haven (1958) is formed by cables suspended from a rigid arched keel. At Tokyo, seven years later, Kenzo Tange roofed the twin gymnasia for the 1964 Olympic Games with concrete slabs hung from massive steel cables to create two of the most dramatic architectural forms of the century.

These are very heavy forms of tension structure compared with the types below.

Cable net structures

As above the supporting structure is separated from the roof covering. The structure consists of a three-dimensional net of steel cables, and the covering probably of plastics (acrylic, PVC or polycarbonate). Glass reinforced plastic has been used but it tends to become brittle and less translucent with age. Suitable plastics for coverings are listed in Table 5.1, published by kind permission of the Football Stadia Advisory Design Council and the Sports Council.

An excellent example of a cable net roof is the Olympic Stadium complex at Munich (Figures 1.10 and 5.1) where a covering of transparent acrylic

	Profiled metal sheeting		Concrete	PVC		Acrylic	GRP	Polycarbonate		Fabric	
	Steel	**Aluminium**		**Single glaze**	**Double glaze**			**Single glaze**	**Double glaze**	**PVC-coated**	**PTFE-coated**
Relative cost factor (supply and fix) as at 1992 in the UK	1.2		2.5 to 8.0	2.4 to 4.0	3.0 to 5.0	2.4 to 4.0	1.5 to 3.5	4.5 to 7.0	6.0 to 8.0	3.0 to 5.0	5.0 to 8.0
Durability	Good	Good	Good	Medium	Medium	Medium	Medium	Good	Good	Medium	Good
Flame retardancy	Incombustible		Incombustible	Self-extinguishing		Class 1 (when edges are protected)	Class 1	Self-extinguishing		Approx Class 1 equiv.	Class 0
Transparency	Opaque		Opaque	Transparent: 70% to 85% light transmission, which lessens markedly with time.		Translucent or transparent: 50% to 70% possible light transmission, which lessens moderately with time.	Opaque	Transparent: 80% to 90% visible light transmission, which lessens slightly with time.		Translucent	

Table 5.1 Comparative properties of roof covering materials

Figure 5.11 The Faro Stadium in Portugal, also known as the Estádio do Algarve, was completed in 2003. It was designed to seat around 30 000 spectators (a figure that could be reduced in future), of whom 20 000 are covered by a fabric roof. The pair of canopies are supported by a system of catenary cables spanning 210 metres between four 72 metre tall masts. *Architects: HOK Sport Architects*.

Photograph: Patrick Bingham Hall

panels is supported by a web of steel cables. Because the covering in this case was designed to be relatively rigid, deformation in the cable system had to be minimized by very powerful pre-tensioning, leading to high costs for the masts and other anchoring members.

Membrane structures

Unlike the preceding two types, the roof covering material forms both the structure and the enclosure. Suitable fabrics include:

- PVC-coated polyester fabric. This is cheaper initially than the next type below, and easy to handle. But it has a life of only about 15 years, the fabric tends to sag with time, and the surface becomes sticky with age and requires frequent cleaning.
- Teflon-coated glass fibre fabric (also known as PTFE-coated glass fibre fabric). This is an expensive roof by any standards but it has a longer life than the type listed above and, being Teflon, it is to some degree self-cleaning. Use of this material is limited or banned by some authorities because of a tendency to produce toxic fumes in a fire. But as fire is not normally a hazard in stadium roof situations the material ought to be acceptable in this context. Use of an expert designer is essential, together with a fire engineering approach.

The Faro Stadium in Portugal (Figure 5.11) and Oita Stadium in Japan (Figure 5.14) provide elegant examples. Examples in the UK include the Mound Stand at Lord's Cricket Ground, London of 1987 (see Figure 5.2) with a translucent PVC-coated woven polyester fabric with PVDF top coat; the Sussex Stand at Goodwood Racecourse of 1990; and the Don Valley Stadium at Sheffield in 1991. The Riyadh Stadium in Saudi Arabia is an example of a complete stadium roofed in fabric.

Advantages

- Cable net or fabric roofs can be designed to lend an airy, festive appearance to a stadium, especially when seen from a distance. Given the aesthetic difficulties discussed in Sections 5.1 and 5.2 this can be a valuable attribute.
- If a translucent membrane is used the spectator spaces underneath may have a lighter, more open feel than with opaque roofs. It may also reduce the shading of the pitch which causes problems for

grass growth, as discussed in Section 5.4.2, and for television coverage as discussed in Section 18.1.4.
- Tension structures can be adapted to many stadium layouts, and do not dictate a particular plan form.

Disadvantages
- Very sophisticated design is needed for all tension structures, and it is best to use structural engineers with previous experience and a track record of successful designs.
- More systematic and intensive maintenance is required than with other structural forms.
- Fabric roofs require very careful detailing of rainwater guttering.

vii Air-supported roofs

An air supported roof consists of a plastic membrane which forms an enclosure, either on its own or in combination with a wall structure, and is supported by positive internal pressure provided by fans. These membranes are commonly formed in PVC polyester, sometimes with cable reinforcement in the case of larger roofs.

Advantages

Air supported roofs are relatively low in capital cost.

Disadvantages
- Full enclosures are vulnerable to damage.
- Design life is relatively short.
- The system needs to be continually pumped to keep the interior adequately pressurised.

Examples

The leading air-supported roofs are mostly in North America. Those in the USA are the Hoosierdome in Indianapolis (1972) with a seating capacity of 61 000 and the Silverdome in Pontiac (1973) with a seating capacity of 80 000. The latter is shown in Figure 5.12. The leading Canadian example is BC Place in Vancouver (1983) with a seating capacity of 60 000. All these roofs are of fiberglass. The best-known Japanese example is the so-called ‘Big Egg’ in Tokyo.

viii Space frames

A space frame is a grid of structural members which is three-dimensional in shape and also stable in three dimensions, unlike, for instance, a roof truss, which is stable only in its own plane. Such frames can be constructed of any material but are commonly of steel.

Advantages
- Capable of spanning large distances.
- Suitable for all-over roofs with only perimeter support.

Disadvantages
- A space frame is efficient and sensible only if spanning in two directions. Plan proportions should therefore be roughly square, and preferably not have a length-to-width ratio greater than 1.5 to 1. This structural form will therefore not be appropriate for normal stand roofs unless the sections of roof between structural supports can be of these proportions.
- Space frames tend to be expensive.

Examples

The San Siro Stadium in Milan is roofed over by an aluminium deck supported from steel lattice beams (Figure 5.13). The roof covering is translucent polycarbonate sheeting. It must be said that this was a very expensive solution which has not functioned as well as expected (the main failure being that the grass on the pitch is struggling to survive, probably as a result of excessive shading, though that is no criticism of space frame roofs as such).

ix Opening roofs

Increasing numbers of stadia are being designed with roofs that can open and close, the latter giving protection from the weather and thus enabling indoor events of all kind to take place and encouraging multi-use – see Chapter 8.

The geometry and mechanism of a moving roof can take many forms. An early ambitious example was the design for the Montreal Olympic Stadium of 1976, which proposed a gigantic fabric roof over the central area, supported by cables from a high reinforced concrete tower. This would be pulled up and lowered, rather like an umbrella. Unfortunately the proposal proved to be too ambitious and the roof was fixed in a permanent form.

Since then the technology of retractable roofs has greatly improved.

Photograph: Barry Howe Photography

Figure 5.12 The 80 000-capacity Silverdome in Pontiac, USA, with a roof of Teflon-coated Fiberglass supported entirely by internal air pressure and restrained by a diagonal network of steel cables. The roof membrane is 6 per cent translucent. *Architects/engineers: Howard Needles Tammen & Bergendoff (HNTB)*.

Photograph: Fausto Bernasconi

Figure 5.13 The San Siro Stadium in Milan (see also Figure 5.6) is an example of a space frame roof. *Structural engineer: Prof. Ing. Leo Finzi*.

A highly elegant example is provided by the Oita Stadium in Japan (Figure 5.14), designed by the KT Group, Takenaka Corporation. The venue has a maximum capacity of 43 000 spectators and was completed in 2001 for the 2002 World Cup. The stationary part of the roof is clad in titanium, while the movable panels are lightweight Teflon membranes. These panels are retracted by a wire traction system

Figure 5.14 The Oita Stadium in Japan (see also Figure 4.5 and Appendix 3) has a particularly neat closing roof, consisting of two lightweight panels that slide together to meet above the centre of the playing field. The action is reminiscent of the closing of an eye. *Architects: Kisho Kurokawa and associates*.

and slide over the main beam arch, meeting exactly above the center of the field. The action resembles an eyelid closing, hence the popular name 'the Big Eye' by which the stadium is known.

The Millennium Stadium in Cardiff (Figure 5.15), designed by HOK Sport Architecture and WS Atkins, provides a particularly large-scale example. The venue seats up to 74 500 spectators and opened in 1999 to host the Rugby World Cup. The roof has a total fixed area of approximately 27 000 m^2 around the perimeter; and in the centre a moving area of 9 500 m^2. The latter comprises two panels above the playing field, which slide apart to create an opening of 105 x 80 metres. It takes 20 minutes to winch the closing sections into place along rails, which rest on the massive 220 metre long primary trusses. Its form and operation are simple and uncomplicated – a factor to be taken into account when looking at lifelong maintenance.

Further selected examples of moving roofs include the following:

- The Amsterdam ArenA (see Figure 8.1 and Case study 2) which opened in 1996 and seats up to 51 000 spectators. It is primarily a football stadium but is also extensively used for pop concerts and other entertainments.
- The 63 000 seat Arizona Cardinals football stadium – see Case study 3.
- The Miller Park (Brewer) baseball stadium in Milwaukee, which has a 7-panel roof that opens and closes like a fan, and is claimed to close in about 10 minutes.
- The Reliant football stadium in Houston (see Figure 8.1 and Case study 19).
- The Rod Laver Arena in Melbourne (see Figure 1.15).
- The 47 000 seat Safeco Field baseball stadium in Seattle.
- The Telstra Dome in Melbourne (see Figure 8.3, and Case Study, page 291).
- The Toronto Skydome (see Figure 4.2).
- The Centre Court at the All England Lawn Tennis and Croquet Club, Wimbledon, which is being fitted with a new sliding roof (see Figure 2.4). The closing has to be accompanied by sophisticated air conditioning to ensure that the natural grass surface performs similarly whether the roof is open or closed.

5.8.5 Roof coverings

We can best summarize the many requirements of roof coverings by quoting the authors of *Stadium Roofs* (see Bibliography): 'Materials used for roof covering need to be lightweight, tough, water-tight,

Figure 5.15 The Millennium Stadium in Cardiff, Wales (see also Appendix 3) is a pioneering example of a stadium with a very large retractable roof. *Architects: HOK Sport Architects*.

Photograph: Patrick Bingham Hall

incombustible, aesthetically acceptable, cost-effective and durable enough to withstand the effects of outdoor weathering, including ultraviolet light. They should also be strong and stiff enough to span between primary and secondary elements, supporting snow and other superimposed loads, including wind forces. Over the facility areas ... such as private boxes, kitchens, restaurants and toilets, the roof construction may require additional thermal and/or acoustic insulation.'

Opaque coverings

Profiled metal sheeting is cheap, easy to fix, and very commonly used. Steel sheets generally come in galvanized, plastic-coated or painted form. Aluminium sheets are lighter and inherently resistant to atmospheric attack, but have less impact resistance and will suffer electrolytic corrosion when in contact with other metals or with concrete, and chemical attack when in contact with wood that is subject to wetting: in both cases separating membranes must be used at all contact points.

Concrete is so heavy that it will seldom be used as a roof covering as such, but where the roof structure is also the covering (for example a shell or slab) the chosen material may well be concrete. The problems which must then be addressed are likely to be excessive weight (which may be reduced by using lightweight aggregates) and the unattractive weathering that is associated with concrete surfaces. Silicone treatments may help reduce the latter, but if the stadium is to be built in a climate that is both rainy and polluted the concrete should preferably be given a finish such as tiling. If this is unaffordable then it will be very difficult to avoid the concrete gradually becoming stained and unattractive-looking, as discussed in Section 5.3.1.

Translucent coverings

Rigid plastics include acrylic (of which perspex is one variant), PVC and polycarbonate sheeting. These materials are waterproof and strong, can withstand reasonably large deformations without damage, and have reasonable impact resistance. Examples of rigid

Figure 5.16 Oriole Park at Camden Yards, Baltimore, is an example of a stadium in the streetscape (see also Figure 25.1). *Architects: HOK Sport (Kansas City).*

Photograph: Esto Photographics

translucent roofs include the 1972 Olympic Games stadium in Munich (Figure 5.1) which uses acrylic panels; the stadium at Split in Croatia which uses tinted 'lexan' sheeting; and the 2000 Olympic Games stadium in Sydney (Figure 2.1) which has triple-wall polycarbonate varying in tint to be more translucent at the front edge.

Non-rigid plastics include PVC-coated polyester and PTFE-coated glass fibre. Examples are those already mentioned: the Mound Stand at Lord's Cricket Ground, the Sussex Stand at Goodwood Racecourse, and the Don Valley stadium in Sheffield.

Table 5.1 gives guidance to both rigid and non-rigid types of translucent roofing.

5.8.6 Completely enclosed stadia

Stadia with permanent roofs over the playing area are to be found in the USA in particular, where they are known as 'domed' stadia. Examples include the Louisiana Superdome, New Orleans; the Silverdome, Pontiac; the Astrodome, Houston; the Hubert H. Humphrey Metrodome, Minneapolis; and the Hoosier Dome, Indianapolis.

Many of these structures use translucent coverings. Such a covering gives a welcome effect of visual lightness, a pleasant open ambience, and it does assist television broadcasting by reducing contrast between sunlit and shadowed areas.

But even the best-performing translucent roofs will not permit grass to grow on the playing field below. If this is not important (as tends to be the case in the USA, where the great national sports do not require a natural grass surface, and where intensive multi-use favours hardwearing synthetic surfaces) the decision between an open or enclosed stadium becomes a relatively straightforward matter of balancing the relative costs and revenues of the two options against each other. But in Britain and Europe, where both soccer and rugby require natural grass pitches, the fully enclosed stadium will usually be ruled out in principle.

6. Security and anti-terrorism measures

6.1 Introduction
6.2 The threats from terrorism
6.3 Authorities
6.4 Implications for management and operation
6.5 Responses by the design team
6.6 Conclusion

6.1 Introduction

Security in this context means the protection of a building or its occupants from various external threats that might cause danger to the people in the building, or interfere with its normal operation. These threats could be crime, natural disasters or human error for example, and the actions to counter them will range from elements of the design of the building to operational procedures by the management or outside agencies. In recent years the threat from terrorism has become a factor that must be taken into account when staging major sporting competitions and this chapter concentrates on that threat.

There can be no absolute answers in countering such threats, and this chapter only gives an outline of some of the major issues. It should be read in conjunction with the guidance on emergency egress in the event of fire in Section 14.6.2. The authors would stress that anti-terrorist measures are a highly specialized subject, and expert advice is essential. The level of threat is judged by the police, who should be consulted on this aspect throughout the design process.

6.2 The threats from terrorism

The following is a summary list of some of the methods that terrorists could use to attack high-profile events, which has been extrapolated from the experience of past terrorist incidents. Note that the aim of terrorists can be to harm people, to take them hostage or to cause alarm.

Explosive devices
These may be delivered by a number of means including parked vehicles; large vehicles driven by

a suicide bomber; devices carried by an individual; and explosives delivered by a missile. They could include devices with radioactive ingredients. In the past incidents they have been brought to the building on the day of the attack or delivered in advance and detonated at a significant time.

Firearms
These can be brought into the sports venue or, in the case of sniping, used from a long distance.

Chemical, biological or radiological agents
These include various agents that can act on the body in different ways and can be delivered as powders, liquids or gas.

Incendiary devices
These could cause the greatest hazard in the concourses and interior spaces of the stadium.

Electronic devices
Modern buildings rely on a plethora of computer systems from building management systems, ticketing systems to different types of communication systems. Some of these can be disturbed by hacking in over the internet and all of them by interfering with the power supply.

6.3 Authorities

As mentioned in the introduction, it is important to contact those public bodies who can give an assessment of the perceived likelihood of terrorist attacks, and may already have planned out their response. The authorities that may be involved in dealing with a terrorist threat include the police; local authorities; national security organizations; and emergency services organizations. Proposed stadia designs should be discussed with these agencies, who will have valuable specialist knowledge to contribute.

6.4 Implications for management and operation

6.4.1 Management responses
The accepted method of understanding the threat and what to do about it is a 'risk assessment', which is a formal method of setting out what is known about the potential attacks, and then analyzing what can be done both to reduce the likelihood of such an attack succeeding, and to ensure the safety of the occupants of the building when it does happen. The management of a sports venue should prepare contingency plans setting out how they would act in the event of the various possible incidents. Different events, even in the same venue, will have different levels of threat associated with them and be vulnerable in different ways.

It should be noted that the response to terrorist, and all other serious threats, is a team effort, which will normally be lead by the management of the venue, except in some high-profile situations where it could be lead by government security agencies.

6.5 Responses by the design team

The design of the facility can influence the way in which managers and security authorities are able to handle the emergency, and the way in which a crowd will behave. The following notes summarise some of the key matters, and should be read in conjunction with Figure 3.3, showing the zoning of stadium planning.

Firstly the terrorist threat is constantly changing, and the ideas on how to counter it are evolving too, so a building with space to allow some flexibility of activity within it will be more useful.

6.5.1 Vehicular parking and access
- Parked vehicles must be kept away from the perimeter of the stadium.
- It must be ensured that vehicles do not pose any threat, whether they are VIP or service vehicles that enter the building before the event or on the event days.
- It must be ensured that emergency vehicles can enjoy unhindered access into the stadium throughout any kind of terrorist incident. It may be difficult to reconcile such ready access with planned security measures, and resolving this conundrum will need discussion between the security advisers and local authority.

Measures designed to protect buildings from vehicular attack, such as bollards and other forms of barriers, can often conflict with crowd flow, emergency vehicle access, and the urban design of the surroundings. A careful balance is required to provide security without the stadium coming to resemble a prison.

6.5.2 Access into the stadium for spectators, staff, and the media etc. through the perimeter

This is an early line of defence to prevent potential malefactors from entering the facility. Significant changes of practice and requirement may be expected here in the future in locations where there is thought to be a threat – for example, the increasing use of search equipment as at airports. Space to allow searching to take place should be allowed, normally outside the main ticket check line, but sometimes inside it.

6.5.3 Circulation inside the stadium

At overall planning stage the design team should as far as possible 'design out' all potential places of concealment, for instance by ensuring that the stadium has clear simple spaces with no hidden nooks and crannies.

At detail design stage it will be similarly helpful to 'design out' high-level places where threatening packages could be placed out of sight. The use of sloping upper surfaces on all high-level window sills is one example of a sensible precaution.

6.5.4 Structural collapse

The aim is to delay the collapse of the building for long enough, in the event of an explosion, to give people ample time to escape.

The key factors for delayed collapse include structural robustness, ductility, and redundancy. Robustness essentially means a general sturdiness. Ductility means the ability, particularly of joints and connections, to stretch, bend, and deform rather than break. Redundancy means the ability of a structure to transfer loads from one set of members to another, thus permitting the structure to survive even if, for instance, a column is removed. Steel or *in-situ* concrete frames score best against these criteria. Load-bearing masonry scores badly; and so do pre-cast concrete frames unless the connections between components have been designed with very great care.

Design strategies may also include progressive collapse, sacrificial façades, etc.; but it may be found at the end of the day that an engineered solution cannot be adequate to the challenge, and that other and wider mitigation methods must be explored.

Again these are highly specialized matters and reputable experts must be consulted.

6.5.5 Air intakes

All ventilation intakes for artificial or natural ventilation must be placed where they cannot be interfered with, and where it is impossible to introduce chemical gases etc. into the facility. In addition consideration should be given to control systems that can seal off external air intakes in the event of an emergency.

6.5.6 Control rooms

It is vital that all control rooms (which are described in more detail in Section 19.2.4) continue to operate throughout any kind of emergency. The following measures can be incorporated in their design.

- The control room should be designed to remain intact and functioning in the event of explosions or other serious security problems in the stadium. For increased security it may also be located where it is invulnerable to such attack (e.g. an off-site location); and a secondary back-up control room is often incorporated in case the main one becomes unusable.
- Electrical supply must be maintained throughout any emergency.
- Provision can be made for command and communications facilities (CCTV, PA, BMS, etc.) to be remotely controlled off-site, or integrated with national security services systems.

6.5.7 Glass

As a top priority, effective measures should be taken to eliminate the horrific injuries that may result from flying glass, which typically causes around 95 per cent of all injuries in an explosion. Glass, especially in large sheets, should never be untreated annealed glass, and can be made safe by one of three methods:

- Using laminated safety glass. This consists of layers of annealed glass (which for added safety may be toughened, see below) glued to interlayers of extremely tough plastic, thus producing a sandwich of material that offers a high degree of resistance to explosions and also bullets. If the glass does break the composite sheet still hangs together, rather like a curtain, and does not disintegrate into lethal flying shards. This is the most expensive method.

- Using toughened safety glass. This is up to five times stronger than conventional annealed glass, and if the glass does break it disintegrates into crumb-like fragments which are neither large enough nor sharp enough to cause serious injury. Typical cost may be about a fifth less than that of laminated safety glass.
- Applying transparent safety film to ordinary annealed glass. Though they are paper-thin, such films will hold the glass together if broken, and counteract the formation of flying shards. Typical cost may be a third or a quarter of the cost for laminated safety glass.
- More sophisticated blast-absorbing and wire-catch systems are also available.

Frames and blast-resistant glazing should be designed to resist blast loads together. The frames may need to be reinforced to take the strain, and the glass securely seated in deep rebates.

The words ‘to resist blast loads’ above should not be taken to imply strengthening the outside of the building to the point that blast loads cannot escape. Some facades are now being designed to resist the effect of an *external* blast on structure without proper consideration of the likely effect of an *internal* blast on this blast-resistant envelope. The question must in these cases be asked ‘Where is the pressure wave going to go?’ This must be allowed for.

6.6 Conclusion

It needs to be understood that no conceivable range of security measures can provide 100% security to a building or its occupants. The aim is threat mitigation, i.e. finding the right balance between the perceived security threat, and the range of counter-terror measures that are taken both in terms of stadium design and event management, in a way that won’t unduly disturb the operation of the building or inconvenience the spectators. All the systems must be integrated to work smoothly together – the building structure and materials; the information technology, and the management strategies. Consultation with the agencies mentioned in this section will be essential.

7. Activity area

7.1 Playing surfaces

7.2 Pitch dimensions, layout and boundaries

7.1 Playing surfaces

7.1.1 History

Informal sport has been played on grass fields, city squares or open ground for hundreds of years but it was not until the middle of the nineteenth century that sports became organized and conditions were defined under which the sport could be played fairly. These early, rather loose, conditions later became rules and eventually the laws of sport were born. A notable exception is tennis which had its origins as an indoor sport and only later took to the outdoors. The surface to be played upon was often specified in these rules, as it was recognized that the nature of a game differed when the surface it was played upon changed.

The established rule of ball sports being played on natural surfaces was unchallenged until 1966 when the Houston Astrodome opened. This was the first completely covered stadium in the world and was designed, using the best technology at the time, with a transparent roof and natural turf playing surface. Unfortunately, the grass did not grow below the transparent roof for a number of reasons, one of which was that the steel structure holding up the solid roof was substantial and hindered the natural light from penetrating to the playing surface. No transparent or translucent roof has yet permitted the growth of natural turf suitable for playing ball sports.

In order to avoid this show case stadium turning into a disaster, a manufactured synthetic grass was woven using green plastic and laid over the existing ground. This product was called ‘Astroturf’ after its host venue, the ‘Astrodome’ and variants of this original synthetic grass have covered many other sports surfaces around the world.

Synthetic sports surfaces have since been developed into more sophisticated constructions, all with the enormous advantage to a stadium manager that he can hold different events on the same playing surface, one after the other. Although players and team coaches tended to prefer a natural grass surface for its playability, artificial surfaces were approved for American football and spread quickly through the USA. They are now officially accepted by FIFA for soccer matches and are beginning to be installed by clubs around the world, though they have not yet been accepted by national federations for major matches.

7.1.2 Current requirements

Table 7.1 shows the playing characteristics of tennis court surfaces, reproduced with the permission of the Lawn Tennis Association.

7.1.3 Natural grass surfaces

Advantages

Natural grass remains the most user-friendly of surfaces, and the only permissible choice for some sports. The advantages of natural grass are:

- It is aesthetically attractive.
- It gives a speed of rebound and a degree of rolling resistance that is just about right for most ball sports.
- It provides reasonable (though variable) purchase for players feet when dry or wet.
- It gives a surface that is neither excessively hard nor excessively soft for comfortable running.
- It is less injurious to players who fall than most alternative finishes.
- If irrigated it is a relatively cool surface in hot climates.
- It will continually self-repair and regenerate.

Disadvantages

The major limitation to the use of grass surfaces is that they cannot be used in roofed stadia, and are difficult to keep healthy even under partial cover. The reason is that grass needs ample light for really healthy growth, and air movement, humidity and temperature levels need to be kept within fairly strict parameters. To date it has proved impossible to arrange all these matters satisfactorily in a totally enclosed stadium, even using the most transparent roofing materials. In theory supplemental artificial lighting does help but there are no real-life applications to demonstrate the effectiveness of this solution, and in any case the energy costs of such lighting may be prohibitive.

Even in a partly-roofed stadium the size of the roof aperture, the shadow-effects of the surrounding structure and other such factors may lead to disappointing results. One example of failure is the San Siro Stadium in Milan which was redeveloped to accommodate 80 000 spectators for the soccer World Cup in 1990. Only the spectator seating areas are roofed, with a central opening over the playing area; but even though this aperture is approximately

Surfaces	Ball–surface interaction			Spin		Player–surface interaction		
	Speed of court	Height of bounce	Trueness of bounce	Topspin	Slice	Sliding/ firm footing	Traction (slip or non-slip)	Resilience (hardness)
Grass	Fast	Low	Variable	Little	Yes	Firm footing with partial slide	Slip	Soft
Synthetic turf	Fast	Medium to low	Variable	Little	Yes	Firm footing but partial slide on sand filled	Mainly non-slip	Medium to soft
Impervious acrylic	Medium	Medium	Uniform	Yes	Yes	Firm footing	Non-slip	Hard to medium
Porous macadam	Slow	High	Almost uniform	Yes	Little	Firm footing	Non-slip	Hard
Shale	Medium	Medium	Variable	Yes	Yes	Sliding	Slip	Medium to soft
Continental clay	Slow	Medium	Almost uniform	Yes	Yes	Sliding	Non-slip	Medium to soft

Source: *Tennis Courts*, published by the LTA Court Advisory Service. Reproduced by kind permission of Christopher Trickey.

Table 7.1 Playing characteristics of tennis court surfaces the size of the football pitch below, the grass is struggling to survive. The lesson to designers must be one of caution.

A second limitation is that grass cannot survive the same intensity and frequency of punishment as most artificial surfaces. This relative fragility will inevitably conflict with the stadium's need to maximize the number of event days per annum for profitability.

The 'pitch replacement' concept

One response to the problems outlined above is the concept of 'pitch replacement' on an organized and systematic basis. The principle is to remove the grass when not needed, to allow other events to take place on an artificial surface underneath. There are many removal techniques: (i) a Canadian method of growing the turf in large boxes which can then be moved out of the stadium on rails; (ii) a German method of growing the turf on pallets 4 m square which are then moved on the hovercraft principle; and (iii) a Dutch concept of leaving the natural grass in place and constructing above it a new platform supported on remote-controlled hydraulic legs. In the UK, Odsal Stadium in Bradford has used a simple system of restoring the corners of a football pitch which had been cut off by a speedway track around the pitch: grass was grown on wooden pallets with a reinforced plastic mesh sub-base, and these were moved away to storage by forklift truck before speedway events. Further notes on this topic are provided in Section 5.4.2.

Installation

Planting and maintaining a grass pitch is a task for specialists. All the advice given below is for general background understanding only: a specialist consultant should be retained from the outset to give advice, draw up a detailed specification, invite tenders and supervise the work.

Figure 7.1 shows the elements of a typical grass-turfed surface, and should be studied in conjunction with the following notes.

For bowling greens and croquet the upper grass surface must be smooth, true and absolutely level, necessitating very good subsoil drainage arrangements. For other sports the grass surface can be less exacting but should be smooth and free from surface unevenness, and possibly laid to a slight fall for water disposal. Maximum permissible gradients must be checked before design with the relevant governing bodies, because such rules are constantly being upgraded, and the main fall should ideally be from the centre to both sides of the pitch and not in the direction of play.

The species of turf grass must be carefully chosen for the correct playing characteristics, resistance to wear and disease, and suitability for its particular climatic and physical environment and the season of play. An appropriate cultivar or mix of cultivars will be specified by the consultant and supplied by specialist growers. 'Fescues' and 'bents' are commonly

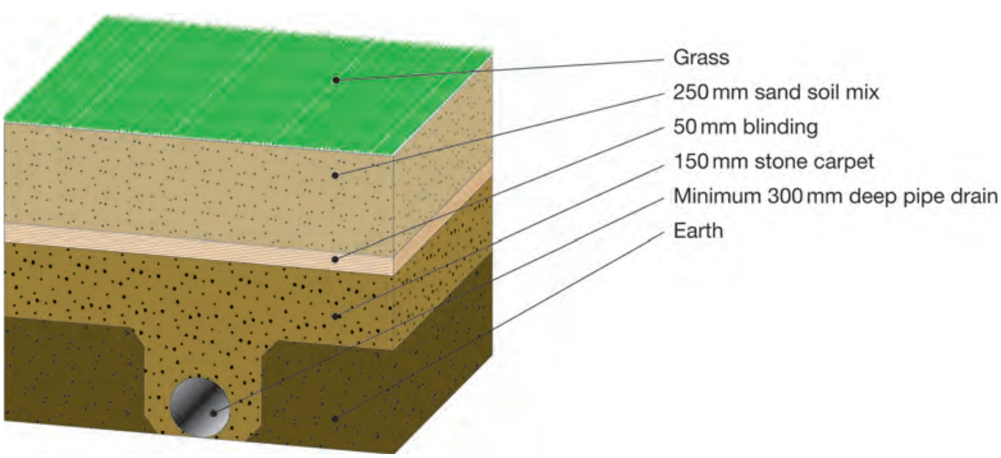


Figure 7.1 Elements of a typical natural grass playing surface.

chosen species. As an instance, the famous grass surface of Wimbledon Centre Court is resown every year with 66 per cent Troubadour perennial rye grass, 17 per cent Bingo chewings fescue, and 17 per cent Regent creeping red fescue. This is the best mix for the specific soil, drainage and other conditions found at Wimbledon, but other situations will demand other specifications.

Immediately beneath the grass surface is a layer of topsoil, often consisting largely of sand, with a depth of not less than 100 mm and usually averaging about 150 mm. This layer must contain no stones or injurious material, must be permeable enough for water drainage, and must be uncontaminated and well-fertilized for healthy growth. Using some local suitable-seeming soil will not be good enough: the material will almost certainly be obtained from specialist suppliers to the precise specification of the consultant, and will probably contain a large quantity of graded sand.

Beneath the topsoil is a blinding layer of fine material (ash, crushed stone or the like) to fill the voids in the surface below and provide a smooth base for the topsoil.

Beneath the blinding layer is a zone of graded stone to ensure that all excess water can drain away freely to pipes laid in trenches below. There may be sheets of tough water-permeable membrane laid between the foundation layer and the formation surface to prevent soil from being forced up into the foundation layer and obstructing the free flow of water. This decision, the depth of the graded stone layer, and the layout and fall of the drains will depend on subsoil conditions and will all be decided by a specialist.

Drainage

Adequate drainage is a necessity, and the above methods may need to be supplemented to avoid standing pools of surface water after heavy rainfall and to minimize expensive 'down-time' in wet weather. There are basically two methods of drainage – passive and active.

The *passive* approach relies on gravity to drain away the water, and one method of enhancing the basic system described above would be the cutting of deep 'slit drains' into the subsoil by specialist machine, and filling these with sand or fine gravel to help surface water flow down quickly into the land drains. This is quite expensive and needs to be carefully costed before a decision is taken.

The *active* approach uses pumps, usually activated by water-sensing electronic devices in the field, to literally suck the water off the pitch and into underground storage chambers, thus clearing the surface very quickly and maximizing the availability of the pitch for revenue-generating activity. Special drainage pipes may be laid for this purpose, or alternatively cellular technology may use the same underground network of pipes both for irrigation and drainage simply by reversing the direction of flow by computer control.

Irrigation

Traditionally grass pitches have been watered by sprinklers, usually of the pop-up kind, but these are being challenged by underground water delivery systems. Using special porous low-pressure water supply pipes (or possibly the underground drainage system with the direction of flow reversed by computer control as suggested above) which allow a uniform 'weep rate' along the whole length of the pipe, a steady supply of water – possibly mixed with fertilizer and weed-control additives – seeps directly to the grass root zone. The advantages that are claimed for sub-surface irrigation include:

- A lusher, tougher growth of turf grass than overhead watering, which tends to create a stressful cycle of drought and flood conditions.
- A deep root system rather than a shallow one.
- Less tendency for the soil to compact (this being a major problem with intensively-used pitches).
- Probably less water-loss by evaporation than would be the case with surface irrigation.
- Similarly, a conservation of fertilizers, insecticides and herbicides.

Underground irrigation pipes are normally laid between 150 mm and 350 mm below the surface, spaced from 450 mm to 900 mm apart; but specialist advice must be sought.

Heating

Many major stadia in cold climates use some form of under-pitch heating, the most common type being based on a system of hot water pipes operated by gas boilers and thermostatic sensor controls.

Electrical heating on the principle of an electric blanket is an alternative commonly used method.

The most important aspect of this type of installation is the laying of the pipes or cables, which must be high enough to heat the pitch but low enough not be damaged by pitch aeration and other surface works. A free-draining pitch is essential if heating is to be considered.

Maintenance

Day-to-day maintenance operations are discussed in Section 22.2.1.

7.1.4 Artificial grass (synthetic turf) surfaces

In completely enclosed stadia artificial grass will almost certainly be chosen in preference to natural grass for the reasons given in Section 7.1.3 above.

For other situations, while synthetic grasses have great virtues and will undoubtedly become more widely used, specifiers must not see them as a magically everlasting, maintenance-free answer to all problems. Capital outlay is high (which means such pitches need to be fairly intensively used to justify the initial cost); the surface is not everlasting, six to eight years being a typical life expectancy; the surfaces may need to be watered before play to keep dust down and keep them cool in summer; sand-filled turfs need periodic re-sanding; markings, if painted, need replacement two to four times a year; and regular cleaning and repair are essential.

But having made these cautionary remarks it must be said that synthetic turfs have very great advantages in terms of their ability to endure intensive use in virtually all weathers. There are three basic categories of permanent surfacing.

Non-filled turf

This is made of nylon, polypropylene, or polyethylene and is available in water-permeable or impermeable types, and comes in the form of a turf-carpet with an underlying shock-absorbing layer, the latter available in various densities and thicknesses. The turf and the shockpad may be supplied already bonded, or they may be supplied separately and bonded together on site. Turf and shockpad are laid by specialists on a smooth asphalt substrate which in turn rests on a base of broken stone, sand, and gravel designed to suit the particular situation. Various pile-types and pile-lengths (typically 10 to 13 mm) are available to suit individual sports and conditions. This type of surface has been the preferred option for field hockey at the highest level since 1972.

In the past it was said that artificial turf caused more skin-burn than natural grass in sports such as rugby, but manufacturers claim that this need no longer be true. On this, as on choice of turf, design of substrate, and general installation, up-to-date specialist advice must be sought.

Sand-filled turf

This is a variant of the previous type, consisting in most cases of polypropylene or polyethylene with an upright pile that is longer and more open than the non-filled type. This pile is backfilled with sand up to 2 or 3 mm from the surface. As described here it has become a very popular surface for club tennis courts because the playing characteristics are not dissimilar to natural grass, but the court remains usable throughout the year including winter. The sand infill takes two to three months to settle in, and needs brushing two or three times a week plus regular top-dressing to maintain its condition. This type of artificial turf is specifically suited to outdoor use and usually carries a 5-year guarantee, though the life may exceed 10 years with good maintenance.

As is the case with the non-filled systems described above, sand-filled turf is normally laid on a shockpad to increase player comfort and reduce ball bounce and roll.

Sand-filled turf has had a reputation of causing injuries when players fall, but when properly designed, with an appropriate pile height and shockpad thickness, this need not be the case: if in doubt the advice of the relevant sports governing bodies should be sought. Occasional watering after a prolonged period of dry weather will help reduce the risk of friction burn.

Turf with mixed fills

One of the limiting factors in the use of sand-filled, or indeed non-filled surfaces, is the limitation on footwear on such a surface. Football and rugby studs are unsuitable both from the comfort of the player and the potential damage to the surface. This problem has led to the development of synthetic turf surfaces that are particularly suited to football and rugby.

The technology features an extra long pile of 50 to 70 mm which is filled with a combination of silica sand and rubber granules. The benefits of this surface are that the player can use a normal boot, the rubber infill acts as a further cushion, and the ball bounce and roll are reduced to compare favourably with natural grass.

In 2005 FIFA announced that synthetic turf pitches built to their 'Two Star' standard could be used at the highest levels of the game in FIFA competitions.

Combined natural and synthetic turf

Natural and artificial surfaces have begun to merge, and systems are now available in which plastics are used to reinforce the root structure of grass – for instance in the form of a plastic webbing through which the natural grass grows, or a system of stitching tufts of synthetic fibre into the natural grass sward. By this means the user-friendliness of a natural grass surface is combined with the superior durability of artificial turf, hopefully giving stadium managers the best of both worlds.

As practical experience of these combined systems increases and the technicalities are perfected they may well become the compromise of the future, offering a cost-effective, multi-use natural playing surface. In that case sporting authorities will soon have to face some interesting decisions as to whether these systems are to be classified as 'natural' or 'artificial'. Because of climatic difficulties, the Ulleval stadium in Norway has used such a system for many years.

Temporary synthetic turf surfaces

Some experimental work has been done on providing demountable synthetic turf systems that can be laid over the permanent natural turf for short periods then removed to an adjacent storage point. This would allow, for instance, hockey to be played in a rugby stadium. The same principle has been used to install a top class cricket wicket into a soccer or rugby field in a stadium.

7.1.5 Synthetic non-turf surfaces

Synthetic surfaces are expensive to lay but offer the possibility of all-weather high-intensity use and much reduced maintenance. They have therefore become very popular for athletics tracks. The material used for this type of surface is called a polymeric system and there are two primary categories of polymeric namely impervious and porous.

Impervious surfaces

These surfaces may be laid as cast in-situ polymerics, wet poured in successive layers and finished with a granulate surface to provide the wearing layer, The surface may also be created in one piece by installing a prefabricated, factory produced sheeting manufactured in lane widths and adhered to the structural base. This form of polymeric surface is the most popular for indoor tracks. The base for impervious surfaces is normally an asphalt laid to fine tolerances over a standard road construction crushed stone sub-base. To shed surface water, impervious athletics tracks must slope to the inside lane and the gradient should not be steeper than 1:120. The surface water is normally collected by a drainage channel, inside the running kerb, leading to an appropriate surface water outfall. Polymeric athletics surfaces are normally designed to a finished thickness of 13 mm to cope with the spiked running shoes, though thicker sections are normally provided at the take-off and landing areas for field events.

Porous surfaces

This type of polymeric surface is again wet-poured in successive layers but the construction utilizes a rubber granulate base layer with no fines and bonded by polyurethane binder. The wearing surface is spray applied and consists of coloured rubber granules in a polymeric binding agent. Since the system needs to be porous the base construction will be an open textured bituminous macadam on a porous sub-base construction. Although, when new, this system is porous, tracks are normally constructed with a cross-fall, as above, to cater for the eventuality of eventual sealing due to pollution.

7.1.6 Markings

In the case of natural grass the line markings may consist of a temporary powder containing lime. In the case of synthetic turf, markings are normally cut into the surface when the pitch is being laid, using coloured strips of the same turf. Markings can also be painted on to the synthetic turf surface but this is by no means permanent and the lines will require regular re-painting. In the case of non-turf surfaces the markings are normally painted on to the surface using a specially formulated polymeric paint with fillers to reduce slip. Though this paint is very durable, re-painting may be required during the life of the track.

Governing bodies will give guidance on correct line widths and colours, and whether the width of the line includes or excludes the playing area – a crucial matter.

7.1.7 Protective coverings

If the surface cannot be removed and is vulnerable to damage there are protective covers which will preserve it when the stadium is used for concerts or other activities which make use of the playing area. Natural grass especially needs protection, but covers can usually be left down for only about two days before the grass beneath starts to suffer damage. There are cases where grass pitches have been covered for up to two weeks and survived, suffering only discoloration, but a natural grass pitch would not be ready for immediate sporting use after such an experience.

For grass protection, Wembley Stadium in London has in the past used a resilient underlay covered with a stiff hard-wearing rubber layer above, these materials being stored in large rolls outside the stadium and transported to the ground in special vehicles. More recently Wembley have assisted in the development of a new system which consists of translucent tile squares (actually 1 m by 1 m boxes about 50 mm deep) which lock together to provide a good even surface for concert usage, but allow the grass below to grow and survive.

7.2 Pitch dimensions, layout and boundaries

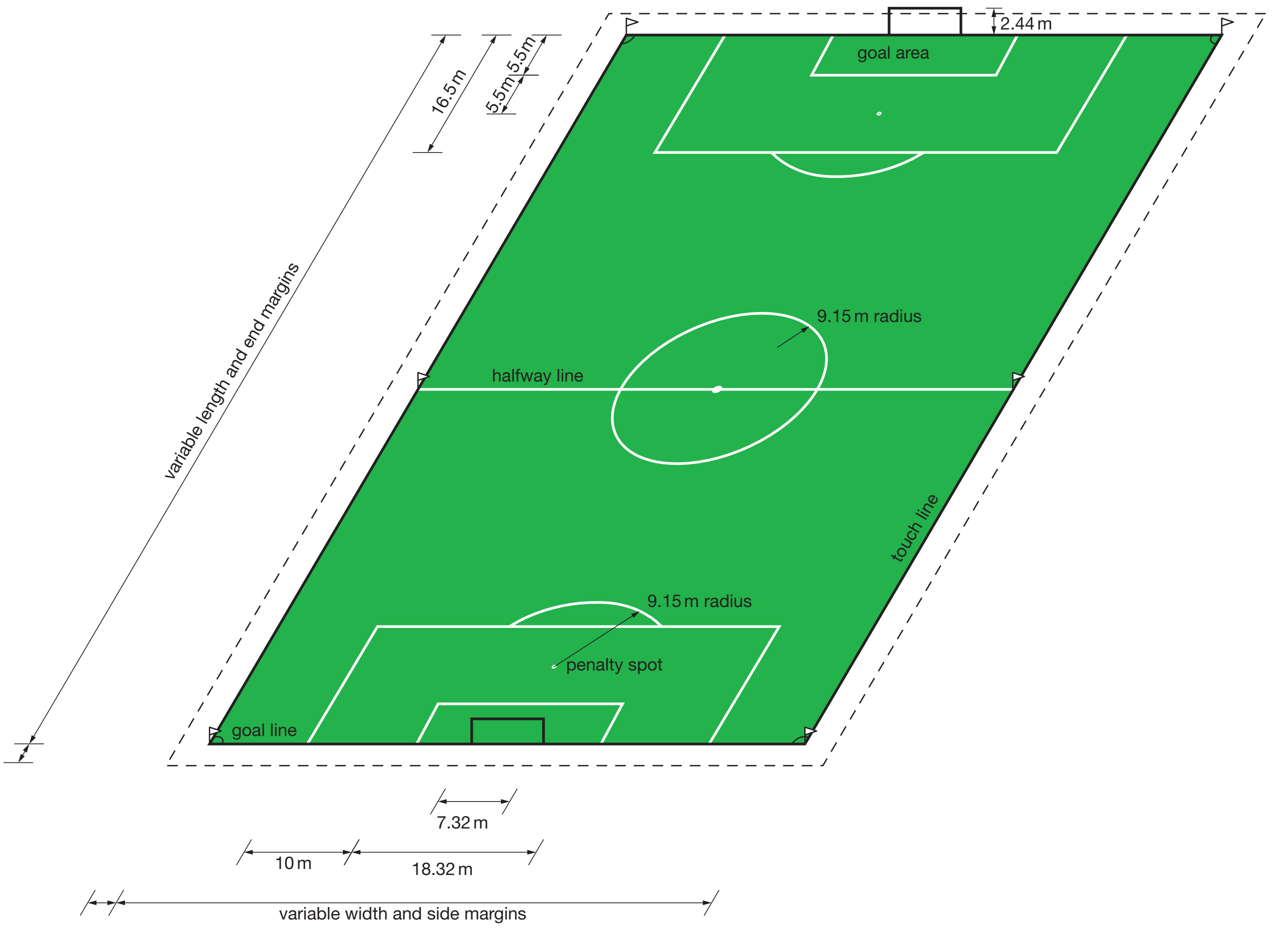
7.2.1 Dimensions and layout

Figures 7.2 to 7.13 set out the basic dimensions of the playing areas plus surrounding safety zones for the major sports. Some of these are simplified versions of more complex official requirements too detailed to fully reproduce here, and many may become out of date within the lifetime of this book. Therefore these diagrams must be checked with the relevant governing bodies before final design.

The following summaries of advice for specific sports are taken with due acknowledgement from Volume 1 of the *Handbook of Sports and Recreational Building Design* (see Bibliography).

Football

Pitch dimensions for Association Football (more commonly known as football or soccer) are shown in Figure 7.2. Safety margins should be 6 m wide behind the goal line and 3 m along the side touch-lines and the grass surface should extend beyond the touch lines by at least 3 m and 2 m respectively. A natural turf pitch is recommended by the governing bodies and is the only surface allowed for some competitions, but the use of artificial surfaces may become more widely accepted.



Dimensions from UK football association.
Note: Field size for FIFA / UEFA matches is 105 x 68 m.

Figure 7.2 Pitch size and layout for football or soccer.

Rugby Union football

Pitch dimensions are shown in Figure 7.3. There should be a margin of at least 6 m at each end of the pitch and at least 2 m, but preferably 6 m, at each side. Natural grass is currently the only accepted surface. Markings are in white, 76 mm wide, and are not included in the playing area.

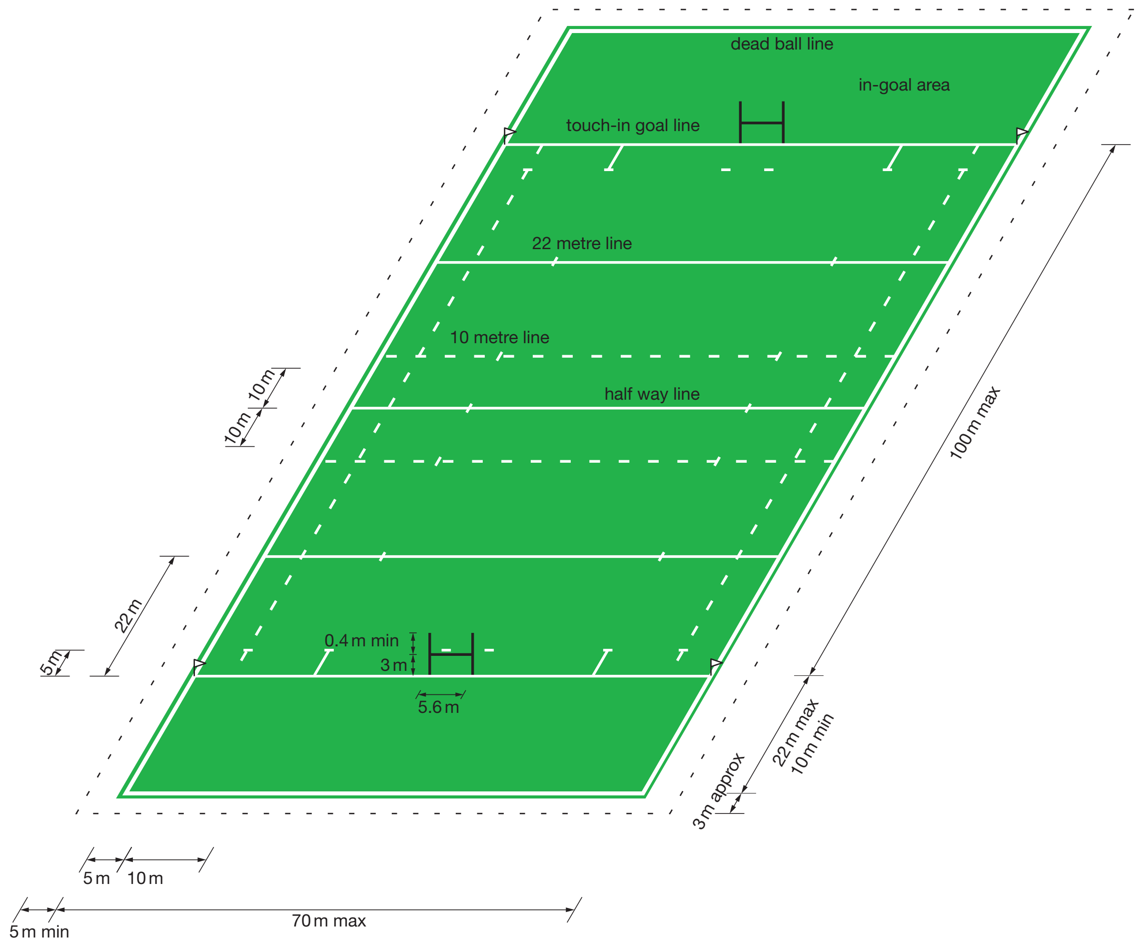


Figure 7.3 Pitch size and layout for rugby union football.

Rugby League football

Pitch dimensions are shown in Figure 7.4, and there must be no obstruction such as fencing within 5 m of the touch-line. Natural grass is currently the only accepted surface except that rubber-crumb or synthetic turf is acceptable for training. Markings are in white, 76 mm wide, and are not included in the playing area.

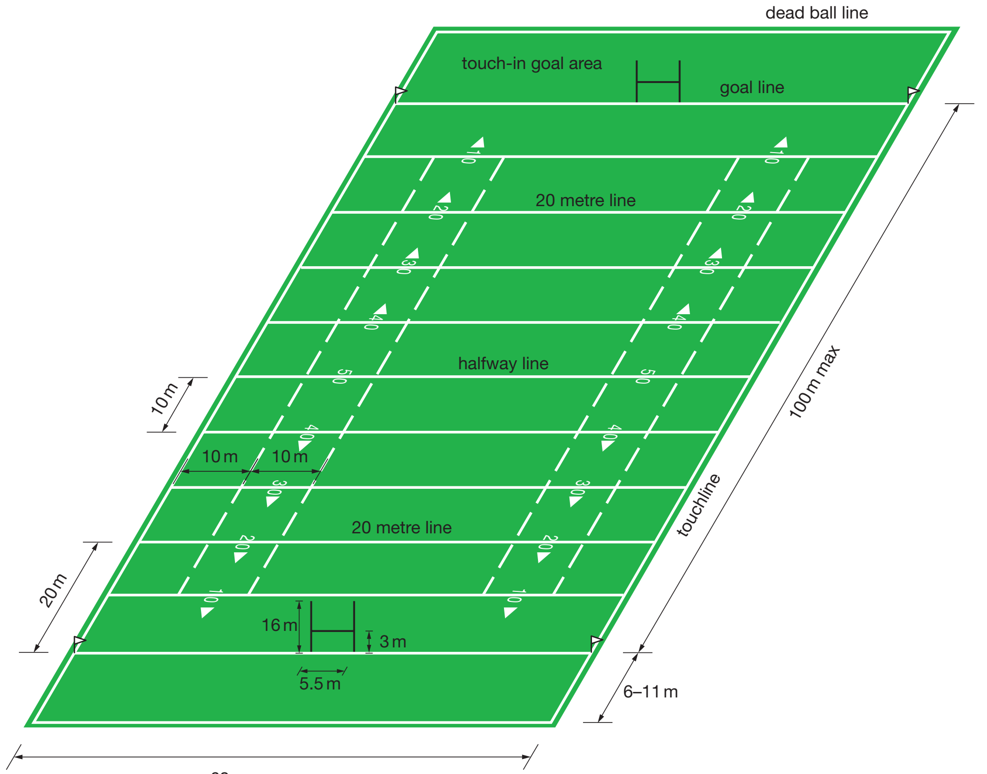


Figure 7.4 Pitch size and layout for rugby league football.

American football

Pitch dimensions are shown in Figure 7.5, and there must be a safety margin of at least 1.83 m, but preferably twice that, all round the field. Both natural grass and synthetic turf are acceptable. Markings are in white or failing that yellow, 100 mm wide, and the playing area excludes the side lines but includes the end lines.

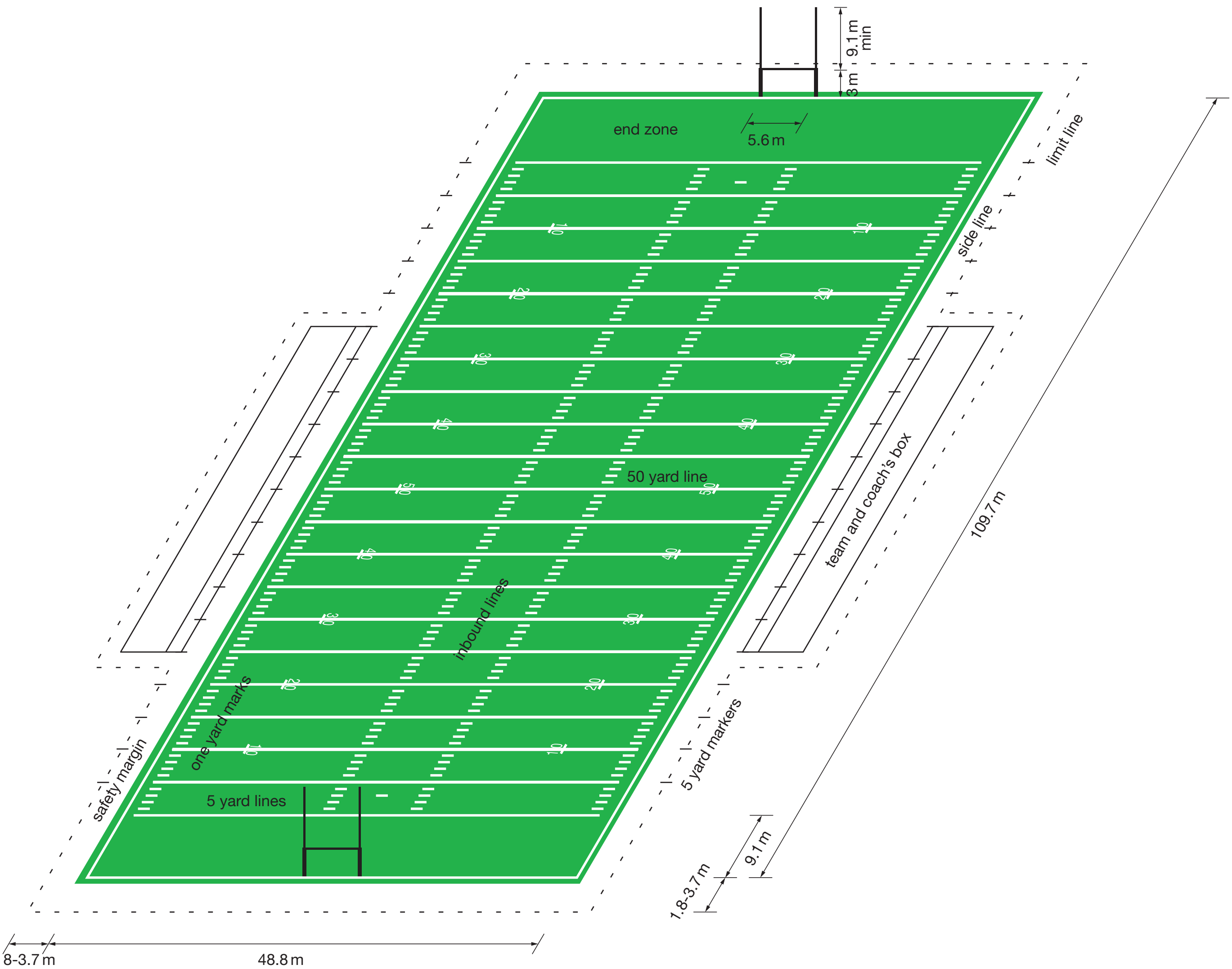


Figure 7.5 Pitch size and layout for American football.

Australian Rules football

Pitch dimensions are shown in Figure 7.6, and a surrounding gap of 3 m is generally recommended between spectators and the oval boundary line. The game is played on grass only. Markings are in white, 100 mm wide, and are included in the playing area.

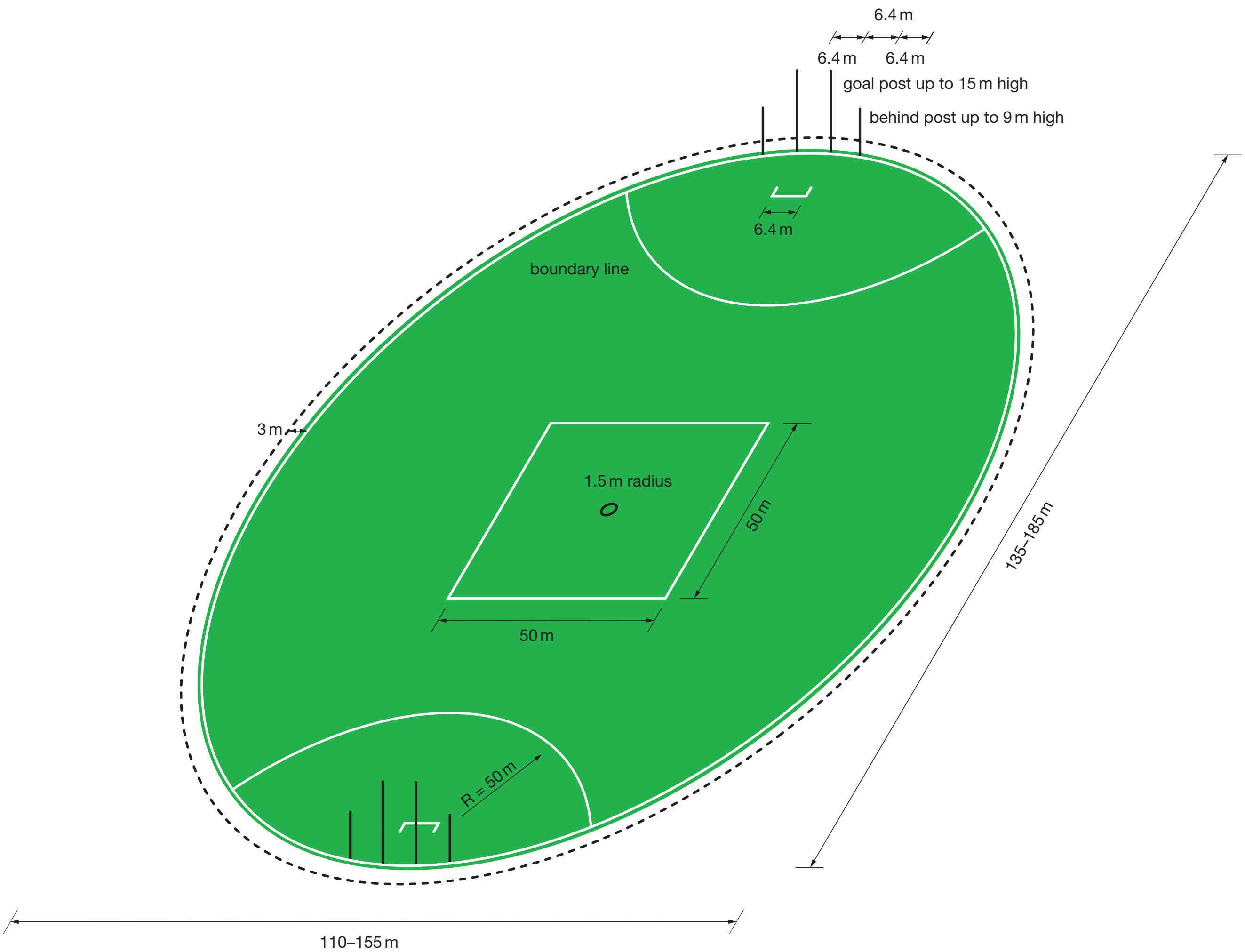


Figure 7.6 Pitch size and layout for Australian Rules football.

Gaelic football

Pitch dimensions are shown in Figure 7.7, and a margin of 1.5 m is required on all four sides. Pitch surface may be grass, synthetic turf (sand-filled) or shale. Markings are in white, 50 mm wide, and are included in the playing area.

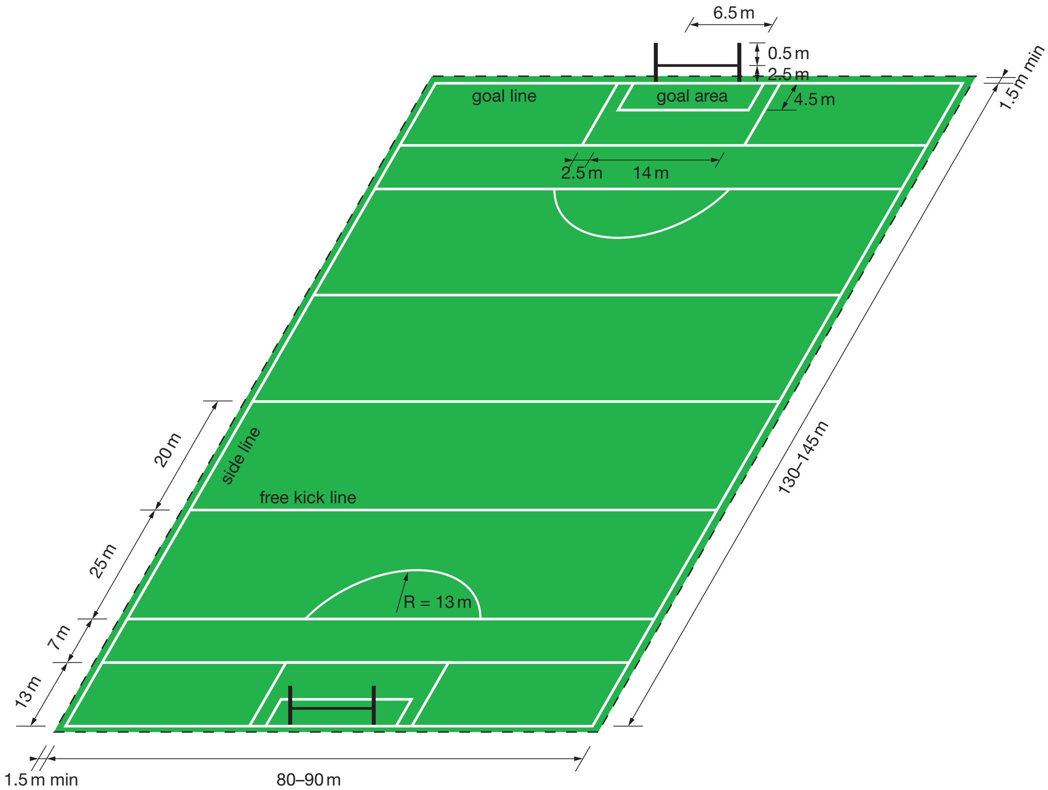


Figure 7.7 Pitch size and layout for Gaelic football.

Hockey

Pitch dimensions are shown in Figure 7.8. The surface may be grass or synthetic. Markings are in white or yellow, 75 mm wide, and are included in the playing area.

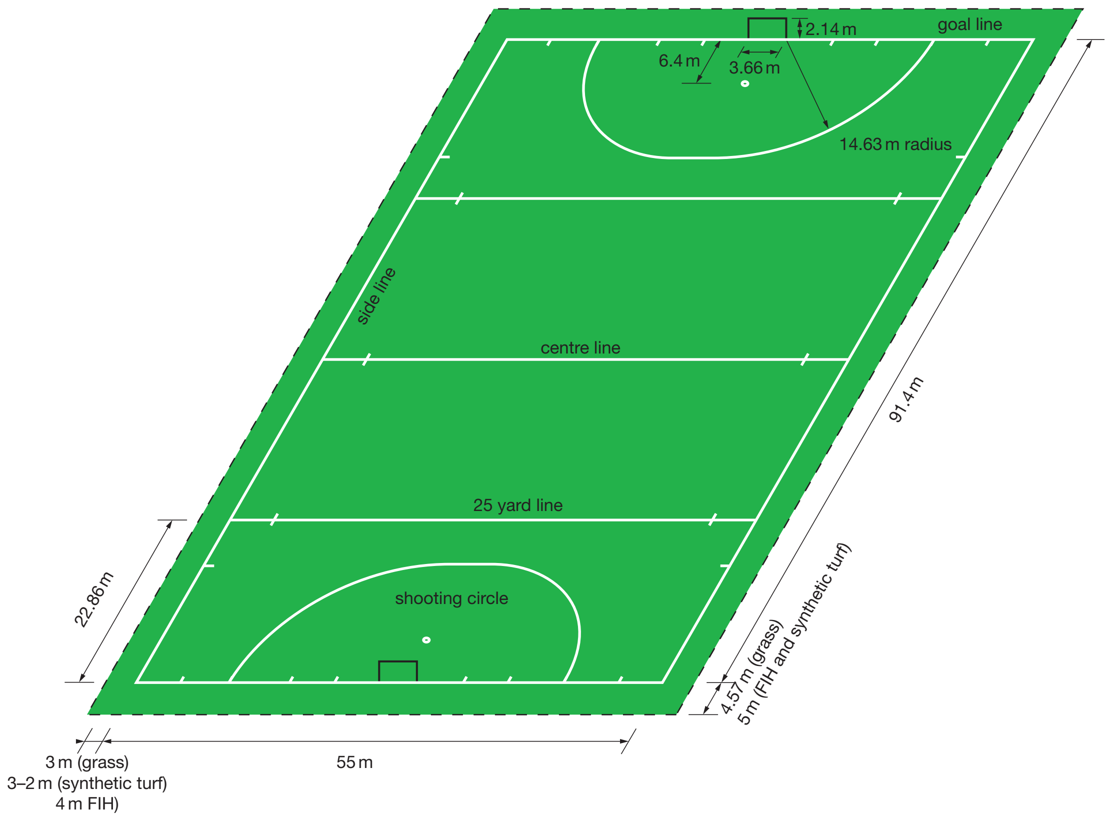


Figure 7.8 Pitch size and layout for hockey.

For a grass pitch it is currently recommended that there should be margins of at least 3 m along both sides and 4.57 m at both ends, but preferably more, so that the pitch can be shifted from time to time to minimize wear; and for a synthetic pitch there should be a minimum of 5 m between the end line and any obstruction, with the synthetic grass extending at least 3 m all round the pitch. All these regulations are subject to change and advice must be sought.

If sand-filled synthetic turf is used there must be two large-capacity water hydrants near the pitch to allow for watering.

Hurling

Pitch dimensions are shown in Figure 7.9. Margins of 4.57 m are required at each end, and margins of at least 3 m along each side. Markings are in white, 50 mm wide, and are included in the playing area.

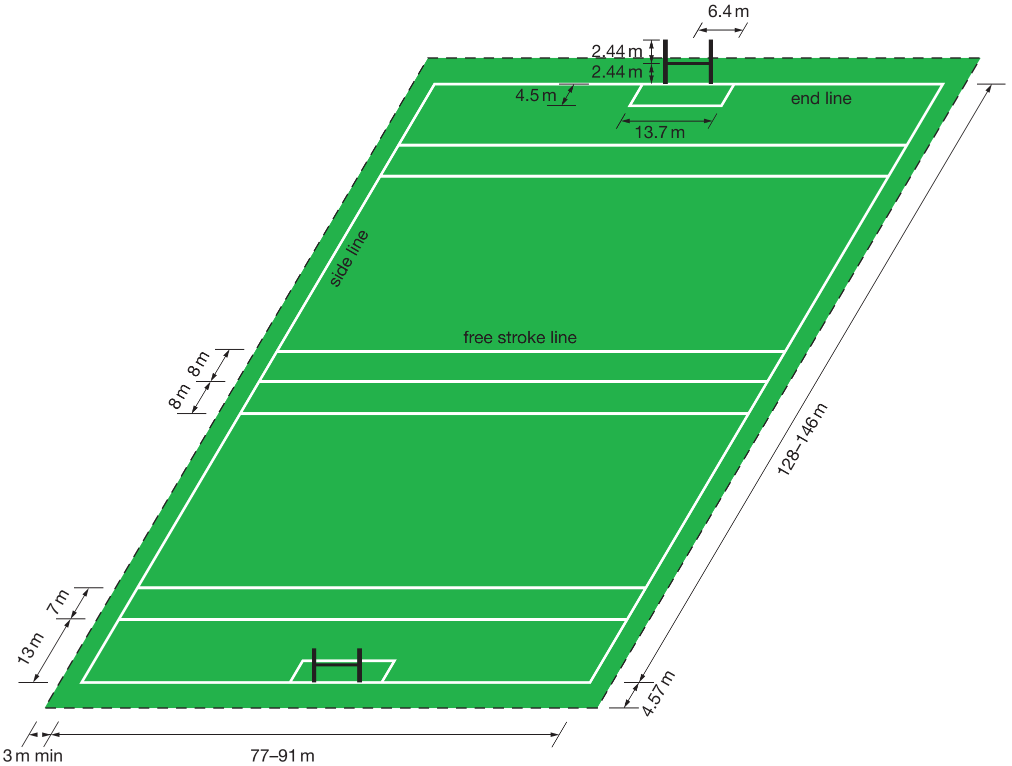


Figure 7.9 Pitch size and layout for hurling.

Baseball

Pitch dimensions are shown in Figure 7.10, and the surface may be grass or synthetic turf. A batting cage is strongly recommended. Markings are in white, 127 mm wide, and are included in the playing area.

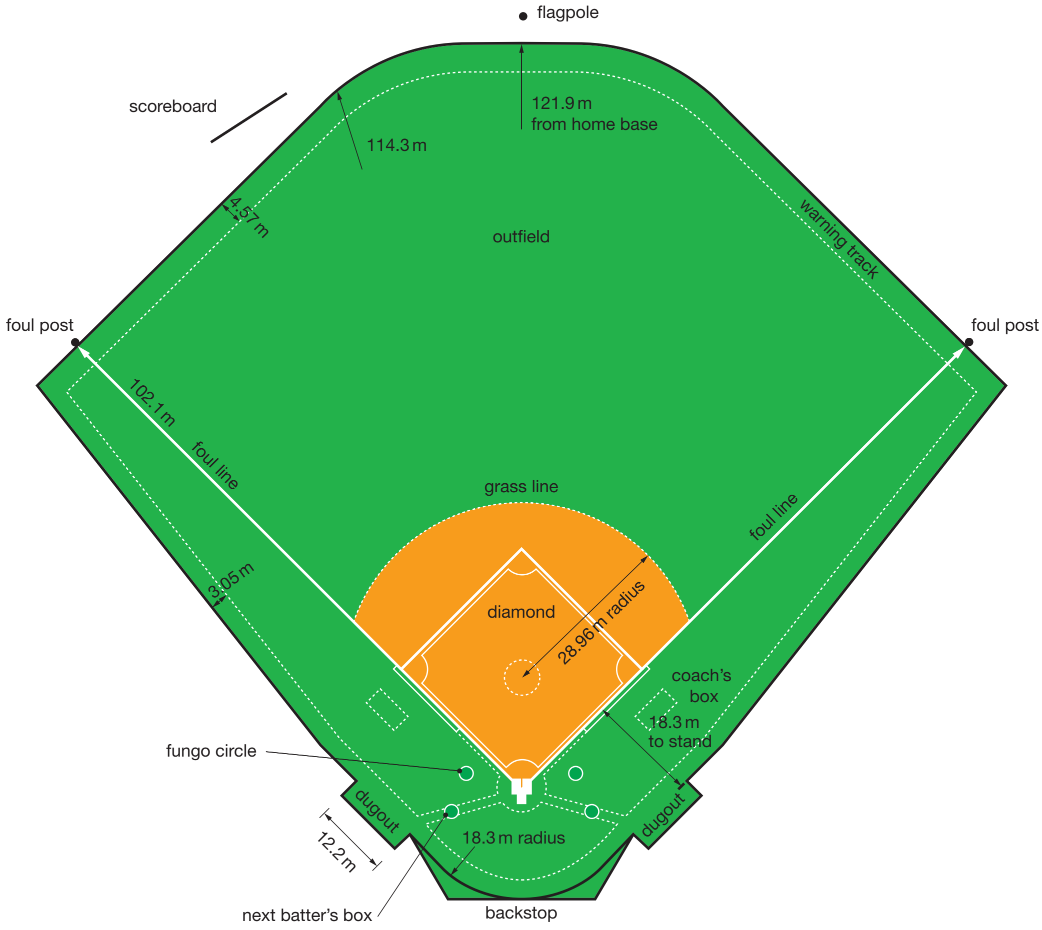


Figure 7.10 Pitch size and layout for baseball.

Cricket

Pitch dimensions are shown in Figure 7.11, and the surface may be natural turf or any of several synthetic finishes as recommended by the governing body.

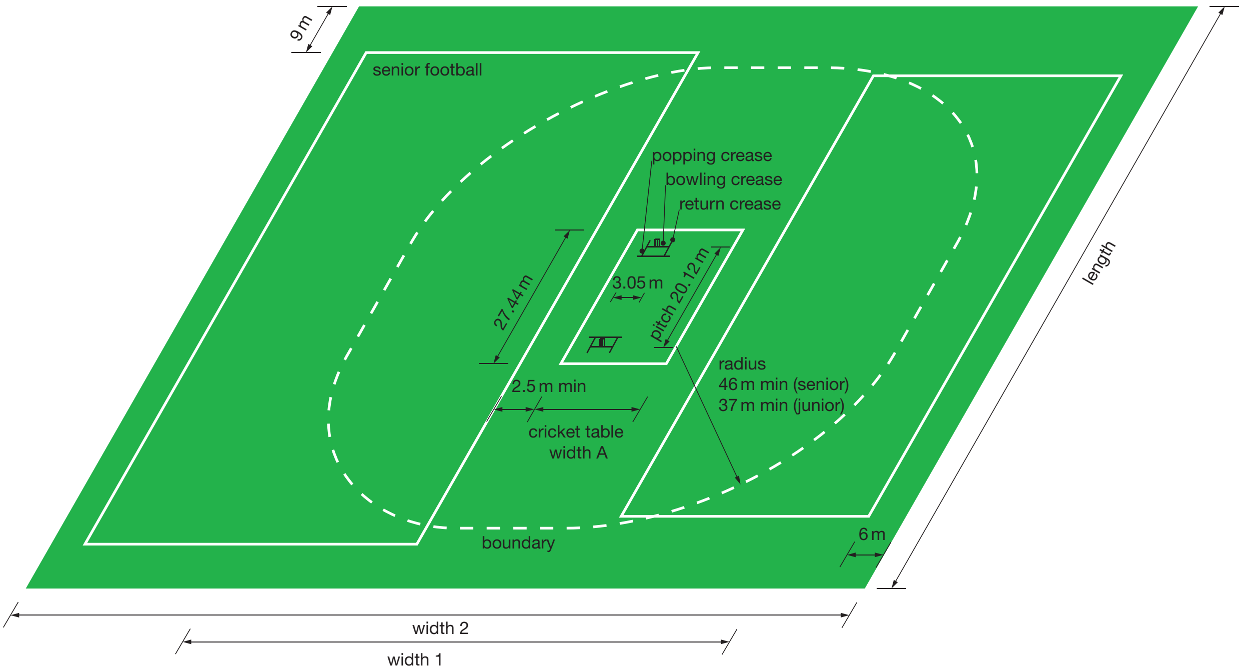
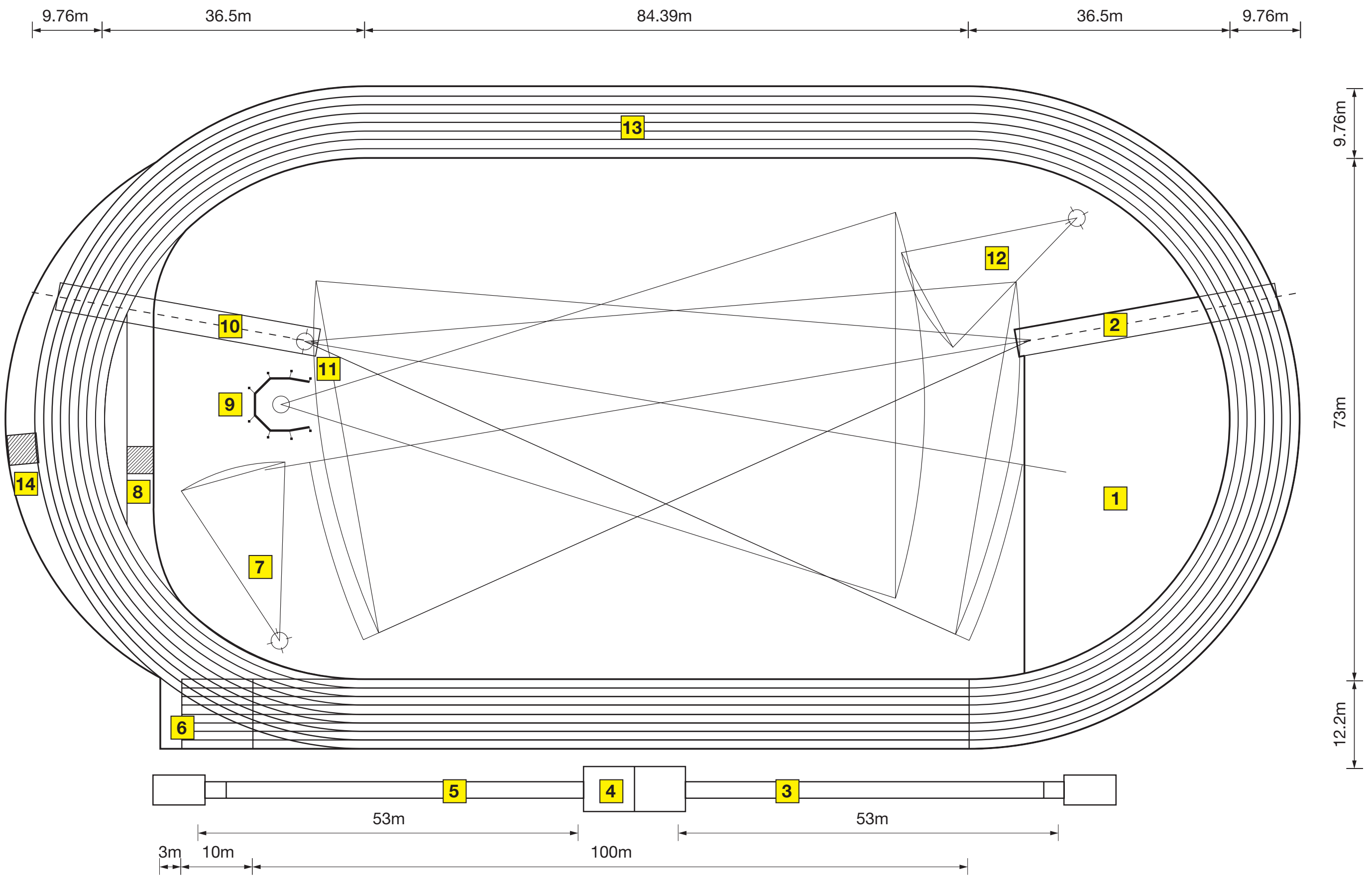


Figure 7.11 Pitch size and layout for cricket.

Athletics track and field

Figure 7.12 gives guidance on layout, but different arrangements are possible to suit different circumstances. Table 7.2 gives a guide to lane provision, and in the UK a common choice is a six-lane, 400 m track together with indoor training facilities. Lanes are always 1.22 m wide to the centre of markings. Whatever the layout, the central area must have a natural grass surface because this is obligatory for field throwing events. The running tracks on the other hand may be surfaced with a variety of synthetic materials. On this and all other aspects of athletic track and pitch design the governing bodies must be consulted for precise and up-to-date information.



1. High-jump area
2. Javelin
3. Double width long/triple jump
4. Double pole vault landing area
5. Double width long/triple jump
6. 10 lane sprint
7. Shot put
8. Steeplechase water jump (internal)
9. Throwing cage (preferred UK location)
10. Javelin
11. Disabled access to cage
12. Shot put
13. 8 lane circuit
14. Steeplechase water jump (external alternative)

Note: The locations of field events can change.

Figure 7.12 Pitch size and layout for athletics track and field.

Standard of use	Number of lanes* recommended	
	Synthetic all-weather surface	Hard porous (waterbound) surface
Minimum standard international competitions; British Athletic Federation Area and Regional competitions and below	6 lanes	7 lanes
International competitions	8 lanes with 8-lane straight(s)	8 lanes
Full standard international competitions	8 lanes with 8-lane straight(s)	7 lanes with 9-lane straight(s)
Major international competitions	8 lanes with 10-lane straight(s)	
* All lanes are 1.22 m wide to the centre of markings.		

Table 7.2 Recommended lane provision in athletics tracks

Figure 7.13 Pitch size and layout for lawn tennis.

Lawn tennis

Pitch dimensions are shown on Figure 7.13 and in Table 7.3, and the characteristics of alternative surfaces summarized in Table 7.1. All markings are in white and between 25 mm and 50 mm in width except the centre service line which must be 50 mm and the base line which may be up to 100 mm wide. On these and all other matters the International Tennis Federation (ITF) should be consulted for precise and up-to-date information.

Marked out playing area	International and National Championships		Club and County		Minimum recreational standard	
	m	ft	m	ft	m	ft
Court length	23.77	78	23.77	78	23.77	78
Court width	10.97	36	10.97	36	10.97	36
Length of net (doubles)	12.80	42	12.80	42	12.80	42
Runback at each end	6.40 (1)	21 (1)	6.40	21	5.49	18
Side run out, each side	3.66 (1)	12 (1)	3.66	12	3.05	10
Side run between aligned courts without separate enclosure	ND	ND	4.27	14	3.66	12
Overall size of enclosure(s)						
Length	36.58 (1)	120 (1)	36.58	120	34.75	114
Width for one enclosed court	18.29 (1)	60 (1)	18.29	60	17.07	56
Width for 2 courts in a single enclosure			33.53	110	31.70	104
Width added for each additional court			15.24	50	14.63	48
Note (1): May need increased overall dimensions for court officials, furniture and sponsorship boards.						

Table 7.3 Tennis space requirements

7.2.2 The playing area surround

The detailed design of the zone surrounding the playing area must be verified with the governing bodies and safety authorities. Such requirements cannot safely be given here: they vary from sport to sport and from country to country, and are subject to change. Purely as an example of the provisions that might be required, the following criteria are laid down by FIFA and UEFA for football pitches:

- There should be two units of seating, accommodating ten people each, on the two sides of the centre line. They must be at ground level and protected from the weather.
- Advertising boards must never obstruct spectators' sight lines, must under no circumstances be located where they could endanger players, and must not be constructed in any fashion or of any material which could endanger players. They must not be higher than 900mm and must be located at least 6m behind the goal, at least 5m behind the side lines and at least 3m behind the corner flags.

7.2.3 Perimeter walls and barriers

All sports require some kind of barrier between the pitch and the spectators, and the requirements for these are laid down not only by the governing bodies for the sports concerned, but also by local safety authorities and police. Detailed advice is given in Chapter 9.

8. Sports and multi-purpose use

8.1 Introduction
8.2 National sports traditions
8.3 Financial viability
8.4 Catering for different sports
8.5 Catering for non-sports performances

8.1 Introduction

As stated at the beginning of this book stadium economics are such that it is difficult – though not impossible – for a stadium to earn a profit for its owners. One of the key ways of closing the gap between costs and revenues is reducing to an absolute minimum the number of days per year when the stadium is unused and earning no money – i.e. maximizing the number of 'event days'. For covered stadia the aim should be 200 or even 250 event days per annum.

To make this feasible, the physical design of the venue should allow a wide range of different activities to be accommodated, both sporting and non-sporting.

Unfortunately not all activities are readily compatible. In the case of sports, compatibility depends on factors such as:

- The size and shape of the playing field.
- The playing field surface.
- The preferred relationship between spectators and performers.
- Whether the stadium is roofed or open to the weather.
- National sporting traditions.

This book deals only with stadia (which can be defined as those buildings that accommodate the larger format sports, whether in the open or under cover), and not with arenas (which are essentially indoor venues, usually smaller than stadia); but it is worth noting that the latter are often multi-purpose buildings for sports plus concerts, exhibitions and the like. If a stadium is designed for concerts and has a roof that covers the pitch, either permanently or by shutting for a particular occasion, it could perhaps be defined as a large arena.

The above factors are discussed in more detail below.

Photograph: HOK Sport Architecture

Figure 8.1 Two examples illustrating the wide range of uses for which stadia can be designed. Figure (a) shows a rodeo parade being staged in the Reliant Stadium in Houston, Texas, which has a maximum seating capacity of 69 000 (see also Appendix 3). *Architects: HOK Sport Architecture.* Figure (b) shows a dance event in the Amsterdam ArenA, which has a maximum seating capacity of 51 000 (see also Appendix 3). *Architects: Rob Schuurman and Sjoerd Soeters.*

8.2 National sports traditions

In continental Europe there has been a tradition for a city to establish a 'municipal' stadium for the use of its citizens playing and watching a wide range of sports. The facility is often initially funded by the city authority and supported by a football club, which may run its own lottery and plough the profits back into the stadium. Often the stadium accommodates an athletics track around the pitch and thereby provides a multi-purpose facility although one which is heavily weighted towards football financially.

In the UK a typical club football ground is designed for soccer only and may never host any events other than a full timetable of matches for the club's season. This is largely explained by the fact that the separation of the spectators from the playing field by a running track, effectively pushing everyone away from the action by 10 or 12 m, has never gained acceptance among British fans. British football clubs pride themselves on providing a close concentrated atmosphere to watch the game and consequently forego the possibility of sharing their grounds with an athletics club. It is possible that by using movable seating tiers and other devices, the close football atmosphere and athletics can be made to work together, but there is as yet no strong trend in this direction.

In the USA several different approaches have evolved which combine functions on the same site. The two major stadium sports in the USA of American football and baseball do not coexist easily in a stadium unless the basic plan configuration can change. Solutions sought are either as a dual use venue with movable seating; a double venue where two separate stadia cohabit the same site; or an attached arena for basketball and ice hockey.

Because American venues try to host so many different types of events, the annual timetable may comprise very few matches of the primary sport for which the stadium was designed – for example, some American Football stadia have a programme of only twelve games in a season. Rather than leave an expensive asset empty for much of the year these owners prefer to use the building for other events outside the main sport.

8.3 Financial viability

8.3.1 Types of sharing

Multi-purpose use of a stadium does not necessarily have to be based on two sports, as clubs are sometimes able to find a compatible partner within the same sport. There are many examples around the world of sports clubs sharing facilities while in Australia ground-sharing is supported by the administrators of Australian Rules football.

More commercial developments of the leisure industry can also be compatible. The undercroft of a stand in Bristol, in the UK, successfully houses an indoor bowling rink. Extensions to the stadia at Sheffield Wednesday and Arsenal football clubs have accommodated training halls that double up as function rooms. Other ideas which have been explored are the inclusion of television studios, cinemas, health centres, squash courts, swimming pools, hairdressing salons and children's activity spaces.

The unfortunate fact about combining other activities with a stadium is that by its very nature the structure is inflexible with substantial supports at regular points around its perimeter. It is sometimes difficult to insert large spaces into this structure and therefore their inclusion must be planned from the beginning, tending to suggest a certain lack of flexibility. One alternative is to add these facilities on to the stadium as a separate but connected structure. This has been done successfully in a number of places in both Europe and the USA. Utrecht Stadium in Holland has a substantial office building grafted to its side, while the Hoosier Dome and a number of others in the USA have enormous exhibition and convention centres directly attached to the main stadium.

8.3.2 Sharing support areas

There are very few sports which can make a substantial subsidy to a stadium and if idle stadia are to become well used and profitable it seems that the emphasis in the additional accommodation should be on entertainment and commerce rather than sports.

For instance, if a stadium has restaurants and lounges, boxes, or other hospitality rooms these can be let out on non-match days. Uses that could be accommodated are:

Room	Secondary use
• Restaurant or lounge	Conferences, dinners, dances, weddings
• Bar	Parties
• Concourse or hall	Exhibitions
• Private box	Meetings

The requirements for each of these uses are different, and specialist advice should be sought when designing for them.

Figure 8.2 The club restaurant in the Telstra Stadium, Sydney, Australia (see also Appendix 3). *Architects: HOK Sport Architects Corporation.*

Photograph: HOK Sport Architecture

8.3.3 Complementary facilities

Where there is perceived to be sufficient local demand, areas for other uses can be constructed as part of the stadium. Often these are complementary to the sports usage. Such complementary facilities include:

Additional use	Comment
• Hotel	Spectators can be residents on match days.
• Retail	These can be for sports-related shops.
• Health clubs or sports halls	Can be complementary to team changing areas.
• Offices	For related companies or institutions.
• Cinemas	Can be used for conferences or stadium tours.

8.3.4 Maximizing event days

Event days must be maximized while still maintaining the core function of the venue. This multi-use should be designed for at an early stage as every event requires different equipment and support services, some more than others. If these facilities are not designed into the fabric of the building from the start they can be an expensive addition later and may not justify the holding of the event.

These specialist 'extras' include such things as the electric power required for pop concerts or the support rings in the roof for a circus. The multi-purpose use of a stadium is the primary reason for considering covering the entire grounds. For many years sports fans have been prepared to risk the elements and attend an event, but when the financial viability of the development relies on a guarantee of good weather, covered or domed stadia are a valid solution. Most major outdoor events these days are insured against inclement weather, but the premiums paid come out of the profits from the event.

The USA has led the way in maximizing the number of events a stadium may accommodate in one year. New covered venues in Europe are aiming for up to 250 event days per year where only 5 to 10 per cent of these events are football, usually the primary use of European stadia.

The use of facilities for more than one purpose is not limited to the pitch, but should include all the support amenities which are contained inside the structure. Private or hospitality boxes can be opened up to be used as banqueting rooms, or with the addition of a small shower and a folding bed could be converted into a hotel bedroom. Players changing rooms and training areas can become health clubs during the week and restaurants and lounges can become convention or conference centres.

At the very beginning of a project the list of possible uses for the stadium must be prepared and be selected on a rational order of priorities such as the following.

1 How often will the event occur? (*frequency*)
2 Amount and cost of specialized equipment required for the event (*establishment cost*)
3 How much money will they generate? (*revenue*)
4 Are they compatible with preceding or forthcoming events? (*compatibility*)
5 How long will it take to prepare for and clear up afterwards? (*set up and knock down time*)
6 Will the event recur on a regular basis? (*repetition*)

To help in an understanding of how versatile stadia can be and the number of events which are possible, Table 8.1 lists a typical schedule of events theoretically possible in a modern stadium in the UK.

Whilst it should be every stadium manager's aim to have as many event days as possible, and follow the example of the Toronto Skydome (Figure 4.2) which has achieved over 200, this is not always possible. It took them four years to achieve this level of use with 107 events days in 1989, 165 in 1990 and 188 in 1991.

Before its redevelopment Wembley Stadium in London was a financially successful stadium, with a seating capacity of 80 000 spectators and one of the most advanced ticket booking systems in the world, but was limited to around 35 event days a year by the local authority because of the perceived disruption events have on the surrounding area. This is surprising as Wembley has been functioning as a stadium for over 60 years. The stadium was, and is again, part of a larger conference, arena and exhibition complex which adds to its viability – see Case Study, page 292.

Type of event	Number of days per year
Major football matches	6
Minor football matches	14
Celebrity events	2
Concerts	6
American football	6
Motor sport	4
Sports festival	2
Hockey	1
Schools events	2
Charity events	2
Equestrian dressage and jumping	4
Baseball	2
Boxing	2
Conventions and meetings	4
Exhibitions	10
Athletics	2
Mass dinners	2
Special events	3
Circus	6

Table 8.1 Typical stadium events table

Being part of such a larger complex is another method by which more functions are found for stadia. For this to be done successfully, a covered stadium is ideal such as the Hoosier Dome complex in Indianapolis. It was built on a city centre site next to an existing 12 000 m^2 convention centre with the stadium's 8000 m^2 planned as an extension to this centre. It used the existing car parking and transport infra-structure and relied on public funding as well as major private sponsorship for its construction.

With Europe's regular inclement weather and the catchment population of many large cities, it is not surprising that a number of these multi-purpose covered stadia are being considered.

8.4 Catering for different sports

Moving on now to more detailed design matters, the following are the factors that must be taken into account when considering the multi-use of a stadium by more than one sport.

8.4.1 Playing fields

Certain combinations of sports can be easy to accommodate in the same building as the requirements for playing and watching are similar. Examples include soccer and rugby, which are played on grass fields of similar width but different lengths. Some principal examples of sports that are commonly played on the same field are shown in the list below:

Sports	Comments
Soccer and rugby	Fields are of similar size and shape.
Soccer and athletics	The soccer pitch fits inside a standard 400 m running track, but the track separates the spectators from the edge of the soccer field which is unpopular with fans in some countries.
Australian rules football and cricket	Fields are of similar size and shape.
Australian rules football and rugby	The spectators for rugby are further away from the touch line than is desirable.

For certain other sports the playing areas are so different that they cannot easily be accommodated in the same building. Examples include American football and baseball. Figure 4.1 shows the Truman Sports Complex in the USA, where it was decided to provide separate venues for the two sports.

But the problem is not insoluble, as demonstrated by the Pro Player stadium in Miami, which despite the difficulties accommodates both. In such situations one sport has to be the primary game for which the building is designed, and the secondary sport has to accept arrangements that are, to whatever degree, a compromise. Thus in the Pro Player stadium the seating tiers are a rectangle in the normal set-out for American football, and when a baseball game is to be played one side of the lower tier retracts to create a large enough field for the baseball triangle.

For more detail on the sizes and shapes of playing fields see Chapter 7.

8.4.2 Viewing positions

Each sport (or other type of performance) has its own preferred viewing positions, as set out in Chapter 11, and the seating layouts for some sports are so different that they may be difficult to accommodate in the same building.

In striving to provide for true multi-use, various ways of altering the viewing geometry of a stadium on a temporary basis have been attempted. Moving pitches have been tried, but the most common and most successful are movable, or at least retractable, seats. More detail on these is given below.

8.4.3 Movable and retractable seats

This idea evolved in the 1960s from the attempt to house American football, played on a rectangular pitch, and baseball, played on a diamond shaped pitch, in the same building. It was only partially successful – many believe it was an unacceptable compromise for both sports and did not fully satisfy the requirements of either, even though a high standard of venue could be achieved and problems of access could be solved.

A reaction against this compromise came in 1972 when the dual stadia complex of Kansas City, Missouri was opened; this included two stadia, one of 78 000-seat capacity to be used for American football, the other of 42 000-seat capacity for baseball – see Figure 3.1.

Nevertheless there have been many subsequent attempts to design stadia which can be reconfigured for the maximum variety of events, particularly in North America. The most ambitious example is the Toronto Skydome (Figure 4.2) which opened in 1989 and can be adapted, by movable seating, to the following uses. It should be noted that the seating numbers given below are the original ones, and may since have altered to meet changed circumstances.

- Auditorium configurations to allow 10 000 to 30 000 seats as desired.
- A hockey or basketball configuration of 30 000 seats.
- A baseball configuration of up to 50 000 seats.
- A football configuration of up to 54 000 seats.
- Various configurations allowing up to 68 000 spectators for rock concerts or other entertainments.

The Toronto Skydome is exceptional, and in view of the costs involved very few stadia could ever provide the degree of flexibility outlined above. But at more modest levels there is widespread use of movable seating tiers all over the world.

One example is the Pro Player stadium in Miami which accommodates football as the primary sport, and baseball as a secondary use, as noted in Section 8.4.1 above.

Another is the Telstra Dome in Melbourne, Australia, which accommodates 50 000 spectators to watch rugby (rectangular pitch), cricket (oval pitch) and Australian rules football (oval pitch). The precast concrete upper tiers are fixed in an oval shape, but the steel lower tiers, slightly curved in plan, can move forward on wheels over the cricket pitch to be closer to the rugby touch line. This stadium also has a closing roof to allow sports to be played in any weather conditions and to enable the building to host a wider range of non-sports events. See Figure 8.3, and Case Study on page 291.

In the case of stadia used for both football and athletics, continental European spectators do not seem to mind the great distance between spectator and

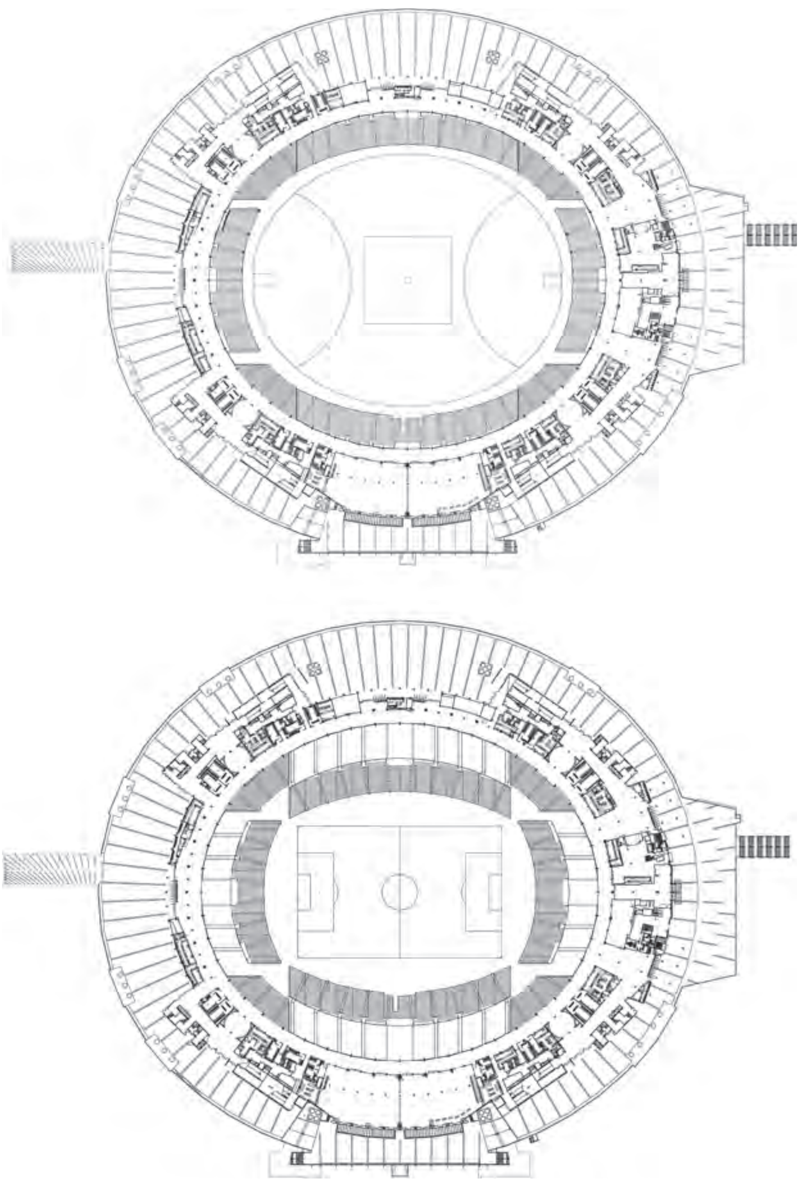


Figure 8.3 Floor plans of the Telstra Dome showing the lower tiers retracted around the larger Australian football field, and extended to be closer to the smaller rugby pitch.

football pitch created by the intervening athletics track, whereas in British football there is a tradition of close viewing which most interested parties wish to preserve. The answer to this conundrum may lie in movable or retractable stands which can be located close to the football playing field for the winter season, covering the athletics track, and then moved back for athletics events in the summer. The Stade de France in Paris is one example of a venue which was designed to allow the seating to move back over the athletics track.

However, such solutions are expensive, and a degree of public funding is usually required to make them viable – either directly or indirectly.

8.4.4 Movable seat types

Movable seating can be supplied in any numbers, from a few hundred to several thousand, to suit the types of events anticipated and the configurations required. Generally speaking the greater the variety of events a stadium is required to host, the larger the number of movable or retractable seats to be provided. The most usual types are the following:

- Rigid seating tiers mounted on steel tracks.
- Rigid seating tiers with large retractable wheels.
- Rigid banks of seats moved about on air or water cushions.
- Retractable seats on folding or telescopic frames.

The first three types are pushed manually or mechanically from one pre-planned position to another to suit the current event, while the retractable type is compactly stacked or folded into a wall when not in use, and 'concertinaed' out into position when needed. In all cases the ideal is to have prepared storage spaces, usually under the tier above, where temporary seats can be stored out of the way and quickly rolled or folded out into the correct position when required.

8.4.5 Possible future developments

The possibilities for movable seating tiers are entering a new era, with better and more easily maintained systems being developed.

Sports stadia of the twenty-first century may consist of flat concourses at different levels above the playing surface, with retractable seats pulled out as necessary and the remaining levels used for a variety of catering functions. If such ideas are applied it will be necessary to calculate very carefully their effect upon viewing sightlines for the remaining viewing areas.

8.5 Catering for non-sports performances

Concerts have particular requirements in terms of seating layout, and many larger and smaller sports venues are able to host these when the weather is right. The earliest groups playing in stadia put up with the buildings that were available to them and installed all temporary stages and accommodation, but as the concert circuit has become more established stadia have been constructed specifically designed for concert use.

The elements that can be incorporated to reduce the temporary set-up include:

- Stage positions with a flat slab, suitable headroom and foundations.
- Power connection points.
- Changing rooms and other areas for performers.
- Manouvering and unloading space for delivery lorries.
- Tiers designed to allow crowd dancing.

With temporary installations other events have been held in stadia and the variety of these is as great as the human imagination. Examples include equestrian events, car racing, car racing on snow, motorcycle racing, car shows, boxing matches, religious conventions, and political rallies.

9. Crowd control

9.1 General
9.2 Perimeter fences
9.3 Moats
9.4 Changes of level

9.1 General

Control of crowds and separation of spectators from participants has been a problem faced by designers since the first time real difficulties were experienced by stadium managers during Roman times. A group of people coming together to enjoy an event is a 'crowd' and must be carefully managed from the moment they enter the zone of influence of the stadium. Sometimes very little encouragement is needed for that crowd to become a 'mob' and eventually that mob to become a 'riot'. The managing of people must be considered from the very beginning of a stadium project if this adverse encouragement is to be minimized. The majority of people place great importance on the way they are treated by staff at a venue with 92 per cent indicating in a survey in the USA that customer service should be the number one priority of management. It is this 'customer service' together with the architecture of the venue which will serve to maintain the goodwill of the spectators.

If members of the public misbehave the management of the venue need to be able to intervene quickly to ensure that a small incident does not become a large one. The building will assist the management in this task if firstly it does not provide opportunities for misbehaviour, and perhaps even encourages people to behave well; and if secondly it has closed-circuit television and to allow the stewards enough space to see problems arising, and get there easily to deal with the situation.

It is the authors' experience that in some instances where stadia have been designed to a good quality, fans have respected the building that has been provided for them; whereas when spaces have been constructed with the expectation they will be vandalized there is more likelihood they will be.

One of the primary problems that has arisen in the past is with spectators entering the field of play when not wanted. The design of the barrier at the front of the seating tiers can have an influence on this.

The Colosseum and similar Roman amphitheatres developed their own type of separation in the form of a surrounding wall – possibly designed more to protect the spectators from the activities taking place in the arena than the other way round. Bullrings in Spain and southern France developed along similar lines with a change in height between the first row of seating and the bullring, essential to ensure the safety of the audience. In the latter part of the twentieth century the roles have been reversed, with the boundary serving to protect the activity area from the spectators.

There are three commonly-used design techniques for separating the activity area from the spectators: perimeter fences, moats, and changes of level.

9.2 Perimeter fences

9.2.1 Advantages

There are two good reasons for having a robust fence (Figure 9.1) between spectators and pitch. The first is protection of players and officials from hostile spectators. The second is the protection of a natural grass pitch surface from compaction of the subsoil by spectators' feet.

9.2.2 Disadvantages

The first is that most fences are an obstruction to proper viewing of the game, and usually are unsightly.

The second has to do with safety. In cases of mass panic on the stands or escape from fire, the playing field is an obvious zone of safety (see Section 3.3.6) and an intervening fence which prevents people from reaching it can create a death trap. Two recent experiences in Britain demonstrate this. The first, more fully described in Section 3.3.1, was at Valley Parade Stadium, Bradford, where an even greater disaster than the one which did happen was prevented only by some spectators being able to escape on to the playing field. The second was at Hillsborough Stadium, Sheffield, where the perimeter fence between the standing terrace and the pitch was a contributing factor to the death of 95 people in a crowd surge.

9.2.3 Choice

In each case the pros and cons of a fence must be carefully balanced and the case discussed with the governing body concerned and with the local police and safety authorities, whose views will carry great weight. The following factors should be taken into consideration:

- The need for a fence is most likely in the case of soccer, particularly in countries or individual grounds with a history of violent crowd behaviour.
- The most problematical cases are those where highly valued traditional customs conflict with the latest safety trends – for instance, sports grounds with a tradition of allowing crowds

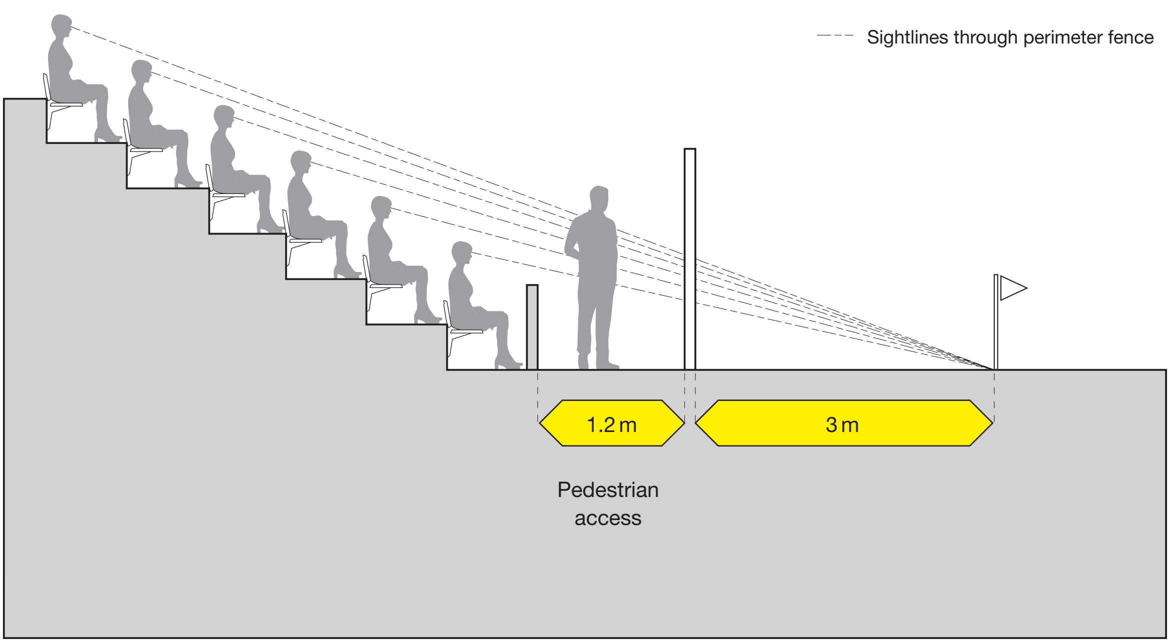


Figure 9.1 Perimeter fences protect the pitch from crowd invasion but also obstruct viewing, are often unsightly and may hinder escape in cases of emergency.

on to the pitch at certain matches. Croke Park in Dublin, the home of the Gaelic Athletic Association (and where gaelic football and hurling have their roots) has a custom of allowing the crowd on to the pitch to carry off the winning captain on their shoulders (and also allowing lifting small children over the turnstiles to sit on the knees of their parents in the stands). These practices are under threat from the new wave of safety consciousness but are not inherently dangerous if properly controlled. Twickenham had a tradition of spectators coming on to the pitch after rugby matches but this is not now allowed. Customs such as these contribute to the special character of individual stadia and should not be thoughtlessly destroyed by blanket insistence on universally-applied safety techniques. Some modification to take account of individual circumstances should be the aim. For instance Wembley Stadium in London (Case study 25) and Croke Park have used a modified type of fence called a 'cat's cradle'. This is a wire cage the height of a low fence which does not obstruct vision but is difficult to climb across.

Most football grounds in the UK have now removed perimeter fences altogether.

9.2.4 Design criteria

- The latest version of the FIFA & UEFA guide, as of 2006, states that certain top-level matches cannot be played in a stadium with fences or screens round the pitch. Where they can be used, they should include emergency exit gates (see below).
- A key reference in the UK is the *Guide to Safety at Sports Grounds* (see Bibliography), also known as the 'Green Guide'. Chapter 10.16 of the *Guide* recommends that pitch perimeter fences should not be used in new sports grounds under any circumstances. In existing stadia where such fences are already in place, maximum height should be 2.2 metres.
- The fence must be robust and if there is not a crash barrier incorporated into the design then the fence should be capable of withstanding crowd pressures equal to those which would normally be expected of a crowd barrier at a height of 1.1 m above the nosing.
- The fence must be as unclimbable as possible.

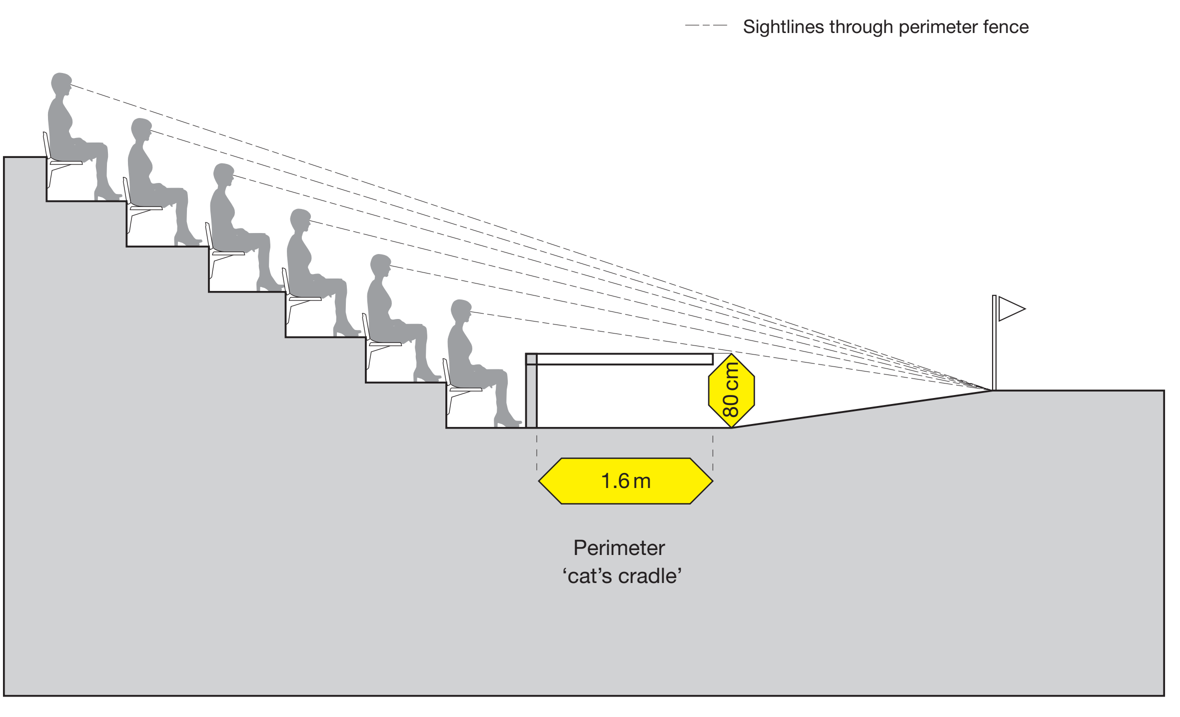


Figure 9.2a The cat's cradle fence at Wembley Stadium, London.

Figure 9.2b One of the authors negotiating a cat's cradle perimeter fence.

Photograph: Geraint John

- The design should allow the fence to be 'unobtrusive' and permit the best vision possible through to the playing area. The use of transparent materials such as glass and polycarbonate are possible but the effect of dirt, weather, unwanted reflections and wear and tear must be considered.
- There must be adequate provision for escape through the fence, either in the form of gates, opening panels or collapsible sections. Whichever method is used for escape it should be recognized that this is a critical element of the design and it should be as 'fool-proof' as possible. The openings should be sized in accordance with the total number of spectators required to gain access on to the playing area in an emergency. These openings should be clearly identified visually. In recent years several versions of an opening or collapsible fence have been developed, particularly in France. If opening or collapsible fences are to be incorporated into a stadium they must be of a design capable of withstanding the significant loads of crowd pressure when in use and it must be ensured that, under these conditions, the opening mechanisms will remain reliable and 'fail-safe'.
- In a multi-purpose stadium the fences should be removable so that they are only used on those occasions when some form of separation is necessary such as for 'high risk' football matches but not for a pop concert. It may be that in the future this type of separation will be required on other sporting occasions.
- Whatever means of access to the field is designed through this perimeter fence it should be under permanent supervision by stewards during an event.

9.3 Moats

9.3.1 Advantages

It is relatively easy to design the pitch side of a moat to be unclimbable and also to police a moat with security staff so that crowd invasion is easily controlled. The moat may serve a further purpose in providing a circulation route around the stadium for three groups of people:

- Officials and security staff needing to gain quick and easy access to some part of the viewing stands.
- Ambulances and emergency vehicles.
- The media: the Olympic Stadium in Barcelona was modified partly to meet this aim, as mentioned in Section 1.2.5.

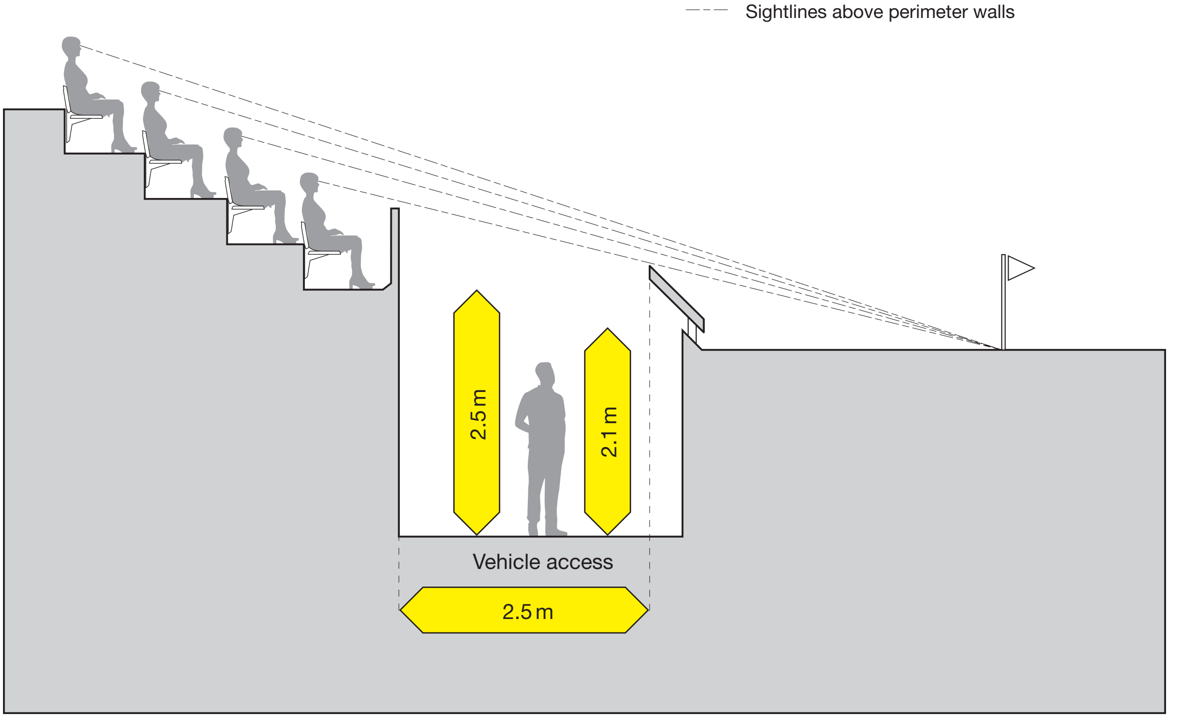


Figure 9.3 An inaccessible moat.

The major advantage of the moat is that the crowd control and other functions listed above can be achieved inconspicuously and without impeding the view of spectators to the field. Its aesthetic qualities are therefore far superior to those of a perimeter fence.

9.3.2 Disadvantages

Use of a moat will increase the distance between the playing field and the spectators. For this reason moats may be more appropriate to larger stadia, where an additional 2.5 m or 3 m will be a relatively modest fraction of the overall dimensions involved.

9.3.3 Design criteria

The most precise recommendations are those laid down for football stadia by FIFA and UEFA: a minimum width of 2.5 m and a minimum depth of 3.0 m; sufficiently high barriers on both sides to prevent people falling into the moat; and the provision of safety escape routes across the moat in those stadia where the playing area is a means of escape in an emergency. Moats should not contain water but be constructed in such a way that unlawful intrusion on to the pitch is prevented – for example by climbing obstructions inside them (Figure 9.3).

For stadia generally the following criteria apply:

- It may be important under emergency circumstances to allow access across the moat on to the playing area and therefore a method of bridging the 'gap' should be incorporated, either on a permanent or temporary basis.
- A method of gaining access to the pitch for service vehicles must be found by either a bridge, ramp or adjustable platform so vehicles may drive directly on to the pitch. In some situations heavy vehicles may be necessary, particularly where the stadium is used as a concert venue and large quantities of stage building materials will be used.
- In addition to allowing the spectators to cross the moat on to the pitch in certain circumstances access can also be provided for the spectators into the moat if it is to be used for public circulation. In these circumstances correctly designed

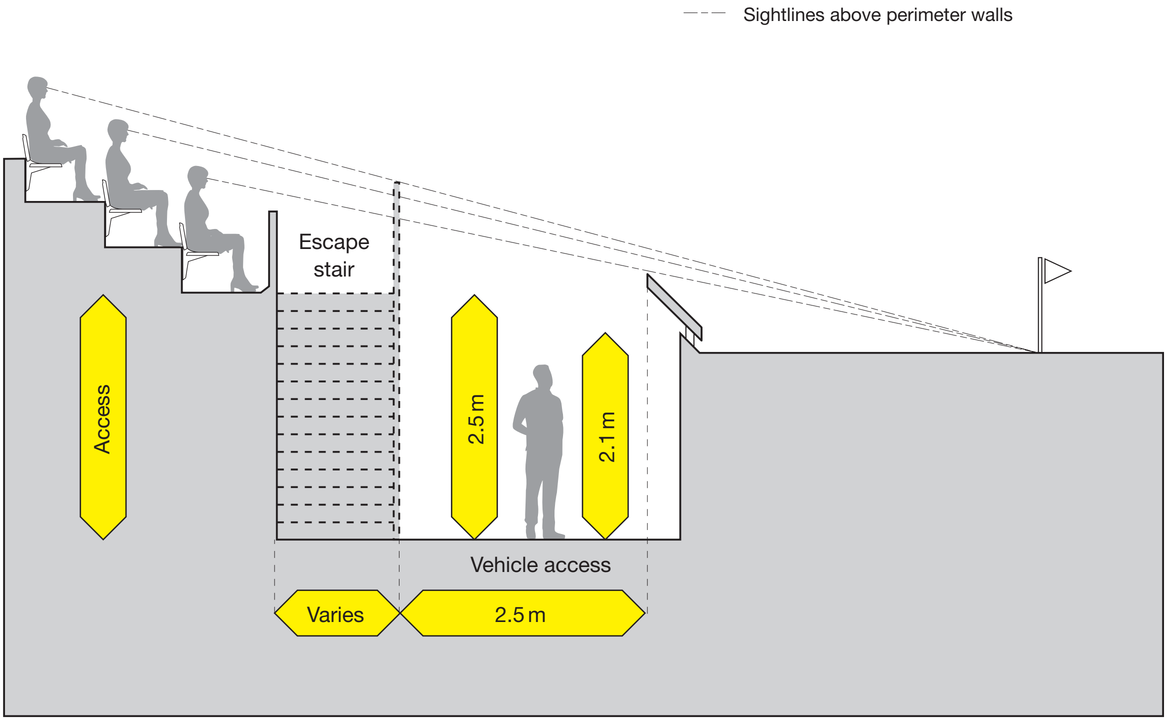


Figure 9.4 A typical accessible moat. Note that the stair handrail will intrude into spectators' views.

stairways must be provided at regular intervals around the circumference of the moat to provide egress into the moat and from the moat to the outside of the stadium. This route can be either underneath the tiers of seating or at the corners (Figure 9.4).

- The dimensions of the moat should be sized so as to prevent spectators attempting to jump across from the front row of the terrace as well as providing a wide enough escape route if it is to be regarded as a means of egress. In addition to the above requirements, if it is to be used for vehicular access around the stadium by police, ambulance and other service vehicles, it should have a minimum of 2.5 m clearance.
- The moat may be used to help clean the spectator terraces. Debris and refuse can be air blown or swept forward with the moat containing rubbish skips so that the waste is deposited directly into the container. The front balustrade should have openings or be designed at the base to accommodate this.
- Access for players, performers and police on to the pitch should be provided by way of tunnels or covered crossing points directly into dugouts for the teams, if this is appropriate.
- Kiosks for the sale of refreshments can be provided in the moat under the terrace so that spectators descend into the moat via staircases during the interval.

9.4 Changes of level

The combination of a depression, less deep than the moats described above, and a barrier, not as high as the fences described in Section 9.1.2, gives quite an effective deterrent to crowd invasion of the pitch while still providing good access around the perimeter of the pitch for official use (Figure 9.5). Alternatively the first row of seats can be lifted sufficiently high above the playing area (Figure 9.6) to make pitch invasion difficult, though not impossible. This is the so-called 'bullring' method often used in the USA.

9.4.1 Advantages

The bullring method has the advantage of being able to accommodate a large number of players, officials and others at the side of the pitch without obstructing the view from the spectator seats, hence its popularity in the USA.

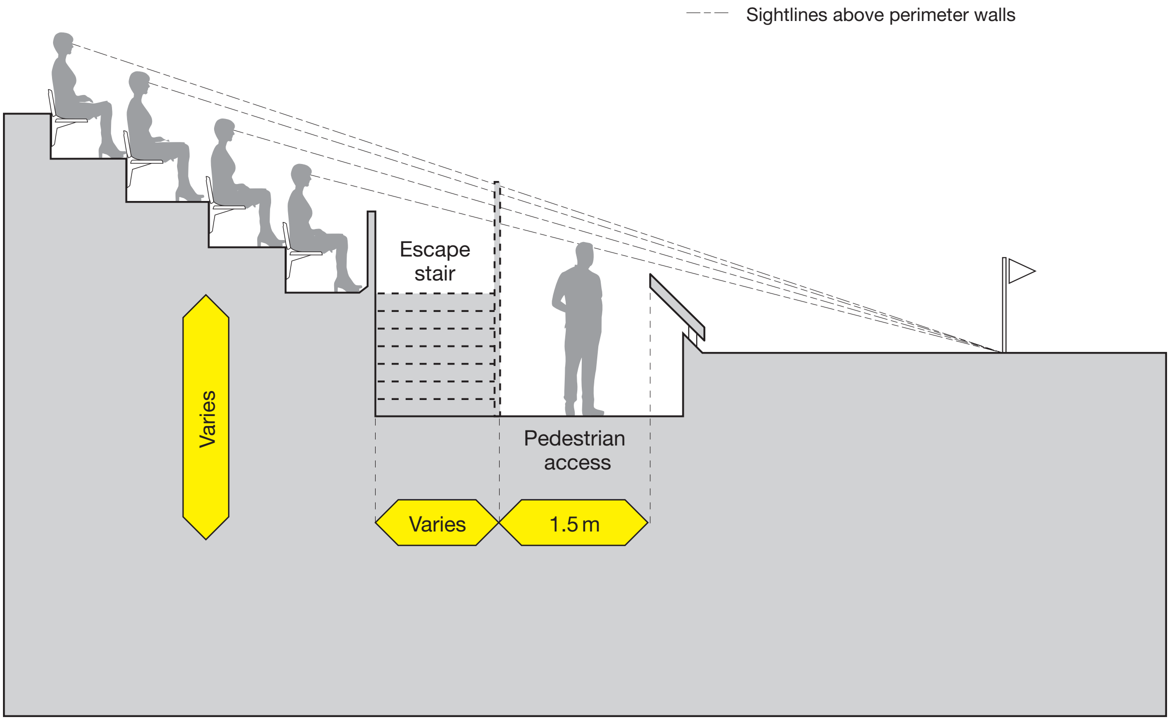


Figure 9.5 A 'half moat' or combination of low fence and shallow moat. Note that the stair handrail will intrude into spectators' views.

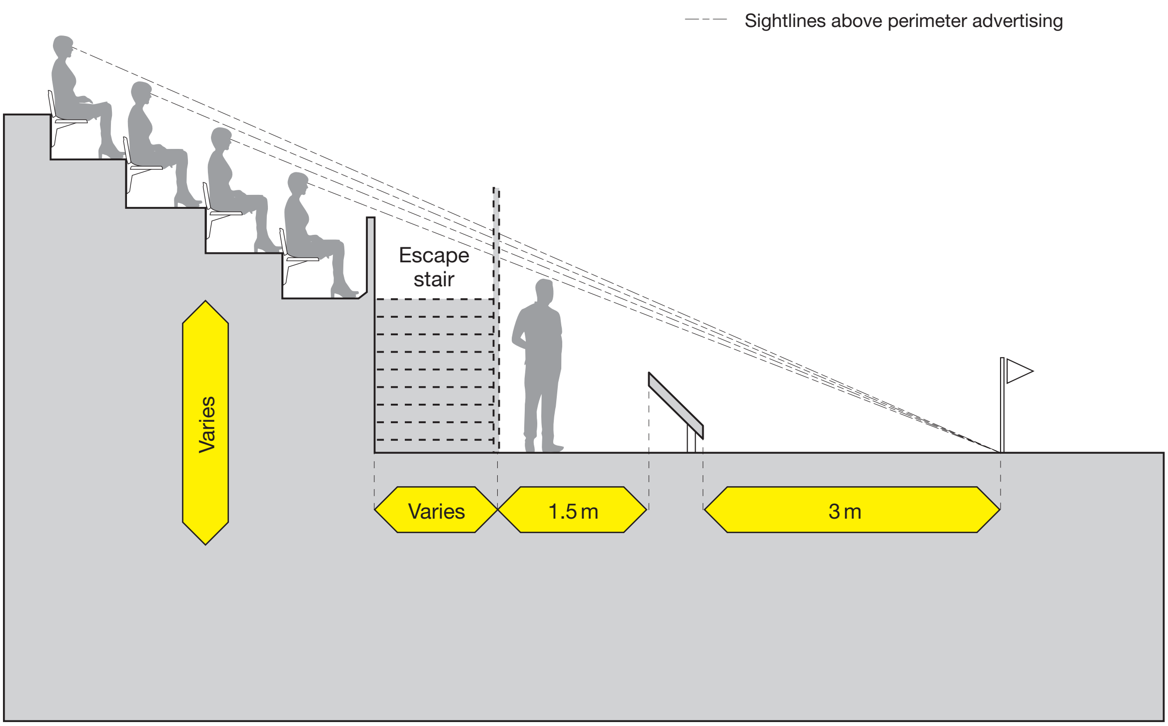


Figure 9.6 The 'bullring' solution, or level change, is widely used in baseball and American football stadia in the USA. Note that the stair handrail will intrude into spectators' views.

9.4.2 Disadvantages

Both of the methods described above are only moderately effective barriers to pitch invasion, deterring only the less motivated invaders. They are therefore most suitable where crowds are known to be well-behaved or where good stewarding is provided.

Lifting the height of the first row of seats, as in the bullring method, hampers the design of good sight-lines from the seating tier behind, particularly in large stadia.

9.4.3 Design criteria

Typical dimensions of the moat plus barrier method are a 1.5 m deep moat, plus a 1 m high fence on the pitch side. Typical dimensions of the bullring method are to raise the first row of seating 1.5 m or 2 m above pitch level.

10. Providing for disabled people

10.1 Equal treatment
10.2 Sources of information
10.3 Design process

10.1 Equal treatment

10.1.1 Basic principles

It is now accepted in most developed countries that disabled people should be able to participate in sports events (see Figures 10.1 and 10.2), have reasonable opportunities of being employed as officials or acting as referees, and be able to attend as part of the spectator crowd without suffering any avoidable disadvantage compared with other people.

In planning for spectators this means that disabled people should be able to find out about forthcoming events; plan their visit; make the journey; and buy their tickets just as easily as everyone else. They should have a good choice of seating positions; enjoy the same sightlines from their seats as other spectators; have equal access to refreshment and retail facilities; and have equal access to suitable toilets.

The underlying pressures towards greater inclusiveness are to some degree social and commercial, but increasingly the requirement for equal treatment is being demanded by law. As examples:

- The USA led the way with the Americans with Disabilities Act 1990 – for an overview visit www.usdoj.gov/crt/ada/adahom1.htm
- Australia followed soon after with its Disability Discrimination Act 1992 – for an overview visit www.hreoc.gov.au/disability_rights/
- The UK passed its own Disability Discrimination Act in 1995, and has since enacted several amendments. For an overview visit www.disability.gov.uk/

Except where otherwise stated, all guidance in this chapter is based on UK legislation.

To state the position in the UK briefly: the Disability Discrimination Act prohibits service providers (a term that includes the organizers of sporting events) from providing a worse service to disabled persons than to the rest of the population. This legal requirement affects both the physical design of the stadium, which must be as easily usable by disabled people as by others, and the organizational aspects of the event.

As instances: if the lettering on the booking form is too small to be read by a person with impaired vision; if a person who is hard of hearing cannot

Photograph: Photo courtesy of the Institute of Leisure and Amenity Management

Photograph: Graham Bool

Figure 10.1 Disabled people are increasingly participating in sports, both (a) in general settings and (b) in highly competitive situations such as the Commonwealth Games and Olympics.

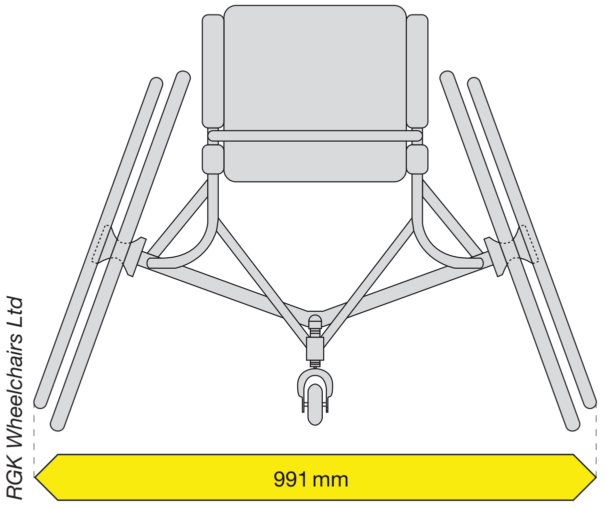


Figure 10.2 Width of a sporting wheelchair. Standard wheelchair width, for comparison, is normally taken as 700 mm.

hear the assistant at the ticket office; if a wheelchair user does not have a reasonable choice of good seats in various parts of the stadium, cannot readily reach such a seat, or has worse sightlines than able-bodied spectators once in that seat; or if a disabled person does not have ready access to a suitable toilet, then the event organizers may be in breach of the law and be liable to legal action on the basis of discrimination.

10.1.2 The meaning of disability

The legal meaning of the term 'disabled' is now very wide and goes far beyond wheelchair users – though people in wheelchairs are, in terms of physical building design, perhaps the most difficult category to cater for and therefore a crucially important user group.

Pages 14 to 19 of *Accessible Stadia* (see Bibliography) summarise the physical and mental conditions that are recognized as disabilities under the UK's Disability Discrimination Act. They include the following:

- Impaired mobility. People with impaired mobility include wheelchair users who cannot leave their wheelchairs; wheelchair users who arrive at the ground in a wheelchair and then transfer to a seat; and ambulant disabled people, who do not need a wheelchair but move with difficulty and may use a stick or walking frame.
- Impaired vision. These are people with eyesight problems which cannot be corrected simply by wearing spectacles. They may have difficulty in reading booking forms, tickets, programmes, or wayfinding and other signs.
- Impaired hearing. These are people who are hard of hearing or deaf. They may find it difficult or impossible to communicate with assistants in ticket offices, to hear stadium announcements, or to follow spoken commentaries.
- Impaired understanding. These are people with learning difficulties or mental disabilities. They are even more reliant on simple, clear building layouts, clear signposting, and on helpful and kindly staff than the rest of the population. In fact these features will be very helpful to virtually all stadium users, and should be a high priority for event organizers.

It is officially estimated that in 2006 a fifth or more of the whole British population may be covered by the Disability Discrimination Act, and there are proposals in preparation to widen the definition even further. In the UK full and equal provision must be made for all such people whether they are present at the stadium as spectators, as players and athletes (for instance at events such as the Paralympics), as officials, or as venue employees. Similar trends are at work in the USA, Australia, and other developed countries.

10.2 Sources of information

10.2.1 Guidance on satisfying UK regulations

Accessible Stadia, produced and published by the Football Stadia Improvement Fund and the Football Licensing Authority, is the most authoritative guide to the design of accessible stadia in the UK.

Designing for Accessibility, published by the Centre for Accessible Environments, is an equally authoritative guide to the design of public buildings in general. It is much simpler than the official documents listed below, and will greatly help designers in getting the basic design decisions right.

Approved Document M of the Building Regulations has the force of law and its provisions must be heeded in England and Wales (Northern Ireland and Scotland have their own regulations, but these are fundamentally quite similar to *AD M*).

British Standard BS 8300 is considerably more detailed than *AD M*, and is the leading UK standard on the *inclusive* design of buildings in general. It is advisory and does not have the force of law, but conformity with its recommendations will help demonstrate that the requirements of the Disability Discrimination Act have been met.

Inclusive Mobility: a Guide to Best Practice on Access to Pedestrian and Transport Infrastructure is the most authoritative UK reference on the design of footways and other pedestrian areas; car parking, bus stops and taxi ranks; the correct use of tactile paving surfaces; and the correct use of signage and other information systems in public buildings.

The Bibliography gives more detail on all the above publications.

10.2.2 Guidance on satisfying USA regulations

ADA and ABA Accessibility Guidelines for Buildings and Facilities is the official USA guide on designing for disabled people. The whole document should be consulted, but Section 802 is particularly relevant to stadium design. The Bibliography gives more detail.

10.3 Design process

10.3.1 Simplifying strategies

Accessibility regulations can be dauntingly complex, as a glance at some of the above documents will demonstrate, but the following suggestions may help designers get a grip on the overall process:

- Do not start by planning a stadium for ‘general’ users, and then check references such as *Accessible Stadia* at a later point to add special features for ‘disabled’ users. Instead, set out from the very outset to design a venue that has maximally clear routes for both ingress and emergency egress; excellent signposting; generous spaces; good acoustics, and excellent sightlines, so that everyone – including those who move with difficulty, don’t see well, don’t hear well, or are slow in understanding – will find it a safe and easy environment.
- Then use the ‘journey sequence’ approach to imagine the entire sequence of events for each type of spectator (or player, or official) as he or she looks up information about a forthcoming event; plans the visit; makes the journey to the venue; moves from the bus, coach, or car to the main entrance; buys the ticket; gets to the seat; views the match; visits the toilets; has a drink or a meal; and leaves the venue. Within reason no one, regardless of physical or mental fitness, should encounter any difficulty at any point along such a journey sequence.

For the UK, pages 25 to 66 of *Accessible Stadia* give authoritative guidance, starting with disabled spectators’ arrival at the stadium entrance, continuing through most of the stages noted above, and ending with the provisions that must be made for emergency egress. The sections below follow a similar sequence.

10.3.2 Advance information

Disabled people are even more reliant than other prospective spectators on good information about a forthcoming event – ‘good’ both in the sense of (a) *what* information is provided, and (b) the *form* in which it is made available.

As an example of (a): people with impaired mobility (most importantly, but not only, wheelchair users) must be able to satisfy themselves in advance that their journey to the venue, and the venue itself, will be obstacle-free and that they will have ready access to an accessible toilet when necessary. If they cannot be sure of these things then they dare not risk setting out on the journey.

As an example of (b): people whose eyesight is so poor that they cannot read small or normal-sized print may need their information in large print or in audio form.

For stadia in the UK, the checklist on pages 72 and 73 of *Accessible Stadia* (see Bibliography) will help event organizers deal with the above matters.

For stadia in the USA there is no readily available nationally recognized guidance on these particular matters.

10.3.3 Arriving at the stadium

The routes from rail stations, bus stops, and coach drop-off points to the stadium entrance should have firm and smooth (but anti-slip) surfaces such as asphalt, concrete, evenly-laid pavings, or resin-bound gravel – loose gravel or earth is not acceptable. Kerbs at road crossings should be dropped to be flush with the carriageway, so that wheelchair users are not obstructed.

For stadia in the UK, modified coaches carrying disabled spectators should be able to drop off their passengers not more than fifty metres from the stadium entrance, and the route from drop-off point to entrance should preferably be under cover.

For stadia in the USA, Chapter 4 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on accessible routes, and Chapter 5 deals with parking spaces and related matters.

Car parking

For stadia in the UK, paragraph 4.1.2.3 of British Standard *BS 8300* (see Bibliography) states that in addition to a designated space for each employee who is a disabled car driver, 6 per cent of total car parking capacity at recreation and leisure facilities should be allocated to disabled people. But it adds that this number may need to be increased in sports stadia that 'specialise in accommodating groups of disabled people'. At all stadia the parking bays designated for disabled people should be provided as close as feasible to the principal entrance, and the routes from car park to stadium entrance should conform with the criteria for safe and easy usage noted above.

For stadia in the USA, Chapter 5 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) deals with parking spaces, passenger loading zones, and related matters.

Access routes

In Britain, access routes to and around stadia should have a clear width of at least 1.8 metres if there is intensive use by spectators in both directions, and 1.5 metres (with 1.8 metre wide passing places at intervals) if routes are less busy. Surfaces should be as noted above.

Walkway gradients steeper than 1:20 should be designed as ramps, with handrails, kerbs, and level landings at regular intervals as resting places. If the overall rise of the ramp is greater than 300 mm then steps should be provided in addition.

There should be excellent signage all the way from the stadium gate to each individual seat – see Section 10.3.11 below.

For stadia in the UK, paragraphs 2.1–2.3 and the checklist on page 73 of *Accessible Stadia* should be consulted on all the above matters.

For stadia in the USA, Chapter 4 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on accessible routes; and Chapter 7 deals with signs.

10.3.4 Buying a ticket

The ticket office should have an induction loop for people who are hard of hearing, and a section of the counter should be lowered to 760 mm for wheelchair users. This section should have a knee space beneath that is at least 500 mm deep and 1 500 mm wide, with a clear height of at least 700 mm to the underside of the counter.

For stadia in the UK, Section 11.1 of British Standard *BS 8300* gives detailed design recommendations on the design of counters and reception desks in general.

For stadia in the USA, Chapter 9 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on the design of counters, and Chapter 7 deals with assistive listening systems.

10.3.5 Passing through the turnstiles

Disabled spectators should not enter the stadium via the main turnstiles, but have separate entry gates specially designed and managed for their use. Preferably these should be manned by a specially trained steward. One reason for providing special entrances for disabled people, apart from the fact that they themselves appear to prefer such an arrangement, is that this enables managers to accurately 'count in' the wheelchair users. In the UK this is a safety requirement, as explained in more detail in paragraphs 6.1–6.3 of *Guide to Safety at Sports Grounds* (see Bibliography).

In England and Wales, table 2 of *Approved Document M* of the Building Regulations gives the minimum clear width of entrance doors to buildings used by the general public as 1 000 mm.

For stadia in the UK, paragraphs 2.4–2.7 and the checklist on page 73 of *Accessible Stadia* should be consulted. See also section 6 of *Guide to Safety at Sports Grounds*.

For stadia in the USA, Chapter 4 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on doors, doorways, and gates.

10.3.6 Circulating within the stadium

For stadia in the UK, horizontal routes such as concourses and corridors to which wheelchair users have access should have a clear width of at least 1.8 metres. If intrusions by columns or ducts are unavoidable, these should always leave a clear corridor width of at least 1.0 metre. In England and Wales, section 3 of *Approved Document M* of the Building Regulations governs all aspects of horizontal movement, and section 8 of *Guide to Safety at Sports Grounds* makes specific recommendations for sports facilities.

Photograph: Geraint John

Figure 10.3 In countries such as the UK, USA and Australia wheelchair users are now entitled to a reasonable choice of viewing positions in new stadia, and good sightlines over the heads of spectators in front. Figure 11.12 shows diagrammatically how such sightlines can be achieved by means of a 'super riser'.

Vertical movement for ingress is normally provided by stairs, always augmented by passenger lifts and/or ramps for those spectators (such as wheelchair users) who cannot negotiate stairs. Design criteria for all of these will be set by national codes and building regulations. In England and Wales, section 3 of *Approved Document M* of the Building Regulations governs all aspects of vertical movement, and Section 7 of *Guide to Safety at Sports Grounds* makes specific recommendations for stairs and ramps in sports facilities.

For stadia in the USA, Chapter 4 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on accessible routes, including ramps and lifts; and Chapter 5 deals with stairways and handrails.

10.3.7 Viewing the event

All spectators, disabled and able-bodied alike, should have a good choice of viewing locations in various parts of the stadium (Figure 10.3); have a comfortable seat as explained in Section 12.7; and enjoy good sightlines as explained in Section 11.4. The days when disabled spectators could be herded into one or two ghetto-like enclosures, separated from their friends and the rest of the crowd, where they were unable to see over the heads of the people in front whenever the latter rose to their feet at exciting moments, have gone forever.

These matters are covered in greater detail in Sections 11 and 12 of the present work.

For stadia in the UK, paragraphs 2.13–2.25 and the checklist on pages 73–74 of *Accessible Stadia* should be consulted. See also sections 11–14 of *Guide to Safety at Sports Grounds*.

For stadia in the USA, Chapter 8 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on wheelchair spaces, and gives detailed advice on sightlines for spectators in wheelchairs.

10.3.8 Using the refreshment facilities

Disabled people should find it just as easy as other spectators to enjoy the use of bars and restaurants, either alone or with their friends. Suitable facilities should be located as close as possible to viewing areas. Because disabled spectators may not be able to get to both toilets and refreshment facilities in the short breaks during matches, when circulation areas tend to be very crowded, it may be wise for clubs to provide them with a dedicated refreshment order service, performed by trained stewards or volunteers.

Bars and service counters (including self-service counters) should have one section lowered to a level of not more than 850 mm above the floor for the use of wheelchair users. Such sections should have a knee-space beneath with a clear height beneath of at least 700 mm to the underside of the counter.

For stadia in the UK, paragraphs 2.30–2.31 of *Accessible Stadia* should be consulted.

For stadia in the USA, Chapter 9 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on dining surfaces and counters.

10.3.9 Using the toilets

Disabled people should be able to find and use appropriate sanitary accommodation as easily as those who are able-bodied. Suitable toilets should be dispersed around the stadium, and no wheelchair user should need to travel a horizontal distance of more than 40 metres from his or her seat to the nearest suitable toilet.

Scales of provision and design details vary, and must be ascertained for the particular country in question. For details of toilet provision for disabled people in the UK and USA see Chapter 16.

10.3.10 Leaving the stadium

Because spectators tend to arrive at sports venues in small groups spread over a period of time, but to leave simultaneously, designing and managing for safe egress requires much greater care than designing for safe entry. This applies particularly to emergency egress, when tens of thousands of panic-stricken people may be rushing for the exits in disorderly fashion.

Disabled spectators, particularly those in wheelchairs, should be able to enter and leave as easily as others, and they are particularly vulnerable in the above conditions. Beyond suggesting that those seating areas that are designated for disabled viewers should preferably have their own entry and exit routes in order to minimize conflict between disabled and able-bodied people, this topic is too specialized to treat here.

For stadia in the UK, paragraphs 2.35–2.44 of *Accessible Stadia* should be consulted. See also Sections 9 and 15 of the *Guide to Safety at Sports Grounds*.

For stadia in the USA, Chapter 4 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on accessible routes.

10.3.11 Signs

Disabled people are even more dependent than others upon good signage. A well-coordinated, consistent signage system should be used throughout the stadium, with visual signs augmented by audio information and tactile signs (such as raised lettering, numerals and symbols) to help those with poor eyesight.

The UK

Section 10 of *Inclusive Mobility* (see Bibliography) gives comprehensive and detailed guidance on the size of letters and symbols, typefaces, colour contrast, and positioning of visual signs. It also gives brief guidance on tactile signs and on audible information in public places.

The USA

Chapter 7 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides guidelines on signs and other information systems.

11. Spectator viewing

11.1 Introduction
11.2 Ground capacity
11.3 Viewing distances
11.4 Viewing angles and sightlines
11.5 Obstructions to viewing

11.1 Introduction

11.1.1 Design aims

The design team's task is to provide seats or standing places for the number of spectators required by the brief, and to do so in such a way that the spectators (including wheelchair users and other disabled people) have a clear view of the event, and are comfortable and safe. This chapter outlines all the viewing design factors.

11.1.2 Sequence of decisions

The starting point for design is the size and orientation of the playing field, both of these being dictated by the sporting functions to be accommodated. See, therefore, Chapter 3 for pitch orientation and Chapter 7 for pitch dimensions.

Next a notional 'envelope' can be drawn for the spectator areas surrounding the pitch. The inner edge will be as close to the pitch as possible, allowing for a safety barrier as described in Chapter 9, while the outer edges will be determined by:

- The required spectator capacity (Section 11.2).
- The maximum acceptable distance from the pitch to the furthest seats (Section 11.3.1), and the preferred viewing locations for that particular sport (Section 11.3.3).

Finally this schematic plan must be converted to a fully developed three-dimensional stadium design taking full account of good viewing angles and sightlines (Section 11.4.2), safety limits on the steepness of rake (Section 11.4.3), and no unacceptable barriers such as roof supports interfering with the view (Section 11.5).

11.2 Ground capacity

11.2.1 The need for realism

The most important decision in planning a new stadium, or expanding an existing one, is the number of spectators to be accommodated.

When developing a building brief, the design team and client organization often over-estimate this figure. Natural optimism plays a part in this. Sporting clubs always believe their attendance is about to increase dramatically, even though statistical evidence may show that it has been stable for years or even dropping; stadium owners like to believe that if only they had a bigger venue then more people would attend, even though many seats in their existing smaller stadium remain unfilled; and consultants may find it more exciting to get involved in big plans than small ones, which tends to encourage expansive thinking.

There are circumstances in which an attractive, well-planned new facility may attract more spectators. For instance, the club may be able to increase its 'gate' by an organized recruitment campaign or, in the case of European football, if it gains promotion in the league system. Also, the fact that a new stadium is comfortable, safe and well-designed may in itself attract more spectators. But experience shows that attendance will tend to revert to earlier figures, after the novelty has worn off, unless the new crowd can be enticed to stay by means of effective marketing or by the team's performance.

It is therefore a golden rule never to increase stadium capacity beyond that which is known to be necessary, and can be demonstrated to be affordable both in capital cost and running cost. The factors which will lead to a preliminary estimation of ground capacity are the following:

- The sport(s) and other activities to be accommodated.
- The size of the catchment area surrounding the development.
- The aspirations of sponsors, public institutions and owners.
- The past history of the site or sports club.
- Practical site limitations.

This decision on capacity can only be provisional: it may not be possible to provide the desired number of seats while still giving adequate quality of view, adequate shelter, or fit the stadium successfully on to its site and into its surroundings. The implications of seating numbers must therefore be carefully checked against considerations such as:

- The quality of view and distance from the action.
- The type of roof possible, where relevant, and therefore the extent of shelter.
- The aesthetic character of the development both internally and when viewed from outside the stadium.
- The cost of the structure and support facilities, and its running costs.
- Safety management and staffing on even and non-event days.
- The extent and range of support facilities which are viable.

11.2.2 Official requirements

A minimum seating capacity, including a more detailed breakdown into the following categories, may be set by the types of events to be held at the venue.

- The proportion of viewing spaces allocated to officials, VIPs and directors.
- The proportion of viewing spaces allocated to (a) wheelchair users and (b) ambulant disabled spectators.
- The proportion of standing places to seats.

In some cases the governing bodies will lay down standards in one or more of the above categories, which must be met if certain types of matches are to be played there.

Provision for general spectators, officials, VIPs and directors

The recommended seating capacities for various types of sports are constantly being revised, and designers should contact the relevant governing bodies for latest information. The allowable proportion of standing places should be verified particularly rigorously, because the general trend is for such accommodation to be phased out.

Provision for wheelchair users

As regards scale of provision, in the UK Table 4 of the *Guide to Safety at Sports Grounds* and para 2.13 of *Accessible Stadia* (see Bibliography) recommend that spaces should be provided for the numbers of wheelchair users shown below; and Table 3 of Approved Document M of the Building Regulations (see Bibliography) recommends a small number of additional removable seats – see the table. These very generalized figures should however be tested in specific cases by consultations with local groups representing disabled supporters.

Total seated capacity	Number of wheelchair spaces
Under 10 000	At least 6, or 1 in 100 of seated capacity, whichever is greater.
10 000 to 20 000	100 plus 5 per 1000 above 10 000
20 000 to 40 000	150 plus 3 per 1000 above 20 000
40 000 or more	210 plus 2 per 1000 above 40 000

As regards location, the reference *Accessible Stadia* (see Bibliography) makes several recommendations which include the following.

- Areas for disabled spectators should, where possible, be dispersed throughout the stadium to provide a range of locations at various levels and various prices. We would however emphasize that for practical and safety management reasons it will normally be necessary to retain some grouping of wheelchair-using spectators.
- Viewing areas should be accessible to disabled spectators with the minimum of assistance.
- Designated viewing areas should be provided for both home and away supporters. Many supporters with disabilities suffer isolation and intimidation when situated among, or close to, able-bodied supporters of the opposing team.
- Spectators who use wheelchairs should not feel cut off from spectators in the main body of the stand.
- Access should be available to different areas of a seating deck for semi-ambulant and ambulant disabled people.
- Smaller groups of disabled spectators dispersed throughout a stand are a more manageable proposition for safe evacuation than larger groups.

Para 2.15 of *Accessible Stadia* recommends that each designated wheelchair space should measure at least 1.4 m × 1.4 m, to allow for a helper to sit alongside the wheelchair user.

Provision for ambulant disabled spectators

As regards scale of provision, there will normally be many more ambulant disabled spectators than ones in wheelchairs, but as of 2006 there are in the UK no specific recommendations on the number of spaces to be provided. Para 2.16 of *Accessible Stadia* states vaguely that the above table of recommendations for wheelchair users 'should be used to determine the minimum proportion of seated accommodation for ambulant disabled spectators in the whole stadium' but gives no indication of the ratio that might be applied. Again whatever scale of provision that is decided should be tested by consultations with local groups representing disabled supporters.

As regards location, para 2.16 makes the following recommendations.

- Seats intended for ambulant disabled people should be dispersed throughout the stadium, and they should be specifically indentified by management.
- Because ambulant disabled people move with difficulty, such identified seats might best be located at the ends of rows, and close to vomitories.
- Some of these seats should be situated where there are few steps to negotiate, and where the seating rake is not more than 20º.
- In some cases an entire row of seats, appropriately located, could be designed to a higher standard of comfort for disabled spectators as suggested in Section 11.7.
- In all of the above, bear in mind that ambulant disabled spectators may prefer not to sit in areas primarily intended for wheelchair users and their helpers.

Standing accommodation versus seats

This question of seating versus standing accommodation has been so hotly debated, particularly for football matches in the UK as pointed out in Section 1.3.4, that a few paragraphs of comment are merited.

In theory it is possible to accommodate almost twice as many standing spectators per unit area than seated – about two spectators per square metre seated, versus about four standing. Or, if the minimum dimensions for seating given in the *Guide to Safety at Sports Grounds* (see Bibliography) be followed, about 3.1 spectators per square metre seated, versus a maximum of 4.7 standing, giving a ratio of approximately 2:3.

These figures make standing-room seem economically attractive. In fact this advantage is diminishing, because many amenities must be substantially increased for standing spectators. Once the additional numbers of toilets and catering outlets and the increased circulation, escape and safety barrier space are taken into account the cost per person may actually be greater for standing accommodation than for seated.

Leaving economics aside, the decision will be influenced by two main factors – customer expectations, and regulatory or legal requirements. As regards the customer there are strong traditions in favour of standing provision in some sports. Many sports fans are convinced that standing together on the terraces is essential to the spirit of watching the game; in horse-racing facilities it is traditional for over two-thirds of spectators to stand, and wander around, rather than sit on tiered seats. Establishing what kind of spectator will patronize a given stadium (in terms of socio-economic group and other relevant characteristics) is crucial to getting the whole philosophy of comfort, shelter and seat price right for that stadium, and no design should go forward until these matters have been fully clarified.

As regards the law, most authorities believe that the greater the proportion of seated spectators, the less likely it will be that there will be crowd problems, and this belief is influencing the regulatory trend. British football authorities decreed that existing football stadia in the premier league and the championship must be converted to all-seater stadia over a specified period during the 1990s and that no standing terraces be provided in new stadia for these more senior divisions. FIFA and UEFA regulations allow for no standing places in new stadia for national or international matches.

If on balance of all the above factors a decision in favour of standing accommodation seems indicated, it must be remembered that these areas may later need to be converted to seating, for instance if a football team gains promotion into a higher division when FIFA or UEFA standards would come into effect, or when national standards are upgraded to demand all-seating stadia. In Britain the Football Licensing Authority, which believes seating accommodation to be an inherently safer option than standing, recommends that new standing accommodation always be constructed so as to be easily converted to seating.

One way out of the dilemma may be a certain proportion of convertible areas. In Germany, for instance, it is quite common for stadia to be temporarily converted to all-seating for certain matches. While it is technically quite feasible to design stands for such convertibility from standing to seating and vice versa, it increases the capital cost.

One event type where standees are still being tolerated on a large scale is at concerts given in stadia, where the actual playing area is often used for spectators to sit or stand. Fans find their own way and decide for themselves where to take up position, many believing that this spontaneity is essential to the atmosphere of such events. This system is called ‘festival seating’ in the USA, but it is regarded by the authorities as unacceptable and dangerous because of the lack of control the organizers have over the positioning of the crowd. European practice is beginning to change and several countries now require the playing area to have securely fixed seats in place for a pop concert. The covering of the pitch in these circumstances is discussed in Chapter 7.

In conclusion, the present authors believe that instances remain where well-designed standing terraces are acceptable, especially in British football and in horse racing, but they accept that trends worldwide are undeniably towards all-seater stadia, mainly owing to the continual rise in customer expectations of comfort.

If standing areas are provided, then equality laws such as the UK’s Disability Discrimination Act 1995 may well lay down that disabled spectators are entitled to gain access to those areas. In the UK this principle is accepted, but as of 2006 there are no specific recommendations on the provision that should be made. For such guidance as does exist refer to para 2.23 of *Accessible Stadia* (see Bibliography).

11.2.3 Catchment area and past history of the site

In addition to the theoretical numbers laid down by regulation, as in Table 11.1, it is essential to look at the reality of the site itself. While FIFA might

Cost category (approx)	Stadium capacity	Typical seating configuration	Typical forms of structure, modes of access, etc.
Low:	Up to 10 000	10 to 15 rows in a single tier	Structure possibly ground bearing. Access direct from front of seating tier or from short stairs/ramps at rear. Support facilities beneath. Roof cantilever only about 10m, using light steel or concrete sections.
Medium:	10 000 to 20 000	15 to 20 rows in a single tier	
High:	20 000 to 50 000	Up to 50 rows total, disposed in 2 tiers	
Very high:	30 000 to 50 000	Over 50 rows total, in 3 or 4 tiers. 3rd or 4th tiers are usually introduced to overcome site restrictions, or to accommodate a plethora of VIP boxes and similar facilities, and not for increased capacity.	

Table 11.1 Typical cost categories in stadium construction

require a capacity of (say) 30 000 for certain football matches an analysis of the potential catchment area and, in the case of an existing site, an investigation of past attendances there, may show such a number of spectators to be highly unlikely. Realism must prevail.

11.2.4 Cost categories of stadium construction

Stadium capacity may be limited by the required cost of construction. The relationship between construction costs and seating capacities tends to fall into definite categories. If capacity can be kept below the next threshold, and an additional tier and/or structural complication avoided, it may be possible to avoid a disproportionate leap in costs. Table 11.1 summarizes, very notionally, four major categories of this kind (see also Chapter 23).

There are exceptions to this classification of seating capacities and costs. For instance, the Aztec stadium in Mexico (see Figure 11.4) accommodates over 100000 spectators on a single tier of seats surrounding the pitch; and the McMahon stadium at the University of Calgary in Alberta in Canada accommodates over 38000 people in two single-tier stands situated only on the sides of the pitch. Because they avoid second or third tiers both of these stadia undoubtedly have lower relative costs than one would expect, but at the expense of quite unreasonably great viewing distances. They are not examples to be followed uncritically.

11.2.5 Staged expansion

Once a minimum and a maximum number of seats for a particular stadium have been established by the above investigations, the client body may opt for a modest initial facility which can grow with the club.

In the case of an open stadium staged expansion is relatively simple. It becomes very difficult if the final stadium is to be entirely roofed (or ‘domed’ in American terminology). The problem is not the design or construction of the final phase in itself, but the fact that the initial stages, if too modest, may have to bear disproportionately heavy infrastructure, foundation and structure costs to allow for the future additions.

British roofed stadia which have been constructed in a phased manner, and which might be studied if such a development is envisaged, include those at Twickenham Rugby Football Ground in west London; Murrayfield rugby stadium in Edinburgh; the Galpharm stadium in Huddersfield, Yorkshire; and the old Arsenal football stadium in north London.

11.2.6 Extent of roof

Roofing is expensive and has a significant impact on the aesthetic impact of a stadium, but a percentage of roofed area is essential for spectator comfort in most climates. In some localities the roof must provide shelter against the sun, in others against rain, snow and perhaps wind. In some cases shelter will be needed against both at different times of the year.

For each stadium a careful investigation must therefore be made into the sports to be played, the seasons and time of day they may be played, and the local climate: see Sections 3.2 and 5.8. There may also be official regulations requiring a certain proportion of seats to be under cover, and the latest rules should be checked with the relevant governing bodies.

In practice, the seating sections of all new stadia currently being built in Britain and northern Europe are roofed, while the standing terraces are occasionally being left open. It is only in mild climates, such as parts of Australia and the USA, that new stadia are being built with uncovered seats.

11.3 Viewing distances

11.3.1 Optimum viewing distance

Calculation of maximum viewing distance is based on the fact that the human eye finds it difficult to perceive anything clearly that subtends an angle of less than about 0.4 degrees – particularly if the object is moving rapidly. In the case of a rugby ball, which is approximately 250 mm in diameter, or a football, the calculation sets the preferred viewing distance at no more than 150 m between the extreme corner of the field and spectator's eye, with an absolute maximum of 190 m. In the case of a tennis ball, which is only 75 mm in diameter, the preferred maximum distance reduces to around 30 m. Some guidance on viewing distances for various sports is given in *BS EN 13200-2003 Spectator facilities – Part 1: Layout criteria for spectator viewing area – specification* (see the Bibliography).

Setting out these distances from the extreme viewing positions, such as the diagonally opposed corners of a playing field, gives a preferred viewing zone and their average configuration suggests a circle struck from the centre spot on the field, generally referred to as the 'optimum viewing circle'. This circle in the case of football and rugby would have a radius of 90 m, and for other sports as in Figure 11.1.

11.3.2 Practical limitations

The simple circular plan areas developed above are only a starting point for laying out the viewing terraces and must be modified in several ways.

First, it must be admitted that some sports (such as hockey and cricket) are played with a small-diameter ball on a field so large that the size of the field makes it impossible to locate spectators within the theoretical viewing distance. In these cases one must face the fact that viewers will have to watch the players rather than the ball.

Second, the spectators are not sitting at ground level but are raised above the ground by as much as 20 or 30 m in a large stadium. In big stadia the effect of this elevation must be taken into account by calculating the direct distances from the elevated spectators to the centre of the field.

Third, spectators have preferred viewing locations for each particular sport, so that seats in some areas of the optimum viewing circle would be less satisfactory than others at the same distance from the game. This is discussed in the next section.

11.3.3 Preferred viewing locations

It is not always self-evident where viewers like to sit for particular sports. In the case of football, conventional wisdom holds that the best seats are on the long sides of the field, which give a good view of the ebb and flow of the game between the two opposing goal posts. But there is also a tradition for highly motivated team supporters to view the game from the short ends, behind the goal posts, where they get a good view of the side movements and line openings which present themselves to the opposing teams. To designers who do not understand these traditions it may seem ludicrous that a football supporter may insist on watching from behind the netting of the goal posts in crowded conditions when

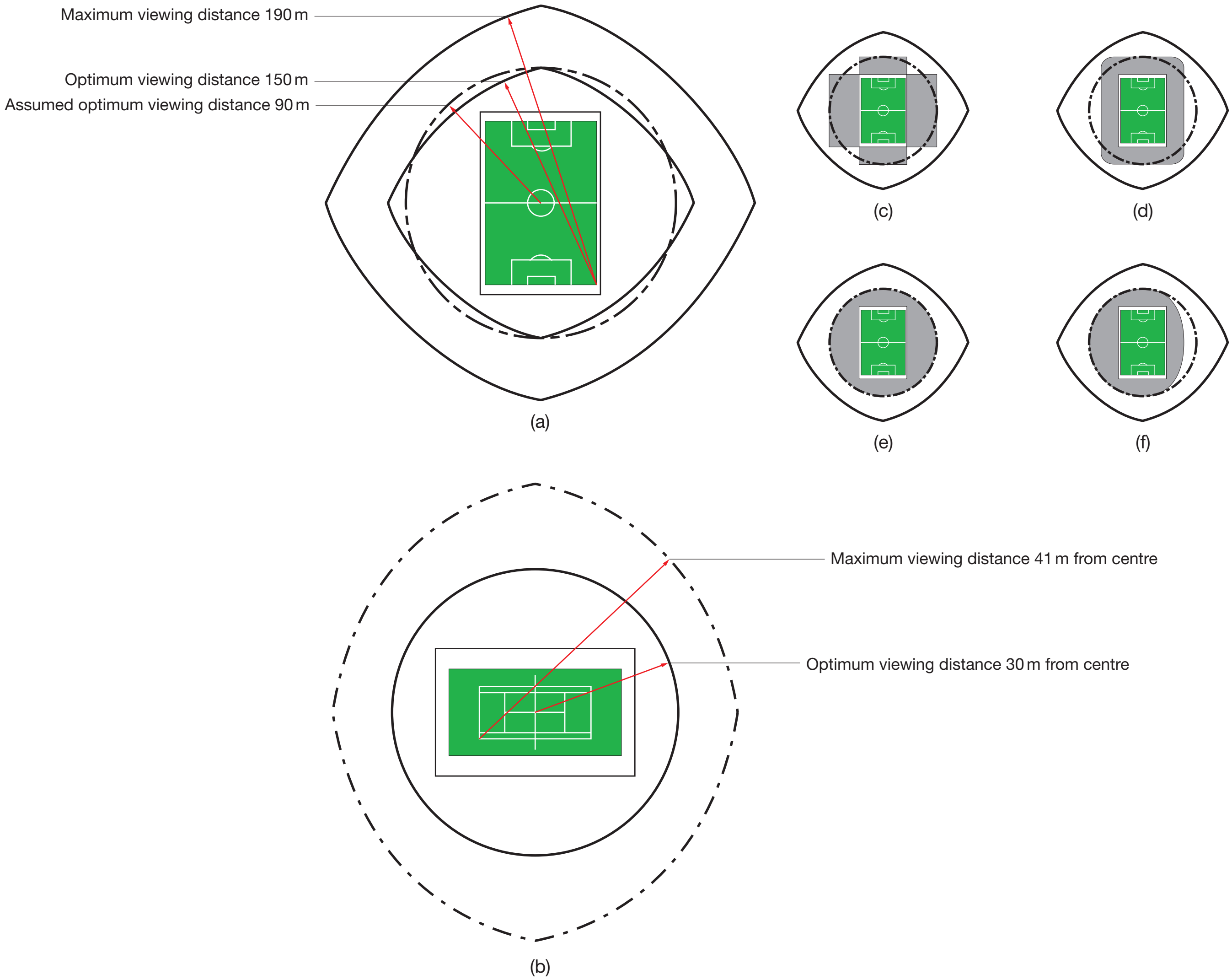


Figure 11.1 Relationship between playing field, optimum and maximum viewing distances and a deduced 'optimum viewing circle'. (a) For football and rugby the optimum viewing circle would have a radius of 90 m from the centre spot. (b) Dimensions for lawn tennis viewing. (c) Separate stands, leaving the potential seating space at the corners unexploited, have traditionally been common. (d) This arrangement brings more spectators within the optimum viewing circle and also offers the possibility of a more attractive stadium design (see Section 6.2.4 of this book). (e) A variation of (c) with the seating areas extending to the limit of the optimum viewing circle, but not beyond it. This type of layout gives an excellent spectator/player relationship. (f) A variation of (d) with only the seating area to the west of the playing field extended back to the limit of the optimum viewing circle. With this layout the majority of spectators have their backs to the sun during an afternoon game.

there is ample space available on the long sides. But such preferences exist, and the design team must identify them for the stadium under consideration, and suitably modify the 'optimum viewing circle' to locate the maximum density of spectators in their preferred positions.

Figure 11.2 shows preferred viewing positions for various sports; and Figures 11.3 to 11.9 analyse some well-known existing stadia.

11.3.4 Exploiting the corners

A decision must be made whether to place four rectangular stands on the four sides of the field with open corners (Figure 11.1c) or whether to surround the pitch with a continuous 'bowl' stadium (Figure 11.1d).

Leaving the corners open is cheaper in construction costs and may in some cases benefit a natural grass pitch by promoting better circulation of air and quicker drying of the grass. But it also sacrifices

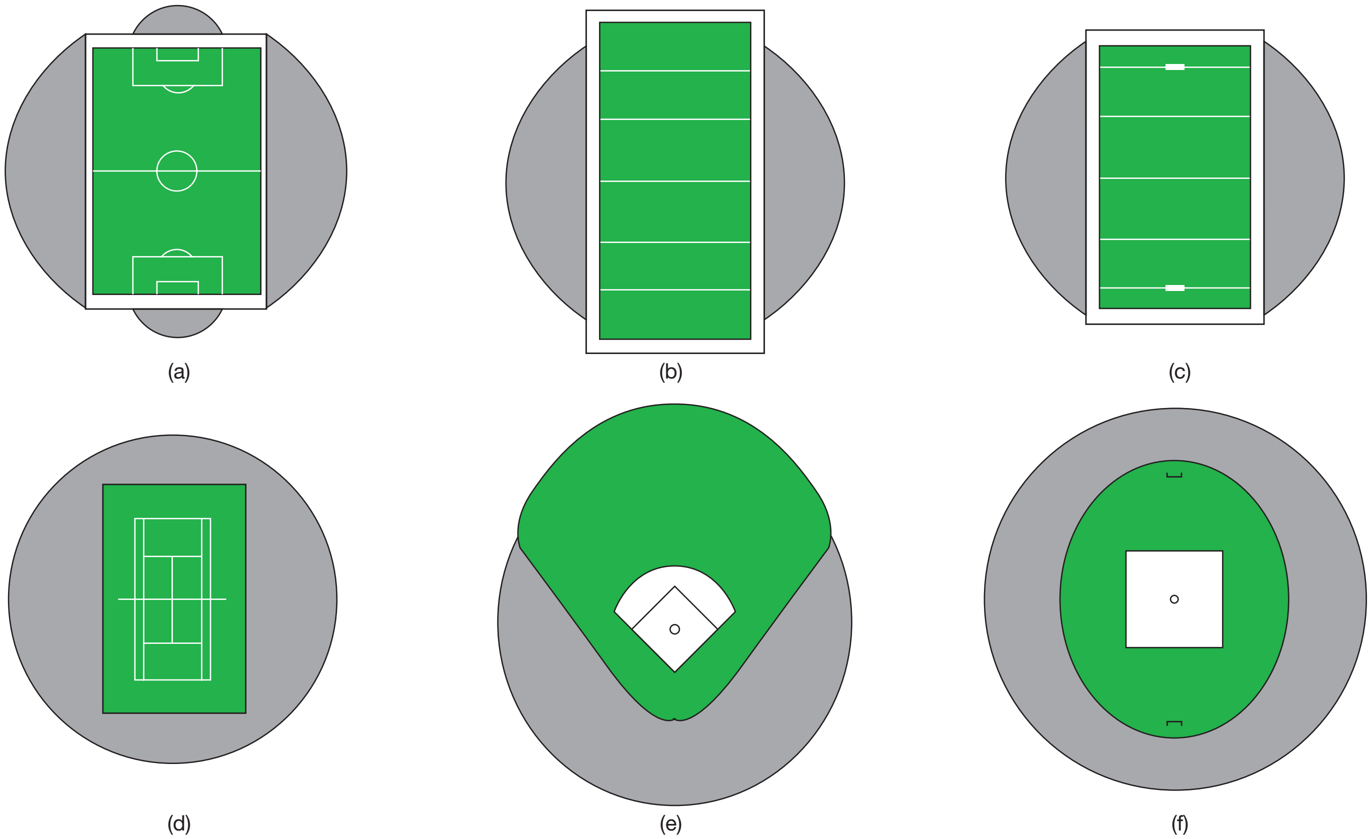


Figure 11.2 Preferred viewing positions for some principal sports. (a) Football; (b) American football; (c) rugby league; (d) lawn tennis; (e) baseball; (f) Australian Rules football.

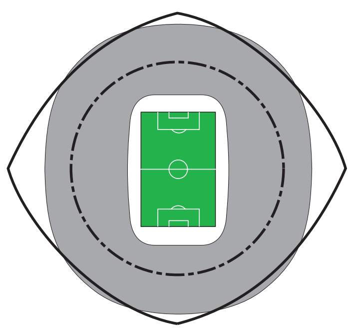


Figure 11.3 Wembley Stadium, London (see also Appendix 3). The new stadium with 90 000 capacity for football or rugby, and the ability to include an athletics track, has a few seats outside the maximum viewing distance line.

valuable viewing space, and the trend is towards fully exploiting the area within the maximum viewing distance as shown in Figure 11.1e. A continuous 'bowl' stadium may offer more comfortable conditions for spectators and players than an open-corner layout, as mentioned in Section 5.8, and may look better than four separate stands meeting awkwardly at the corners (see Section 5.2.4).

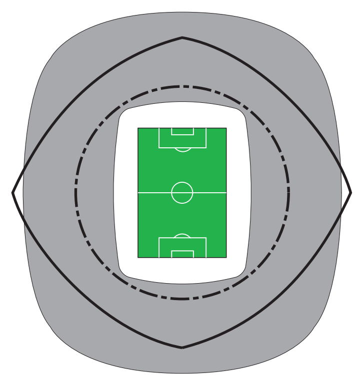


Figure 11.4 Aztec Stadium, Mexico City, built in 1966 exclusively for football. The layout is of the type shown in Figure 10.1d but far too large for satisfactory viewing: most of the 105 000 seats on the single-tier terrace are outside the optimum viewing circle and very many are beyond the maximum viewing distance.

Corners can also offer a good view for some disabled supporters as some wheelchair users cannot lean forwards or sideways in their seats or turn their heads like non disabled supporters.

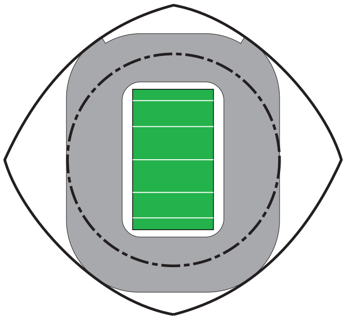


Figure 11.5 The Millennium Stadium, Cardiff (see also Appendix 3). With three tiers and a capacity for rugby of approximately 72 000, all spectators are inside the maximum viewing distance line.

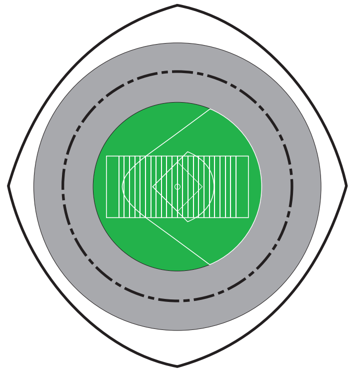


Figure 11.7 A completely circular stadium in the District of Columbia, USA, for American football and baseball. Spectator distances for football are acceptable but those for baseball too great, demonstrating the difficulty of providing for both sports in the same facility.

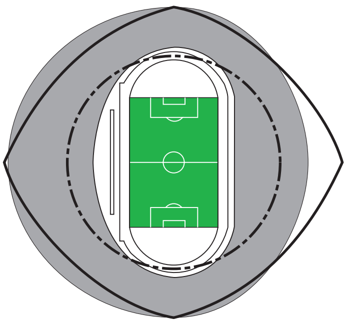


Figure 11.6 The Olympic Stadium built for the 1972 Olympics at Munich and designed primarily for athletic events. The seating geometry is closer to a circle than those above, and is asymmetrical to accommodate most of the 80 000 spectators to the south of the playing field. The arena is so large that virtually all spectators are pushed beyond the optimum viewing circle, but the outer perimeter of the seating areas is kept mostly within the maximum viewing distance. The depth of seating is at a maximum along the sprint lines and finish line.

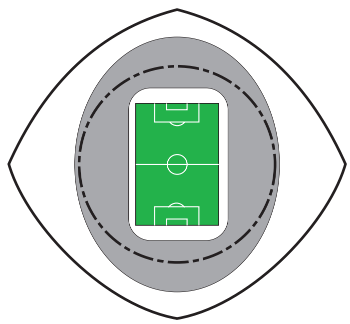


Figure 11.8 Emirates football stadium in London, UK (see also Appendix 3).

11.3.5 Designing for multi-use stadia

Multi-use stadia make sense financially, but they do not necessarily offer the spectator the quality of viewing he would like. Each particular sporting type has its own ideal viewing distances and seat positions, and while it may be possible to satisfy these in a stadium dedicated to one particular kind of sport it becomes much more difficult in a facility that must accommodate different sports with different characteristics. Examples of compatibility and incompatibility include the following:

- Football and rugby are broadly compatible. The playing fields are somewhat different in size but

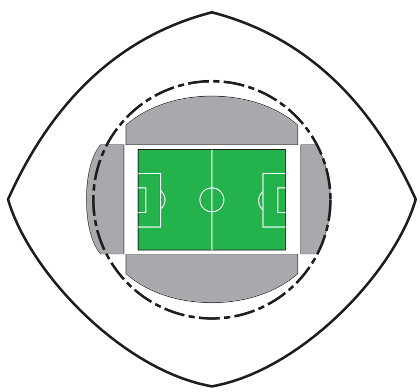


Figure 11.9 The Sir Alfred McAlpine (now Galpharm) football and rugby stadium at Huddersfield, UK, has a capacity of 25 000 in four stands allowing excellent sightlines and accommodating everyone within the optimum viewing circle.

both are rectangular, and while preferred spectator locations are not identical (Figure 7.2) the differences are quite small.

- Football and athletics are much less compatible. Even though these sports are frequently accommodated in the same stadium, especially on the continent of Europe, this is at great cost to viewing quality. Placing an athletics track around the perimeter of a football field has the effect of pushing football fans so far away from the pitch that their sense of involvement with the game suffers.
- American football and baseball (the two great national spectator sports in the USA) are not happily compatible. For reasons of cost they have sometimes been accommodated in the same stadium, but the shapes of the football rectangle and the baseball diamond are so different that viewing conditions for many spectators must be disappointing.

These matters are more fully discussed in Chapter 8.

11.3.6 Conclusion

It must be clearly decided at briefing stage which sports are to be accommodated, at what seating capacities, and the precise degree to which optimum viewing standards may be compromised in pursuit of these aims. Failure to settle these issues at an early stage could lead to a very unsatisfactory stadium.

11.4 Viewing angles and sightlines

We have now evolved a schematic diagram of the proposed viewing areas which hopefully satisfies three criteria:

- The spectator areas are large enough to accommodate the required number of viewers.
- All spectators are as close to the action as possible, and maximum viewing distances have been kept within defined limits.
- Most spectators (including those who are disabled) are located in their preferred viewing positions in relation to the playing field.

The next step is to convert these diagrammatic plans into three-dimensional stand designs with satisfactory 'sightlines'.

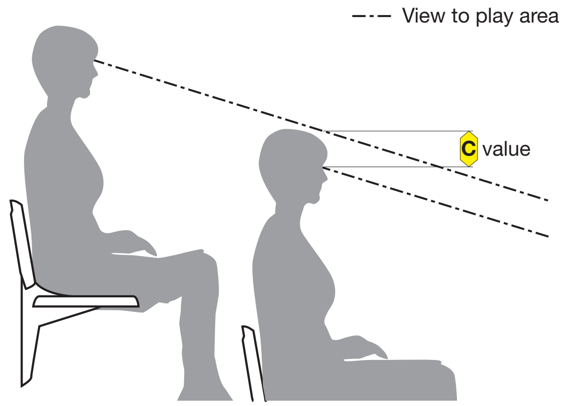


Figure 11.10 The term 'sightline' refers to a spectator's ability to see a critical point on the playing field over the head of the spectator below, and is measured by the '*C*' value.

The term 'sightline' does not refer to the distance between spectator and pitch, though non-technical commentators may loosely use it in this way; it refers to the spectator's ability to see the nearest point of interest on the playing field (the 'point of focus') comfortably over the heads of the people in front. In other words it refers to a height (Figure 11.10), not a distance.

A worked example showing the calculation of N, the riser height is given below:

$$N = \frac{(R+C)\times(D+T)}{D} - R$$

where: N = riser height;
R = height between eye on 'point of focus' on the playing field;
D = distance from eye to 'point of focus' on the playing field;
C = 'C' value;[1]
T = depth of seating row.

If we analyse a spectator position where $R = 6.5$ m, $D = 18$ m, $T = 0.8$ m and we want a 'C' value of 120 mm, then the height of the riser must be:

$$N = \frac{(6.5+0.12)\times(18+0.8)}{18} - 6.5$$

$$N = \frac{6.512\times 18.8}{18} - 6.5$$

$$N = 6.8014 - 6.5$$

$$N = 0.3014\text{ m.}$$

[1] 'C' value = 150 mm spectators with hats; 120 mm good viewing standard; 90 mm head tilted backwards; 60 mm between heads in front

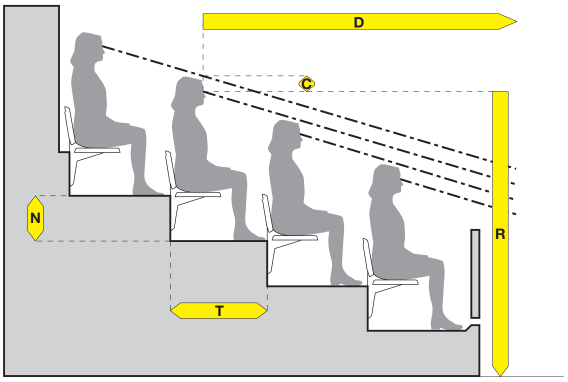


Figure 11.11 Viewing angle. *D* = distance to focus, *C* = '*C*' value, *T* = tread width, *N* = riser height and *R* = riser height from focus.

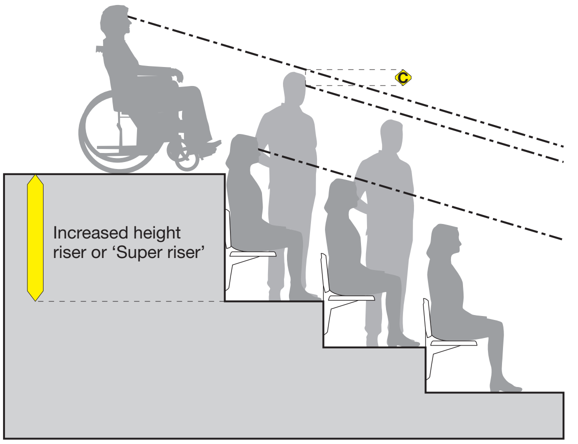


Figure 11.12 Use of a 'super riser' to ensure that spectators in wheelchairs can see over the heads of spectators in front of them, even when the latter rise to their feet.

In principle the calculation method is simple, but in real design it becomes cumbersome because the angle must be calculated many times over for each individual row in a stadium (Figure 11.11). This is because the optimum viewing angle varies with both the height of the spectator's eye above pitch level and its distance from the pitch; and every time either of these factors changes for a particular row of seats the computation described above must be repeated.

C values for wheelchair users

In the UK, para 2.17 of *Accessible Stadia* (see Bibliography) recommends that wheelchair users should be able to enjoy the same C value as other spectators – say 90 mm – even when the spectators sitting immediately in front of them rise to their feet, as tends to happen at exciting moments. This provision, which results from the requirement of para 19 of the UK's Disability Discrimination Act 1995 (visit www.opsi.gov.uk/acts.htm and www.drc-gb.org/) that disabled spectators should not be treated less favourably than others, can be met by the use of a 'super riser' as shown in Figure 11.12.

In the USA, para 802 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (visit www.access-board.gov/ada-aba/final.htm) makes a broadly similar point, but it is somewhat less demanding and is regarded by some as clearer and more logical than the UK provision above.

In other countries less stringent criteria may apply, a matter that should be checked with local rule-making bodies.

11.4.1 Use of computer calculations

Possibly because the calculations are so complex, or because some designers are reluctant to have the clean geometry of their architectural concepts degraded by real-life considerations, several recently-built stadia have failed in this respect. One of the Italian venues for the World Cup in 1990 was found after construction to have such inadequate sightlines that remedial action had to be undertaken immediately, with only partial success. The designers of a Bristol stand were sued by the sports club because of inadequate sightlines for the new facility.

Given the vital importance of getting these sightlines right, it is strongly recommended that computer analysis, using tried and tested programs, be applied to the task. Professional practices specializing in sports stadium design have generally developed their own computer programs which not only carry out all the necessary calculations, but can also generate drawings of the result. Many options can therefore be tried out, with a precise stand profile produced within a matter of seconds.

11.4.2 Calculation method

The method for carrying out such a calculation is described in Section 11.4; the vital steps in the decision-process are set out below:

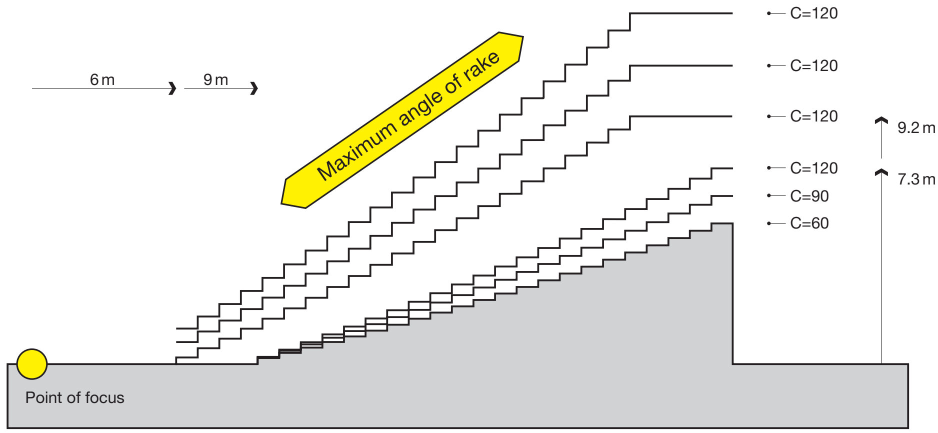


Figure 11.13 Quality of vision is improved by increasing the heights of seats above pitch level; and by bringing the seats closer to the pitch (point of focus).

1 Decide the 'point of focus' on the playing field.
In deciding the 'point of focus', choose the part of the playing field actually in use by the players that is closest to the spectators, as this will be the most onerous condition for the design.

2 Decide a suitable 'C' value.
'*C*' value is the assumed distance between the sightline to the playing area (or activity area), and the centre of the eye of the spectator below (Figure 11.10). In general 150 mm would be an excellent design value, 120 mm very good, and 90 mm reasonable. 60 mm is generally regarded as an absolute minimum for most situations, with spectators able to see mostly between the heads of the people in front or by craning their necks. For new design a '*C*' value of 90 mm is an ideal minimum.

But choice of a suitable figure is affected by several factors. For instance, when the '*C*' value is too small for good viewing spectators can improve their line of sight over the heads of those in front simply by tilting their heads back, thus raising their eye level. If this needs to be done only occasionally spectators may be happy; but they would resist having to do it all the time, especially for events of long duration (see Table 12.1), and especially in the more expensive seats.

Choosing a low value such as 90mm or even 60mm makes for easier stand design (Figure 11.13), and in the case of large stadia these may be the maximum feasible values if an excessively steep seating angle is to be avoided; but in the case of sports where the action moves widely across the field, or where the spectators in front are regularly expected to wear hats, such a value would make for unsatisfactory viewing.

Conversely, choosing a high value such as 120 mm would give excellent viewing, but make for steeply raked stands and create great design difficulties in large-capacity or multi-tier stadia, particularly in the more distant rows.

Choosing the '*C*' value is therefore a matter of judgement rather than incontrovertible fact, and judging it right is absolutely vital to the success of the stadium. Some guidance on recommended *C* values for various sports is given in *BS EN 13200-2003 Spectator facilities – Part 1: Layout criteria for spectator viewing area – specification* (see Bibliography), and this document generally recommends 120 mm as a good value and 90 mm as an acceptable value.

Whatever value is chosen, it is imperative that spectators have a clear view of the whole of the playing area (or activity area) and are not encouraged to stand because of low *C* values or inadequate sightlines.

3 Decide the distance between the front row of seats and the point of focus.
The greater this distance, the shallower can be the rake of the stand, and the lower the back rows, all of which are advantageous factors (Figure 11.14). However, site restrictions may well dictate a tight spacing, in which case a steeply raked stadium becomes inevitable.

4 Decide the level of the front row of seats relative to the playing field.
The higher these seats are raised above playing field level, the better viewing standards will be, but the steeper the rake will be (Figure 11.15). The chosen method of separating the crowd from the playing

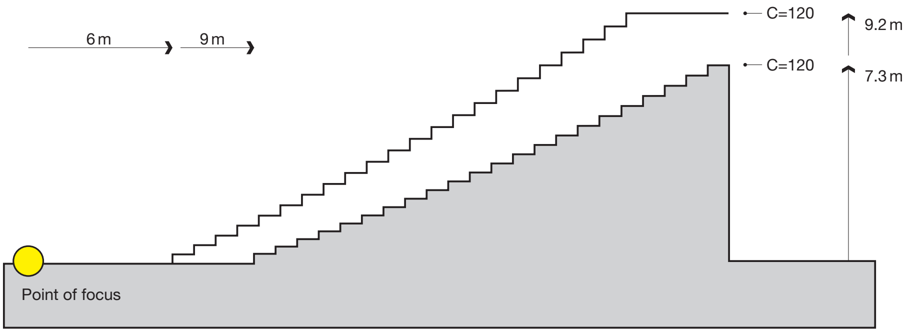


Figure 11.14 The closer the first row of seats is to the point of focus, the steeper the rake will be, and the higher the back of the stand for a given '*C*' value.

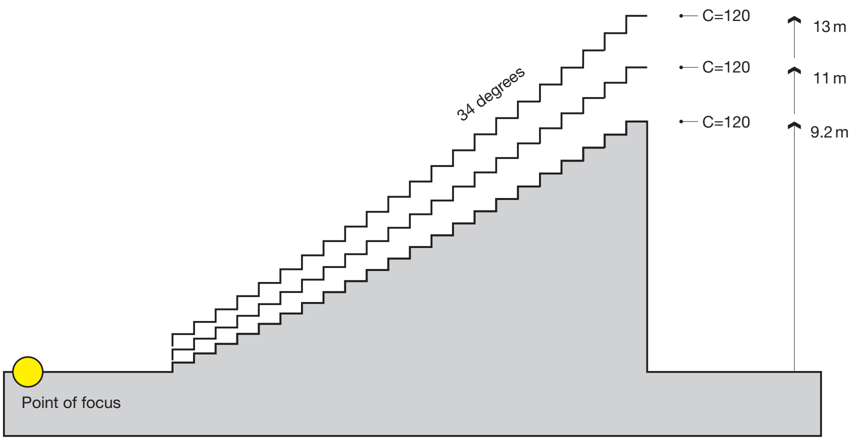


Figure 11.15 The higher the first row of seats above pitch level, the better viewing standards will be, but also the back of the stand will be higher. This may cause problems of building cost and of appearance, and may obstruct access of sunlight to a grass pitch.

field (fence, moat or change of level, as discussed in Chapter 9) will influence this decision. It is recommended that eye height above the pitch should not be less than 800 mm, with 700 mm as an absolute minimum.

11.4.3 Final design

By juggling all the above factors against each other (Figures 11.16 and 11.17), and against site constraints and construction costs, a theoretical stadium geometry will emerge. Some tests that must be carried out on the hypothetical profile are the following.

Angle of rake

Choosing a stadium profile that minimizes the distance between spectators and playing field may give a rake that is too steep for comfort or safety. It is generally accepted that an angle of rake steeper than 34 degrees (approximately the angle of a stair) is uncomfortable and induces a sense of vertigo in some people as they descend the gangways, even if regulations in some countries do allow steeper angles. In Britain the *Guide to Safety at Sports Grounds* (see Bibliography), also known as the '*Green Guide*', recommends a maximum angle of 34 degrees. In Italy up to 41 degrees is allowed, but this extremely steep rake is usually found only towards the backs of the upper tiers. Handrails are then provided in front of each row of seats for safety and to counteract the sense of vertigo.

Not all countries have specific regulations, but in all cases the local codes of practice and legislation must be checked. Where no specific regulations exist the angle of rake will normally be determined by staircase regulations.

Varying riser heights

The calculated rake for a deep stadium will not be a constant angle, but a curve (Figure 11.18), with each successive riser one or two millimetres greater than the one in front. The building process tends to favour standardization, and constructing a stand in this way could be more expensive than straight tiers. Therefore it is customary to divide tiers into facets which provide optimum viewing angles while reducing the variety of riser heights. In Europe and North America, where precision in pre-cast concrete work is relatively easily obtained, the changes in stepping

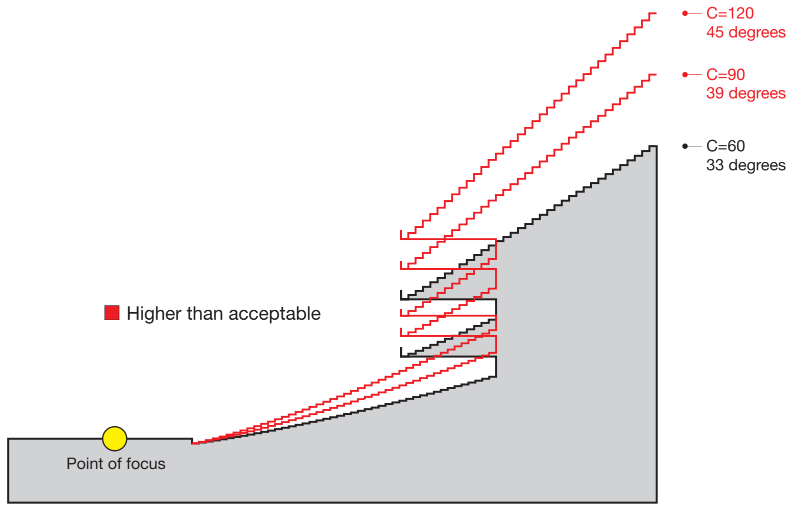


Figure 11.16 One example of the varying results obtained by juggling the factors identified in the foregoing figure.

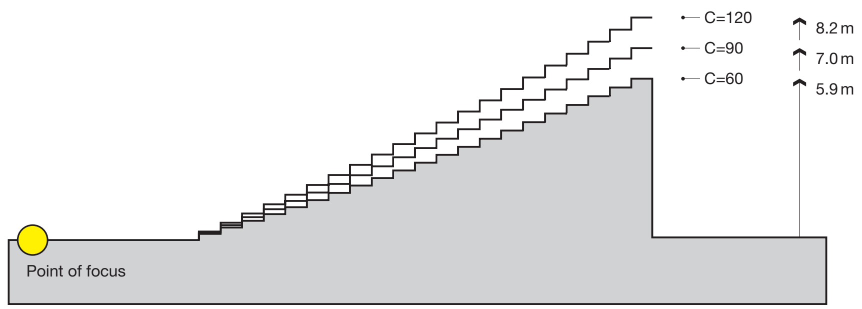


Figure 11.17 The effect of changing '*C*' values on the angle of rake.

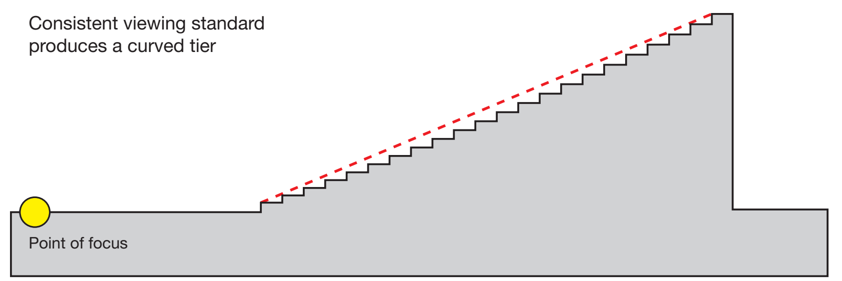


Figure 11.18 The riser heights required to maintain a specified '*C*' value in each row of a tier will not be constant, but will vary from each row to the next. In practice such a curved profile will be built as a series of facets which strike a balance between optimum viewing angles and standardization of construction.

heights could be as little as 10 to 15 mm. In regions with less sophisticated technologies it would be wise to increase the stepping differences to 20 or 25 mm.

When varying seating tier heights cause stair risers also to vary, there might be a conflict with the local building regulations, which sometimes prohibit variations in stair riser heights. This should be checked. In England and Wales the most recent regulations take note of the situation, and waivers are usually obtainable.

When the general design has been completed the view from each seat can be checked by creating a computer image of the playing field from the eye position. If tickets are being sold in advance such images can also be used to inform potential purchasers of what they will see from any given seat.

11.5 Obstructions to viewing

This factor is more critical for some sports than others. In motor or horse racing, a few columns in front of the spectators may be acceptable because the cars or horses are large objects whose movement past the columns is easily tracked. In tennis, by contrast, the repeated invisibility of a small-diameter ball as it speeds to and fro behind an obstructive column would be intolerable. The structural aspects of column-free roof design are discussed in Section 5.8.

12. Spectator seating

12.1 Basic decisions
12.2 Seat types
12.3 Seat materials, finishes and colours
12.4 Choice
12.5 Dimensions
12.6 Seat fixings
12.7 Seating for spectators with disabilities

12.1 Basic decisions

Having arrived at a geometry which relates the spectator areas to the playing field so that the spectators can see the action clearly and without having to crane their necks, the next design task is the seats themselves. Seating design is a matter of reconciling four major factors: comfort, safety, robustness and economy.

12.1.1 Comfort

The degree of comfort required depends partly on the seating time for that particular sport, as shown in Table 12.1. The longer the spectator must sit in one position the more comfortable the seats must be. Comfort costs money, but it also helps attract the customers without whose support the stadium cannot succeed. No easy rules can be given for the trade-off between comfort and cost that must be undertaken in each stadium design, except to say that the worldwide trend is towards higher comfort rather than lower cost.

12.1.2 Safety

From the viewpoint of crowd behaviour there are opposing arguments concerning the safety of seating types.

Event	Seating time
American football	3 to 4 hours
Athletics	3 to 5 hours; sometimes all day (e.g. Olympic events)
Australian Rules football	1.5 to 2 hours
Baseball	3 to 4 hours
Cricket	8 hours a day, perhaps for several days in a row
Football	1.5 to 2 hours
Gaelic football	2 hours
Lawn tennis	2 to 3 hours
Pop concerts	3 hours or more
Rugby	1.5 to 2 hours
Rugby 7-a-side	8 hours

Table 12.1 Seating times for various types of events

The common view is that tip-up seats make for greatest safety because they provide a wider ‘seatway’ or ‘clearway’ (Figure 12.1) than other types, thus making it easier for the public, police, stewards, or first-aid personnel to pass along the rows during an emergency. Against this, some critics argue that

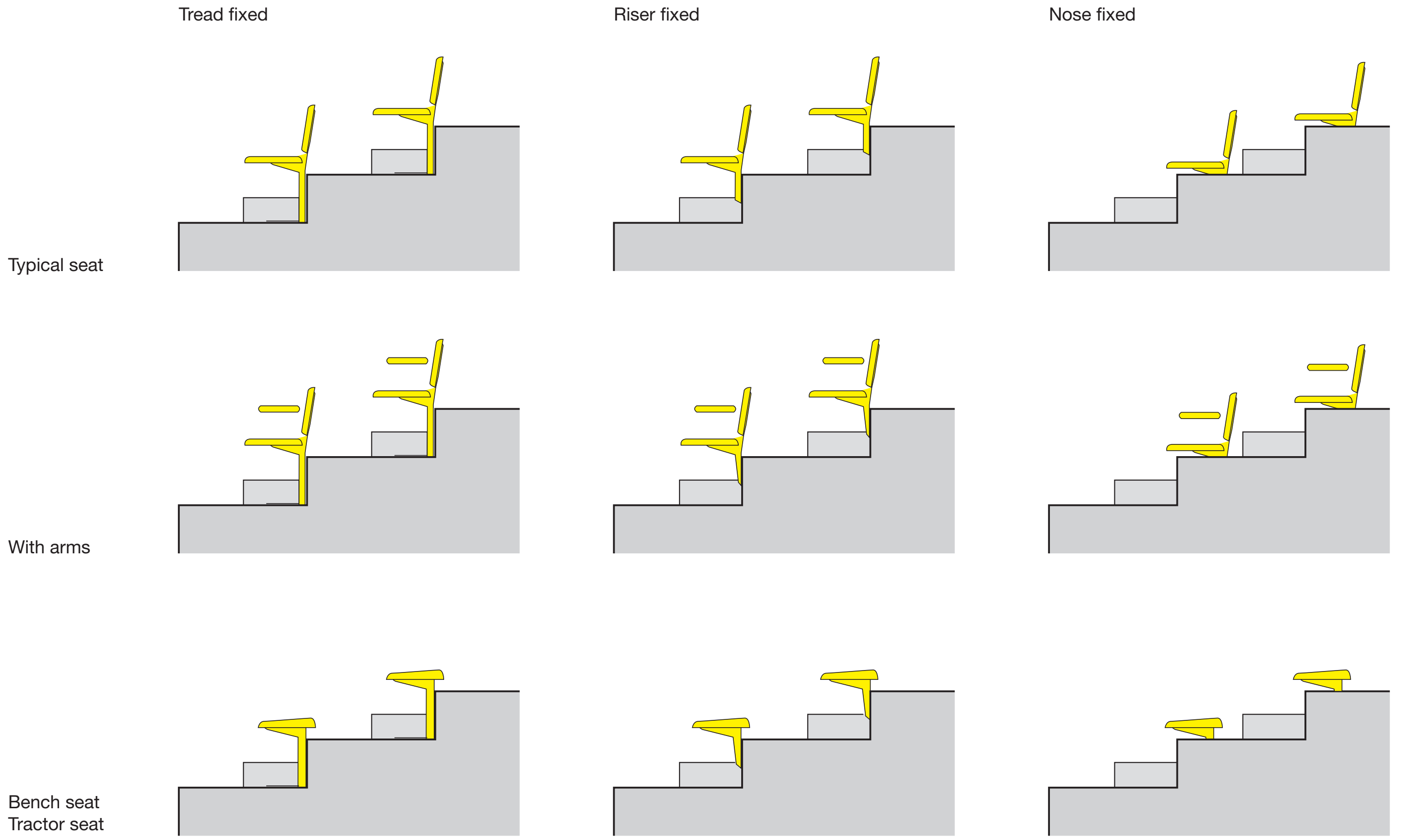


Figure 12.1 There are many seating variations but the plastic tip-up type, either riser-fixed or tread-fixed, is the most common.

bench (i.e. backless) seats are safer because spectators can step over them during an emergency, but this argument seems lost.

Seats with backs provide greater comfort and are generally the norm in modern stadia. But in view of the preceding comments, design teams should investigate carefully the kinds of events and the types of crowds involved before finally deciding seat types.

For fire safety (i.e. the combustibility of the seat material) see Section 12.4.3 below.

12.1.3 Robustness

Two principal questions will help decide how robust seats need to be:

- Are the spectators in the particular stadium likely to behave destructively, for example stand on seats, climb over them, or jam their boots against the seat in front while watching a game?
- Are the seats to be under cover and protected from sun and rain, and will they be regularly maintained and cleaned?

A careful evaluation of these factors will influence choice of seat, frame and fixings as described in Section 12.5 below.

12.1.4 Economy

The very cheapest seating type, usually wood or aluminium slats on a concrete plinth, will seldom be acceptable in major new stadia (Figure 12.1). Apart from customer unwillingness to sit on such an uncomfortable surface for any length of time, this primitive arrangement will probably be unacceptable to regulators.

So the cheapest realistic option will be moulded metal or plastic 'multiple seats' fixed directly on to the concrete terraces, and the most expensive will be upholstered tip-up seats with armrests.

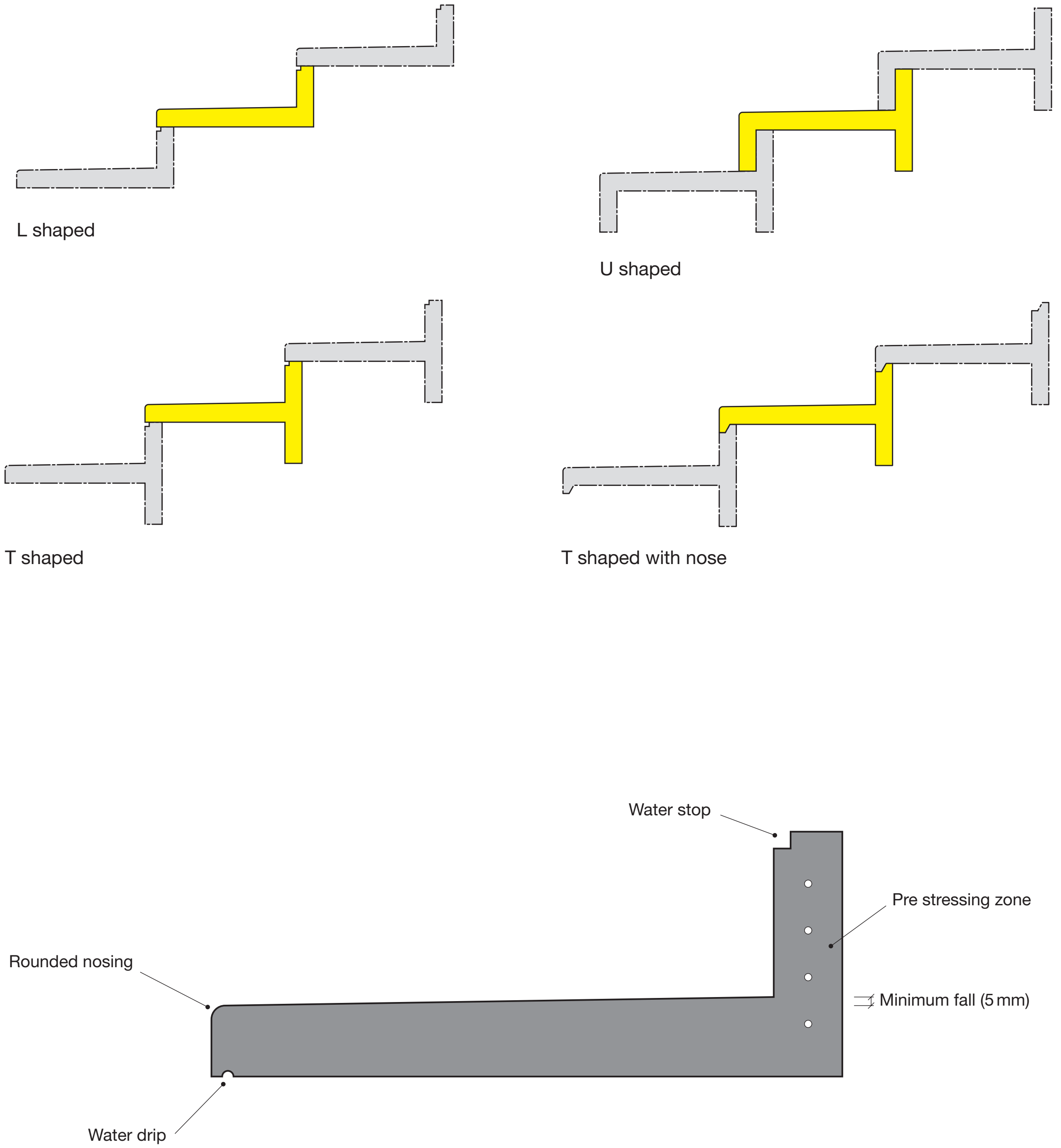


Figure 12.2 Typical pre-cast concrete steppings.

12.2 Seat types

The following examination starts at the cheapest end of the market and describes the various types of seat in rising order of cost and comfort.

12.2.1 Bench seats

Modern bench seats consist of lengths of moulded metal or plastic with individual seat indents, and are usually fixed to the concrete terrace by means of a metal underframe to give the correct height. They are cheap and robust and take up less space than any other kind, the minimum 'seating row depth' as recommended by the British Association of Spectator Equipment Suppliers (BASES) being 700 mm, but see also Table 12.2. However these seats are not comfortable and should be used only in the cheapest admission areas, if at all. If they are used corrosion and decay prevention must be very carefully considered.

Country	Seats			Seating areas	Standing areas
	Maximum number of seats per row	Minimum seat dimensions		People per m^2 (maximum)	People per m^2 (maximum)
		Width (mm)	Depth (mm)		
England*	28 seats	460 500 with armrests 500 recommended	700 minimum 760 recommended	3	4.7 (current standard)
(FSADC Guidelines)	28 seats	450	760		
USA	22 seats	450	762 (with back)		
		450	559 (seat only)		
Germany	72 seats	500	800	2.5	5
Austria	30m bench length	450	750	3	5
Italy	40 seats	450	600	3.7	
Switzerland	40 seats	450	750	3	5
Norway/ Sweden	40 seats	500	800	2.5	5
Netherlands	15m bench length	500	800		

Note: The above figures must be verified before use, as standards are constantly being revised.
* Data from *Guide to Safety at Sports Grounds* (see Bibliography).

Table 12.2 Dimensional standards for seats and standing areas

BS EN 13200-2003 Spectator facilities – Part 1: Layout criteria for spectator viewing area – specification (see Bibliography) suggests a minimum seating row depth of 700 mm and a recommended seating row depth of 800 mm.

12.2.2 One-piece seats without backs

These are much like the type above, but supplied as individual seats. They are also known as 'tractor' seats.

12.2.3 Bucket seats with backs

These are generally similar to tractor seats, sharing the advantages of low cost and easy cleaning, but they are more comfortable. However, they have the disadvantage of requiring much more space than any other seat type except for fixed seats with backs. Minimum 'seating row depth' is recommended by BASES at 900mm, compared with 700mm for bench or backless seats, and 760mm for tip-up seats, these figures to be read in conjunction with Table 12.2.

12.2.4 Tip-up seats

These cost more than any of the above types, and are less robust, but they are rapidly becoming the most widely-used seating type in stadia (Figure 12.3). They are comfortable, and even if non-upholstered when first installed they can be upgraded later. Tipping up the seat allows easy passage of spectators, police, stewards or first-aid assistants, making for greater safety, and it also facilitates cleaning around and beneath the seat.

It is recommended that the seat should be counterweighted (or perhaps sprung) to tip up automatically when not in use; and that moving parts should not have metal-to-metal contact, so that the pivoting action is not degraded by corrosion.

Minimum seat width is stated by para 11.11 of the *Guide to Safety at Sports Grounds* (see Bibliography), also known as the *Green Guide*, to be 460 mm without arms, or 500 mm with arms. However, for comfort and accessibility the Guide recommends a minimum width of 500 mm for all seats. The

Figure 12.3 Tip-up seats can cost more than other types, and can be less robust, but they are becoming the norm.

present authors believe that 465 mm is a reasonable minimum seat width without arms, and 500 mm an acceptable minimum with arms. Minimum 'seating row depth' is recommended by BASES at 760 mm; but see also Table 11.2. The authors endorse this 760 mm as a minimum, with a recommended 800 mm.

The *Guide to Safety at Sport Grounds* states that for new construction the minimum seating row depth should be 700 mm; for comfort and accessibility it recommends at least 760 mm. *BS EN 13200-2003 Spectator facilities – Part 1: Layout criteria for spectator viewing area – specification* suggests a minimum seating row depth of 700 mm, and a recommended minimum seating row depth of 800 mm. The latter also suggest a minimum width of 450 mm with a recommended minimum of 500 mm.

12.2.5 Retractable and movable seats

Retractable or temporary demountable seats are quite widely used in North America to allow stadia to be adapted to a variety of purposes. Details are given in Section 8 of this book, but it should be noted here that if such seats are used they should not interfere with the sightlines or otherwise reduce the viewing standards of the fixed seating tiers.

12.2.6 New trends in seat design

In addition to a trend towards greater comfort, seats in more expensive areas of sports grounds are incorporating holders for cups of drinks, match programmes, and rentable binoculars. Seats are now available that follow on from airline seat designs by incorporating electronic communications in a handset to allow spectators to order food or drink, place a bet, or even watch an event on a screen. We see plenty of opportunity for further development of systems of this type – see for example the illustration in Chapter 2.

12.3 Seat materials, finishes and colours

12.3.1 Materials

Seating materials must be weather-resistant, robust and comfortable. They may include aluminium and certain timbers, but the most popular materials nowadays are plastics – polypropylene (the most widely used), polyethylene, nylon, PVC or glass reinforced plastic. These are easily mouldable to comfortable shapes, and many colours are available (Table 12.3).

Support framing is usually metal (fabricated mild steel or, at a higher price, cast aluminium) but moulded plastic frames are beginning to appear, and combined all-plastic seats and frames. It is too early to comment on the performance of the latter.

12.3.2 Finishes

The plastic seats themselves are self-finished, but their metal frames must receive an applied finish to give adequate life expectancy. We believe that the useful life of a seat assembly should be expected to be approximately 20 years in most cases, though some forms will last longer than others.

As to specific types of finish, an electrostatically coated nylon powder finish is acceptable only where seats are sheltered from the elements; hot-dip galvanizing (in the UK to British Standard 729) is suitable for seat frames exposed to the weather; while the best protection of all is probably given by electrostatically coated nylon powder on grit-blasted,

	UV Polypropylene	UV/Fire Retardancy Polypropylene	UV High Density Polyethylene	Polyamide (Nylon)	PVC Compound	G.R.P.
Raw material cost factor	1.0	1.4	1.2	3.2	1.8	Approx. 7.0
Availability	Readily available	Limited	Readily	Limited available	Limited	Limited
Colour range	Very good	Good	Very good	Limited	Limited	Very good
Volume manufacture	Very good	Good	Very good	Good	Good	Very poor
Flame retardancy to BS 5852	Ignition Source 0	Ignition Source 7	Ignition Source 0	Self-extinguishes	Self-extinguishes	Self-extinguishes
Reaction to low temperatures (−5°C)	Brittle	Brittle	Very good	Very good	Very good	Very good
Reaction to high temperatures (+50°C)	Very good	Very good	Good	Very good	Very good	Very good
Reclamation and recycling	Easy	Moderate	Easy	Moderate	Specialized	None
Weatherability	Good	Good	Good	Very good	Very good	Very good
Deformation	Recovers	Recovers	Poor	N/A	N/A	N/A
Number of years in production	27	04	20+	19	01	25+

Note: The 'raw material cost factor' does not necessarily reflect the unit cost to the buyer and is given only as background information. This table is published with permission of the Football Stadia Advisory Council.

Table 12.3 Properties of the major plastics used for seat manufacture

hot-dip galvanizing. This is more expensive than the other types mentioned but provided it is applied effectively, with the nylon not peeling off should its surface be broken, the nylon coating gives added protection against acid rain, salt and heavy impact.

12.3.3 Flammability

Fire retardance is a vital factor in stadium safety, and the latest legislation or regulations must be consulted before specifying seats.

In the UK the minimum standard of fire retardancy at time of writing is Ignition Source 0 of British Standard 5852 Part 1. Seats are available to the higher standard of Ignition Source 5, of Part 2, but currently in fewer colours, and at a higher price, than the less resistant materials. The use of additives in the plastic to give greater fire retardance is in any case controversial, because when the material ultimately does burn it may produce toxic fumes.

Some authorities argue that the design of the seat is as important in fire safety as the material, and that factors such as the use of double-skin forms which avoid thin, easily ignitable edges should be taken into account when specifying seats.

12.3.4 Colours

Colours are important and can assist the management of the stadium to build colour coded blocks into the seating pattern and match that pattern to the ticketing system. The colour of the seat is also a major factor in the ambience of the stadium when it is partially empty. An alternative approach is to use a varied pattern of colours giving the effect of a number of seated people (see Figure 12.4).

This helps to reduce the feeling of emptiness when there are only a few spectators. Some colours perform better by maintaining their colour thus reducing the effects of brittleness caused by ultraviolet rays

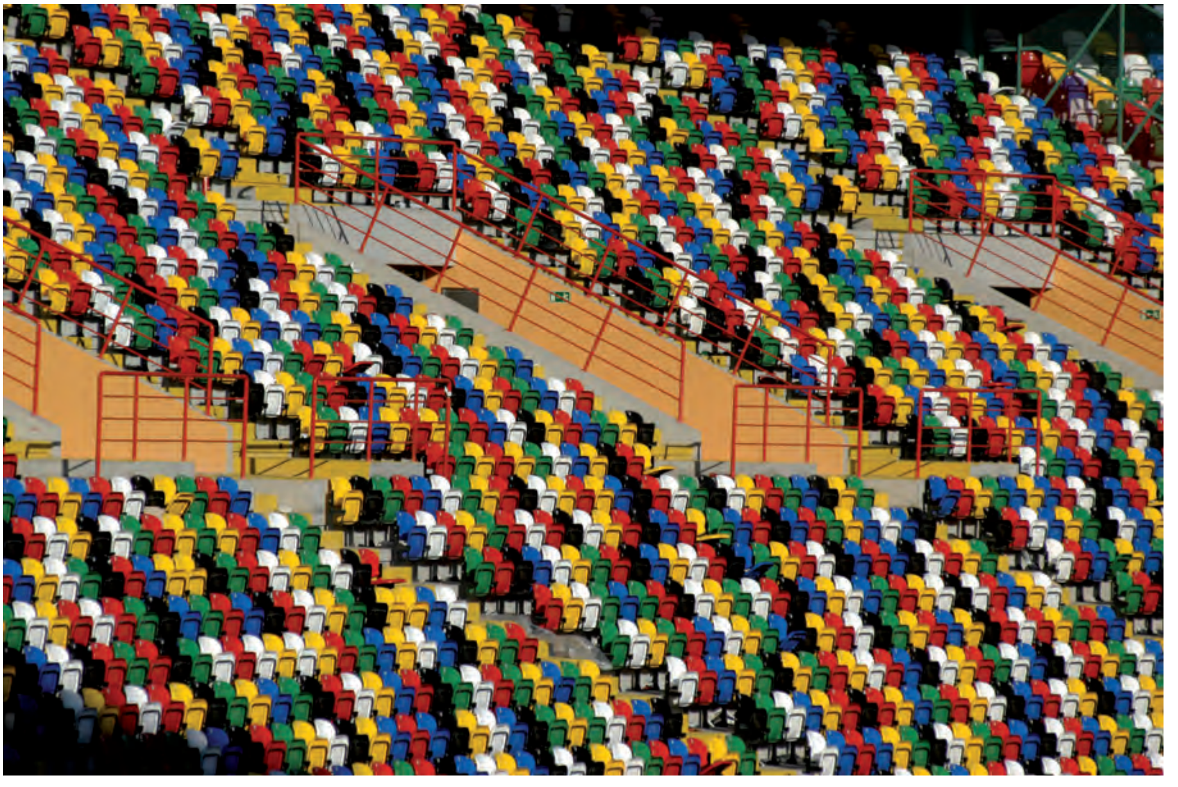


Figure 12.4 At Aveiro Stadium in Portugal (see also Appendix 3) the seats are coloured in the likeness of a crowd so that the appearance of a half-empty stadium is to some degree disguised. *Architect: Tomas Taveira.*

and other environmental pollution, such as acid rain. This can be significant over the expected life of a seat of around 20 years. Additives to plastics can affect this colour quality as well as the actual colour pigment used in manufacture. These additives will also affect the presence of static electricity, which can adversely affect the comfort of spectators.

Colour fastness is measured in the UK according to the British Standard 1006:BO1C 'Blue Wool Standard' and it is recommended that this, or a similar standard, be used when specifying the colour of seats. Extent of exposure to the elements dictates how long the seats selected will look well and hold their colour, but that level of exposure is difficult to define as it will even vary within the stadium bowl itself. UV stabilizers and absorbers will help to retain the seat's appearance. The general rule is that intense colours such as black, blue, red and green are more light fast than softer pastel colours such as sky blues and pinks. Although different seating manufacturers tend to have their own colour range, this selection is really only relevant if the order is for a small number of seats. If sufficient quantities are required almost any colour is possible, depending only on the product chosen.

12.3.5 Cleanability

The seat must be designed to drain easily and not hold water. This is often achieved by designing a drain hole in the centre of the base for a fixed seat. It should be capable of accepting a seat number, being easy to clean, and deterring vandalism. Users will give it more respect if it is clean and well maintained. Cleaning around and under the seat should also be easy, and fixing should be designed with this in mind. In general the fewer the floor or tread fixings, the easier it is to clean the stadium. Riser fixings are therefore preferable.

12.3.6 Fixings

The seat frame should be bolted to the concrete steppings with rustproof fixings – preferably stainless steel, which does not add much to the overall cost of seating, but greatly enhances appearance and durability. Fixings must be very robust: spectators will occasionally stand on seats, or rest their feet on the seats from behind, exerting considerable force. Designers tend to under-estimate the extent of wear and tear received by stadium seats, but one useful standard test is the Furniture Industry Research Association (FIRA) test in the UK. This test is based on British Standard 4875, Part 1, rating 5.

The alternative forms of fixing from which the designer must choose are given in Section 12.7 below.

12.3.7 Refurbishment of existing stadia

In the refurbishment or upgrading of existing terraces the construction of the steppings will limit the forms of fixing which will be feasible – particularly in older facilities. This can be an important factor in re-equipping an existing stadium with a large number of seats, simply because of the number of fixing points which will be required. Complete units of several seats, perhaps even including floors, can be super-imposed over an existing construction. The construction materials for such units can include steel, aluminium, pre-cast concrete or even glass-reinforced plastic.

12.3.8 Other factors

'Riser' type of fixing tends to be preferable to the 'tread' type – see Section 12.7 below. Each seat should be capable of accepting a seat number, and perhaps a sponsor or name plate.

There is also a growing requirement for seats to accept holders for drinks, fixed to the seat frames for stability. These can generally be fitted where a tread width of not less than 700 mm is used.

12.4 Choice

In most stadia, and certainly in larger ones, the above considerations will probably lead to the provision of a variety of seating types, at a variety of prices, for different types of customer.

Areas of cheaper, less comfortable seating may be provided in the form of benches or backless seats. These may allow closer spacing between seats, accommodating more spectators in a given area, in addition to being cheaper to install. But they have the disadvantages described in Sections 12.3.1 and 12.3.2.

The majority of seating will almost certainly be in the form of individual seats with backs – very probably the tip-up kind (Figure 12.3). They are the most comfortable type, giving the greatest width of seatway (see next section) thus providing greater convenience and safety than backless seats. In the case of football stadia FIFA is clear in its recommendation that in major stadia all seats should have backs.

At the top end of the range VIP and other special areas, which will be under cover from weather and not exposed to the worst excesses of crowd misbehaviour, will require comfortably proportioned upholstered seats with backs and arms. The whole subject of private viewing areas is covered in more detail in Chapter 13.

12.5 Dimensions

Seating dimensions must be such as to allow enough space, both side-to-side and from front to back, for comfort and must allow easy passage for police or other personnel during emergencies.

12.5.1 Safety

The absolutely essential requirement is to maintain a clear seatway to allow the movement of spectators along the seat row (Figure 12.5). The minimum

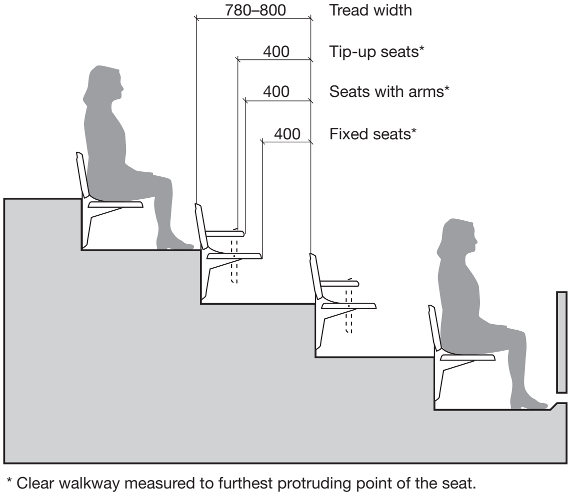


Figure 12.5 Minimum seat dimensions.

recommended dimension is 400 mm, and para 11.12 of the *Guide to Safety at Sports Grounds* (see Bibliography) states that this may be reduced to 305 mm where there are only 7 seats in a row served by a gangway on one side, or 14 seats where there is a gangway on both sides. The bigger the seatway the better, and there are many factors to be considered before coming to a decision. These include:

- The maximum numbers of seats in a row allowed by national regulations. In the UK the maximum is 28.
- Police and stewards may be required to physically remove a spectator. The greater the likelihood of unruliness in the crowd, the more important a wide seatway becomes.
- First-aid personnel may be required to carry out a spectator who is unwell.
- During winter spectators wear large over-coats. Stadia likely to be in use during very cold weather may therefore need larger seatways than those in localities where the weather is always warm.
- Cleaners may have to move along the rows, often with large garbage sacks.
- Wider seatways allow spectators to get out and buy from the concessions more easily.

12.5.2 Comfort

A minimum width of 450 mm is widely accepted around the world; but given the fact that around 95 per cent of men and women are within 480 mm across the shoulders (not including the thickness of clothing, which will be bulky for winter sports) it seems inadequate. 500 mm would give spectators more scope for adjusting their position without disturbing their neighbours. The authors would recommend a reasonable minimum of 465 mm without arms, and a minimum width of 500 mm with arms.

12.5.3 Recommendations

Table 12.2 and Figure 12.5 give recommended seat dimensions taking into account the above factors. These dimensions must be checked against any relevant local or national codes which may apply, though the latter rarely exist and are often inadequate.

Seat height also affects comfort, and a range of between 430 mm and 450 mm is recommended.

12.6 Seat fixings

12.6.1 Fixing types

There are three basic types of fixing, as shown in Figure 12.1. They are:

Tread fixing

The frame rests on, and is bolted to, the terrace floor.

Nose fixing

The frame or seat rests on, and is bolted to, the front edge of the terrace tread. This may be an easy modification to an existing terrace where the spectators sat directly on the concrete.

Riser fixing

The frame is bolted to the front face of the terrace riser, leaving the tread clear.

Another variant is: Combined tread and riser fixing

This may be used where the risers are very shallow – say, less than 200 mm.

12.6.2 Fixing choice

Choice of seat and choice of fixing method are related. Matters to be considered include:

- Seats can be fixed either on lengths of linked framing, or on individual frames. The former is cheaper, but a combination of linked frames and individual frames may be needed to cope with stadium geometry.
- If an existing stadium is being upgraded, a frame type which requires the least modification to the existing supporting terraces will save money. In this connection see Section 12.3.7.
- Frames resting on the tread tend to gather litter around the fixings, and make cleaning more difficult.
- Frames resting on the tread or floor are more likely to rust or corrode in rainy climates.
- Frames fixed to the vertical surface and keeping clear of the floor or tread are easier to clean around, and less prone to corrosion, but they need a minimum riser height of around 200 mm for concrete risers, which may not always be available.

In summary we can say that riser fixing is generally the preference – being easier to clean and less likely to corrode – particularly for tip-up seats, but it is subject to the riser-height limitation mentioned above.

12.6.3 Frame finishes

The three principal types of finish for steel frames – electrostatically coated nylon powder, hot-dip galvanizing, or a combination of the two – were discussed in Section 12.3.2 above.

12.7 Seating for spectators with disabilities

Wheelchair users will generally watch the event from their wheelchairs, parked in spaces as described in Sections 11.2.2 and 11.4, though some may wish to transfer from their wheelchair to a seat once they have arrived.

Ambulant disabled spectators will generally watch the event from seats, the number and location of which were described in Section 11.2.2. As regards design, para 2.16 of *Accessible Stadia* (see Bibliography) recommends that seats designated for the use of disabled spectators should have extra width and extra legroom, and if the seats are fitted with arms the latter should be removable. Although para 11.11 of the *Guide to Safety at Sports Grounds* (see Bibliography) recommends a minimum seat width of 500 mm, and a minimum seating row depth of 760 mm, these dimensions may need to be increased for ambulant disabled people – for instance to accommodate spectators who have difficulty bending their legs.

13. Private viewing and facilities

13.1 Introduction
13.2 Trends
13.3 Design
13.4 Multi-use

13.1 Introduction

Whether private viewing facilities are required, and if so on what scale, is an aspect of the brief that must be carefully thought out for each stadium. These areas often subsidize the seat prices elsewhere in the stadium. The underlying principle is that of differential provision and pricing in order to cater for as many market segments as possible, as explained below.

13.1.1 Range of seating standards

Demand for superior standards of comfort and refreshment facilities, and the willingness or ability to pay for these benefits, varies from person to person. A successful stadium will positively exploit these differences by providing the widest feasible range of seating quality (in terms of viewing position and seat comfort), an equally wide range of catering and other support facilities, and a choice of prices geared to what individual customers are prepared to pay for such differing levels of service.

Table 13.1 lists ten basic categories of seating/standing accommodation in descending order of luxury and price. These are not the only possibilities: other variations such as upper and lower tier, or front and rear positioning, will add to the possible range of viewing standards and ticket prices. The third column of the table indicates the approximate percentage of spectators who may be expected to fall into each category in a given stadium, the basis on which tickets are likely to be sold, and the probable space standards. All of this data is indicative only.

13.1.2 Private facilities

If Andy Warhol was right in suggesting that everyone nowadays is famous for fifteen minutes then it might follow that we will all require VIP facilities at some stage in our lives. However, for an increasing number of people these high standards of facilities will become a normal expectation. Whatever the validity of this theory, private viewing accommodation will be needed in virtually all future stadium developments which need to be financially self-supporting. As sporting events must compete more intensively with the many alternative leisure pursuits available, the provision of comfort instead of spartan simplicity becomes essential for a growing sector of the market, although it must also be said that stadium

1 Private boxes	Self-contained private dining and bar facilities	10 to 20 person boxes 1–2% spectators 3 year contract Tread 850 mm padded and arms
2 Executive suites	Group private dining and shared bar	4–20 person suites 1–2% spectators 1–3 year contract Tread 850 mm padded and arms
3 Club seating and dining	Group seating and group dining with shared bar and lounge	Tables of 2–6 in restaurant 1–2% spectators 1–3 year contract Tread 800 mm padded and arms
4 Club seating	Group seating with shared bar and lounge facilities	Lounge self-contained 2–4% spectators 1–3 year contract Tread 800 mm padded and arms
5 Members seating and dining	Group seating with shared dining and bar facilities	Dining and bar self-contained 1–2% spectators season ticket plus dining Tread 760 mm with arm rests
6 Members seating	Group seating with shared bar facilities	Bar part of 5 above 2–5% spectators season ticket plus Tread 760 mm with arm rests
7 Public seating (several standards)	Seating with public bars and concession areas	Wide range of concessions 50% spectators match or season ticket Tread 760 mm with backs
8 General seating	Bench seating with public bars and concession areas	Range of concessions 5–15% spectators match or season ticket Tread 700 mm no backs
9 'Tennis' boxes	Groups of seats (say 8–12) in self-contained areas	Used in the Telstra Stadium. Equipped with cool box and refreshments delivered
10 Standing terrace (some stadia)	Standing areas with public facilities (more stewarding might be needed)	Range of facilities 5–15% spectators match or season ticket Tread 380 mm

Table 13.1 Range of viewing standards that might be provided in a stadium

facilities and corporate standards are being enjoyed by a wider section of those attending. Also these exclusive seats make a large contribution to stadium profitability. An individual attending a private box may pay many times the price of an average seat and is usually committed to spending handsomely on food and drink bought on stadium premises (or, alternatively, have it bought for him or her).

The income generated from such services is generally quite disproportionate to the cost of provision. Many new developments could not viably proceed without these more exclusive facilities, and for some clubs they are a life-line of financial success. Many of the older stadia are therefore being retrofitted to capture new markets and maximize revenues in this way.

Because private and club facilities can be exploited for a variety of social and other functions, a stadium containing such facilities is generally better suited to multi-purpose uses than a stadium without. To allow such exploitation these facilities should always be designed for flexible use and adaptation.

In these areas, quality and the appearance of quality will be important. Dimmable lighting and well-designed furniture are examples. Branding by corporate clients may be needed. Allowing guests to roam between various boxes, suites, and club enclosures can be desirable, but this is a management decision. Security and control must be taken into account.

13.2 Trends

13.2.1 North America

In the USA, stadium managements work hard at maximizing the number of VIP seats. They try equally hard to maximize the number of revenue-generating facilities added on to these areas, thus enticing customers to spend as much time as possible on the premises before, during and after sporting events. In this way managements hope to extract the maximum amount of money from their captive patrons as a simple necessity at a time of soaring costs.

Patrons with exclusive accommodation rights are encouraged to arrive well before the event and to use the stadium facilities for meals before or after matches, for entertaining business colleagues, and for carrying on business transactions by means of telephones, fax machines and computer facilities provided in a 'business centre' in the VIP area. In the more advanced stadia customers may spend most of the day enjoying themselves (and possibly doing some business) in the VIP area on match days, instead of merely attending for two or three hours. Texas Stadium in Dallas provides a good demonstration of the above possibilities.

13.2.2 The UK

Stadium management in the UK is generally not as commercialized as in the USA, but all the trends outlined above are at work in the UK. The new Wembley Stadium in London (see Case studies) will be a leading example. The Galpharm football and rugby stadium in Huddersfield, Yorkshire, designed by HOK Sport, contains a range of facilities and may also serve as an example:

- 25 000 spectator seats in total.
- 50 executive boxes.
- 400-seat banqueting hall.
- Bars and restaurants, shops and offices.
- 30-bay floodlit golf driving range, dry ski slope.
- Pop concert venue.
- 800 car parking spaces.
- Football and rugby museums.
- Crèch.
- Concessions.
- Indoor swimming pool, dance studio and gymnasium.

The following will also serve as examples:

Wembley Stadium, London

- 90 000 spectator seats in total.
- 160 boxes accommodating 1918 people.
- 2 pitch-view restaurants seating 154 people each.
- Mid-tier seating for 14 400 club spectators.
- A Corinthian Club in the lower tier, with its own restaurant seating 1900.
- Concourse with cafés, food outlets, bars and kiosks.

Emirates Stadium, London

- 60 000 spectator seats.
- 150 executive boxes, backed up by 3 network bars each accommodating 70–100 people.
- 6 800 club seats.
- 4 large bar/restaurants overlooking the pitch.
- 4 quadrant bars.
- Directors' restaurant overlooking the pitch and seating 110.
- Diamond club restaurant overlooking the pitch and seating 200.
- Concourses with food outlets, bars and kiosks.

13.2.3 Other countries

Trends in private facilities vary throughout the world. With due allowance for exceptions it can be said that managements in Japan are following roughly the same course as those in the USA; that those in France and Spain are also taking an increasingly commercialized approach; but that those in Germany tend to oppose anything that smacks of 'privilege', preferring to provide customers throughout the stadium with seats that are as equal as designers and managers can make them. In the Middle East and the Far East stadia are mostly large utilitarian bowls, with no frills, where most people come for the single purpose of watching a game of sport. The main exceptions to this general rule are race courses, which are most elaborate in Asia.

13.3 Design

13.3.1 Degree of detachment from the pitch

An important early decision with private viewing facilities of all kinds is whether the people in these areas should see the match from behind a fixed glass wall as seen in Figure 13.1a. This is quite common practice in the USA but less so in the UK. British examples include Tottenham Football Club and Queens Park Rangers stadium in Loftus Road, London.

Choice must be left with the stadium owner, but the authors believe that an atmosphere of full involvement with the game is vital, and that 'piping' crowd noise into a sound-proof enclosure behind a fixed glass wall is not an adequate substitute. The preferred solution is to locate private enclosures or

Type A
Advantages: Complete privacy and comfort
Disadvantages: Separation from the atmosphere of the ground

Type B
Advantages: Privacy maintained but users see event as spectators
Disadvantages: Separation between viewing and dining

Type C
Advantages: Flexibility of use
Disadvantages: Users remote from event when using facility

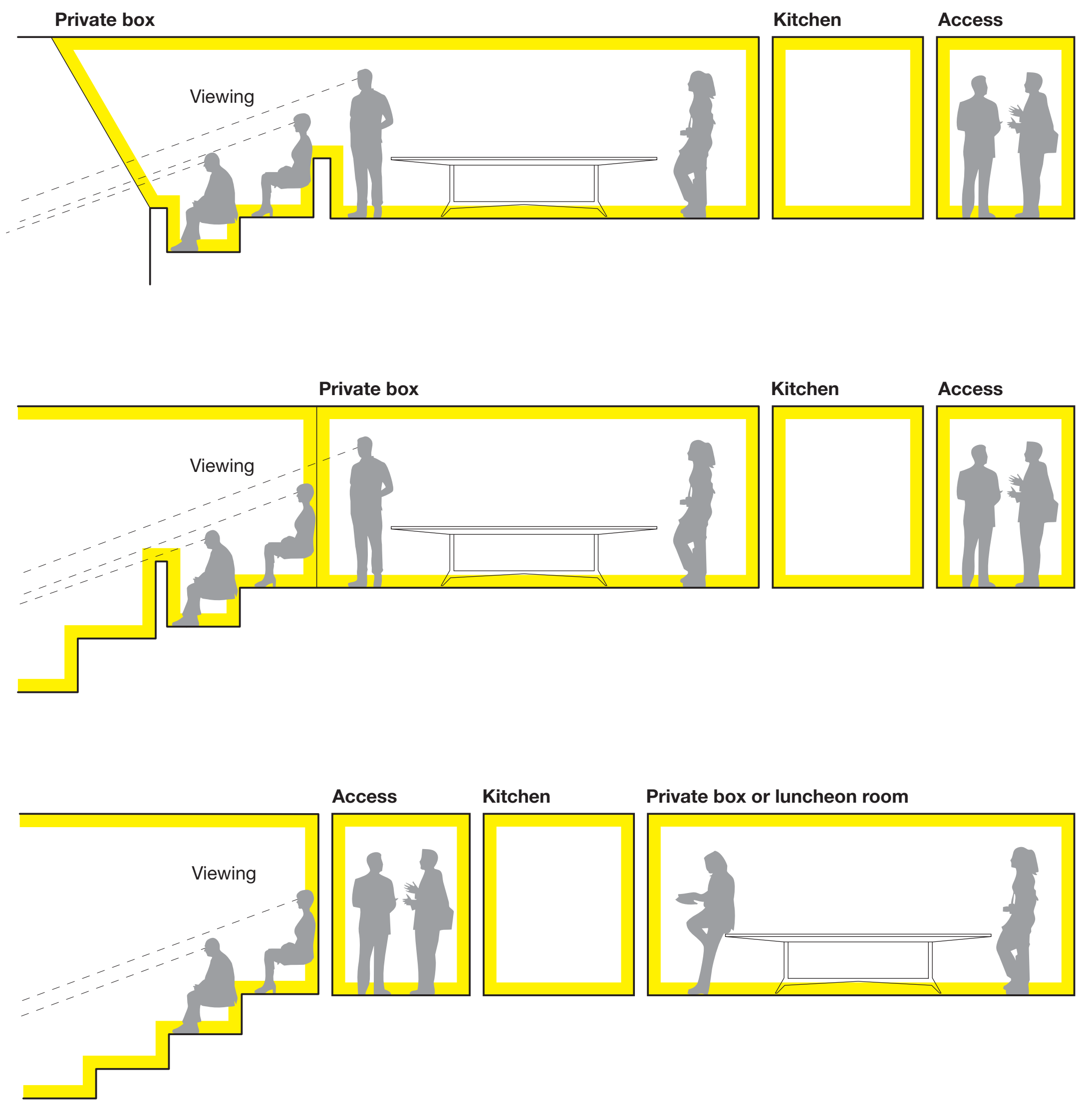


Figure 13.1 Three possible arrangements for private viewing: Type A behind glass; Type B in the well of the stadium, with the private box immediately behind; and Type C in the well of the stadium with an access corridor immediately behind. Each option has its advantages and disadvantages as noted. Climatic and security aspects may also have to be taken into account when choosing which type is to be used. For type A, the Melbourne Cricket Ground (MCG) has installed a compromise solution allowing upward-opening windows, enabling the interior to be opened to the stadium bowl.

boxes with seats in the well of the stadium, outside the building enclosure, and to locate the hospitality and other facilities behind these, shielded by glass (Figure 13.1b). However, climatic and security aspects have to be taken into depending on the location. A compromise solution is noted in Figure 13.1c.

Once this basic decision is taken the detailed design of the various types of private facility can commence, as outlined below.

13.3.2 Private boxes and executive suites

As indicated in Table 13.1 these are the most exclusive and highest priced facilities. Each box (Figure 13.2) commonly accommodates 10 to 20 people but there is no rule about this: the determining factor may simply be the number of seats that can be fitted in without compromising comfort or viewing standards. Each box is usually provided with its own food servery, bar and perhaps toilet (or, if this is too expensive, access to group toilets).

Kitchens and serveries

These should be at the back of the box, possibly with separate access from the box users so that catering staff can come and go without disturbing customers. Depending on the standard of catering provided the servery can be as simple as a single straight bench without drainage, or as luxurious as a well-fitted U-shaped bench arrangement with integral bar, ice-making machine, coffee maker, and water supply/drainage facilities for washing-up.

If the boxes are planned as pairs their utility services can be combined in one duct, and one door may give access to both serveries.

Toilets

Each box could have its private toilet but this will be expensive and a more usual solution is for toilets to serve a group of boxes. Toilets should have private and secure access and be to 4-star hotel standard.

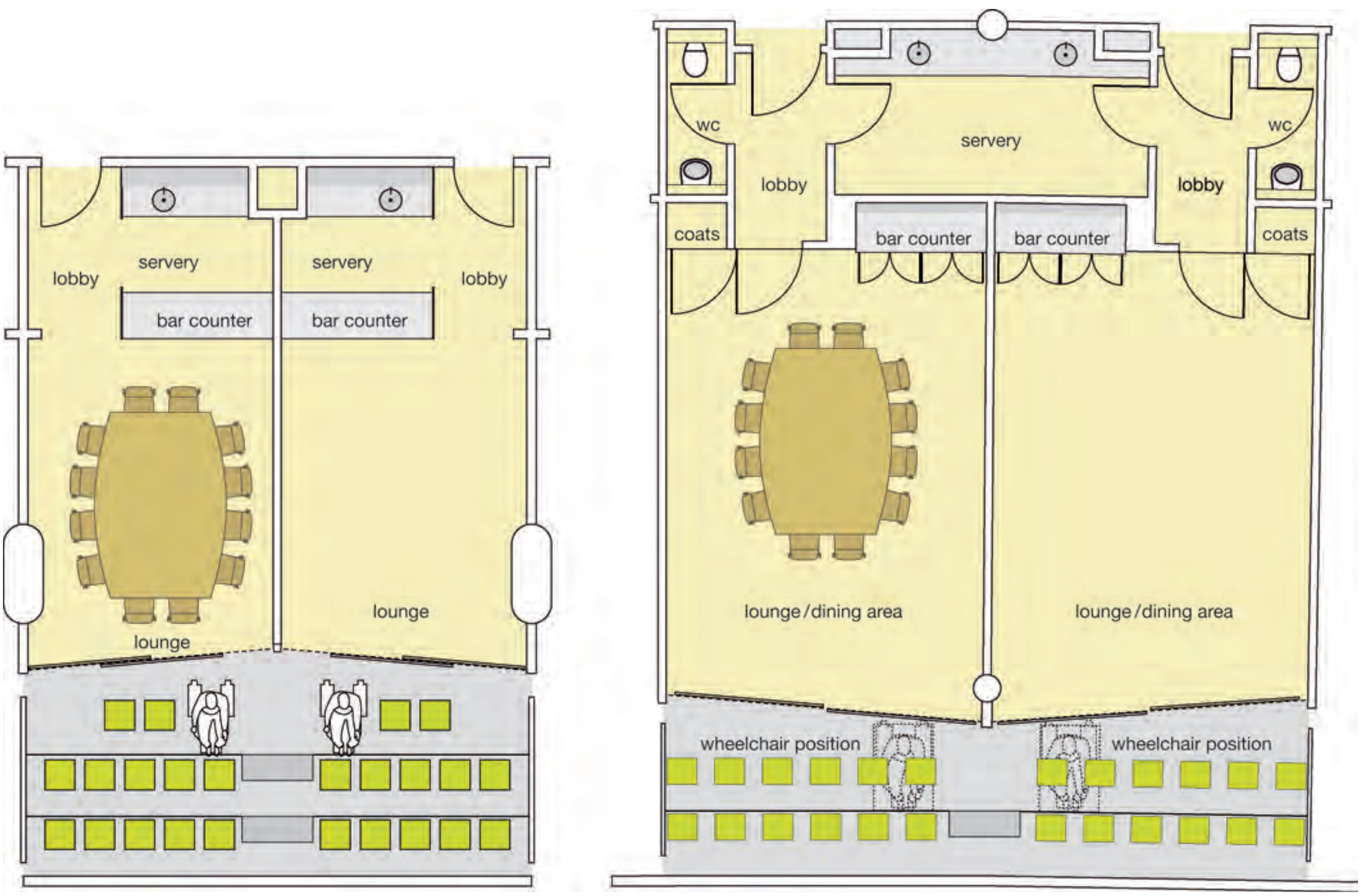


Figure 13.2 Typical private viewing box layouts.

If toilets are provided in groups, there should be a higher proportion of female toilets than for the rest of the stadium.

Private box lounge

This is a common lounge where box-holders can meet other holders for socializing or business. It should have a food servery, bar and access to private toilets.

13.3.3 Executive suites

These suites are similar in principle to club enclosures (see below) but they provide higher standards of comfort and style, and probably a higher degree of privacy to cater for more demanding customers willing to pay higher prices. There are examples in the USA which offer patrons a prime view of the playing field from theatre-type seats in an air-conditioned club room with a range of superior catering services available exclusively to members.

13.3.4 Club enclosures

Club enclosures are 'exclusive' sections or levels of the general stadium (Figure 13.3) with their own restaurants, bars and toilets, and very comfortable seating, catering for affluent patrons who are willing to pay a premium for superior facilities but not prepared to commit themselves to 10 or 20 individual places as expected of a private box-holder. They are likely to be found mainly in larger stadia.

Since the use of such facilities will vary from one match to another these areas should be designed so that they can fulfil other functions on non-event days, or when they are not being used for a particular event.

Each club area will have its own bar and perhaps kitchen facilities, depending on the catering organization of the particular stadium. It may have its own individual toilets, which should not be combined or shared with other users. Accommodation may be needed for three types of users. The areas vary greatly from venue to venue, but good spatial allowances should be made, for instance 1.5 to 2.0 m^2 per person.

Guest room or directors' lounge

This is used for entertaining invited guests of the host club, and the area of the room is usually of the order of 60 to 100 m^2. The space needs to be directly linked to the directors' facilities of the host club and preferably have direct access to the directors' viewing area, but need not overlook the pitch.

Visitors' room

This area is for use by the directors and guests of the visiting club. Again, the room area should be about 60 to 100 m^2 and be directly linked to the directors' facilities of the host club with direct access to the directors' viewing area. It need not overlook the pitch.

Sponsors' lounge

This is a space used by the sponsors of the club or individual event to entertain their invited guests. It can consist of one or more private hospitality boxes (see above) or be provided as a completely

Figure 13.3 Stepped restaurant at Cheltenham Racecourse. *Architects: HOK Sport Architecture.*

independent space which, when not being used by the sponsor, is let out for general entertainment purposes. The approximate area might be 50 to 150 m^2 and it need not overlook the pitch.

13.3.5 Members' enclosures

These are similar in nature to the club enclosure above but less luxurious, as suggested by the provisions in Table 13.1.

13.4 Multi-use

If carefully designed, private facilities such as club enclosures or boxes can serve many purposes other than being used for the actual event – see Chapter 8. The use of movable walls between boxes, for example, would allow the area to be opened up into a larger dining room at times when the boxes

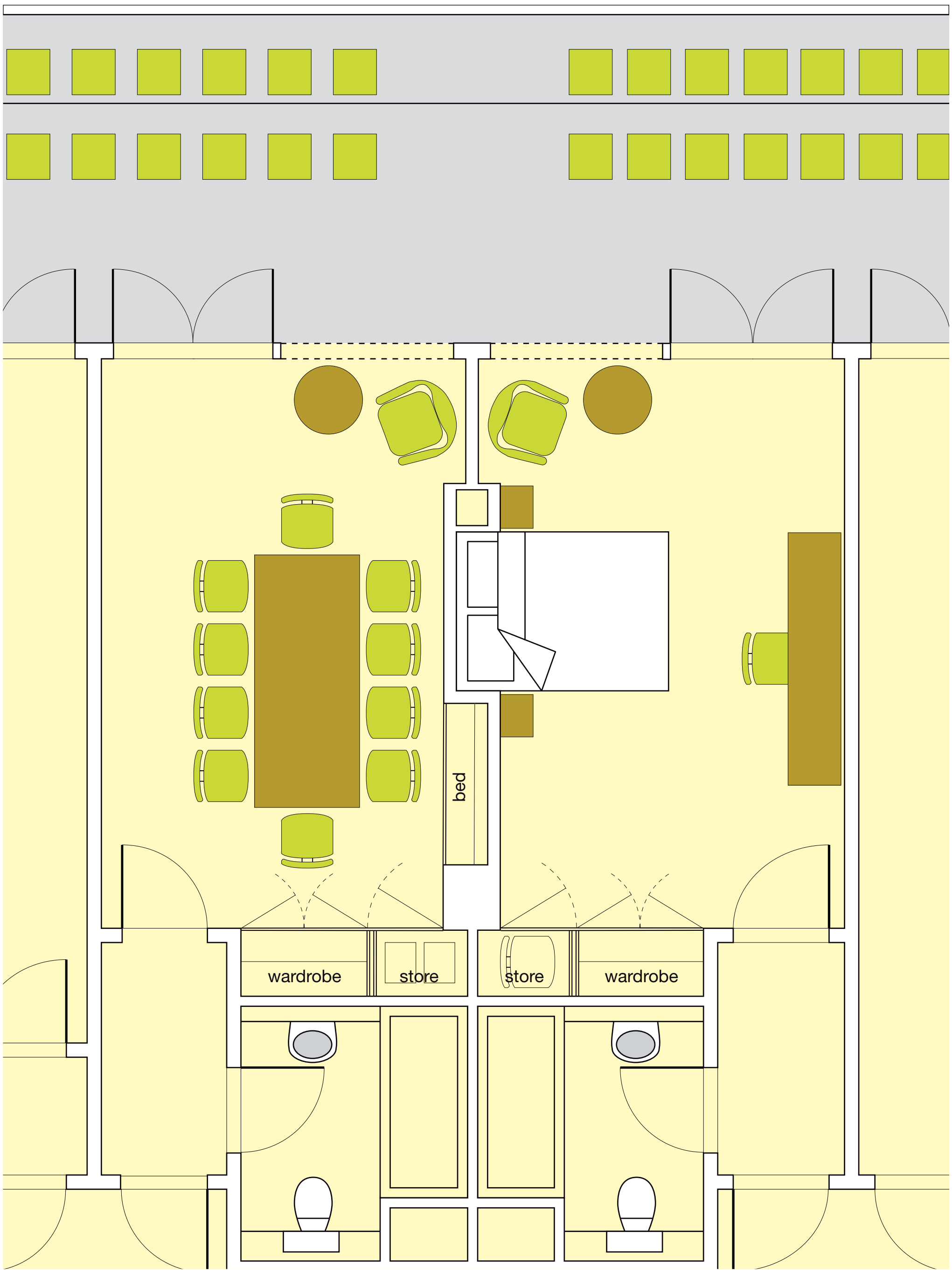


Figure 13.4 Example of a private viewing box that can be converted into a hotel room.

are not in use, and perhaps as a public restaurant on non-event days. However, movable walls are expensive in capital and management costs, and this must be decided with the operators. An alternative is to provide a permanent but varied range of uses.

Private boxes are quite similar in size to hotel bedrooms and in theory they could, with a modest increase in capital cost to include a full bathroom, be designed for such dual use from the outset (Figure 13.4). The Skydome in Toronto was a pioneering stadium in this context, and the more recent Galpharm stadium in Huddersfield is an example of a stadium incorporating private boxes that can be converted into hotel rooms.

14. Circulation

14.1 Basic principles
14.2 Stadium layout
14.3 Access between Zone 5 and Zone 4
14.4 Access between Zone 4 and Zone 3
14.5 Overall design for inward movement
14.6 Overall design for outward movement
14.7 Elements
14.8 Facilities for people with disabilities

14.1 Basic principles

Circulation planning in stadium design has two main objects: the comfort and the safety of occupants.

Comfort

People should be able to find their way to their seats (or to toilets or catering facilities, or back to the exits) easily, without getting lost or confused. In addition, they should be able to move about with pleasure, not being jostled in overcrowded spaces, having to climb excessively steep stairs, or risk losing their footing as they negotiate the many changes of level which are inevitable in large stadia.

Safety

Safety requires maintenance of all the above desirable characteristics in panic conditions – when, for example, hundreds (perhaps thousands) of spectators are fleeing in fear of a fire, an outbreak of violence in the crowd, or some other real or imagined danger. Even better, preventive measures should minimize the risk of such situations arising in the first place. This should preferably be achieved by skilful design, so that people *want* to go where they have to be in the stadium and are not *made* to go there.

In the following sections we show how these requirements can be catered for in practical terms.

- First, in Section 14.2, we examine the implications of circulation requirements upon stadium layout as a whole.
- Then, in Sections 14.3 and 14.4, we give planning guidelines for the circulation routes themselves.
- Finally, in Sections 14.5 to 14.7, we augment the above planning principles with detailed design data – dimensions, types of equipment and the like.

14.2 Stadium layout

Circulation planning has two major influences on the overall stadium layout – zoning the stadium for safe escape from fire, and subdividing the stadium for crowd management.

14.2.1 Zoning

As already described in Section 2.3 the modern stadium is designed as five concentric zones:

- Zone 1 is the *playing field* or activity area and central area of the stadium.

- Zone 2 comprises the spectator *viewing areas* consisting of standing terraces or seating tiers, hospitality boxes or other viewing areas and their associated gangways and vomitories.
- Zone 3 is the *internal circulation area* – the concourses with food and drink kiosks, toilets or other facilities along it, leading via gates or stairs to ...
- Zone 4, which is the *external circulation area* surrounding the stadium building but within the perimeter fence.
- Zone 5 is the area *outside the perimeter fence*. It will contain the car parks and the bus and coach off-loading areas.

The purpose of the zones is to enable spectators to escape in case of emergency – first from Zone 2 to either Zone 1, or Zone 3 or 4 (the 'temporary safety zones'); and thence to the 'permanent safety zone' of Zone 4 or 5 and the outside world. Such escape must be possible in specified times, which then determine the distances and widths of the relevant escape routes: see Section 14.6.2.

In stadia accommodating more than 15 000 or 20 000 spectators all five of the zones can be present but in smaller stadia, where spectators exit directly to the exterior from the spectator viewing and internal circulation areas, Zones 3 and 4 can be combined. Such small stadia will not justify a perimeter fence, but to compensate for that they will require particularly diligent stewarding at the exits.

14.2.2 Subdivision

Subdividing the total ground capacity into smaller units or sectors of about 2500 to 3000 spectators each allows for easier crowd control and for a more even distribution of toilets, bars and restaurants. Each of these sectors should have its own independent circulation routes as well as its share of ancillary facilities.

Separation of different categories of spectator should form part of this division system. For example:

- Separation of seated and standing areas; and
- Segregation of fans from opposing clubs.

The actual division between areas can sometimes be achieved simply by barriers or changes of height. In the case of separating rival fans each sector should be completely independent. This independence may go as far as to require protected routes leading all the way from the nearby transport services to the turnstiles (secured by police), and from the turnstiles to the seating areas.

Because of the decisive effect of the subdivision pattern on circulation route planning, management must be consulted at an early stage on how the seating areas in the stadium are to be split up.

In single-tier stands the division lines may run from top to bottom, with policed 'sterile zones' separating the two blocks of 'home' and 'away' fans. This pattern has the advantage of flexibility (the sterile zone can easily be shifted from side to side to allow for a greater or smaller number of fans in a particular area) but the sterile zones represent a loss of revenue, and the problem of ensuring access to exits, toilets and catering facilities for everyone needs careful planning.

In two-tier stands the top-to-bottom division is again a possibility; alternatively one group of fans can be put in the upper tier and the other in the lower tier. If the 'away' fans are in the upper tier there is no risk of pitch invasion, but there is a real possibility of missiles being hurled on to the 'home' fans below, and any kind of trouble is difficult to deal with because of the relative inaccessibility of the upper levels. If the 'away' fans are put in the lower tier trouble is easier to deal with, but there is a risk of pitch invasion, thus calling for larger police numbers or more intensive stewarding.

14.3 Access between Zone 5 and Zone 4

Ideally, and if space allows, a modern stadium should be surrounded by an outer circulation zone of 20 m width or more to allow spectators to walk around the outside to get to their seating area. The security control line where tickets are checked can either be at the face of the building, between Zones 3 and 4, or at the outside of the external circulation between Zones 4 and 5. If we look at the situation where the control line is at the outside of the external circulation area, Zone 4, a perimeter wall or fence some distance from the stadium will be required.

Such a perimeter barrier would be at least 20 m from the stadium, and would ideally be strong enough to withstand crowd pressures, high enough to prevent people climbing over, and containing several types of entrance and exit gates:

- Public entrances leading to the main seating terraces.
- Private entrances giving players, concession holders and VIP ticket holders separate access to their particular areas.
- Emergency service access for ambulances, etc.
- Flood exits for emergency emptying of the grounds.

These are now dealt with in turn.

14.3.1 Public entrances

In some stadia, checking of tickets coming into the grounds is made at this perimeter point; in others it is made at the stadium entrances between Zones 4 and 3; in yet others by some combination of the two.

Circumnavigation between gates

If control is exercised at the perimeter of the building, and if each entrance gives access only to some parts of the stadium (either by physical design, or by subsequent management policy) then circulation routes should be provided in Zone 4, outside the perimeter barrier. People who have come to the wrong entrance gate should be able to circumnavigate to the correct one while still remaining in the same Zone. Conversely, if there will be no control on seating positions at the perimeter then there is no need for such circulation routes, as spectators may enter the stadium via any turnstile. These matters should be clarified beyond doubt with management at briefing stage if faulty design is to be avoided.

Congregation space outside gates

Outside all perimeter access points in Zone 5 or 4 there should be sufficient space provided to allow the congregation of spectators before entering through gates or turnstiles. This congregation space should be sized and positioned so as to avoid congestion and allow a free flow of spectators when the gates or turnstiles are opened. See also the notes on crowd control barriers under Section 14.7.1.

Other safety measures

In all cases public entry doors should be used only for the purposes of entry, and all public exit doors only for the purposes of exit. The simultaneous use of any gateway for both entry and exit can create risk. If such two-directional gates are used they must be *additional* to the exit gates required for emergency outflow as calculated in Section 14.6.2 ('timed exit analysis').

Amenities such as ticket offices, toilets, bars or restaurants should always be located a safe distance away from the nearest entrance or exit to allow a congregation of people without risk of a crush.

Number of gates

There are several ways of allowing spectators into the stadium, but most fall into the two broad categories of gates and turnstiles. Gates are cheap, and an open gate of a metre's width can allow approximately 4000 spectators to pass through per hour whereas turnstiles are expensive and will only pass through 500 to 750 spectators per hour. Detailed design notes are given in Section 14.7.1.

Location of gates

The location of entrance gates in the perimeter barrier will depend on three factors which may to some degree conflict with each other, requiring an early decision on priorities:

- To avoid congestion entrances should be spaced at regular intervals around the circumference.
- If mutually hostile fans must be kept apart it is again desirable for entrances to be widely separated.
- But management may want entrances to be grouped closely together for convenience of staffing and security.

Any conflicts between the above requirements must be resolved before design commences, by obtaining a very clear statement of design priorities from management at the briefing stage.

Segregation of fans

It is necessary here to say more about the second factor mentioned above – whether to allow for the enforced segregation of certain groups of spectators before they enter the stadium.

Where the anticipated spectators are known to be 'game-orientated' rather that 'team-orientated', and to behave peacefully, there is no need for special provisions. Spectators at tennis, rugby or athletic events tend to fall into this class. So, perhaps for different reasons, do American football and baseball crowds: because distances between competing clubs in the USA are so great, there are seldom large numbers of 'away' fans present at matches.

The case is generally different with football crowds in Britain and Europe (principally the Netherlands, Italy and Germany) and in South America. These fans tend to be strongly partisan and attend matches primarily to support their home teams. Supporters of competing sides may be hostile and aggressive, in which case they cannot be allowed to mix freely and must be separated all the way from their arrival in Zone 5 to their seats.

Provision must then be made for systems of barriers (preferably movable) in Zone 5 which will funnel groups of spectators to widely separated entrances, which in turn lead to separate parts of the stadium. This causes two problems for designers:

- Separate turnstiles and horizontal and vertical circulation spaces, perhaps also with separate toilets, etc., could lead to expensive duplication of facilities.
- It will be necessary to visualize at this stage how the stadium may be divided between seating areas for 'home' and 'away' supporters, and the entrances and routes must be so designed that rigid separation can be maintained at some matches, while freedom of movement is possible at others.

14.3.2 Private entrances

These entrances are for players, VIPs, directors, sponsors and the media. They should be close to a special VIP parking area, with a sheltered connecting route, and should be well separated from the public entrances.

Access should be by open gate rather than turnstile, with a higher level of security staff present, and lead to a secure route all the way to the seat. Quality of design and finishes must be markedly superior to the rest of the stadium, with the ambience of a superior hotel.

14.3.3 Emergency service access

Provision should be made in the perimeter barrier for emergency service access between Zones 5 and 4. These access points must be stewarded constantly and will be opened only in exceptional circumstances. They should connect directly between the stadium interior (Zone 1) and the public road network (Zone 5) for fast and unimpeded ingress and egress by ambulances, fire engines or other emergency service vehicles. Widths and gradients must allow for this.

14.3.4 Flood exits

Apart from the gates and turnstiles described under *Public Entrances* above there must be separate and additional flood exits, allowing a stadium that may have taken three hours to fill, to empty within a matter of minutes.

These exits should be located at regular intervals around the perimeter so that every seat is within a reasonable distance from an escape, and preferably in a direct line with the vomitories and staircases in Zone 2 and 3 to allow spectators a clear, direct and continuous line of egress from the building (though this is not always possible). The gates must open outwards and have a sufficient clear width to allow the prescribed number of people to pass through safely. A minimum width of 1200 mm is recommended in the UK.

14.4 Access between Zone 4 and Zone 3

14.4.1 Stand entrances

First ticket checks and, if necessary, body searches will probably have been made at the outer entrances (see Section 14.3.1 above). Second ticket checks are made at the stand entrances, which may be either gates or turnstiles. Secondary checks are more informal than those at the main entrances or turnstiles, and more of a customer service than a stringently applied safety measure. Further ticket checks may also be made at other points along the way to the seat if different groups of spectators need to be separated to go to different seating areas.

The same basic rules apply as for outer entrances: there must be enough space to avoid all risk of a crush developing and public facilities such as ticket offices, toilets (except those for people queueing to get in), bars and restaurants must be located a safe distance away.

14.5 Overall design for inward movement

14.5.1 Clarity of routes

People enter the stadium from the area outside (Zone 5) and must then thread their way through a succession of turnstiles, corridors, circulation passages and doorways to the individual seating or standing position (Zone 2). But a large multi-level stadium can be a very confusing place and a spectator may rapidly become exasperated if he cannot, for example, find his way from the entrance gate to block 12, row K, seat 275 and must repeatedly double back to try another route.

There are four methods for minimizing or avoiding this problem:

- Keeping choices simple (so that people are never faced with complex or difficult decisions).
- Ensuring clear visibility of the whole stadium (so that people always know where they are in relation to exits).
- Clear signs.
- Good stewarding.

Good stewarding is a matter for management rather than design and will not be pursued here; but detailed notes follow on the three design measures listed above.

Simple choices

As far as possible the visitor should never be faced with an interchange where many routes are open to him, only one of which is right. It is easy to make a mistake at the best of times and moving along in a crowd, perhaps under pressure or in conditions of haste, almost guarantees getting it wrong.

The ideal is to provide the spectator with a series of simple Y or T junctions as he moves from the entrance gate to his seat, facing him in each case with an elementary choice of 'yes' or 'no'. He must be confronted with one (and only one) decision at a time, in such a way that when he has taken the final decision he has arrived at his seat. Six typical decisions are:

1. Am I a 'home' or 'away' supporter? At stadia where intergroup conflict is possible (e.g. football) these two groups should be segregated before they have even entered the stadium (see Section 13.3.1).
2. Am I a seated or standing ticket holder?
3. Am I seated in the upper or lower tier?
4. Am I in the blue or red section?
5. Is my seat in rows 1 to 10, or 11 to 20?
6. Where is my seat in the row?

The flow diagram (Figure 14.1) shows in schematic form a typical circulation pattern where choices have been reduced to 'yes' and 'no' decisions both when entering the stadium and when leaving. In this example there are several main entrances, each giving access to a different part of the stadium, thus making it possible for management to segregate 'home' and 'away' fans even before they have entered the stadium simply by allocating separate entrance gates to each.

The above straightforward principles are complicated by two practical requirements. First, there may be a need (already mentioned in Section 14.3.1) to separate the entrances used by 'home' and 'away' supporters. If so, this will tend to conflict with the desirability of keeping all entrances close to the administration centre, and therefore close to each other.

Second, while the primary circulation route should lead the spectator in the correct direction in deterministic fashion as described above, there should also be a secondary route allowing the spectator who has ended up in the wrong place to find his way back. This secondary 'correcting route' is almost as important as the primary circulation routes.

Clear visibility

Sports stadia are not the place for clever architectural games relying on tight, disorienting passageways opening into great public spaces to create a sense of spatial drama (as do some highly acclaimed theatres, concert halls and cinemas). Clarity is the first priority at every stage of entering or leaving the stadium, and designers should try to make the stadium

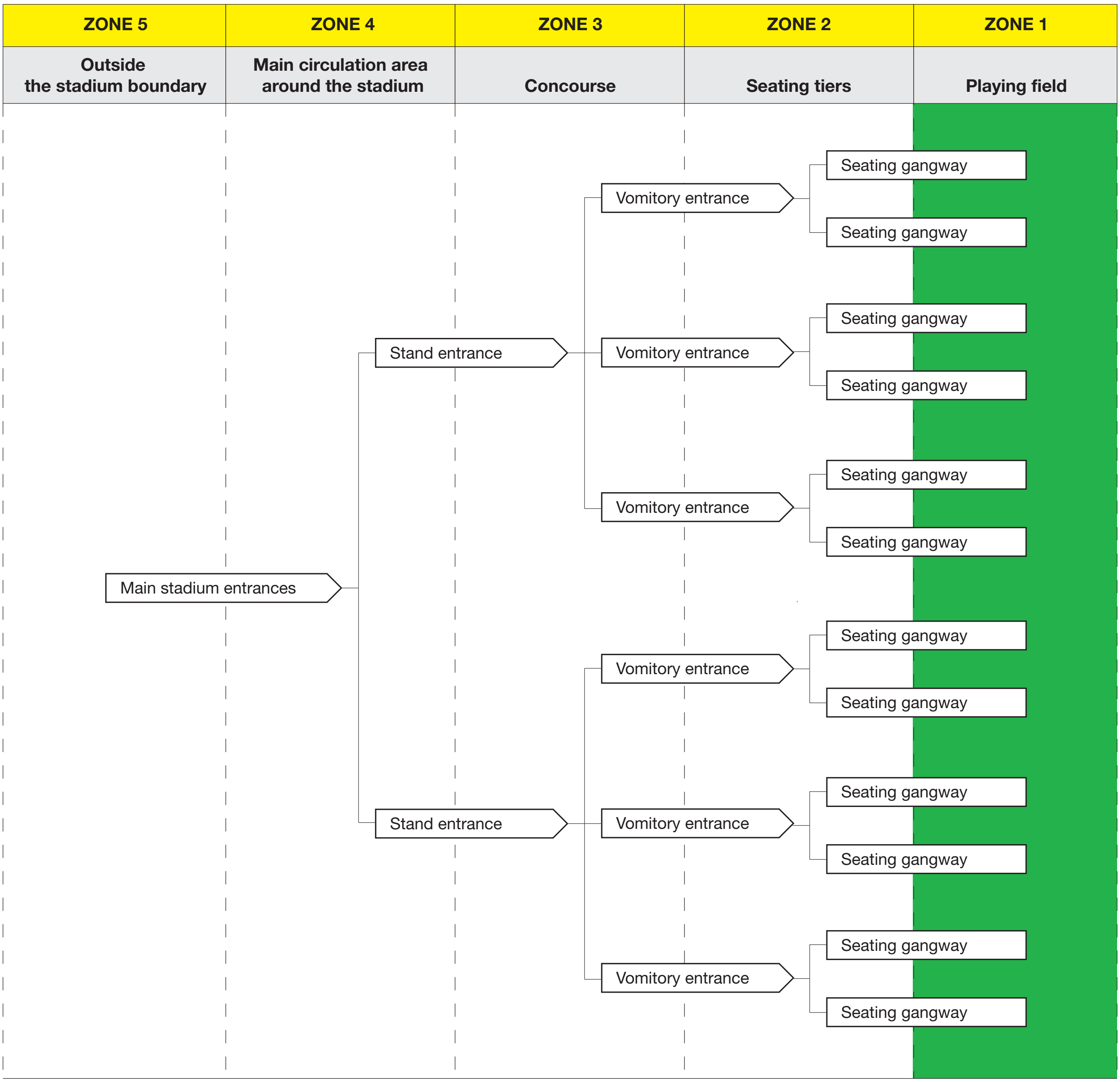


Figure 14.1 Spectator flow from gate to seat. Movement will be smoothest and safest if the spectator is faced with a sequence of simple choices, as shown.

as open as possible, so that crowds are visually aware at all times of where they are, and that alternative means of escape are open to them if needed.

It is desirable that spectators should be able to see from one exit stair to another and be aware that there is an alternative route. This helps prevent them panicking.

The need for maximum visibility is especially important in the case of sudden changes in direction, in width of corridor, in surface level, or in lightness and darkness. Such abrupt changes can be dangerous and should in general be avoided; but if that is impossible then the stadium-user should see them clearly in advance so that he does not stumble upon the transition unprepared.

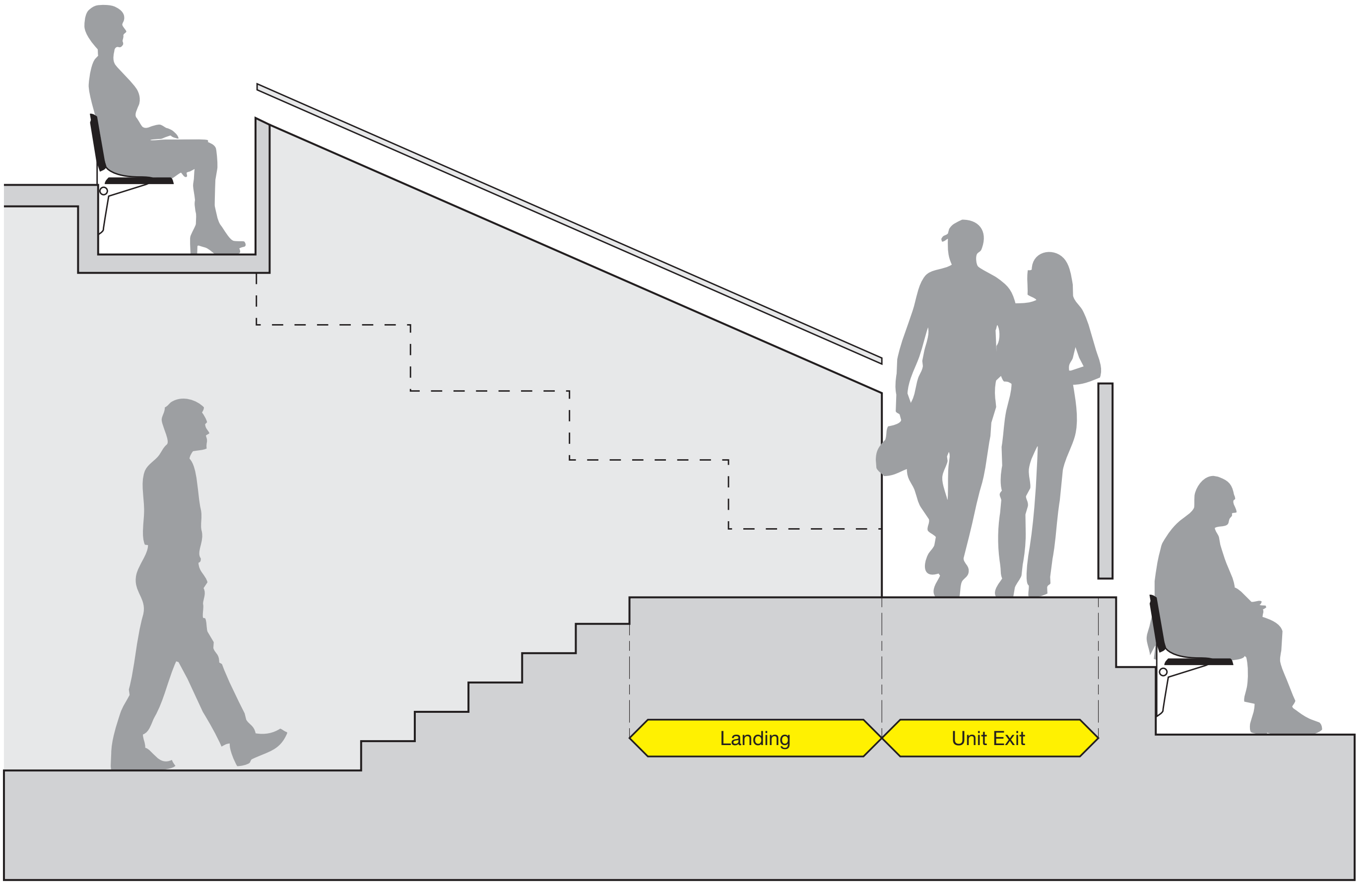


Figure 14.2 Changes of level can be beneficial if carefully designed. The short stair helps slow down incoming spectators, and enables those leaving to see over the heads of the people in front. Provision for people in wheelchairs has to be handled separately.

An awareness of the layout of the stadium may be enhanced by carefully-judged changes in level. For instance, spectators can be made aware that they are about to enter a different area, and must adjust their pace, by a short upward ramp. Or their sense of where they are and what lies ahead can be improved by enabling them to see over the heads of those in front, by means of a downward ramp or stair.

Figure 14.2 shows a beneficial change of level of this kind, through a vomitory. Entering the seating tier via a ramp or a short flight of stairs serves two purposes: on entry, forward pushing by the spectators into the relatively narrow seatways is reduced by the preceding rise in level; and on leaving, spectators can see over the heads of those in front of them and are therefore much more aware of the circumstances ahead. This 'awareness' is important as it is the unknown which creates anxiety in a crowd and can lead to panic. Note however that access for wheelchair users to their viewing positions (see Chapter 11) will need to be along a flat, or gently ramped, access way.

Clear systems of signs

Clarity of stadium layout should be reinforced by an equally logical system of signs if spectators are to find their way about easily, dependably and safely.

A comprehensive sequence of signs should begin off the site, directing traffic and pedestrians first to the correct part of the ground, then to their particular entrance, and then stage by stage to every individual part of the building. The 'direction' signs leading people along their route must be supplemented at regular intervals by 'information' signs which give information on the location of different seating areas, catering outlets, toilets and other amenities. All signs should be designed for ease of reading; placed high enough to be seen over people's heads and located in a consistent way so that people know where to look as they hurry through the building. Control should be exercised during the entire lifetime of the stadium to ensure that signs remain compatible with the overall design of the stadium and its landscaping. The needs of people in wheelchairs must constantly be borne in mind.

To make things easy for the customer, signs should be colour-coordinated with the areas to which they lead, and with the tickets for those areas (for example red signs and tickets for the red seating area) and they should provide information in easy stages. For example, a spectator heading for seat K27 in block 12, section 7 would find the following sequence of 'staged' signs easy to understand and follow:

SEATING BLOCKS 6 to 12

followed by:

SEATING BLOCK 12, SECTIONS 6 to 10

followed by:

SEATING SECTION 7 ROWS 13 to 27

The alternative combined sign shown below would be much more difficult to grasp, leading to dangerous hesitations and contra-flows in the traffic:

SEATING BLOCK 6 to 12, SECTIONS 6 to 10,
ROWS 1 to 36

In addition to signs, large clear maps, above head level, are vital at all key points, particularly to help people who have difficulty with the local language. They should be oriented so that 'up' on the map points in the same direction as the reader's view of the stadium (otherwise the viewer must go through mental contortions correlating directions on the map with those in the stadium) and each map should have a *You are here* arrow.

14.5.2 Safe areas

While clarity and simplicity of circulation routes will do much to promote safe, comfortable spectator movement, it should be recognized that on

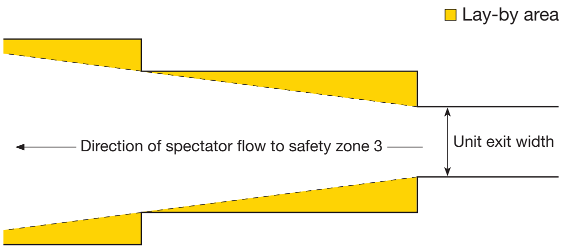


Figure 14.3 Lay-by areas on the main circulation routes allow people to stop and think without blocking the traffic flow.

entering or leaving an area some people will inevitably change their minds and decide to head for the opposite direction instead. This happens for many reasons, from forgetting a coat to wanting to visit the toilets or wishing to see friends. Such changes of direction can have a disrupting effect on the natural flow of the remainder of the crowd.

We recommend that indecision of this kind be planned for, in as much as it is impossible to change human nature. Quiet or safe areas should be provided off the sides of the circulation routes much as lay-bys are provided beside motorways. These lay-bys enable people to stop and take stock of the situation without obstructing others, and then head off in the opposite direction if they wish.

Lay-by areas of this kind can be used as a method of stepping out the sides of the circulation route, to widen it towards the exits (Figure 14.3). This has the advantage of increasing the flowspace outwards, while at the same time providing safe areas for people who want to stop and think, or turn round.

14.5.3 Distancing of facilities from circulation routes

Many ancillary facilities must be provided in a stadium if spectators are to fully enjoy an event: programme sales kiosks, bars, cafeterias, childcare centres and the like. These should be eye-catching and pleasing, but off the main circulation routes so that queues of people do not disrupt the primary circulation flow. Such facilities should always be located at least 6 m away from entrances or exits.

14.6 Overall design for outward movement

14.6.1 Normal egress from stadium

This layout should follow the same pattern as the branching of a tree. Tracing the route back from the individual seat to the exit gate, one may say that the individual twigs lead to small branches, which lead to larger branches, which lead ultimately to the trunk which is the public road. The twigs or smaller branches should never be connected directly to the trunk as this may cause the flow on the branchline to hesitate, causing congestion and aggravation and (if the stadium is being emptied in conditions of emergency) serious risk.

Signs and maps should work both ways – for incoming spectators trying to find their way to their seats, and also for spectators trying to find their way back to the exits. Exit signs must be particularly clearly visible, possibly illuminated, and will be governed by safety legislation in most countries, which means that the design team should check with the local fire and safety authorities.

14.6.2 Emergency egress from stadium

In the UK the *Guide to Safety at Sports Grounds* (see Bibliography) recommends that the escape time from any seat, in all new stadia constructed of concrete and steel, must be no more than eight minutes. Unfortunately it does not specify where the escapee should be after eight minutes.

The requirement in Italy is that it must be possible to clear the seating areas of all spectators in five minutes, and then to clear the entire building structure of spectators in a further five minutes.

The above examples serve to indicate the kind of rules which may apply, and are illustrative only. Each country will have its own national and/or local regulations, and all regulations change over time, therefore the current situation should always be checked with the local fire and safety authorities before design commences.

In many cases such rules will specify evacuation of a stadium simply in terms of a number of minutes, but this is not a completely adequate yardstick for safety. The true requirement is that spectators must be able to move from their seats to a temporary safety zone, and thence to the permanent safety zone (see Section 14.2) in a specified time. From this requirement may be calculated both the maximum allowable *distances* from spectator seats to intermediate places of safety, and thence to exits, and the minimum allowable *widths* of all the passageways and doorways along those routes. The calculation that should be made is that known as 'timed exit analysis' (TEA).

Timed exit analysis

This is a step-by-step computation of the time it takes spectators to move from their nearest vomitory (the journey from seat to vomitory being ignored for the purposes of this calculation) to a place of permanent safety. It proceeds as follows:

1. Take the 'worst case' in each subdivision of the stadium. This will be the vomitory furthest from the exit in the section under review, or the one serving the greatest number of spectators.
2. Calculate the distance in metres from that vomitory to the 'temporary' safety zone (see Section 14.2.2), and thence to the 'permanent' safety zone. Level areas and ramps must be measured separately from staircases.
3. Assume that spectators move along the level floors and ramps at 150 m per minute, and down stairways at 30 m per minute. Further assume that 40 people per minute can pass through one 'exit width' (600 mm for corridors and also for doorways, gates, etc.).
4. Add up the walking times for the 'worst case' spectator selected above, all the way from his vomitory to Zone 4.
5. Subtract this time from the 'escape period' required by regulation, or in case of doubt from eight minutes.
6. Calculate widths of all passages and doorways or gateways along these routes in units of 600 mm (i.e. a passage that is 600 mm wide is 'one unit exit width', one that is 1200 mm wide is 'two exit unit widths'). Now check that the total number of spectators seated or standing in a particular section can actually exit in the time calculated above, and if they cannot then widths must be increased.
7. Repeat the above 'distance' and 'width' calculations for each subdivision of the stadium, so that no spectator seating or standing area has been missed out, and revise the stadium layout if necessary until the entire stadium complies with safety requirements.

An example is given in Figure 14.4.

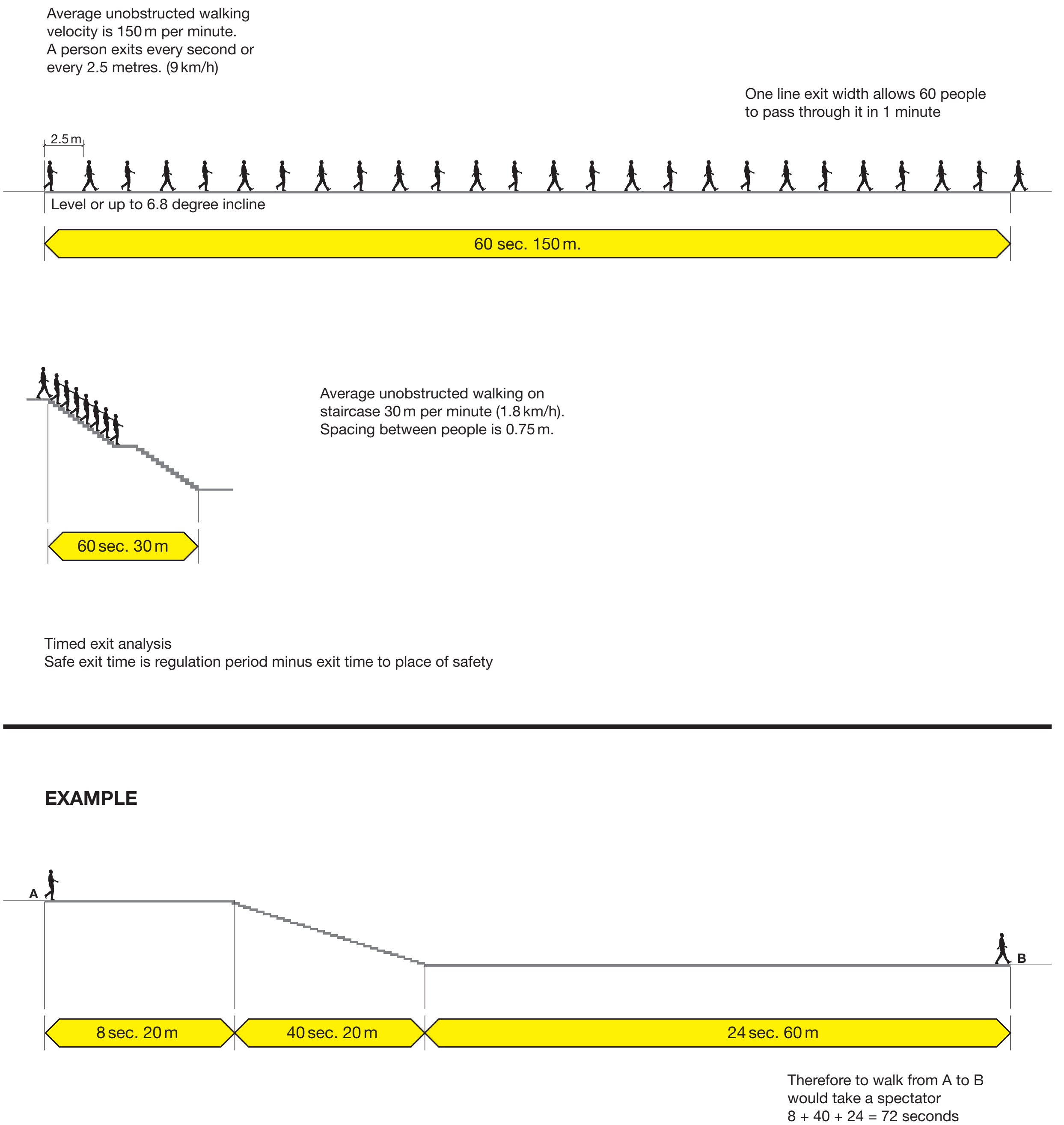


Figure 14.4 The use of 'timed exit analysis' to design escape routes that will allow spectators to move from their seat to a place of safety within a specified time. Minimum evacuation times will increasingly be laid down by law as societies become more safety conscious.

14.7 Elements

14.7.1 Entrances and exits

Gates and turnstiles

Gates are cheap, and an open gate of a metre's width can permit the passage of approximately 4000 spectators per hour; but they are a relatively unsophisticated form of control apparatus. Turnstiles are expensive and will allow only 500 to 750 spectators per hour to pass, but they offer the stadium management several advantages:

- They automatically count the number of spectators.

- They check tickets more precisely and more reliably than a human attendant could do, and can automatically exclude ticket-holders from areas they should not enter.
- With computer ticketing technology becoming more accessible, tickets can be individually coded and individually named. There are various technologies available whereby tickets can be swiped internally or externally to the reader, or read by a proximity reader. This can result in a steward being alerted to a problem with the ticket or the customer, the gate refusing to open, or the customer being advised that a message awaits him at the office. This technology has become increasingly widely exploited as it offers management a full and detailed record of event attendance, a record of individual customer characteristics, and the possibility of more precisely targeted marketing.
- Turnstiles can be used for the paying of money – but this should be discouraged as it leads to problems of security and financial control. Ticket purchase on the day should be handled in separate ticket sales areas at least 10 m away from the turnstiles (see Section 17.2.1).

Turnstiles also have disadvantages:

- Although some machines can be folded back in the 'open' position – to allow egress through the same opening as entry – they are not usually a good method for clearing the grounds.
- Really high-volume, reliable, sophisticated systems such as those seen in metro stations currently cost more than stadium managements are willing to spend, while those which are affordable to stadium managements may not be good enough or secure enough.

Turnstiles are gradually being improved and responding to new computer technology, and will increasingly revolutionize customer throughput at stadium entrances.

Scales of provision

Registering reversible turnstiles, and space for ticket takers, should be provided on a basis of one turnstile for every 500 to 750 spectators depending on the type of event (see below). In addition to these, one exit turnstile or gate should be provided for each group of turnstiles to allow for the ejection of spectators when required.

Subject to the requirements of local safety regulations or authorities, which must always be checked, the following data offers useful guidance. These figures should be verified before use in case of subsequent amendment after publication of this book.

- In the UK the *Guide to Safety at Sports Grounds* (see Bibliography) recommends a maximum entry rate of 660 persons per hour passing through each gate or turnstile. This allows an easy calculation to be made. If the brief states that a particular section of the stadium must be filled in one hour, then one entry turnstile must be provided for every 660 spectators. If a section must be filled in forty-five minutes, then one entry turnstile must be provided for every 495 spectators – and so on.
- For football grounds in Scotland, the Scottish League requires at least one entrance turnstile of the automatic revolving type per 500 of capacity, with a total minimum in all cases of ten turnstiles, not including entrances for season ticket-holders or special passes.
- For football grounds in England and Wales the relevant governing bodies should be contacted for latest guidelines.

As noted in Section 10.3.5 disabled spectators should not enter the stadium via the main turnstiles, but be provided with separate entry gates specially designed and managed for their use.

Ancillary spaces and equipment

There should be fixed crowd control barriers and the possibility of additional temporary barriers in front of turnstiles to control queues. For long queues these should be arranged in a serpentine pattern. Such barriers, especially temporary movable ones, are likely to develop a messy appearance after the stadium is no longer under the designers' control. The design team should take particular care to specify a system which can be adapted to changing circumstances by managers for many years to come, without degrading the stadium image. It may be necessary to design a special area in advance of the gates or turnstiles where spectators can be searched to prevent prohibited items being brought into the stadium.

Storage space should in all cases be provided at each entrance gate or turnstile to store items confiscated during entry. A cashier's and/or controller's booth can also be provided adjacent to each entrance gate or turnstile. Requirements will depend on the way management intends to handle control and money-taking, therefore this must be checked at the briefing stage.

In severe climates, heating or cooling may be needed at the entrance area for inclement seasons.

14.7.2 Horizontal circulation elements

Dimensions

Spectators should be able to move from the entrances to their seats fast enough to allow the stadium to be filled in a reasonable period (say, two hours), and in the reverse direction they must be allowed to escape in a very much shorter period in case of emergency.

For egress great care must be taken to design a pedestrian 'pipeline' that will maintain its required feed-through capacity all the way between the perimeter gate and the individual seat, without risk of congestion at any point along the way.

An evaluation must be made of each stage of the journey:

1 *Entrances*. For convenience, the number of people passing through the gates or turnstiles per unit of time should be limited to a certain maximum, otherwise problems of dispersal and the risk of bottlenecks may occur. Scales of provision were given in Section 14.7.1 above.
2 *Exits*. Outward-opening flood exit gates must be provided to allow the high-volume flows of people described in step 6 of Section 14.6.2. Their clear widths must be based on 40 to 60 people per minute passing through one 'unit exit width' of 600 mm.
3 *Concourses, corridors and other passageways*. Minimum widths will be set by the TEA calculation outlined in step 6 of section 14.6.2.
4 *Areas of particular congestion*. There must be generous additional space to the minimum calculated widths at all entrances to (or exits from) toilets, eating/drinking facilities, and ticket windows – the latter to be spaced at least 10 m away from entrances and exits. It is particularly important to allow ample circulation space at the head and foot of each stair flight or ramp, where people get slowed down by the change of gradient. These points may in effect become funnels, with a mass of fast-moving people behind pushing against those in front who have been slowed down. If there is not enough space for the pressure to be dispersed, very dangerous situations can develop.

14.7.3 Vertical circulation elements

There are a limited number of methods to provide vertical circulation which will link the various levels of the stadium and give access to the concourses. The alternative options are taken in turn below.

Stairs

Stairs have the advantage of being the most compact vertical circulation method, in plan, and consequently the easiest to design into a scheme. But they have the disadvantage of being arguably more dangerous than ramps in an emergency situation. They should be planned in pairs if at all possible, the two stairs preferably sharing a common landing so that there is always an alternative route available should one of the stairs become blocked.

Maximum gradients will depend on the local building regulations, which must be consulted, but would normally be around 33 degrees. Within the prescribed limits a steep angle is actually an advantage as it allows a fast descent and rapid emptying of the stadium. Clear widths will be determined by the emergency egress requirements outlined in Section 14.6.2.

Finishes, provision of handrails and lighting design may be influenced by the local building regulations, which should be checked.

Ramps

Ramps have become popular recently and are used extensively in Italy and the USA. Figure 14.5 shows the Telstra Stadium in Sydney.

They have several advantages:

- Spectators are less likely to lose their footing on a ramp than on a stair, and if they do stumble or fall the consequences will be less serious than on a stair.

Figure 14.5 Circular ramps in Telstra Stadium Sydney (the Sydney 2000 Olympic stadium) – see also Figure 5.6b and Appendix 3.

Photograph: Patrick Bingham Hall

- Ramps are an ideal method of allowing service vehicles to move from level to level. This eases the problems of large-scale stock, catering or retailing provision, and of refuse removal. Ramps also allow easy passage for wheelchairs, and for transporting sick or injured spectators to the exits during events.

Circular ramps have particular advantages:

- Because the slope down a circular ramp will vary according to the line of descent taken, pedestrians are given a certain amount of freedom to select either a steeper, faster route near the centre, or a shallower, easier route near the perimeter.
- The view walking along a circular ramp is less forbidding than a long straight ramp.
- Whilst a straight ramp must have landings at intervals, a circular ramp need not – though this needs to be carefully checked against national and local regulations. The latter often do require mid-landings for reasons of safety and convenience for disabled people and wheelchair users.

For all the above reasons ramps are a safe, convenient and increasingly popular way of moving large numbers of people to different levels of the stadium, and circular ramps are the most common form.

The disadvantage of ramps is their size. Since the maximum gradient is 1:12 their internal circumference works out at no less than 35 to 45 m. This makes a ramp a very awkward element to absorb into the site area, and difficult to handle elegantly from the architectural point of view. The corners of the stadium are the most usual position (Figure 14.5) and visually successful examples include the circular ramps in the Joe Robbie Stadium in the USA and the San Siro Stadium in Milan – see Figures 5.6 and 5.13.

Maximum gradient will be determined by the local building regulations, but should in the authors' view not exceed 1:12. Minimum width will be determined by the calculation described in Section 14.6.2, subject to local building regulations.

Finishes, provision of handrails and lighting design may be influenced by the local building regulations, which should be checked.

Escalators

Relatively few escalators have been installed in sports stadia because of their high capital cost and the fact that their capacity cannot usually be

Figure 14.6 Escalators in the Amsterdam ArenA – see also Appendix 3.

taken into account when calculating the exit widths required, but the Amsterdam ArenA provides a spectacular example (see also Case Study, page 267).

Other exceptions are to be found particularly in racecourse stadia, where escalators have been used in many different countries. Here they give fast access to the higher viewing levels and can of course be reversed, operating upwards before the race and downwards afterwards, though care should be taken with the use of them for egress. Local regulations may not allow them to be used for emergency exit and in some circumstances where there may be crowd pressure they may not be suitable for normal exit.

Examples of use include the Arrowhead and Royals stadia in Kansas City, Missouri, the Giants Stadium in New York, the Selangor Turf Club in Kuala Lumpur and Twickenham (UK).

Elevators

Elevators (lifts) are too small and slow to account for the movement of any significant number of people. Their most appropriate role in sports stadia is to transport relatively small numbers of people to the upper levels of the stadium with speed and comfort. Such users may include:

- VIPs. Their private hospitality boxes tend to be at the upper levels of the stadium, and their comfort must be catered for even if this is expensive.
- The media. Radio, TV and newspaper rooms, too, are likely to be at the upper levels and could possibly be associated with the private hospitality facilities. The same elevators might then be used by both groups.
- Staff and service operations. Providing special elevators for service staff would be expensive, and it would be best to locate a small number of elevators in such a way that various usage could be made of them, including staff. Management must then ensure that there are no clashes of use, for example elevators conveying refuse at a time when VIPs are likely to be using them.
- Disabled and wheelchair users. Elevators can provide otherwise impossible access to upper levels for people in wheelchairs (see below).

14.8 Facilities for people with disabilities

See chapter 10 for a description of the particular entry and exit requirements of disabled people.

15. Food and beverage catering

15.1 Introduction
15.2 Automatic vending machines
15.3 Concessions
15.4 Bars
15.5 Self-service cafeterias, food courts and restaurants
15.6 Luxury restaurants

15.1 Introduction

Attractive and efficient catering facilities will increase customer satisfaction and can also make a vital contribution to stadium profitability and spectator safety.

More people attending an event now expect to buy a reasonable quality and range of food and drink on the premises, and their expectations are constantly rising as a result of the great improvement in catering standards generally. The challenge to stadium owners and managers is therefore to provide the widest possible range of eating and drinking facilities, from quick-serve outlets at one extreme to luxurious private dining rooms at the other. If they can get right the scales of provision, the locations, the quality of service and the price levels for all their customer types they stand to earn valuable additional revenue.

Generally the spend per head on food and beverages at an event is higher in the USA than elsewhere, partly no doubt because US spectators have more money to spend, but also because American managements have gone to great lengths to please the customer by the scale, quality and attractiveness of the catering outlets. Other countries, including the UK, are beginning to follow the North American example.

A balance must be struck between the capital and running costs of extensive kitchen and serving facilities, and the return they generate in terms of direct sales.

15.1.1 Maximizing revenues

An obvious way of improving the 'revenue to cost' ratio is to make the maximum use of catering facilities once they have been installed. Wherever possible these should be designed to cater not only for regular stadium spectators but also for receptions, banquets, dinners and other functions throughout the year. Restaurants ought to be open not only on match days, but on as many other occasions as customers can be encouraged on to the premises; private box-holders should be encouraged to use their facilities not only during matches, but for general social relaxation or corporate entertainment on event days and at other times as discussed in Chapter 13.

If spectators are to be encouraged to make full use of restaurants and catering concessions, other aspects of stadium design and management need to be addressed. Spectators should be encouraged to arrive at the stadium early and stay late – a use-pattern which would also ease the problems of crowd circulation and traffic movement.

In the UK and Australia part of the problem lies in changing strong existing traditions whereby spectators attend a local pub before a sporting event, particularly football and rugby, the pub acting both as a meeting point and a suitable beverage outlet. This results in late arrival at the stadium and an unnecessary crush, creating crowd control problems. Indeed, pre-match drinking was one of the suggested contributory factors to the Sheffield Hillsborough disaster in the UK in 1989. In addition, having fans spend their money off the premises does nothing for stadium profitability.

Some of the methods for extending customer time at the stadium lie in marketing and management, for instance providing warm-up events before the match, or showing highlights of the event on a video screen afterwards.

But design too must play its part: there must be adequate circulation routes to seats, and treads of sufficient width to make spectators feel comfortable about carrying their purchases back to their seats without disturbing others. The provision of accessories such as carrier bags, trays and frames for carrying several drinks safely and drink holders fixed to seats also help to encourage increased purchasing.

Long-established habits will change only if people learn to expect a good standard of product and service, with an enticing range of foods and beverages available. There should, within reason, be something for everyone – the customer who wants to enjoy a leisurely sit-down meal in prestige surroundings; the customer with less to spend, who will be satisfied with a self-service cafeteria; and the customer in a hurry, who wants a variety of fast-food or take-away outlets to choose from in a concourse near him. And it is important to realize that these categories no longer reflect the stratifications of society: the take-away kiosk may be patronized by the holder of a high-price ticket who happens to be in a hurry, and the sit-down restaurant by a less affluent family giving themselves a treat. All facilities should be available to everyone (Figure 15.1).

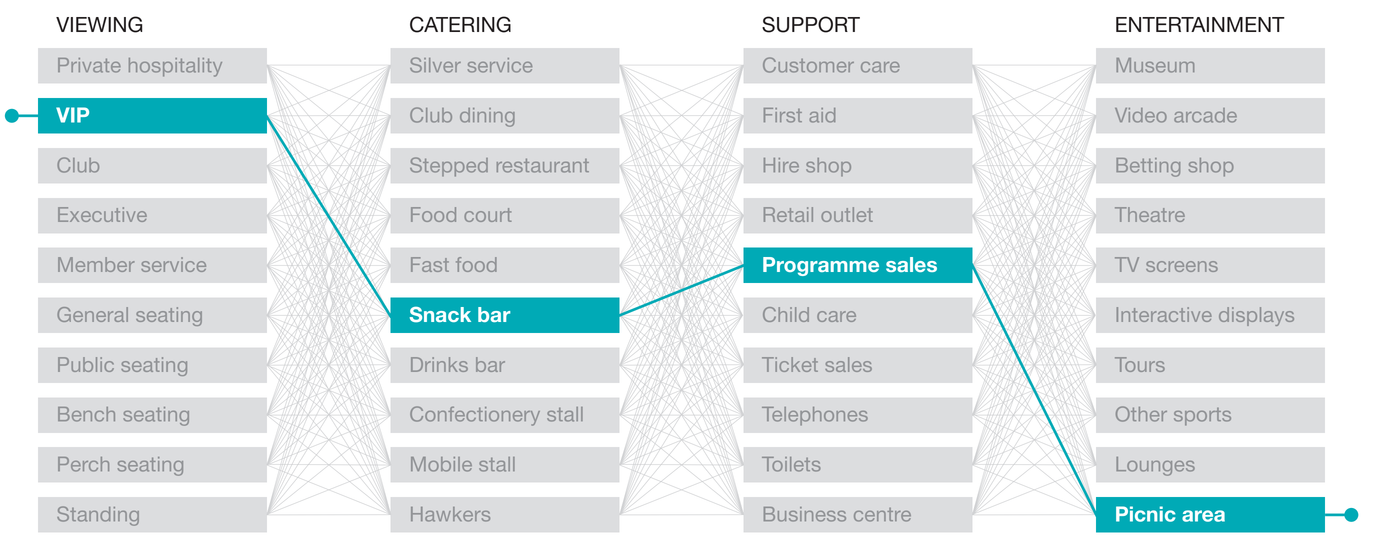


Figure 15.1 The trend in stadium design is away from fixed relationships between customer class and service type, towards freedom of choice between wide range of services. The diagram shows the rich network of potential cross-connections that is desirable.

15.1.2 Sharing capital costs

It is now common for the stadium owner to enlist the support of an established catering organization, thus sharing the burden of capital costs, and bringing in the wealth of marketing and managerial expertise which exists within such specialized organizations. Catering firms in turn are starting to appreciate the opportunities which exist at sporting venues where tens of thousands of people come to spend their day in an atmosphere of relaxed leisure. This is precisely the mood in which the public parts with its hard-earned money, and catering specialists know how to capitalize on this mood.

The viability of using a catering firm is directly related to the number of events held per annum. The fewer the events, the greater the attractions of using outside catering (with once-a-year events as described in Section 15.1.4 below as the extreme example). Conversely, the greater the number of events the greater the opportunity for the stadium organization to set up its own internal catering operation using permanently employed staff.

Leased concessions

It is now common for a named franchise such as MacDonald's or Burger King to take a concession space for the sale of its products, and in larger stadia there may well be several independent franchise outlets in a single concourse.

Leased concessions can operate in several different ways. One arrangement is for the catering firm to finance the construction of certain catering outlets in a stadium in return for a period of exclusive sales at that venue. The stadium will usually take a percentage of the sales in this situation. Such a partnership needs careful control. From a design point of view the caterer will understandably want to dictate much of the planning and layout of the stadium catering facilities as it affects his income, and he will have essential knowledge on the provision of cabled and piped services to feed these areas. The stadium owners and management must heed these views, especially as the caterer might well invest millions as part of the arrangement; yet it is essential they remain in overall control of functional and aesthetic design matters if the stadium design is to be consistent.

15.1.3 Self-managed operations

Self-managed operations are owned and managed by the stadium administration, though usually operated by a separate department to the one running the grounds. They can in theory include the same wide range of operations as specialist contractors, but in practice are often limited to the large fixed catering facilities such as restaurants, bars and private boxes, leaving the fast-food sales to concession holders.

The advantage of a stadium operating its own catering organization is that it may then have better control of revenue and also of customer service, with more power to vary the catering 'mix' at any desired time.

Rangers Football Club in Glasgow, whose home is the Ibrox Stadium, is a British example of stadium owners managing all aspects of the catering operation themselves.

15.1.4 Temporary catering facilities

There are many examples of enormous catering operations undertaken with very little in the way of permanent infrastructure. Although this mobile method of catering is used throughout the world the British seem to be particularly adept at it, probably because so few major sporting events in the UK possess adequate permanent facilities.

At the Silverstone Grand Prix the total permanent catering facility consists of only one restaurant serving about 200 people, and a small kitchen. On the day of the Grand Prix, however, thousands of hot meals are sold to the 185 000 spectators who attend over the three days. Around 95 000 people attend on the day of the final and more than 12 000 hot sit-down meals are served in the one and a half hours before the race. Around 95 per cent of these meals are served 'under canvas' from temporary kitchens and dining areas set up inside tents and other temporary buildings.

Even more impressive are the figures for the Wimbledon Championships. Because of its two-week duration it is the largest sporting catering organization in the world. In addition to snacks and drinks, 1500 catering staff serve 100 000 lunches in private marquees erected on the grounds. The amount of food and drink consumed during this brief period each year includes 12 tons of smoked salmon, 23 tons of strawberries, 190 000 sandwiches, 110 000 ice-creams, 285 000 teas and coffees, 150 000 scones and buns, 12 500 bottles of champagne and 90 000 pints of beer.

The help of temporary caterers is regularly enlisted at the Henley Regatta and at virtually every British racecourse which has a major meeting, most notably Cheltenham, the home of national hunt racing. In March each year around 55 000 spectators in 11 000 cars and 360 coaches converge on Cheltenham Racecourse for the three days of the Gold Cup. During that period 8000 sit-down meals are served every day in temporary accommodation, 6000 of them in a vast tented village erected specially for the occasion and taken down immediately after the event is finished. In addition to temporary catering accommodation there are also temporary private boxes, betting outlets, bars and an entire precinct of shops.

A major disadvantage of this form of catering is that it relies on temporary staff who are enlisted for the duration of the event and then return home hoping to work again on the next occasion, which could be weeks away. Such a pattern of employment tends to suit housewives and retired men and women who can be flexible with their time and income, but are not in the highest skill category for the job. The large operators employ a core group of permanent and well-trained supervisors and take on casual serving staff under their direction, particularly for the larger events.

Environmental health requirements are becoming more stringent and may have an effect on temporary catering layouts, costs and efficiency. The maximum temperature at which refrigerated food must be kept is tending downwards (in Britain, 5 deg C rather than 8 deg C), there are increasingly strict standards for floor surfaces, and so on. The latest requirements should be checked with local health authorities.

15.1.5 Design of catering facilities

In stadium design a choice must be made between three broad patterns of catering operation:

- A central kitchen serving all eating areas.
- Dispersed kitchens serving individual eating areas.
- A central kitchen with smaller satellite kitchens between the main kitchen and various individual serveries, each such servery possibly covering a group of private boxes or one large function area. It is typical, for example, for a central kitchen to have a satellite kitchen on each of the upper decks of a multi-tiered stand, serving the outlets on that level.

Each particular case must be analysed on its merits and the most appropriate options chosen. Such strategic analysis, and the design of the kitchens themselves (which must have adequate storage, preparation and delivery spaces), are highly specialized matters which cannot be adequately covered in a book dealing primarily with stadium design. Before commencing detailed design all decisions should be checked with experts in the field. Technology and practice constantly advance and even the best published information sources quickly become outdated.

Good communication and distribution between the various kitchen and serving areas is critical and an independent service elevator (preferably about 2.4 m by 3.0 m) and internal telephone system are essential between different levels of operation. If carefully planned the service elevator can also be used to service the concession area and other functions such as rubbish removal, equipment transportation and general maintenance operations. In smaller venues it may be possible to use the service elevator for passengers as well but then the elevator would only be available for use by the caterers before the spectators arrive and after they leave. This would place constraints on the caterers' operations.

15.1.6 Scale of provision

The size and number of eating and drinking facilities in a stadium will depend on market conditions, the needs of users and the needs of management. It would be rare for a sit-down restaurant of say one cover per 100 spectators not to be viable on the day of an event at any stadium, simply because of the number of spectators in attendance; but how realistically this size could be maintained and operated on non-event days would depend on management. The trend now is to use the restaurant for conference or other functions on days with no sporting events.

Whatever areas are provided for dining should, wherever possible, be linked with movable walls so that a range of spaces can be created to serve one large group, or a series of smaller groups, depending on need. This flexibility is crucial since nobody knows what tomorrow's demands might be, and how the building will be expected to cope.

15.2 Automatic vending machines

Vending machines are the simplest and fastest form of catering service, requiring no personnel and very little space. Units are available for dispensing cold beverages, hot drinks (tea, coffee and chocolate), confectionery, various types of snacks and even mini-meals. The simple fare offered, impersonality of service and cost of provision means that they cannot be a substitute for conventional catering methods. But they do have advantages as a supplementary service:

- They can help cope with peak demand when the restaurants and concessions are over-loaded.
- They offer faster service (as little as 5 seconds for a snack and 12 seconds for a carton of tea or coffee).
- They can be located throughout the stadium, thus allowing customers from all seating areas to get a quick snack or drink without going far from their seats.
- They can offer a service 24 hours a day.

Their disadvantages are the cost of provision, their vulnerability to vandalism and the need for maintenance. Perhaps it is for these reasons that vending machines are not particularly widely used in sports stadia.

15.2.1 Types and dimensions

Automatic vending machines are available as floor-standing or wall-mounted types. Free-standing or surface-fixed units are easiest to install or (when no longer wanted) to remove. But they are more vulnerable to vandalism than recessed types and more likely to create untidy, cluttered public areas. Management must exercise constant vigilance if tidy stadium concourses are not to degenerate into a mess as obtrusive dispensing machines, etc. are placed in every convenient space, perhaps by concessionaires, without adequate control.

The larger machines are floor-mounted (up to 2 m high by 0.9 m deep by 1.2 m wide), and may be with or without legs. Refrigerated models must be mounted about 0.2 m from the wall for adequate ventilation. Service access for most models is from the front. The smaller machines are wall-mounted (up to 0.9 m high by 0.6 m deep by 0.7 m wide), and should be positioned at approximately chest-height so that users can operate them without having to bend over.

All the foregoing generalized comments and dimensions are for preliminary space estimation only, and precise data must be obtained from manufacturers, suppliers or proposed concession holders.

15.2.2 Shell and service requirements

Though the vending machines may be owned and installed by concession holders the stadium management will have to make adequate provision to receive them. Most machines will require some or all of the following services, with isolating switches and valves, depending on the types of product they dispense:

- An electrical supply (probably single-phase) for illumination, power, beverage making, microwave heating and chilling.
- Mains water supply, possibly to a specified pressure, for beverage making.
- Hot water supply nearby for cleaning.
- Drainage outlet for overflow and cleaning.

To cope with spillages and deliberate vandalism all surfaces surrounding food and beverage machines must be durable and impervious, and detailed for easy cleaning. Lighting must be excellent to attract customers, to allow instructions to be easily read and to deter vandalism.

Management should provide disposal bins with self-closing flaps and leakproof inner linings adjacent to all machines. These are to receive discarded wrappings, waste food, and the half-emptied beverage cartons which so quickly turn any area into a sordid situation if proper provision is not made.

15.2.3 Locations and scales of provision

Automatic vending machines are usually provided in areas where space does not allow for a concession kiosk. The latter will always be more popular than machines where there is a free choice. The number of machines to be installed may be calculated from the number of snacks to be served in a given period such as ten minutes. Specialist contractors will be able to give expert advice.

15.2.4 Ownership and leasing arrangements

Automatic vending machines may be purchased by the stadium owner, or installed by a vending company who will then provide services such as regular re-stocking, cleaning and maintenance under contract. If a contract arrangement is envisaged, the information given above must be checked with proposed contractors to ensure that the stadium design allows for their requirements.

15.3 Concessions

These are the next simplest form of catering. Like automatic vending machines they are economical on space, but being staffed they offer a more people-friendly service and are less likely to be immobilized by mechanical breakdown. There are three basic types of concession kiosk, each dependent on food type.

Confectionery kiosks

All the products are wrapped and non-perishable, therefore no equipment is required and the stand is very simple. Its essential components are storage, display space and a servery; it may be little more than a counter. Choice of food is necessarily limited, but there is the possibility of the stadium selling its 'own-brand' products. Gifts and memorabilia may also be sold at these outlets.

Snack bar kiosks

These sell heated food (such as pies and rolls) and hot drinks and therefore need some basic equipment, such as heat/hold cupboards. The kiosk normally consists of a front servery counter and a back storage/preparation counter (Figure 15.2), with the staff acting both as 'servers' and 'collectors'.

Fast-food kiosks

Cooking and preparation takes place in these kiosks, which sell items such as burgers, steaks, chicken or chips. The kiosk therefore has a complete island 'feed-through' bench with separate counter staff (who serve) and support staff (who cook the food and load the shelves).

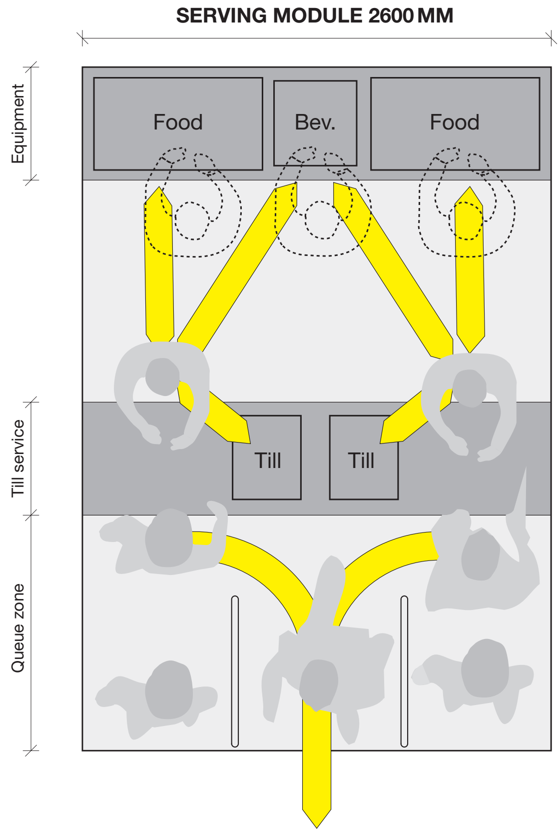


Figure 15.2 Schematic layout of typical 'snack bar' kiosk, where food preparation is not required.

A major decision to be taken when there are multiple kiosks throughout the stadium is whether they should be serviced from a central cooking kitchen, or do their own cooking.

The advantages of a central kitchen are that more food varieties can be made available; that equipment duplication is minimized; that food storage conditions are better controlled; that kiosk staff do not need to be as skilled; that precooking can be done at the most effective times; and that cooking can be combined with restaurant cooking.

The advantages of kiosk cooking are that output and demand can be more closely matched; that the cooked food may be fresher than if brought in from a distant kitchen; that 'good food smells' in a concourse can be a marketing advantage; and that kiosk staff are offered more responsibility and opportunities.

15.3.1 Layout and dimensions

Subject to the comments above on various kiosk types, the essential elements of any take-away stand except the simplest are a serving counter, storage space and preparation space. The basic principles are to design the counter so that the person serving needs only to turn to the right or left to reach the majority of items on sale, and to avoid cross-overs with other staff. The counter may need a security screen to the concourse, and this must be designed for aesthetic compatibility with the stadium as a whole, not be fitted by the caterer as an afterthought.

Precise layout and dimensions will vary with the type of food and beverage on sale and the scale of operation. If there are multiple kiosks in the stadium their design should be standardized throughout. Initially, this should mean economies in equipment purchases, and it will also make it easier for staff to transfer from one kiosk to another without retraining.

If people are likely to congregate near the stand to consume their purchases, the area they will take up may be estimated at 0.5 m^2 to 0.6 m^2 per person. There should be plenty of wall-shelves and free-standing shelf units for the use of people with food and drinks.

15.3.2 Locations and scales of provision

The primary locations for concession kiosks are as close as possible to the access vomitories and concourses, planned so that queues do not obstruct circulation. A total allowance of 1.5 m of counter length per 300 spectators is a figure used in some football stadia, but it may need to be increased where intervals are shorter and the crush for service greater. The principal factors involved are match quality, weather and how easy it is to get service, all of which have an impact on spectator demand.

15.3.3 Shell and service requirements

Except for the most basic stands, selling only packets of confectionery and the like, the preparation space should be provided with the following services (incorporating isolating switches and valves):

- Hot and cold water supply and drainage outlet.
- Electrical supply and lighting, with three-phase outlets for cooking.
- Mechanical ventilation, and an extracting system above the cooking and food preparation apparatus.
- General space heating or cooling for staff comfort, depending on the extremes of temperature likely to be encountered.

15.4 Bars

Even if it is decided that alcohol will not be served during certain sporting events, the provision of bar facilities may still be necessary because the stadium will be used at other times for purposes where such a service will be demanded. Bars of various types may have to be provided.

- At one extreme, intensively used crush bars in public concourses, where large numbers of customers must be quickly served during half-time. These will be highly functional in design, with multiple serving points, and designed for a high proportion of standees.
- At the other extreme, intimate bars in club lounges or luxury dining facilities, where the emphasis will be on a luxurious setting and high-quality service, with comfortable seating for customers who are in no hurry.

There may well be several intermediate grades of bar facility, and portable bars may be necessary for some functions.

15.4.1 Layouts and dimensions

For preliminary space planning purposes it is advisable to allow a customer area of roughly 0.5 m^2 per person if everyone stands or 1.1 m^2 plus per person if half are seated.

The standard bar layout consists of a counter, backed by a serving space, and behind that a shelf for drinks display and preparation, and drinks/glasses storage below or above the counter. If it is compatible with the stadium policy on concessions, part of the counter, perhaps 3m to 5m in length, may be devoted to serving snacks heated in a microwave oven, and probably coffee.

It makes for economy and efficiency if a central serving area is accessible to several bars, saloons or lounges, with bar tenders able to go to the counter where they are needed. The servery should always have direct access to the storage area and possibly a small kitchen.

15.4.2 Locations and scales of provision

There are no particular rules regarding location, and bars should be located where space is available.

At any one time one metre of counter length could accommodate between five standing customers being served (crowded) and three (more comfortable). For customers seated on stools counter length is 0.6 m per person.

15.4.3 Shell and service requirements

The bar area should be set back from the circulation route to reduce congestion, and must be fitted with a roll-down grille or shutter to provide security when the bar is not in use. The grille arrangement should be aesthetically compatible with the stadium design and not a later addition.

If the provision of bar services are to be contracted out to specialists who will be fitting out the spaces to their own specifications, the shell should be provided with the following services (incorporating isolating switches and valves):

- Hot and cold water supply and drainage outlet.
- Electrical supply and lighting, possibly with three-phase outlets for cooking.
- Mechanical ventilation, and an extract system above the cooking and food preparation apparatus.
- General space heating or cooling for staff comfort, depending on the extremes of temperature likely to be encountered.

15.4.4 Ancillary accommodation

There must be storage facilities for drinks (and, in large premises, perhaps also for kitchen supplies).

WCs and washbasins must be provided adjacent to bars, and such facilities should be easily accessible and clearly signposted. The provision of toilets is covered in Chapter 11. In most countries this matter is governed by law, and the scales of provision must be checked with the authorities in each case. In the UK the relevant statutes are:

- The Licensing Acts – for all premises where alcohol is to be served.
- The Public Health Act of 1936, Section 89 and the Food Hygiene [General] Regulations – for all refreshment houses where food and drink are sold.
- The Offices Shops and Railway Premises Act – for employee facilities.

It is most economical if toilets, which are very costly, are located to serve a variety of nearby facilities; and the whole stadium should be planned with this in mind (see Chapter 16).

15.5 Self-service cafeterias, food courts and restaurants

Self-service eateries require fewer staff than restaurants with table service (see Section 15.6) and are designed and managed for a faster rate of customer through-put. This is a vital factor in sports stadia, with their concentrated demand peaks.

The arrangement is familiar to all: food is displayed in a line of refrigerated or heated glass-lidded cabinets, and customers move past with trays, helping themselves to what they want and paying at the end. Part of the counter may be devoted to a carvery and/or hot meal servery where staff assist the customers by carving the meat for them, and serving them with meat, fish and vegetable dishes from heated containers.

The food court is an elaboration of the above principle with several serveries, devoted to a variety of food types and price ranges, surrounding a single seating area. Customers collect their food and drink from their chosen counter, and then find a table in the central area.

15.5.1 Layout and dimensions

Because of the specialized nature of such an operation the restaurant will probably be leased to a specialist operator, who will design and fit out the space himself. Layout and dimensions should be discussed with such firms before the stadium design is finalized.

15.5.2 Locations and scales of provision

Self-service restaurants or cafeterias are usually located at the lower levels of the stadium, near the main kitchens and service roads. They require large spaces.

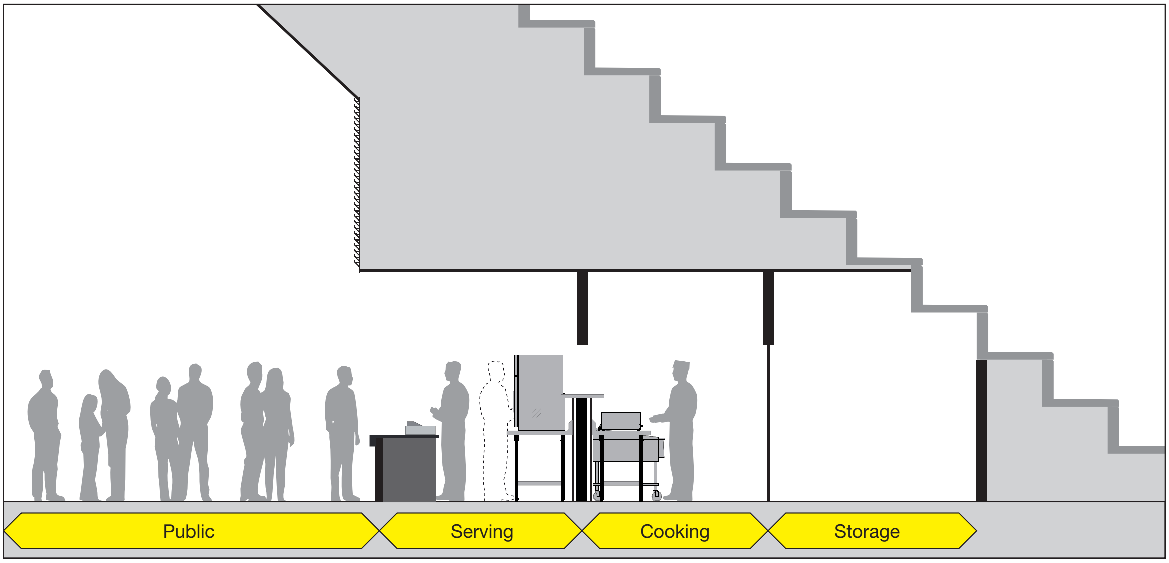


Figure 15.3 Schematic section through a typical food kiosk located on the inside of a concourse under a seating tier.

There are no reliable figures on scales of provision, but a ratio of one seat to 50 or a 100 spectators may be used as a starting range. The precise ratio will depend on the nature of the stadium, the character of its clientele, and the degree to which its catering facilities might also be used for non-sports events.

15.5.3 Shell and service requirements

The stadium management may be required only to provide a simple serviced shell ready to be fitted out by a specialist tenant, in which case the latter should state his requirements. They will almost certainly include the following:

- Hot and cold water supply with isolating valves.
- Drainage outlet.
- Electrical supply and lighting, including three-phase supply for cooking, with isolating switches.
- Mechanical ventilation and an effective extraction system for the cooking and food preparation apparatus (in case of mechanical breakdown or malfunction natural ventilation should also be available).
- Heating or cooling for staff and customer comfort, depending on the extremes of temperature likely to be encountered.
- Security screens between the restaurant and the concourse.

It is possible that additional fitting out would be appropriate, depending on the leasing arrangement, and this might include:

- Cooking equipment such as cookers and fryers, depending on the type of food sales.
- Warmers, beverage storage, cold storage and freezers (these to be large enough for a full day's use).
- Washing-up equipment including sinks and perhaps dishwashers.

15.5.4 Ancillary accommodation

There should be direct entry for service access and bulk deliveries, and easy exit for waste disposal. Restaurants generate a great quantity of refuse of a kind which quickly becomes offensive if not removed.

WCs and washbasins must be provided adjacent to restaurants, and such facilities should be easily accessible and clearly signposted (see also the notes under Bars, Section 15.4.4).

15.6 Luxury restaurants

High-class restaurants will attract customers willing to spend more money in return for better food and service in more spacious surroundings, probably taking more time over their meal. Because of the mark-up such facilities could be particularly lucrative for the stadium management.

15.6.1 Layouts and dimensions

These matters are too specialized to be covered in detail in the present book, and layout should be discussed with specialist firms before the stadium design is finalized.

Ready access will be required for bulk deliveries and waste removal.

15.6.2 Locations and scales of provision

Prestige restaurants are usually located near to the club areas and private boxes.

No generalized guidance can be given on the scale of provision, which will depend on the nature of the stadium, the character of its clientele, and the degree to which its catering facilities might also be used for non-sporting events.

15.6.3 Shell and service requirements and ancillary accommodation

The same notes apply as under Sections 15.5.3 and 15.5.4 above.

16. Toilet provision

16.1 Toilet provision generally
16.2 Toilets for spectators
16.3 Scales of provision for spectator toilets
16.4 Location of spectator toilets
16.5 Detailed design

16.1 Toilet provision generally

Toilets and/or ablutionary facilities may be needed for several individual types of stadium user in addition to those for the mass of spectators. These individual types include:

- Private box-holders and other VIPs: see Chapter 13.
- Television crews, press reporters and radio commentators: see Sections 18.2.2 and 18.6.2.
- Management and staff: see Section 19.7.
- Match stewards and police: see Section 19.7.
- Players and referees: see Section 20.2.
- Medical examination teams: see Section 20.6.

These facilities should be thought of in conjunction with spectator toilets so as to minimize the number of sanitary appliances and drainage stacks in the stadium while still making adequate provision for all types of users.

In smaller stadia it would be uneconomic and quite unnecessary to provide separate toilets for all the groups listed above: common facilities could serve several categories of users provided only that everyone is within easy reach of a usable and suitable toilet. In the largest stadia it may be necessary to provide completely separate facilities. For each particular case the design team must find the right balance between:

- The cost advantages of having only a few centralized drainage stacks in a stadium (these being a particularly high-cost element, especially at the upper levels of multi-tiered stands), and
- The user convenience of maximal dispersal of toilets throughout the stadium, with short distances (preferably no more than 60 metres) and the minimum of changes of level between users and the nearest facility.

16.2 Toilets for spectators

The bulk of these will of course be inside the stadium but there should also be toilets outside the perimeter fence (Zone 5, as defined in Section 3.3) for the benefit of those queuing for an event.

	Urinals	WCs	Wash basins
Male	Minimum of 2 for up to 100, plus 1 for every other 80 males or part thereof	Minimum of 1 for up to 250, plus 1 for every other 500 males or part thereof	1 per WC and 1 per 5 urinals or part thereof
Female	No recommendations	Minimum of 2 for up to 50, 3 for 51 to 100, plus 1 for every other 40 females or part thereof	Minimum of 1, plus 1 per 2 WCs
Note: There are no official UK recommendations specifically for sports stadia, and the above figures for places of entertainment are the closest approximation. If applied to sports stadia the balance of provision is unlikely to be right, and Table 11.2 should be followed. But if the stadium is to be used also for non-sporting events, then WC and wash basin provision should satisfy the above formula rather than the lower figures in Table 16.2.			

Table 16.1 BS 6465: Part 1. Minimum recommendations for cinemas, concert halls and similar buildings

16.3 Scales of provision for spectator toilets

Good toilet provision is intrinsic to a venue's image while inadequate provision, uneven distribution and poor quality are major sources of complaint from spectators. Insufficient toilets or urinals to meet the needs of large crowds of fans can also lead to misuse of the facilities, offending and driving away potential visitors and club members, thus reducing stadium revenue.

There are three separate design problems to be addressed:

- Providing an appropriate ratio of male to female toilets.
- Providing for the intensive use of toilets in very short periods of time.
- Providing an appropriate proportion of toilets for disabled spectators.

Ratio of male to female toilets

For public buildings in general, the most recent UK recommendations are the following:

- The authoritative *Good Loo Design Guide*, published in 2004, quotes approvingly the British Toilet Association's recommendation that the required number of female cubicles should equal the number of male cubicles plus the number of male urinals × 2. Thus, if there are three male cubicles and four male urinals, the BTA recommends fourteen female cubicles.
- British Standard *BS 6465 Part 1: Code of practice for scale of provision, selection and installation of sanitary appliances*, published in 1994, gives a set of minimum recommendations that are summarized here in Table 16.1.

For stadia in particular, there are no official UK recommendations, but the UK Sport Council published in 1993 a useful guidance on behalf of the Football Stadia Advisory Council. That guidance is discontinued but its principal recommendations are summarized here in Table 16.2. It is anticipated that a future edition of the SGSG Series of Sport Grounds and Stadia Guides will update this otherwise excellent guidance.

Within the framework set by the above documents, specific figures must be decided for each stadium after a thorough analysis. Every type of event, or club membership, will have its own ratio of male to female spectators. For instance:

- If a stadium is designed for multi-purpose use, including concerts, then the male:female ratio will approach 1:1.
- Tennis or athletics clubs or events will have higher proportions of women than will soccer or rugby.
- Clubs with high family memberships will usually have above-average proportions of females.
- Higher status clubs, and clubs in pleasant parts of town, will tend to have a higher proportion of women than those with a 'basic' image or environment.

	Urinals	WCs	Wash basins
Male	1 per 70 males	1 for every 600 males, but not less than 2 per toilet area, however small	1 for every 300 males, but not less than 2 per toilet area, however small
Female	No recommendations	1 for every 35 females, but not less than 2 per toilet area, however small	1 for every 70 females, but not less than 2 per toilet area, however small
Note: Slab or trough-type urinals should be calculated on the basis of not less than 600 mm per person. All suitable wall areas not needed for other purposes should be exploited for additional urinal provision over and above the minimum recommendations.			

Table 16.2 The UK Football Stadia Design Advisory Council's minimum recommendations for newly constructed or refurbished sports stadia and stands. These figures apply to each individual accessible area

At a particular event there may also be different gender mixes in different parts of the stadium. For instance:

- There will be a higher proportion of women in the private or family enclosures of British football stadia than in the standing terraces.
- There will be a higher proportion of women among the home supporters at a European football match than among the 'away' supporters.

On the basis of the above data the gender mix should be reflected in the proportions of toilets provided for that event. Organized clubs keep a record of the male/female split for particular occasions, and such club records are the only reliable source of briefing information for a new stadium design. Figure 16.1a shows a female unit, and Figure 16.1b a male unit, based on an 80:20 male:female ratio which would be suitable for many current stadia, and which could be distributed evenly throughout the building. The male unit incorporates a unisex cubicle for wheelchair users (see below), opening off the corridor so that both men and women have access to it. The diagram should not be taken to imply that this is the only suitable location for such a facility, though it should be near the main toilets.

In view of the variation of the male/female ratio from event to event some flexibility should be built into toilet provision. Movable partitions, or defined sections which can be labelled either 'male' or 'female' for a particular event, are two possibilities. These solutions may seem an extravagance, but the problems of inadequate provision and customer dissatisfaction are so great in stadium design that all possible solutions must be considered in the interests of attracting more spectators.

Numbers of appliances

The fact that demand comes in extreme peaks (for brief periods toilet facilities can barely cope with the number of users, while for most of the time they are completely unused) creates a serious problem for the design team. The cost of providing enough WCs and urinals to avoid all queuing would be extravagant, while the problems caused by saving money and not providing enough facilities affronts customers.

In the absence of more specific guidance from the client or from local regulatory bodies, the recommendations of British Standard *BS 6465 Part 1: 1994 – Code of practice for scale of provision, selection and installation of sanitary appliances*, should be used – see Table 16.1. These figures should, if possible, be improved upon, particularly in stadia where spectators will be exposed to winter weather (which causes more frequent use of toilets) or where events are staged with long stretches of time between intervals or where large amounts of beer may be consumed.

Temporary facilities

Owing to the high cost of providing permanent toilets we suggest that only the normal anticipated use of the stadium be catered for in this way, but that provision be made for adding portable facilities (for example 'portaloos' in the UK) for special events, such as pop concerts, which may attract vastly greater numbers of spectators than normal, or continue for longer periods. Preferred locations for such additional facilities need to be planned in advance, so that they can be easily slotted in and serviced.

Proportion of toilets for disabled people

A certain proportion of the toilets provided should be suitable for use by disabled people, both in terms of their location and their design. This percentage

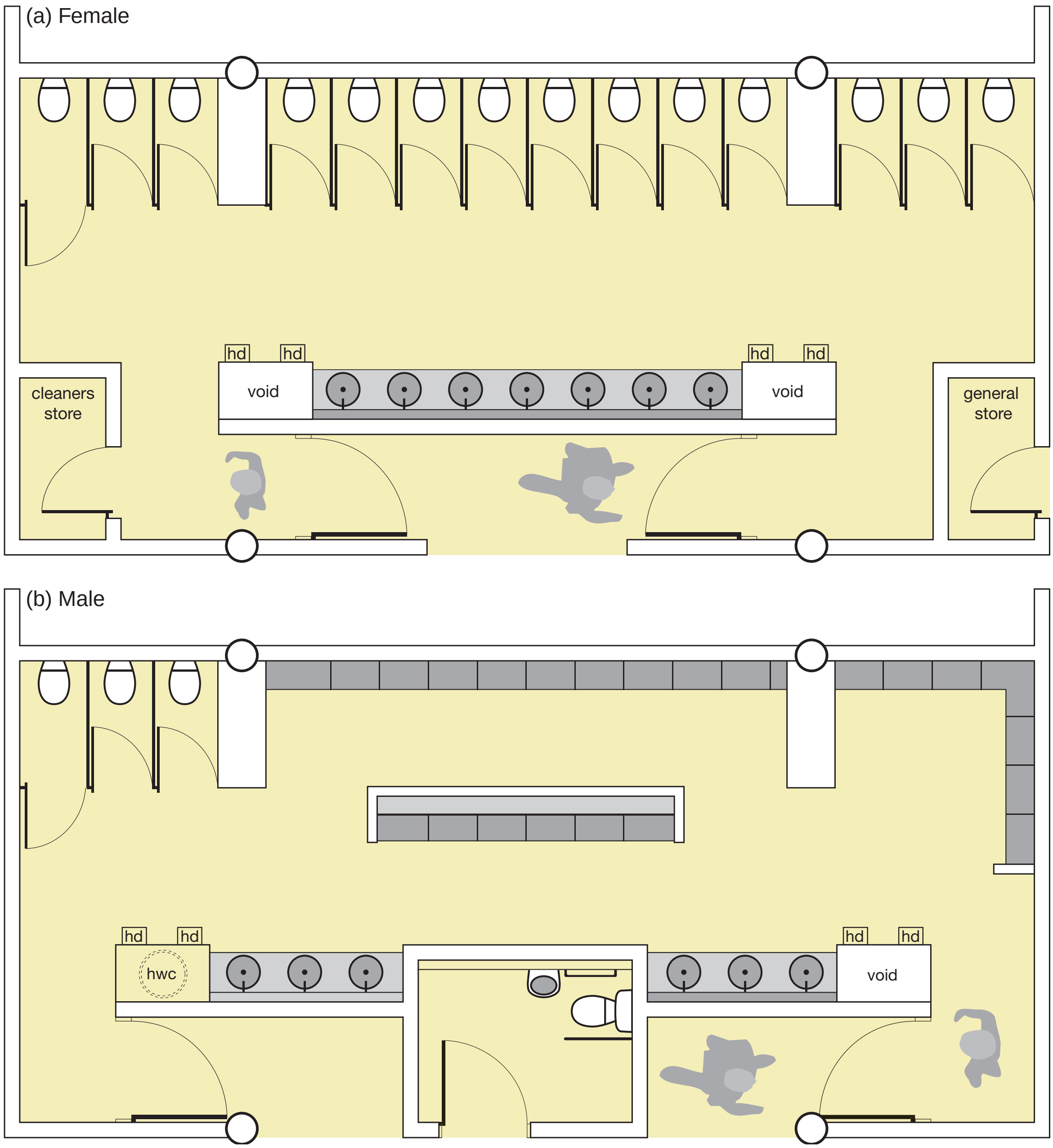


Figure 16.1 Moderately sized toilet units such as the two illustrated above, evenly distributed throughout the stand, are preferable to highly centralized provision. The correct male:female ratio should be researched for each individual case but the 80:20 ratio shown here is a widely recognized 'club' standard. Note the plan layout for fast throughput. Toilets for spectators who are disabled are kept separate, see Section 16.3.

may be laid down by local regulations, which should always be consulted.

For the USA, Chapter 6 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography) provides detailed guidance on accessible toilets.

For the UK, the situation is summarized in the following paragraphs.

Two types of WC compartment should be considered – special cubicles for people in wheelchairs, as shown in Figure 16.2a; and enlarged versions of a standard WC cubicle, fitted with special handrails,

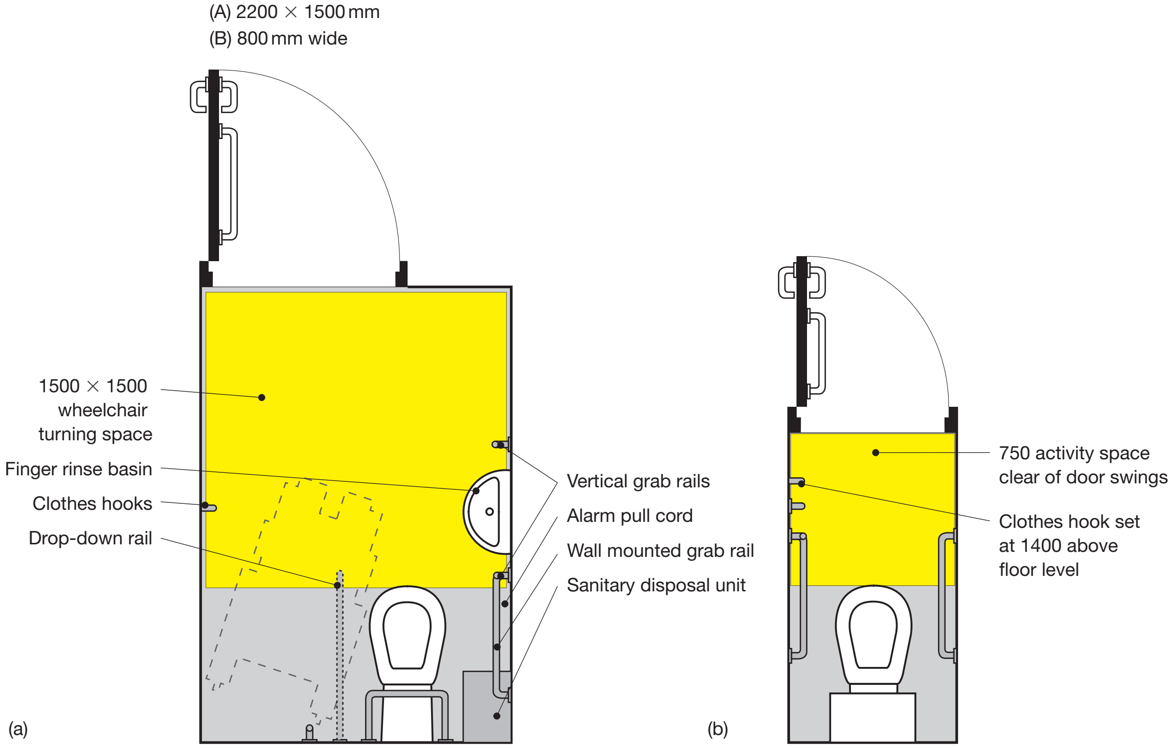


Figure 16.2a, b A 2200 × 1500 mm Unisex WC cubicle suitable for wheelchair users. If it is the only toilet facility in the building, then the width should be increased from 1500 mm to 2000 mm, and the compartment should include a standing height wash basin in addition to the finger-rinse basin associated with the WC. A 800 mm wide WC cubicle suitable for ambulant disabled people – i.e. those who have impaired mobility, but do not need a wheelchair.

for the use of ambulant disabled people (i.e. those who have impaired mobility but are not in wheelchairs) as shown in Figure 16.2b. These simplified diagrams are based on Diagrams 21 and 18 from *Approved Document M* of the Building Regulations for England and Wales. More extensive and detailed guidance is given in the three documents listed in Section 16.5. Note in the latter that where more than one WC compartment is provided, both left and right handed transfer layouts should be provided.

With respect to the numbers of each type of WC that are required:

- As regards ambulant disabled people, *Accessible Stadia* (see Bibliography) states that there are currently no UK recommendations on toilet provision.
- As regards wheelchair users, *Accessible Stadia* supports the UK National Association of Disabled Supporters (NADS) recommendation for the provision of one accessible WC per 15 wheelchair spectator spaces.

16.4 Location of spectator toilets

The aim should always be a large number of smaller toilets (such as the units shown in Figure 16.1) dispersed throughout the stadium rather than a small number of big units – though this must be balanced against the cost advantages of a centralized drainage system, and a reasonable compromise struck between cost and convenience. Such units should be distributed as evenly as possible, including all levels of a multi-tiered stand, with no seat more than 60 metres from a usable toilet and preferably on the same level.

In the case of toilets for disabled people, para 5.10 of *Approved Document M* of the Building Regulations, which applies to England and Wales, recommends that wheelchair-accessible WCs should be located as close as possible to the seats for disabled spectators, with a maximum horizontal travel distance of 40 metres.

Toilets should lead off concourse areas, be easily and safely accessible, and be on the same level as the concourse. They must never lead directly off stairs: if a change of level is essential at that point it should be in the form of a ramp. The location should allow for plenty of circulation space around the entrance and exit areas, wide entrance and exit doors, and through circulation, with spectators able to enter by one door and leave by another with single-direction flow.

Stadium toilets should, wherever the overall stadium layout allows, be located against an outer wall to allow for natural light and natural ventilation. Mechanical systems are expensive and prone to malfunction or complete breakdown, leading to very unpleasant conditions, but they will of course be needed where openable windows are not feasible.

Finally, as already mentioned, there should also be toilets outside the perimeter fence (Zone 5) for the benefit of those queuing for an event; and if temporary toilets are to be used for infrequent events then their locations must be designed into the complex at the beginning to allow for easy installation and servicing.

16.5 Detailed design

All surfaces should be hard-wearing, impervious and easily cleanable, with coved corners and angles. They should be capable of being hosed down, with a trapped outlet to drain away water. Providing urinals flush with the finished floor helps in this regard.

Sanitary appliances should be specified from 'vandal resistant' ranges, with cisterns and pipework concealed in independently accessible ducts. In the case of urinals, flushing troughs should be used rather than independent cisterns as the former require less maintenance and are quickly recharged.

Hot and cold water should be provided from impact taps which turn themselves off automatically after a specified period. There should also be hand dryers.

In climates where frost may occur it is essential to provide reliable trace heating to the pipework and cisterns, or reliable background heating to the toilet space, throughout the winter – even when the stadium is not in use. If this is not done the system must be drained down after each match in winter to avoid the danger of burst pipework.

For the USA, comprehensive details of accessible toilets are given in Chapter 6 of *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (see Bibliography).

For the UK, comprehensive details of accessible toilets are give in the following four UK information sources, publication details of which are given in the Bibliography.

- Section 5 of *Approved Document M* of the Building Regulations, which applies to England and Wales.
- Section 12.4 of British Standard *BS 8300: 2001 – Design of buildings and their approaches to meet the needs of disabled people – Code of practice.*
- The *Good Loo Design Guide*, published by the Centre for Accessible Environments.
- *Accessible Stadia.*

17. Retail sales and exhibitions

17.1 Introduction
17.2 Advance ticket sales
17.3 Programme sales
17.4 Gift and souvenir shops
17.5 Museums, visitor centres and stadium tours

17.1 Introduction

People attending a sporting or other event are a natural captive market: they have come to enjoy themselves, are in a leisurely (possibly euphoric) state of mind, and may well want to take away some memento of the occasion.

As every unit of currency spent within the stadium perimeter will contribute to the financial viability of the stadium as a whole, it is in the interest of management to exploit this profit-making opportunity to the full: an enticing variety of retail outlets in and around the stadium should be a vital part of every design or management brief.

Some owners and managers have been very energetic in exploiting these opportunities. In the UK, for instance, Wembley Stadium has aggressively pursued several different uses of its facilities (sport, entertainment, exhibitions and conferences) and has in each case exploited the merchandising opportunities offered by the huge captive markets. The results are impressive, with retail sales at its pop concerts measured in hundreds of thousands of pounds per annum. Or, to take a very different example, at the Cheltenham Gold Cup a veritable 'village' of shops is set up around the course for two or three days every year, very successfully selling everything from key-rings to Rolls-Royce cars.

17.2 Advance ticket sales

Spectators who have enjoyed their day are in an ideal frame of mind to buy tickets for future events, and they must be given every opportunity to do so. Advance tickets should therefore be sold before, during and after each sporting event from booths strategically located for maximum sales.

17.2.1 Locations and scales of provision

In addition to the main ticket offices in the central ticket sales area at least four advance-ticket booths should be provided between Zones 4 and Zone 5 (see Section 3.3), with a number of windows accessible from Zone 5, and one window accessible from

Zone 4 (i.e. inside the perimeter fence) or Zone 3 (on the stadium internal concourse) depending on stadium size.

The total number of windows should be one window per 1000 spectators serving Zone 5, plus one window per 5000 spectators serving Zone 4. On this basis a 20 000 seat stadium would have four advance-ticket booths, each with five serving windows facing Zone 5 and one window facing Zone 4.

The booths should be evenly distributed around the grounds, but in such a way that the windows serving Zone 4 are clearly seen by the crowds leaving the stadium after a match. The windows should be at least 10 m away from the turnstiles so that normal circulation is not obstructed by queues of ticket-buyers congregating around the ticket booths.

17.2.2 Design

Each kiosk should be provided with the following fittings:

- Counters fitted with money trays.
- Lockable cash drawers.
- Signs with interchangeable panels for seat prices.
- Heating or cooling as required.
- General power outlets and lighting.
- Queuing rails for crowd control.

The booths should be designed to be eye-catching, both in terms of its form and its signs, the latter possibly including imaginative neon signs – as for instance in the Toronto Skydome in Canada.

17.3 Programme sales

The sale of programmes is vital to any stadium, and there should be plentiful selling points in all spectator areas.

17.3.1 Locations and scales of provision

Programme kiosks must be provided in all subdivisions of the spectator area, both inside the perimeter (Zone 3 and Zone 4) and outside (Zone 5). Serving positions should be provided in the ratio of one position for every 2000 to 3000 spectators in the surrounding zone. Additionally, mobile vendor or ‘hawker’ sales should be considered in the ratio of one per 500 spectators.

17.3.2 Design

Each kiosk should have from two to eight serving positions, depending on the type of sales and the number of spectators to be served, and be fitted with a roller shutter, pin boards for a display of current events, and light and power points. Each kiosk should have direct access to a secure store room of about 6 m^2, and a storage area for restocking of approximately 15 m^2 to 20 m^2, both fitted with shelves.

17.4 Gift and souvenir shops

An enterprising large stadium may have the following range of gift shops and related facilities:

Permanent souvenir shop

This is a gift shop selling stadium or club-related sports equipment, books, compact discs and other souvenirs. It may be combined with the following facility.

Stadium museum/exhibition space

This is a showcase for the history of the grounds (and the sports played there) displaying equipment, trophies and films. The latest ideas in interactive video displays are ideal for this location and have been used extensively at theme parks around the world. A good example is the Noucamp Stadium in Barcelona.

Detached shop

This could be located remotely from the stadium, for example in the town centre if the sports facility is on the outskirts.

17.4.1 Locations and scales of provision

The Souvenir Shop should be located so that it can be approached from both inside the grounds (Zone 3 and Zone 4) and outside (Zone 5). Accessibility from Zone 5 is important to allow the shop to operate even when the stadium is not in use. As ease of parking would assist such off-period sales, a nearby short-stay parking area should be provided.

From all points of view an ideal location for the souvenir shop would be adjoining the administration offices and central ticket sales office. This allows for ease of operation and staffing, plus dual use of a small parking area by both administrative staff and shop customers. The same remarks apply to the Stadium Museum and the Exhibition Space.

17.4.2 Design

Retail sales outlets in stadia are usually provided to concessionaires as serviced shells, possibly fitted out by the stadium management. There must be adequate storage space, either as a room of about $10 m^2$ near each individual concession, or as a centralized area of perhaps $200 m^2$. These must be securely lockable.

Each shell should be provided with the following services:

- Heating or cooling as required.
- General power outlets and lighting.
- Security grille.
- Pinboards for posters.
- Audio and video system.
- Display cases and shelving – clothes are the biggest selling items and suitable racks must be provided.

17.5 Museums, visitor centres and stadium tours

Museums and visitor centres can be very important additions, ensuring a large number of visitors to the stadium. The Barcelona Noucamp Stadium, for example, repeatedly has more visitors per annum to the museum than spectators to see games in the stadium itself. It is possibly the most attractive museum in the city, rivalled only by the Picasso Museum, and is obviously a major source of income. The museum is fitted with extensive photographic displays, trophy cases, models of the stadium and moving image displays. Outside there is a well-used shop selling clothing, souvenirs and memorabilia, together with parking for a large number of coaches and refreshment facilities both inside and outside.

Similar successes include Wembley Stadium in London, which runs visitor tours of the stadium with crowd sound effects to thrill the visitors, and Manchester United's stadium which also has an impressive museum. England's national 75 000 seat rugby stadium at Twickenham in London has a very large shop and a museum of rugby, which has interactive displays and items of memorabilia, together with an audio-visual theatre showing footage and matches from early days to the present. Visitors are invited to explore behind the scenes, the changing areas and experience the players' tunnel.

17.5.1 Location and scale of provision

The museum and visitor centre are primarily for use on non-match days and so should be entered from outside the stadium. If they are also to be used on match days consideration should be given to whether it is suitable for them to be accessible to ticket-holders inside the security line. A visitor centre is only likely to attract the public if it is of sufficient size to keep them interested for enough time for it to be worth a visit. A stadium tour will only operate on non-match days and should be combined with other visitor areas.

17.5.2 Design

The design of successful attractions is an area where knowledge of the latest ideas and technology are important so specialist designers should be consulted. A typical stadium tour might visit the pitch, changing rooms, VIP areas and control room, and should finish by the stadium shop. If the stadium is expecting to act as a tourist attraction it will need to provide toilets and an attractive café for visitors.

See also Chapter 25 on Stadia and tourism.

18. The media

18.1 Basic planning
18.2 Outside facilities
18.3 Press facilities
18.4 Radio broadcast facilities
18.5 Television broadcast facilities
18.6 Reception, conference and interview rooms
18.7 Provision for disabled people

18.1 Basic planning

18.1.1 General

Facilities for the media are an integral part of stadium design, not least because of the large sums of money that are nowadays earned from the media rights for sporting events. These facilities involve the three main categories of public information and entertainment services – the press (including newspapers and magazines), radio, and television. Clubs may also have their own media requirements for Club TV and websites.

The support facilities described below will be needed in full in the case of major new stadia. In smaller venues some may be scaled down or omitted or combined with others, subject to briefing advice from the client or from the media themselves. Because of the importance of these services we recommend consultation with radio and television companies at the earliest design stages.

18.1.2 Locating media facilities in the stadium layout

Detailed advice for specific facilities is given in the sections below, but we start with four basic planning considerations which will influence the stadium layout as a whole.

- First, all media facilities should be grouped together on the same side of the stand as the team dressing rooms. It is extremely inconvenient for media representatives to have to cross to the other side of the stadium to attend interviews.
- Second, this cluster of facilities should be close to, and easily accessible from, the parking zone for television and radio broadcast vehicles, and perhaps for outside catering and toilet vehicles, as described in Sections 18.2.1 and 18.2.2 below.
- Third, these facilities should also be relatively close to a section of the parking area set aside specifically for media representatives' cars.

A final overall planning factor is that one section of ordinary spectator seating should be adjacent to the Press area, and accessible from it, so that it may be converted to Press usage when demand for Press seats outstrips provision, as will happen when exceptionally newsworthy events are covered. Making proper provision for such dual use while conforming with the specific requirements given in Section 18.3.1 will need careful planning.

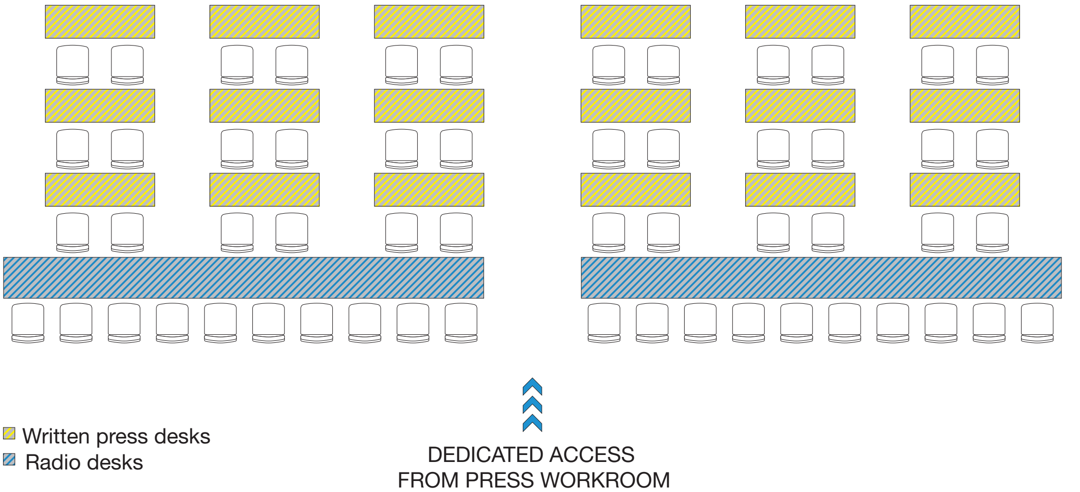


Figure 18.1 Press and radio area.

18.1.3 Types of media facilities required

The following paragraphs offer suggestions on reasonable provision, but it is essential in all cases to consult media representives before taking any firm decisions.

Up to three separate types of media activity take place in a stadium and each one must be catered for.

Direct coverage of the event

This activity happens while the match is in progress and requires:

- Press seats for the use of newspaper and magazine reporters. The seats must have an excellent view of the pitch and the central area of the stadium. See Section 18.3 below.
- Cabins for radio commentators, again with an excellent view of the pitch and central area. See Section 18.4 below.
- Seats for television commentators, obviously with an excellent view of the pitch and central area. These seats can be enclosed or in the open, and commentators are most likely to want to be near the main TV platform. Section 18.5 below.
- Platforms for television cameras. See Section 18.5 below.

Figure 18.1 indicates in schematic form a typical press and radio area.

Interviews with players and others

This activity happens inside the stadium before and after the match, away from the pitch, and requires interview rooms and support facilities inside the stadium, preferably but not necessarily overlooking the pitch and central area. See Section 18.6 below, for large stadia.

Preparation and transmission of copy

This activity requires a press working area and associated telecommunications facilities, with no need at all to overlook the pitch. See Sections 18.6 and 18.7 below.

18.2 Outside facilities

Increasing numbers of technical and staff support vehicles are being brought on to site for radio or television broadcasts, and parking space must be provided for these fairly near to the media entrance. These vehicles may require the use of satellites for transmitting the signal, and careful location of dishes or antennae could be critical. This area should be fenced in and secure, with controlled access during events. It should be provided with electrical and water supplies, telecommunications and drainage services.

18.2.1 Parking area for technical support vehicles

Radio and television technical support vehicles will require heavy cabling runs into the stadium for each particular event, and if the cables are not permanently installed it would make sense to provide permanent cable ducts from their parking zone to the relevant parts of the stadium for this purpose. There should be early consultation with the relevant radio and television companies to determine the required duct routes and dimensions.

18.2.2 Parking area for temporary catering and toilet vehicles

Mobile canteens and toilets for media personnel may be required for matches attracting particularly heavy radio or television attention. Special parking areas should be set aside for these, clearly designated, and provided with drainage, water and electrical services. The canteens and toilets should be separated. The canteen location should be relatively pleasant and clean, not a corner of the parking area reeking of diesel fumes.

18.2.3 Media parking

There should be a reserved parking area fairly near the media entrance for the cars of visiting media personnel.

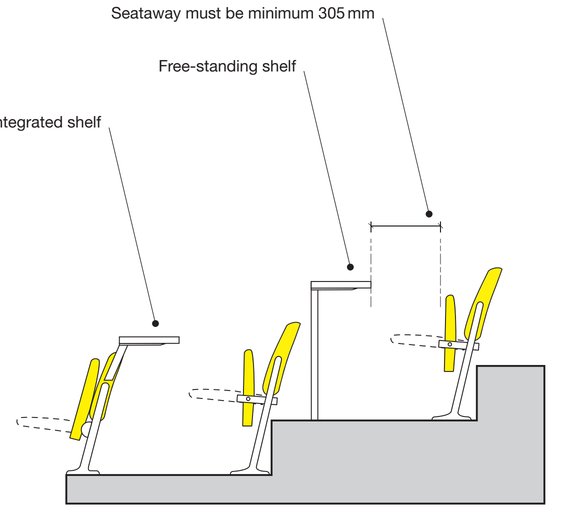


Figure 18.2 Press box seating options.

18.3 Press facilities

The following paragraphs offer suggestions on reasonable provision, but it is essential in all cases to consult media representives before taking any firm decisions.

18.3.1 Location and design

Newspapers and magazines are the oldest form of news and entertainment dissemination. They remain of great importance and must be properly catered for.

The press seating area must be located along one side of the stadium (a side not facing the sun during daytime matches) with excellent views over the pitch area. This side should be on the same side as the dressing rooms. It must be under cover and must be separated from the public seating area by a well-defined barrier. Access should be via a separate protected entrance route that is well supervised, linking back to other press facilities within the stadium. This entry route could be combined with VIP access: see Section 14.3.2.

The press seats themselves should have either a folding or fixed desk top (Figure 18.2). Seat width should be at least 500 mm, and to allow comfortable working conditions, which may involve writing, making telephone calls and using a computer, there should be ample space between seats. Each desk top should be provided with a data and telephone point and lighting, to allow coverage of night-time events. A popular seating configuration is the twin-desk arrangement, with 2 seats sharing a central data/IT console as shown in Figure 18.1, which provides a more private working space for the written press in particular. Figure 18.2 shows various press box seating options.

As already mentioned, it may be necessary on occasion to re-allocate some of the public seats to the press and one section of public seating must be located and designed so as to allow this. The location of this section of spectator seating must afford an excellent view of the field, and must be under cover. These seats need to be directly accessible from the main media working area; separable from the rest of the spectator area by temporary barriers; and the seating design should allow for writing surfaces to be fitted. There must be provision for telephone and data outlets to virtually each position.

The required depth of the press desks can often be greater than the depth of the tier on which they are located. The reprofiling of the tier required to accommodate the desks may lead to sightline restrictions to the adjacent spectator seating, which need to be carefully managed.

18.4 Radio broadcast facilities

Facilities are needed not just for national or international broadcasting, but also for local broadcasting, which includes transmissions to local community areas and hospitals. These services are increasing in popularity.

The following paragraphs offer suggestions on reasonable provision, but it is essential in all cases to consult media representives before taking any firm decisions.

18.4.1 Commentator's cabins

Commentators' cabins should be provided in a central location to the side of the pitch, with excellent viewing and openable windows to allow the noise of the crowd in if wanted. They should be located so as not to face the sun. All commentators must be able to comfortably see all parts of the central area and pitch, and preferably also the players' entrance to the field, while seated comfortably at their desks.

Cabins should open off a secure and protected lobby area. Each cabin must have a continuous worktop against the window overlooking the pitch, comfortable movable seats and monitor screens let into the worktop, all designed in accordance with advice from the relevant radio stations. Normally there will be three commentators per cabin, sitting at least 1.5 m to 1.8 m apart at individually serviced positions, separated by transparent soundproof screens. The total area required for such a three-person cabin will be approximately 15m^2.

Other fittings and finishes will be determined by expert advice, but in all cases there must be a 'quiet' floor (carpet or rubberized finish to eliminate impact noise), acoustically absorbent walls and ceilings, and sound-resistant doors with acoustic sealing round the edges. Partitions between cabins must be sound-resistant.

Services to each individual commentator's position will include microphone, electrical and telephone/data outlets plus ducting for future services.

18.5 Television broadcast facilities

As before, the following paragraphs offer suggestions on reasonable provision, but it is essential in all cases to consult media representives before taking any firm decisions.

18.5.1 Commentators' cabins

These can be similar to those for radio commentators, but media representives should be consulted. Television comentators may also prefer to sit out in the open at a desk similar to that for the written media, as described in Section 18.3.1.

18.5.2 Camera platforms

Provision must be made for camera platforms of at least 2 m by 2 m surface area, in positions agreed with the relevant television companies. Even in small sports grounds television camera positions will be a consideration as these platforms can also be used by the clubs for internal video recording for training or for historic records, or to cater for the increasing sale of video recordings of matches to supporters (the Arsenal football club in London sells about 30 000 of its match recordings). There is also the possibility of local television broadcasting, including closed circuit broadcasts to local hospitals and other community outlets.

Temporary platforms may be required for large-scale events and it is helpful if these can be converted to spectator seating when not in use.

18.6 Reception, conference and interview rooms

Again the following paragraphs offer suggestions on reasonable provision, but it is essential in all cases to consult media representives before taking any firm decisions.

18.6.1 Media reception desk

This is the focus of inquiries and the control point where all media visitors report on arrival before proceeding to the various facilities described below. This area should therefore give access to all other media facilities, and ensure that such access is completely secure.

The media reception desk should be equipped with all facilities needed for dealing with information-seekers, including telephone/data points, monitoring screens and electrical power outlets.

18.6.2 Toilets and washrooms

These will probably be provided immediately after the reception desk, before the routes to the various media facilities split apart, so that they are passed by all incoming or outgoing visitors. They should be to superior standard, and be hygienic with easily cleaned wall and floor surfaces. Facilities for cleaning and washing down should be provided, with a trapped waste outlet in the floor. Ample natural ventilation through openable windows should be provided in preference to mechanical ventilation systems, which are prone to malfunction or even breakdown, leading to unpleasant conditions which do the image of the venue no good. For some occasions additional temporary toilets may be required outside: see Section 18.2.2.

18.6.3 Canteen, bar and refreshments

Refreshment facilities should preferably also be located in the common entrance area, where all visitors will pass them before the various routes divide up. A good quality eating and drinking area is required, pleasant and attractive but also robust. The room can be fitted out with a variety of dining tables and stackable chairs, standing wall shelves and free-standing units.

In case the above facilities are not adequate for certain occasions, provision may have to be made in the parking area close to the media entrance for mobile catering: see Section 18.2.2.

18.6.4 Press working area

This is the area where media representatives are briefed, gather information packs and press handouts, relax and exchange gossip, and carry out their work (such as writing and transmitting reports). It will comprise a cluster of rooms leading directly off the common media entrance zone. All of the following functions must be catered for in the design, almost certainly as separate rooms in the case of larger stadia, but perhaps with some combination of functions into a smaller number of rooms in more modestly sized stadia.

Information room

Not far beyond the reception desk, in a location which will be passed by all incoming visitors, should be a room provided with pinboards for press notices and the like, and a mounted work-bench where information packs and brochures can be laid out. The bench-top should be at a height suitable for comfortable writing in a standing position. No windows are needed to the information room, but in that case good artificial ventilation must be provided.

Press lounge

This must be a comfortable room in the same general area as the facilities listed above, fitted with movable comfortable chairs and low tables. The decoration and lighting should be attractive and conducive to relaxation, the floor should be carpeted, and the room should have acoustically absorbent materials fitted to walls and ceiling.

Press conference room

This is a multi-purpose room, probably the last of the sequence of rooms clustered around the media entrance area, intended primarily for press conferences but suitable also for meetings of other kinds when not needed for press functions (very few are used only by the press). A movable dais should be provided where those addressing the meeting can be seen clearly by all who are in the room. The decoration scheme should be pleasant but not distracting, and allow space on the wall behind the dais, and on the dais front, for information panels. TV and recording facilities are often required and a control room at the rear of the space is useful.

Central press work room

For the most efficient use of space this may be a temporary rather than dedicated area, used at other times for meetings and exhibitions. Extensive tables and chairs must be provided, and the latter must be stackable (with adjacent storage rooms, see below, to accommodate them when not needed). There should be a movable dais, also stored elsewhere when not needed, and extensive pinboards on the walls for notices, instructions and general information for the press. A raised floor which will allow services to be run underneath is ideal. There must be generous provision of telephone, data and video terminals.

18.6.6 Administrative facilities

This is the working area of the public relations personnel who are responsible for briefing, meeting and cultivating the press and other media representatives. It must therefore be adjacent to, and have direct access to, the above group of facilities.

Stadium press officers' room

The press officers' room will be a standard office of about 150 m^2 with desks and chairs, space for filing cabinets, office equipment and cupboards, and preferably with a large wall pinboard.

Telephone/data points must be provided, and services for word processing and computing facilities will need to be considered.

Secretariat

A standard secretarial office of about 100 m^2 should be provided close to the press officer's room. It will need to accommodate one or more desks for word processing, filing cabinets and cupboards; and must be provided with generous electrical and telephone/data points.

18.6.7 Interview facilities

Beyond the reception and conference facilities described above, and closer to the playing field, will be a room or group of rooms used by newspapers, radio or television commentators and photographers for interviewing players and others. The reason for locating this section near the playing field is to allow for easy access to players before they go on to the pitch, or after they have come off. A view of the pitch is also a desirable but not essential feature.

Interview studio(s)

This room (or rooms) should be pleasant, fitted with comfortable movable chairs and low tables. The decoration scheme should rely on simple wall surfaces, possibly covered with plain curtains as a backdrop to televised interviews. While windows are not essential it is an advantage to have good views over the playing fields. The rooms must be artificially ventilated or conditioned so that windows can be kept shut to exclude outside noise. Studios must have good sound insulation, and all mechanical systems must be silent in operation.

Mixed zone

Some competitions, such as the UEFA Champions League, require open access to players by the media after an event. In this case a 'mixed zone', located between players' and media areas, can be used to enable players and media to mix for open interviews.

Television studio

A studio with panoramic views of the stadium is often required by TV broadcasters for hosting transmission of an event. A large window, with unobstructed views of the Stadium, is preferred. This can be remote from the other media facilities, and need not be accessible to the players. Introductions and summaries are often carried out here, and the fit-out of the space can be basic as host broadcasters generally bring their own staging, lighting, and set dressing.

Television control area

The television companies will want a control room adjacent to the interview studio. Requirements should be checked directly with them.

Photographers' working area

Press photographers may need one or more darkrooms, though facilities for chemical development are rapidly becoming obsolete owing to the use of digital cameras. If needed, dark rooms should be planned without windows, with light-sealed doors and effective artificial ventilation or air conditioning (the latter also light sealed) to get rid of chemical fumes. Sinks and bench-tops must be provided, and an illuminated 'room occupied' sign to prevent interruption.

18.6.8 Telecommunications area

Somewhere between, or adjacent to, the press working area and the interview facilities may be the following group of service rooms:

Telephone room

This room must have excellent ventilation, which may be either natural or artificial; must be acoustically quiet; and must be fitted with a number of separate telephone positions, each with an acoustic hood for privacy, and a shelf for writing. Windows are not necessary.

Toilets

If the facilities described above are very far from the toilets and washrooms itemized in Section 18.6.2 it may be necessary to provide an additional toilet in this area.

18.7 Provision for disabled people

Laws such as the Disability Discrimination Act in the UK, and its counterparts in other countries including Australia and the USA, now require all facilities in stadia – including those for the media – to be fully accessible to disabled people. For guidance see Chapter 10.

19. Administrative operations

19.1 Basic planning
19.2 Facilities for permanent management
19.3 Facilities for temporary events management
19.4 Facilities for visitors
19.5 Provision for stewards
19.6 Facilities for police and security officials
19.7 Toilets
19.8 First aid facilities for staff and spectators
19.9 Provision for disabled people

19.1 Basic planning

19.1.1 User types

The majority of administrative personnel to be accommodated will be those employees responsible for the day-to-day running of the stadium, and for administration of the resident sports club (if there is one).

Their numbers will be augmented from time to time by an influx of temporary personnel to help manage certain individual events on a one-off basis. A suite of offices and associated accommodation must be provided for both these groups as described in Sections 19.2 and 19.3 below. All of these officials will need hospitality facilities to entertain players and distinguished visitors, and these are described in Section 19.4.

A third group of people to be catered for are the stewards who will be brought in on match days for crowd control. Their requirements are set out in Section 19.5.

Finally, provision must be made for the police and security staff; their needs are described in Section 19.6. All user groups need good access (Figure 19.1).

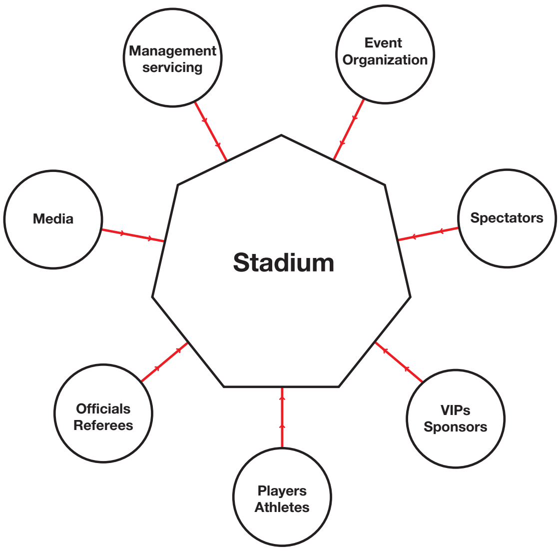


Figure 19.1 Access to the stadium by the seven main user groups.

19.1.2 Locations

Administrative facilities (except for police and security offices) should generally be close to the following areas, with reasonably easy access to them:

- VIP facilities, especially the Directors' and VIP hospitality rooms and viewing boxes (see Chapter 13);
- Media facilities, especially the Press working area and the stadium Press Officer's room (see Section 18.6);
- Team managers', officials', and referees' facilities (see Chapter 20).

The administration entrance will normally be in the centre of the main side of the stadium and an area of car parking for officials and their guests must be provided nearby.

19.1.3 Scales of provision

General guidance is given in the sections below, but specific accommodation requirements can only be determined by direct discussion with the client and police authorities. Figures given here are therefore provisional and must be carefully checked as the brief is compiled.

19.2 Facilities for permanent management

Offices and ancillary accommodation should be provided for:

- Staff responsible for marketing, promotion, advertising and ticketing of events.
- Staff responsible for administration and finance. Their needs will include secure facilities for cash receipts and credit card checking.
- Staff responsible for building services, energy control, lighting, mechanical and electrical equipment and sound equipment.
- Staff responsible for maintenance and security, and for emergency operations.

Subject to detailed discussion with the client, the rooms discussed in the following seven sections will be needed in most cases.

19.2.1 Offices

In a large stadium there should be offices for the Director (20 m^2), secretariat (12 m^2), other staff members (12 m^2 per person), public relations and marketing (12 m^2 per person) and event organization (12 m^2 per person). In smaller stadia some of the above could be combined for economy. These rooms should be designed with finishes, equipment and lighting to good office standards.

19.2.2 Board room

Fittings and furnishings should be of a standard befitting this VIP space. They should include a suitable boardroom table and comfortable chairs, drinks and refreshment cupboard, refrigerator, and perhaps a small bar if the room is to be used for hospitality at events (which is often the case). A display of photographs and a secure cupboard for trophies and mementoes should be considered, the latter to be extremely secure in view of the value of the contents.

The area of this room would typically be between 30 m^2 and 50 m^2. Depending on the size of the stadium and its operation the board room may be used for hospitality or other purposes.

19.2.3 Appeals room

A room should be available for hearing appeals, but this is usually not a dedicated room.

19.2.4 Stadium control room

This is the nerve centre from which the entire venue is controlled, both in normal times and in emergencies, and its correct location, design, and fitting-out are of great importance. Comprehensive advice for football stadia is given in *Control Rooms* (see Bibliography), and the following brief notes are no substitute for the full data given in this essential reference.

According to para 2.5 of *Control Rooms*, any police officers who may need to be present during a match will work within the stadium control room, but if a dedicated police control room is thought necessary, see Section 19.6 below.

For notes on the protection of the control room against attack by terrorists or others see Section 6.5.6.

Figure 19.2 The control room at Galpharm Stadium, in Huddersfield, is located to give a clear view over the playing field which cannot be obstructed by, for instance, spectators.

Location

First, the location should give the clearest possible view over the playing field (Figures 19.2 and 19.3), and this view must not be obstructed by, for instance, spectators. It should also give a view over the circulation areas (see Chapter 14), and spectator accommodation (see Chapter 11), by means of closed circuit television cameras. The cross-sections shown in diagrams 4 and 5 in *Control Rooms* illustrate some of these points.

For football grounds in the UK, diagrams 2 and 3 in *Control Rooms* show a range of options. In order not to look into the sun the ideal location will be on the north, northwest, or west stand; and for a clear view a position at the very back (i.e. the highest point) of the chosen stand will in many cases be best. For other sports and other countries the precise location may be different, but the basic principles outlined in *Control Rooms* will still be relevant, and should be studied.

Second, the control room ought ideally to be adjacent to the police control room, and possibly combined with it, so that an integrated response to an emergency is possible.

Third, the control room should be easily accessible to everyone who needs to use it, and as near as possible to the pre-event briefing area.

Photograph: Esto photographics

Figure 19.3 A clear view over the playing area (the one shown here is Oriole Park at Camden Yards, Baltimore) from the control room is essential.

Diagram 6 in *Control Rooms* shows the spatial relationships of the control room and surrounding facilities. This diagram applies specifically to football stadia, but it will be generally helpful for other situations.

Design

No particular room size can be recommended, as circumstances vary so much, but the plans of four worked examples, shown on pages 37 to 40 of *Control Rooms*, will help designers come to a rational decision on room dimensions and layout.

The room must be equipped with TV monitors; telephone links both inside and outside the stadium; microphones for internal sound broadcasting and public address purposes; control panels for stadium lighting; and other technical features. All room finishes must be acoustically absorbent and the door must be soundproof.

Though the windows overlooking the pitch may be openable they will usually be kept shut for noise exclusion, therefore artificial ventilation will be vital.

A benchtop placed against this window will be the main working surface. Personnel should be provided with comfortable chairs, and should be able to see the pitch and central area and the electronic screens from a seated position at this bench.

19.2.5 Video and electronic screen control room

This room must be linked with the stadium control room above and similarly designed and furnished, with space for two or three seats. These must have excellent views of the screens described below and of the spectator area.

Video and electronic screens

Any major stadium today must be equipped with one or two electronic or video screens which may be used for announcements, advertisements, safety instructions, etc. They may sometimes be used for replays, either to entertain the spectators or (more rarely) to assist officials and judges.

Screen size and characteristics will depend on the type of stadium, the kinds of events staged, and the distance to spectators. Increasingly large screens are available and the technology is changing and improving rapidly.

Screens should be at the ends of the pitch where they can be seen by the maximum number of spectators; in some cases it may be desirable to have two screens, one at each end of the playing area. Orientation should be such that the sun does not fall directly on the screen face, as this can severely detract from the quality of the image.

All these matters, especially the position of the screens, should be carefully checked with the sports bodies concerned. Screens must on no account distract participants, particularly in the case of athletics.

19.2.6 Computer equipment room

Computer equipment rooms should be designed in line with the best current practice. Lighting should be even and to a high standard, and ventilation excellent. The floor can be raised with underfloor services and easily cleaned finishes. Vibration and noise from other parts of the building must be minimized.

As computers become smaller and less dependent on special environments the above requirements are becoming less stringent, and the need for special accommodation of this kind may be gradually disappearing. Requirements should be checked at briefing stage.

19.2.7 Building maintenance and services rooms

Accommodation will be needed for building maintenance staff and equipment, the number of facilities depending on the management policy being followed.

Some stadia are operated by hiring the services of specialist contractors, who bring in not only their own staff but much of their own equipment too. In these cases only basic accommodation need be provided, comprising at least the following

- Groundsmen's rooms.
- An equipment room.

In other cases, stadia are operated by their own permanent staff and equipment; in these cases additional accommodation will be needed.

All equipment rooms must be finished with hard-wearing, low-maintenance surfaces. Floors may be smooth concrete or some other impervious, hard finish. The maintenance of service connections and equipment should be easily carried out.

19.3 Facilities for temporary events management

As stated in Section 19.1.1 additional personnel will be brought in from time to time to manage particular events such as circuses, pop concerts or religious gatherings. These requirements will depend so much on the particular case that no advice can be given here except to stress that the matter must be discussed with the client and appropriate provision made.

19.4 Facilities for visitors

These should include:

- VIP hospitality rooms;
- Players' bar;
- Facilities for match day stewards.

19.5 Provision for stewards

19.5.1 The functions of stewards

Accommodation is needed for the stewards and security staff who are employed on match days as a vital part of the customer service. Their roles include helping spectators to find their seats, generally assisting with information, and keeping order in a low-key way (more difficult situations being the responsibility of security personnel and/or the police).

The duties performed by stewards and the manner in which they are performed vary not only from country to country but also between sports, and even within a single national sport.

In Britain stewards often used to be voluntary and unpaid, with older men taken on out of loyalty to the club, or so that they may see the game. Frequently they were responsible not only for normal customer service duties but also for crowd control, a task for which they had usually not been properly trained. This pattern is changing and younger men and women are increasingly being recruited on a paid basis. This move is partly a matter of stadium economics, aimed at reducing the very expensive police presence demanded at many matches by local authorities, and partly a move towards better customer care. Training in safety control is therefore essential, and in the UK is now being provided to nationally-recognized standards.

A very different pattern is seen in the USA where stewards tend to be more professional and are supported by 'peer security' in their task of keeping order. The term 'peer security' refers to young people drawn from the same socio-economic group as those attending the event. They are sometimes also referred to as 'tee-shirt security' because of the brightly coloured shirts they wear.

Stewarding in the future is likely to be encouraged to be more interactive, with stewards going out of their way to chat to spectators and make them feel welcome.

19.5.2 Numbers of stewards

Because patterns of stewarding vary so much it is impossible to give simple accommodation advice. Every management will have its own methods, and these should be clarified at briefing stage. The following notes offer a starting point for such investigation.

Based on normal British practice, a stadium with an attendance of 10 000 to 20 000 spectators may require 20 to 60 stewards, while one with an attendance of 20 000 to 40 000 spectators may require 60 to 100 stewards. In situations where peer security is included the acceptable ratios may range from roughly one steward to 75 spectators in small stadia, up to one steward per 200 spectators in larger stadia. This number will be made up of the following broad categories:

- Turnstile stewards.
- Door stewards.
- Security stewards (these include peer security) who may comprise about half of the total number.
- Sector supervisor stewards.
- Crowd assessors.
- Crowd safety stewards.
- Fire-fighting stewards.

Ideally the following spaces should be provided to accommodate the above people, but it may be possible for some of these areas to be shared with other staff accommodation:

- Briefing room (based on 1.5 m^2 per steward) for issuing instructions to stewards on the day.
- Stewards' cloakroom where stewards can change and leave their clothing in lockers.
- Storage room provided by the stadium management for official clothing.
- Small kitchen facility for making hot drinks and refreshments.
- Stewards' refreshment area to encourage their early arrival at the grounds.

19.6 Facilities for police and security officials

Police and related security systems are vital considerations in modern stadia but it is not possible to generalize about the number of police who will attend an event. On any typical winter weekend in the UK when football is being played around 5000 police will be on duty around the country. Individual events can have as few as 10 to 50 in attendance at the grounds while major football matches can have as many as 300 to 400 on site. This will be a decision taken by the police themselves in consultation with the stadium management and the club concerned. The decision will have to take into account the following factors.

- Expected attendance.
- Club's past record of crowd behaviour.
- Number and type of visiting supporters.
- Nature and location of the ground.
- Experience of stewards.

As a guide to the number of police inside a ground for football matches in the UK we have listed the numbers suggested in the 1990 Home Office publication *Policing Football Hooliganism*.

Category 1: Smaller clubs (e.g. lower divisions of the Football League), policing may require as few as 30 to 40 officers.

Category 2: Larger clubs (e.g. premier division), some 300 officers may be required on a normal matchday.

Policing was once provided free of charge but now it is usually charged to the stadium management and is a major item in the cost of staging a particular event. In Europe there is a tendency to try to reduce the police presence required, perhaps because the numbers used in the USA and Canada tend to be less. As an example, the number of police used at events in the Toronto Skydome are as set out in Table 19.1.

In comparing this level of policing it must be remembered that most stadia in the USA and Canada also employ their own security staff. They are generally well trained and in the case of the Skydome are taught at their own Skydome University in Toronto. The selection process is quite stringent with only 1 in 6 applicants being accepted and then they receive between 15 to 40 hours of training before they are deployed. Numbers of security staff employed at the Skydome are given in Table 19.2.

To be able to operate the various aspects of this law and order activity we have suggested the following schedule of accommodation which should be considered at the design stage of a large stadium.

- Control room with glass screen overlooking the sports pitch, with video screen consoles in the room (see Section 19.2.4 above).
- Detention rooms of say two cells with toilets.
- Refreshment and rest room facilities for police.
- Waiting and information room.
- Mass arrest facilities – requiring two compounds each to take a group of say 30 spectators, if this is required.

These different types of accommodation are described in later paragraphs. In a major venue where there are separate parts of the grounds dividing the spectators into groups of say 20 000 or more, it may be necessary to provide these security facilities in each sector. Video coverage and monitoring will be needed for stadia over 30 000 capacity. For small stadia, say 20 000 or less spectators, there will only be a need for a single police control room. In Holland, court rooms have been provided on the stadium site to enable justice to be swiftly administered. This needs to be discussed with local police authorities as this is quite a rare practice. All the accommodation should be planned as linked accommodation with controlled, secure access.

Family events	0.5 per 1000 spectators
Sporting events	1.0 per 1000 spectators
Concerts	1.6 per 1000 spectators
High-risk events	3.0 per 1000 spectators

Table 19.1 Police presence at the Skydome in Toronto, Canada

Security managers	2
Full-time security officers	18
Peer security	110
Event security	80

Table 19.2 Security personnel at the Skydome in Toronto, Canada

Police control room

If the police have their own dedicated control room (see Section 19.2.4 above) this area should be fitted with a bench in front of the window, with television and video monitors, service connections and telephone links to both inside and outside the stadium. It should be located adjacent to, or integrated with the stadium control facilities mentioned in Section 19.2.4. There should be movable, comfortable chairs for the police in attendance whilst the public address announcer should be to one side, preferably in a corner to reduce background noise during microphone use. An auxiliary audio control panel could be located in this room which copies the main panel in the management control room.

All CCTV screens should be grouped together in an organized way and monitored by police and other security officials, as well as officials of the stadium, in the police control room. It is from this police control room that all security operations should be monitored, decisions should be taken and instructions given through telephone, wireless and public radio broadcasts. It is also important that camera orientation can be controlled from this room. Whilst many of the cameras used in a full surveillance can be static it is useful, when covering the area of spectator viewing around the pitch, if the camera is able to move. It should be able to traverse sideways and elevate up and down as well as zooming in to specific areas of the crowd, perhaps identifying individual spectators. Along with this monitoring exercise, a method of taking hard copy printouts of particular images should be available, as well as recording any image from any of the cameras being used in surveillance.

19.7 Toilets

All the administrative facilities described in the above sections must have access to toilets for both sexes. Some groups will be able to share toilets, but when distances become too great separate provision must be made. In all cases hot and cold running water, soap, and towels or other means of drying must be provided; space must also be allowed for vending machines, incinerators and waste bins.

For preliminary overall space estimation, the planning consultants DEGW suggest the following floor areas:

- For men allow 1 m^2 per three people for WC, urinal and handwashing space combined. For women allow 1 m^2 per three people for combined WC and handwashing space. 1.83 m by 0.9 m is the recommended size of a WC cubicle.
- For overall space planning allow 1.68 m^2 per WC, 0.93 m^2 per urinal, and 0.75 m^2 per washbasin. These areas do not include the outer walls forming the toilet area, nor the entrance lobbies, but they do include cubicle partitions and the standing space at urinals and basins.

The above notes should be read in conjunction with Chapters 10 and 16.

19.8 First-aid facilities for staff and spectators

19.8.1 Introduction

In addition to the medical and first-aid facilities for players mentioned in Section 20, provision must also be made for staff and spectators. This is a legal requirement in most European and North American localities, and the specific requirements must be discussed with the local health authority.

Relevant UK regulations include:

- The Health and Safety (First Aid) 1981 Regulations and The Management of Health and Safety at Work Regulations 1999.
- The Fire Safety and Safety of Places of Sport Act 1987.

All UK Acts of Parliament may be downloaded from www.opsi.gov.uk/acts.htm

In the European Community, European Economic Community Directive 89/654 covers health requirements in the workplace and directs in Clause 19 that 'one or more first aid rooms must be provided where the size of premises, type of activity being carried out and frequency of accidents so dictates'. This may lead to a more precise definition of the requirements for a first-aid room than those embodied in the UK regulations.

19.8.2 FIFA and UEFA requirements

In the case of football stadia FIFA and UEFA's recommendations for new stadia state that 'every stadium should be equipped with a first aid room or rooms to care for spectators in need of medical assistance. The number, size and location of these rooms should be agreed in consultation with the local health authority'.

Where FIFA and UEFA rules apply, first-aid rooms should in general:

- Be so positioned as to allow easy access to spectators and emergency vehicles from both inside and outside the stadium.
- Have doors and passageways wide enough to allow a stretcher or wheelchair.
- Have bright lighting, good ventilation, heating, electrical outlets, hot and cold water (suitable for drinking), and toilets for males and females.
- Have walls and non-slip floors finished in smooth, easily cleanable materials.
- Have storage space for stretchers, blankets, pillows and first-aid materials.
- Have a telephone(s) allowing internal and external communication.
- Be clearly signposted throughout the inside and outside the stadium.

19.8.3 The Taylor Report

The Taylor Report (which arose from the Hillsborough Stadium disaster of 15 April 1989 in Sheffield, UK) recommended that in British stadia 'there should be at each designated sports ground one or more first aid rooms, which should be in addition to the club's own medical rooms for players'.

Following this a Medical Working Party of England's Football League made a number of specific recommendations. These are in no sense obligatory but are quoted here as useful guidelines. They state that first aid posts should be sited around the stadium, so that no spectator is too far from one, that they should be very clearly signposted and preferably shown in the match programme, and that room(s) should:

- Be at least 28 m^2 and of regular shape. As an interesting comparison, the *UK Guide to Safety at Sports Grounds* (see Bibliography) recommends at least 15 m^2, or 25 m^2 if stadium capacity is above 15 000 spectators.
- Be readily available at all times during an event and be used only for purposes of first aid.
- Be easily accessible from all parts of the stadium and be located near to a point of access for transport to hospital.
- Be near to a WC (which should be accessible to wheelchair users) and to a private waiting room with chairs, where patients and relatives can wait.
- Have doorways of sufficient width to allow easy passage of a stretcher plus attendants.
- Have good ventilation, heating and lighting, and be designated a no-smoking area.
- Have sufficient storage space for equipment.

Room facilities should include:

- Provision to treat three patients simultaneously, with reasonable privacy.
- Stainless steel sink, work surface, wash hand basin, drainage, hot and cold water supply (including drinking water), soap and hand drying facilities.
- All surfaces hard, impervious and easy to clean. (We would add the need for a floor drain, as blood cannot easily be wiped from the floor without risk of infection).
- At least six 13-amp electrical outlets.
- Adequate waste disposal facilities, with provision for clinical and 'sharp' waste.
- Effective means of communication to and from a central control point and the emergency services. A telephone link with an exclusive external line would be the best such means.

19.8.4 Dimensions

Recommended room dimensions have been given above. Stretchers are commonly 1.9 m by 0.56 m, and minimum dimensions to accommodate stretchers and wheelchairs are 0.9 m for doorsets and 1.2 m for corridor widths. An ambulance access road should be at least 6 m wide.

19.9 Provision for disabled people

Laws such as the Disability Discrimination Act in the UK, and its counterparts in other countries including Australia and the USA, now require all facilities in stadia – including those for the administrative personnel – to be fully accessible to disabled people. For guidance see Chapter 10.

20. Facilities for players and officials

20.1 Basic planning
20.2 Players' facilities
20.3 Team management facilities
20.4 Officials' facilities
20.5 Medical examination facilities
20.6 Ancillary facilities
20.7 Provision for disabled people

20.1 Basic planning

20.1.1 General

Every stadium, however small, must provide facilities for the participants in the events held at the venue, but the amount and type of accommodation that is needed varies enormously: a football or rugby match may need facilities for only two teams (including reserves) plus officials, whereas a major international athletics event may attract up to a thousand participants.

It will probably be impossible to provide accommodation on this scale on a permanent basis, and the decision may be to rely partly on temporary accommodation for large-scale events. The guidance below is therefore intended to suggest a 'reasonable' provision of facilities.

If there is a 'home team' then most of the accommodation will concentrate on their requirements as they will be using the facilities on a regular basis for training. If the stadium offers a home to more than one team then it must be decided whether the teams can share facilities or whether a completely separate set must be provided for each. This is usually the case where major sports clubs are involved, although some sharing of training equipment may be possible.

Team changing facilities for the resident team is a very special area. It is their 'home', a place to which few people can gain entry. We recommend that, as with a house, the resident organization be very closely consulted on design, layout and character. If the stadium is also to be used for concerts and other purposes this must be taken into account.

20.1.2 Location of facilities in the stadium layout

Access to outside

There must be direct access between players' changing facilities and the service road outside. This road will be used by coaches conveying teams to and from the stadium, and also by ambulances.

The service road should give access to the team entrance, and also to the playing area so that injured players can be reached quickly and easily by ambulances, etc.

Access to the pitch
There must also be direct, protected access between players' changing rooms and the pitch. At events where players and referees may be subject to attack (such as the hurling of missiles) by the crowd, safety requirements are stringent. Football matches in countries with strong traditions of team loyalty fall into this category, and recommendations are outlined below.

In the case of new stadia for World Cup and European Championship finals, FIFA/UEFA recommend that:

> Ideally, each of the teams' dressing rooms and the referees' dressing room should have its own corridor for access to the pitch. These corridors may join up near the exit to the playing area.
>
> The point where the players and the referees enter the playing area, which ideally should be at the centreline and on the same side as the VIP box, press stand and administrative offices, must be protected by means of a fireproof telescopic tunnel extending into the playing area far enough to prevent the risk of injury to the match participants caused by missiles thrown by spectators.
>
> Such telescopic tunnels should be capable of being extended or closed quickly so that they may be used during the match when a player is leaving or entering the field, without causing unduly lengthy viewing obstruction.
>
> Alternatively, the entrance to the playing area may be by means of an underground tunnel, the mouth of which is situated a similarly safe distance away from spectators.

There should be no possibility of public or media interference at any point within these corridors or security tunnels.

In the case of European Club competitions, the UEFA recommendations simply state:

> In order to guarantee the safety of players and match officials, participating clubs shall provide for an access to the field ensuring safe entry and exit.

Location
Whenever possible players' and officials' accommodation should be situated at pitch level to allow easy and direct access to the playing area.

20.1.3 Scales of provision
Requirements must be determined by discussions with clients and the relevant governing bodies.

20.2 Players' facilities

20.2.1 Introduction
The facilities described below should be directly linked with the media area (see Section 18.1) and the team administrative offices (see Section 19.1), and if possible also with the team directors' suite or chairman's box (see Section 13.1). If these facilities cannot be at ground level, as recommended above, they should be served by an elevator.

Corridor and door widths should be generous, because these are busy areas on a match day: 1.2 m is a minimum width, and 1.5 m preferable. Good ventilation is essential to prevent condensation, as well as a heating and/or cooling system in the changing areas depending on local climate and seasons of play.

The whole area should be secure against unauthorized entry, inaccessible to the public and the media, and have direct, protected access to the pitch as outlined in Section 20.1.2.

Finishes must be robust and easily cleanable, and recent forms of non-slip plastic matting and hard-wearing carpets are ideal for the changing rooms themselves.

20.2.2 Changing rooms for sports
A changing room or locker room (Figure 20.3) should be provided for each home team and at least one visiting team. Two such rooms should be provided for visiting teams if a match is to be held between two visiting teams – unless of course the home team is prepared to allow use of its facilities (which

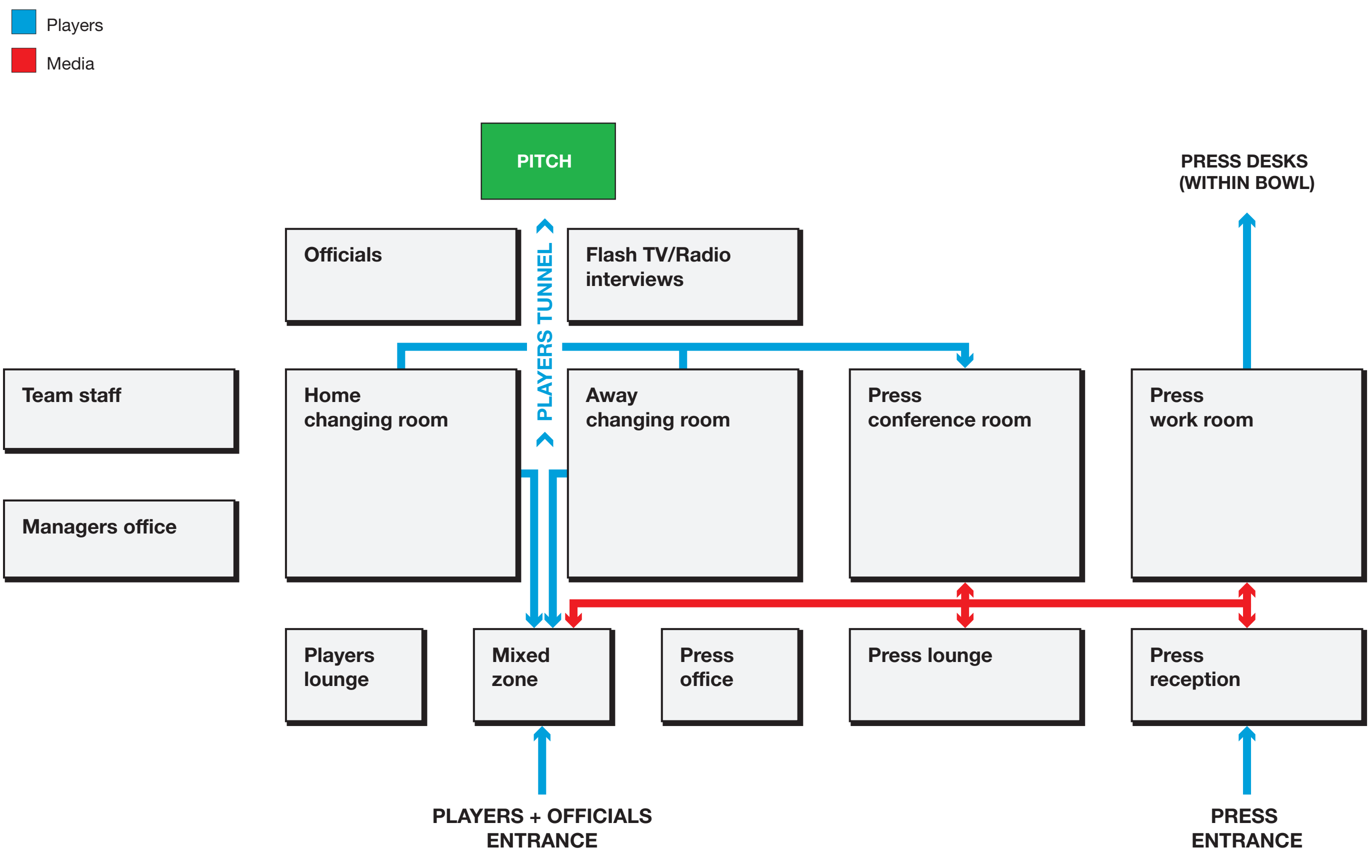


Figure 20.1 Schematic relationship between players' and officials' facilities, the pitch, and media facilities.

is unusual) or the visiting teams are willing to share (which is more usual). Some stadia start the day's events with a 'curtain-raiser', which is often a match between teams in a lower league or junior teams, or even an event from a different sport, and these teams also require changing facilities.

Each changing room should contain a locker, bench seat and hanging space for each individual player (including reserves), each such space being between 600 mm and 900 mm wide and at least 1200 mm deep. In the case of football FIFA requires twenty of these positions, and the requirements for rugby will be very similar. The benches should be designed so that clothes can be kept dry and in good order. American football teams often prefer individual cabinets or open hanging units with side panels, to the open benching that is common for football and rugby.

In the case of new football stadia catering for major matches FIFA/UEFA recommend four separate team dressing rooms.

20.2.3 Massage rooms

At least one massage table or bench is required in each changing area, and two are needed for major stadia.

20.2.4 Washing and toilet facilities

Washing facilities should be directly accessible from the changing area, without going through the toilets. As a general guide there should be one shower per 1.5 or 2 players, allowing 1.5m^2 per player; but specific requirements must be determined by discussions with clients and the relevant governing bodies.

Toilets fitted with both WCs and urinals (if it is a male team) should be provided in the ratio of one position per three players, or as required by clients and the relevant governing bodies. Both washing and toilet areas should be very well served by natural ventilation, and designed to allow thorough washing down of all surfaces, which should be durable and impervious.

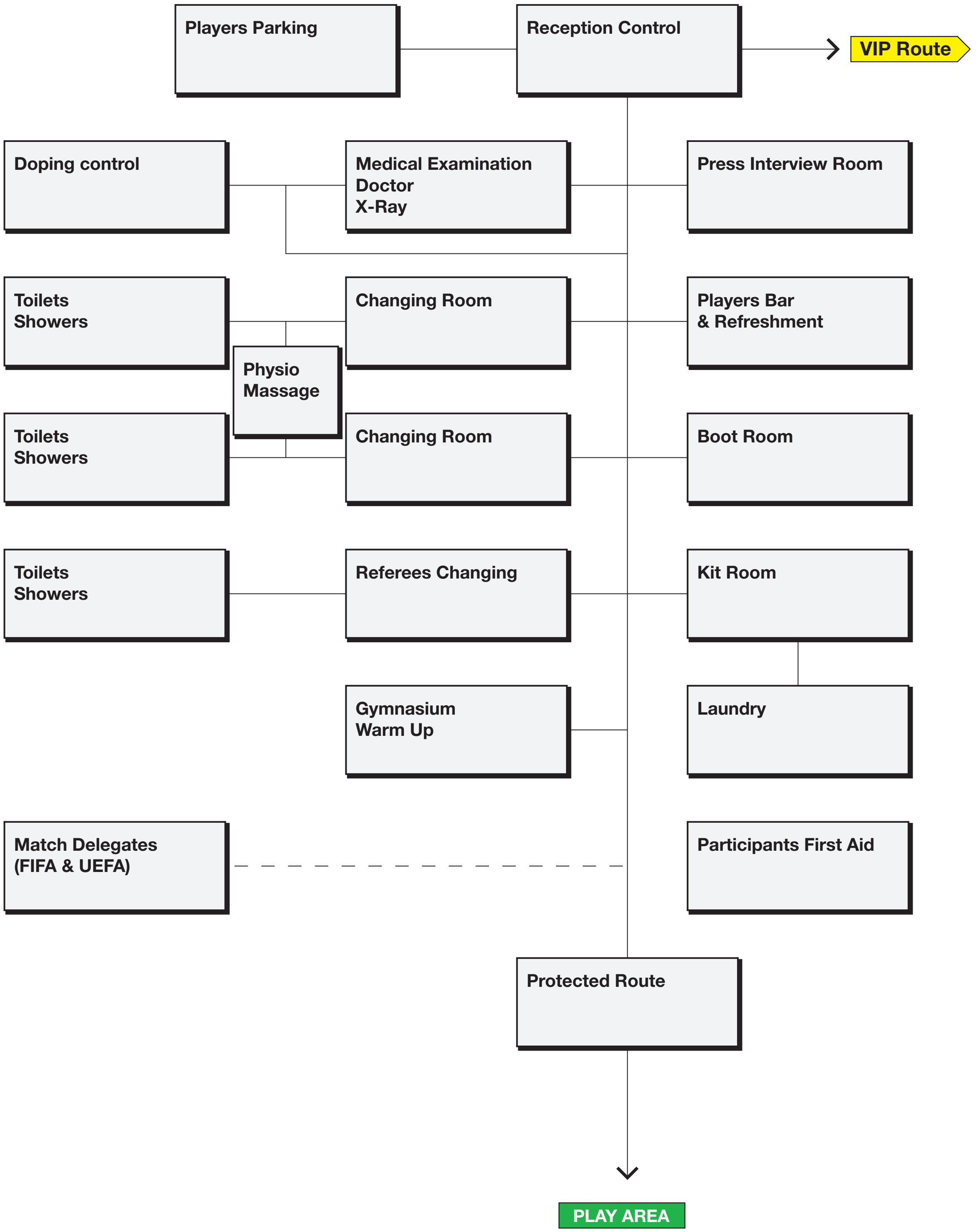


Figure 20.2 Schematic relationship between various players' and referees' facilities.

Photograph: HOK Sport Architecture

Figure 20.3 Players' lockers for the New England Patriots at the Gillette Stadium in Foxborough, Massachusetts. *Architect: HOK Sport Architecture.*

Provision should be made for disabled people – for guidance see Chapters 10 and 16.

20.2.5 Ancillary accommodation

The following accommodation should be provided as part of the changing areas described above:

- A large training room which can be used for preliminary warm-up exercises.
- A players' first-aid room near the pitch, en route to the changing areas.

Additional facilities which may be included or shared between teams, depending on the teams' importance, are:

- A general meeting room for use by the team, with projector and screen (this room could also be used for other purposes such as press interviews).
- A players' bar and games area where players can relax after a game or training session (it should be equipped with a light refreshment kitchen).
- A gymnasium, weights and exercise area.
- A sauna and hydrotherapy area.
- A waiting room with its own toilet for players' relatives.
- An equipment storage area with shelves and cupboards.
- A laundry and clothes drying area.
- A boot cleaning and storage room.

20.3 Team management facilities

This area is not to be confused with the stadium management facilities described in Chapter 19 – unless of course it has been established that stadium managers and team managers will be one and the same body for a particular stadium.

20.3.1 Location

There is no specific requirement, but these facilities are usually on the main side of the stadium, in the same general area as the administration area (see Chapter 19) but probably at a lower level.

20.3.2 Facilities

The rooms to be provided will depend largely on the size of the sports club involved, but will probably comprise the following:

- Reception area of approximately 12 m^2 to 15 m^2.
- General office and secretarial area.
- Executive offices with private entrance.
- Board or meeting room of approximately 25 m^2 to 30 m^2, with bar facilities.
- Team manager's office of approximately 18 m^2.
- Assistant team manager's office of approximately 12 m^2.
- Team coach's office of 12 m^2 to 18 m^2.
- Possibly an office for an assistant team coach.
- A chairman's suite connected to the executive offices.

20.4 Officials' facilities

For every event which takes place on the field there will be officials, judges, umpires, linesmen and referees who require separate changing and toilet accommodation. They will also need some administrative space, which may be shared space in the case of smaller stadia. Provision will depend on the sport being played as well as the number of games being staged in one day.

20.4.1 Location

The rooms described below should be close to the players' dressing rooms, but without direct access. They must be inaccessible to the public and the media, but have direct protected access to the playing area as described in Section 20.1.2.

20.4.2 Facilities and scales of provision

Changing rooms

As a general guide, referee and linesmen's changing accommodation should comprise four spaces, allowing 2.5 m^2 per official, with associated lockers, toilets and showers.

A slightly separate area within the room should be provided with a table and chair for report-writing.

The most precise guidance that is available on scales of provision are the FIFA/UEFA recommendations for new football stadia for major matches, and while these cannot be directly applied to all stadia, they give a useful starting point for compiling the brief.

Appeals room

Every sport is based on a firm set of rules and players who transgress those rules will have action taken against them by the officials of the sport. To allow this judicial process to take place an appeals room or 'court' must be provided. The room must accommodate a jury of five or six people, plus two or three others. It need not be a dedicated space but can use one of the other areas in the stadium if suitably located and planned (see Section 19.2.3).

Match delegates' room

FIFA and UEFA's recommendations for new stadia for major football matches require a special room for the competition officials who sit on the centre bench of the pitch. This room should be close to the general dressing room area and be at least 16 m^2 in size. Equipment should include:

- One desk.
- Three chairs.
- One clothes locker.
- One telephone.

20.5 Medical examination facilities

20.5.1 Location

The accommodation described below should be close to the players' dressing rooms, whilst also having easy access to the outside entrance and to the playing area as described in Section 20.1.2.

20.5.2 Facilities and scales of provision

The specific requirements of local safety authorities and the relevant medical teams will take priority, and must be established as part of the brief. Subject to that, the following advice is given by FIFA and UEFA for new football stadia for major events.

Medical examination room

There should be a room of at least 25 m^2, equipped with:

- One examination table 600 mm wide, accessible from three sides.
- Two portable stretchers, kept alongside the pitch during games.
- One washbasin.
- One glass cabin for medications.
- One treatment table.
- One oxygen bottle with mask.
- One blood-pressure gauge.
- One heating apparatus, such as a hotplate, for instruments.
- Possibly some physiotherapy equipment.

See also Section 19.8 dealing with medical facilities for spectators.

Resident doctor's room

In larger stadia the team doctor should have his own room of 100 m^2 adjacent to the medical examination room and linked to it internally.

X-ray room

Where justified, an X-ray room of about 20 m^2 may be provided close to the medical examination room for examination of injuries.

Dope testing facilities

Stadia to be used for major competitions will probably require a room of at least 16 m^2, equipped with the following:

- One desk.
- Two chairs.
- One basin.
- One telephone.

Adjacent to this room, with direct private access to it, should be a toilet comprising WC, washbasin and shower. Near the dope testing room there should be a waiting area with seating for eight people, clothes hanging facilities or lockers for four people, and a refrigerator.

20.6 Ancillary facilities

Depending on the size of the stadium other facilities can be included which will assist in its operation. These additional spaces must be judged on their merits for each particular occasion.

- Media interview room: this should be adjacent to the team room, and be supplied with electrical and lighting equipment suitable for television broadcasting.
- Players' warm-up area and gymnasium for use before the game.
- A field toilet and drinking fountain close to the access route to the pitch.
- Enclosures or 'dug-outs' which are covered and have direct access to the appropriate team's changing areas.

20.7 Provision for disabled people

Laws such as the Disability Discrimination Act in the UK, and its counterparts in other countries including Australia and the USA, now require all facilities in stadia – including those for players and officials – to be fully accessible to disabled people. For guidance see Chapter 10.

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21. Services

21.1 Lighting systems
21.2 Closed-circuit television systems
21.3 Sound systems
21.4 Heating and cooling systems
21.5 Fire detection and fighting systems
21.6 Water supply and drainage services

21.1 Lighting systems

21.1.1 Introduction

If a stadium is to achieve its full potential use and be operated at night or late afternoon a comprehensive lighting system is essential. Two main types of illumination are needed:

- Lighting of passageways and escape routes so that spectators can enter and leave the stadium safely.
- Lighting the play area so that players and spectators can see the action clearly and without strain. It may be necessary also to illuminate the venue for television cameras, in which case the requirements become more stringent.

Both safety and pitch lighting are required together, since one without the other would be redundant; the only exceptions being:

- Night-time concerts using their own stage lighting systems fed from a power supply on the grounds (which is common practice); or
- Sporting events which finish while there is daylight, but darkness falls before all the spectators have left the grounds (this is most unlikely for major stadia).

In these cases the stadium would need only to supply emergency lighting for spectators.

21.1.2 Emergency lighting for spectators

Requirements

Emergency lighting must fulfil several functions, primarily to:

- Illuminate escape routes and exits clearly, so that spectators are in no doubt about the correct direction of movement in an emergency, and can move along safely without risk of stumbling and falling even when hurrying and in a panic.
- Illuminate alarm call points and fire-fighting equipment so that they may be easily located.

Luminaires should be provided along each passageway and escape route so that there are no dark areas, especially on stairs and landings and at emergency doors. In the UK, an illumination level of at least 1 Lux should be provided along the centre line of general-use escape routes. In open areas larger than 60 m^2, an illumination level of 0.5 Lux anywhere in the core area is the minimum; and for permanently unobstructed routes, 0.2 Lux minimum on the centre line.

All such emergency lighting must continue to operate even if the main power system fails, coming on within five seconds of mains failure.

Installation design

It is difficult to give recommendations for the spacing of luminaires along the general runs of routes, and an inspection of existing buildings may be the most practical guide. For illumination at critical locations we suggest that luminaires be situated within 2 m of all exits and at all points where it is necessary to emphasize the location of potential hazards and safety equipment. Such locations include:

- Along each stair flight to illuminate the nosings.
- At all stair intersections, to illuminate the nosings.
- Near each change of level.
- In front of each exit door.
- In front of each fire door.
- At each exit or safety sign required for safe egress from the stadium.
- Near each fire alarm call-point and each item of fire-fighting equipment.

It may sometimes be difficult to achieve the recommended emergency illumination level of 1 Lux in the large spaces found under stadium structures. Wall-mounted luminaires help overcome this problem, and illuminated signs can make an excellent contribution. Until now such signs (particularly neon signs) have been infrequently used in sports stadia owing to their cost. However the Skydome in Toronto, Canada, is a striking example of the exploitation of neon advertising signs to create a bright and cheerful atmosphere under an otherwise dark grey structure, and to highlight certain locations.

Standby power

There must always be a stand-by generator system in case of failure – a requirement enforced by law in many countries including the UK. Stand-by lighting may be provided in one of two ways:

- As a minimum there might be a separate circuit, usually designed to operate for a specific period of time when there is a mains power failure, and providing only enough illumination to allow for the safe movement of people out of the affected area – at least 1 Lux, as suggested above. The length of time it is required to operate will depend on the circumstances and on the local regulations, but is usually not less than 2 hours.
- More ambitiously the entire lighting system including pitch illumination (see below) may be switched to the stand-by system, maintaining illuminance levels if the mains system fails.

With both methods automatic restart time, in case of failure, should not be more than five seconds.

Continuation of an event

The main floodlighting system will utilize high output, HID (High Intensity Discharge) light sources, which will require individual Hot Re-Strike systems to restart lamps at near full brightness in the event of a mains supply failure. These should be fitted to a sufficient number of floodlights to ensure an adequate level of lighting for play to continue until the full electricity supply can be restored. Those floodlights fitted with Hot Re-Strike (instant re-ignition) should activate simultaneously with the engagement of the standby power system.

Safety lighting

In some sports it may be necessary to provide safety lighting for a short period of time to enable safe stopping of an event in the case of mains supply failure. Safety lighting should not be confused with emergency lighting.

21.1.3 Pitch lighting for players and viewers

Illuminance requirements

If play is to take place at night the sports area should be illuminated to allow players, officials, and those watching both at the grounds and at home on television to see the action clearly. This means that the level of brightness, contrast and glare must be correctly designed over the entire playing area. The most demanding of these requirements is that of colour television transmission, and this specialist area will be discussed later.

The reason we can see any object is because it contrasts with what is behind it in colour or brightness or perhaps both. Colour contrast of a ball and a pitch or an athlete and a running track is largely controlled by the sports governing bodies and therefore is usually out of the control of the designer. An interesting exception to this was the yellow balls and bright clothing introduced by Kerry Packer in Australia some years ago for his night-time cricket World Series. This was a deliberate attempt to make the traditionally white attire and dark red ball more visible to the spectator and hopefully more popular to the public since they would be able to follow the game more easily. It was also essential for the players to see the ball when it was hit high into the night sky. Cricket is traditionally played during the day when the dark ball contrasts against a blue, or at least grey, sky but it would be impossible to see at night. Brightness and glare are therefore the only real controls we have over the visibility of a sport.

Levels of illumination for a sport played at night will generally be lower than those for the same sport played indoors. This is because of better contrast and adaptation when scenes are viewed against a dark night sky. Illumination levels will depend on the particular sport because of the different speeds of action, viewing distances, playing object size, and colour contrasts involved – the faster the object moves the higher the illumination required; and the higher the standards of play the higher the level of illumination required.

Lighting levels will also depend on the size of the venue since those sitting furthest from the action require the greatest level of illumination for them to see to the same standard. The last consideration which may be relevant to a stadium is that our standard of vision deteriorates with age and we require more light to achieve the same level of visibility when we are older. This deterioration can be quite significant, with the illumination levels required by a 60-year-old person possibly four times that for a 20-year-old, simply to achieve the same standard of visibility.

Table 21.1 summarizes typical lighting levels, and degree of uniformity, for a variety of sporting types. It is meant only as a general guide; specific up-to-date requirements should always be obtained from recognized International Lighting Standards (in Europe this is BS EN 12193), published Sports Lighting Guides, and recommendations of the particular sporting associations concerned, before commencing design.

All illuminance levels stated are minimum Maintained Average Illuminance (Em). The ‘maintained average illuminance’ level is the specification level and is inclusive of all depreciation factors that may apply over the periods that occur between planned maintenance. To achieve this a ‘maintenance factor’ is included in all design calculations. This takes into account light loss from the luminaire due to the accumulation dirt on light-emitting surfaces, and lamp lumen output deterioration with hours of use.

The cleaning characteristics of the luminaire will have a significant effect on its performance and cleaning interval. Floodlights for stadia systems require a high degree of ingress protection against dust and water (IP65 to IP66) to ensure maximum performance over long maintenance periods between cleaning and re-lamping.

Glare control requirements

One of the major factors to be considered in designing the lighting system is glare; not only does it affect the players and the spectators but it is often perceived as environmental pollution. Some glare may be impossible to eliminate, but the control of the levels of brightness of the light source and the adjacent background will help to reduce its effect. In small sports grounds glare and direct upward light causing ‘sky glow’ may also be reduced by using floodlights with installed ‘flat glass’ and incorporating one or more internal baffles to control direct viewing of the lamp. Another approach is to position the floodlight outside the observers’ line of sight; players and spectators are likely to be affected by glare when the light reaches them at angles near the horizontal. This is sometimes difficult to avoid in stadia where the floodlighting is mounted on the front edge of the roof.

Glare in floodlighting installations with respect to players and officials is now a calculable parameter, defined by an installations Glare Rating (GR) value. A grid of GR values is generally calculated over the full sports surface, the maximum value achieved becoming the Glare Rating for the sports field. A GR value of less than GR = 50 is normally considered the highest acceptable level for all levels of competition and TV coverage.

Facility	Class III		Class II		Class I	
	Recreational/ training use		Club/ country use		National/ international use	
	Lux	Uniformity	Lux	Uniformity	Lux	Uniformity
Archery (vertical on target)	750	0.8	750	0.8	750	0.8
Archery (shooting zone)	200	0.5	200	0.5	200	0.5
Athletics	100	0.5	200	0.7	500	0.7
Basketball	75	0.5	200	0.6	500	0.7
Bowls: lawn	100	0.5	200	0.7	300	0.7
Crown green bowls	100	0.7	200	0.7	200	0.7
Cycle racing	100	0.5	300	0.7	500	0.7
Cycle speedway	150	0.5	300	0.6	400	0.6
American football	75	0.5	200	0.6	500	0.7
Association football[2]	75	0.5	200	0.6	500	0.7
Rugby league football	75	0.5	200	0.6	500	0.7
Rugby union football	75	0.5	200	0.6	500	0.7
Hockey[3]	200	0.7	200	0.7	500	0.7
Mini hockey	200	0.5	300	0.6		
Lawn tennis[4] over court: PA	200	0.6	300	0.7	500	0.7
Netball	75	0.5	200	0.6	500	0.7
Golf driving range (vertical on dist markers)	50	–				
Artificial ski slope	100	0.5				

Source: *Handbook of Sports and Recreation Building Design (Vol. I Outdoor Sports),* The Sports Council.

Notes:

1 The recommended levels do not include lighting for television broadcasting and for these requirements refer to Vol. 2, ch. II, *Facilities for the Media, CIBSE Lighting Guide*: *LG4 – Sports,* and CIE Guides 67 and 83.
2 There are specific requirements by FIFA and UEFA for international matches and competitions and many domestic leagues and competitions have specific requirements (such as the FA Cup, FA Trophy, Football League, GMCV, etc.). Refer to the *Guide to the Artificial Lighting of Football Pitches* (FIFA) and *Digest of Stadium Criteria*, (FSADC), and Guidelines and Recommendations for Floodlighting for all UEFA Competitions.
3 The FIH recommend 250 Lux for ball training and club competition. Refer to the *Guide to the Artificial Lighting of Hockey Pitches* (FIH).
4 The ITF have specific recommendations. Refer to the *Guide to the Artificial Lighting of Tennis Court* (ITF).
5 Illuminance levels are on the horizontal plane unless stated otherwise.

Table 21.1 Minimum Maintained Average Illuminance (Em) requirements for outdoor sports facilities[1]

Daylight can also present glare problems but has a positive psychological effect on both the participants and the spectators. On a bright day the contrast between areas on the pitch which are in light and those which are in shadow can present a glare problem particularly for television coverage. This contrast can often be minimized by the use of translucent roofing materials which allow some light through the overhanging roof and balances the contrast on the pitch. Translucent roofing materials are discussed in Section 5.8.5.

Installation design

The correct design sequence is to decide the performance levels that are required (see above) together with cost and other limits, then to get competitive quotations for meeting these requirements, and only at that stage to decide the number and type of lamps, their mounting heights and their spacings. It is a mistake to approach the matter the other way round (as is sometimes done) and to decide at an early design stage the number and the heights of lighting towers, and perhaps even the number and

Photograph: Patrick Bingham Hall

Figure 21.1 The pitch at Galpharm Stadium, Huddersfield, lit by floodlights mounted on corner masts.

placement of individual luminaires, and then to seek quotations. Alternative lamp types and floodlights will require different spacings and locations to give the same result, and until the luminaires are known the spacings cannot be decided. Subject to that proviso the following general notes may be helpful.

Small stadia are usually lit by a side-lighting system consisting of three or four floodlights located on one side of the pitch mounted at a height of not less than 12 m. The angle between the fitting and the pitch centre should be between 20 degrees and 30 degrees to reduce glare, and the angle between the fitting and the side line between 45 degrees and 75 degrees to ensure adequate lighting on players at the touchlines.

Larger stadia may use corner columns or masts, with perhaps a number of fittings along the side(s) so that an optimum illumination can be chosen for any particular type of event. Corner masts are probably the most common system in use. They may be expensive but have the advantage of not obstructing any views to the pitch. They should be offset at least 5 degrees from the side, and 15 degrees from the end of the field of play, taken from the centre of the respective side or end to ensure that they are outside the principal viewing directions of spectators and players. Typically, mast height should be at least 0.4 times the distance on plan between the mast and the centre of the field, and mounting angles should be as in the previous paragraph to restrict glare. However, in the final evaluation mast height will be greatly influenced by requirements to achieve recommended Glare Rating limits over the playing surface.

In very large stadia the lighting system will be governed partly by the design of the stadium structure:

- Open stadia will probably use the system described above of four corner masts (Figure 21.1), about 35 m minimum height, possibly supplemented by additional masts around the perimeter if justified by the stadium size. It must be noted that these tall masts can present a major structural and aesthetic design problem, although current floodlight technology has resulted in greatly reduced floodlight quantities which in turn has reduced structural sizes. Where aesthetics are a prime planning consideration, telescopic or retractable masts may offer a solution in difficult circumstances.

Photograph: HOK Sport Architecture

Figure 21.2 Roof-edge floodlighting at the Reliant Stadium in Houston, Texas.

- Roofed stadia may have side-lighting in the form of continuous strips mounted along the leading edges of the roofs (Figure 21.2). These fittings should be mounted at least 30 m above the playing surface to reduce the risk of glare, which may be an insurmountable problem because light reaches the spectators at angles near to the horizontal. On the positive side, the increased illumination of the vertical plane associated with roof-edge lighting may be beneficial to television broadcasting. A hybrid solution using both masts and roof-edge side-lighting may offer a solution in some circumstances.

For larger schemes two or three switching levels may be provided to allow different illumination levels for different kinds of event, ranging from training to a full-scale televised match. It may also be necessary for the floodlights to be rotatable by remote control to illuminate different areas of the arena for different types of events. These matters must be clarified with the client at an early stage.

With regard to the structural design of towers, lattice towers are now rarely used. Static masts are cheaper, easier to maintain, and visually less intrusive. Hinged or 'raise and lower' masts facilitate regular cleaning re-lamping and maintenance, all of which are vital if lamp performance is to be maintained. Telescopic (retractable) masts may be suitable where permanent mast structures are prevented by planning regulations, but they are an extremely expensive solution. Where mast floodlight quantities are excessive, and mast heights greater than 45 m, internal access structures may be considered.

Floodlighting off grandstand roofs is an alternative to the provision of mast-based systems, and offers the opportunity for a continuous-roof stadium design. However floodlight systems produce a very large roof-edge loading which must be considered at the very outset of the stadium design. Where a stadium roof significantly overhangs spectator areas, extending almost to the pitch edge, it may also be necessary to set-back some of the floodlights beneath the roof edge so as to provide enough vertical illuminance on to players at touchlines for both spectators and camera viewing purposes. Access to the floodlights for maintenance purposes should also be considered, with nosed systems requiring substantial catwalks either above or below the roof edge.

Floodlights are generally located along both main side grandstands, with a limited number permitted along end rooflines so as to restrict glare in the principal playing directions. No floodlighting is permitted within an approximately 15 m zone on either side of a line projected along goal axes, to prevent direct glare to goalkeepers in some ball sports, including football and hockey.

21.1.4 Pitch lighting for television

Requirements

Because the camera lens cannot adapt as quickly as the human eye to the variations in lighting on a playing surface, lighting for professional television coverage must satisfy more stringent requirements than even the best spectator standards. If the stadium is to allow for television coverage its lighting design must therefore be based on television standards rather than visual ones. Such standards must take into account the distance at which the action is being filmed, the type of lens being used, the type of camera being used as well as the speed of play and quality of the artificial light source. It is essential that these criteria be developed with expert help, but broadly they are the following:

1 The minimum vertical illuminance level over the sports surface, relative to the maximum camera shooting distance, should be determined. A list of typical values is provided in Table 21.2.
2 The horizontal illuminance distribution of light over the playing surface (pitch) must be uniform, without contrasting dark and light patches on the field.

	Maintained Vertical Illuminance in Lux at maximum camera shooting distances		
Speed of Action	25 m	75 m	150 m
Slow	500	700	1000
Medium	700	1000	1400
Fast	1000	1400	

Notes:
1 For intermediate camera shooting distances, linear interpolation may be applied to the values above.
2 As HDTV cameras become increasingly more sensitive than SDTV cameras, both systems may generally operate under the same lighting conditions (CIE 169).
3 Lamp colour temperature: 4000 K to 6500 K (use from daylight to dusk); 3000 K to 6500 K (night use only).
4 Lamp colour rendition: Ra > 65; Ra > 80 preferred.

Table 21.2 SDTV Standard Definition Television lighting requirements (CIE 83)

3 The balance between average vertical and horizontal illuminance levels over the playing area should be controlled.
4 Acceptable lighting parameters should be achieved for all primary and secondary camera locations.
5 The Glare Rating over the sports surface should be no greater than GR = 50.
6 The light source should be selected with respect to colour temperature (K), colour rendition (Ra), and acceptable survival and lumen depreciation properties.
7 The lighting must be shadow-free, with particular attention given to the prevention of grandstand roof shadowing in mast installations.
8 Spectator areas bordering the play area should be illuminated to at least 25% the average vertical illuminance level over the play area.

Up-to-date guidance on all the above requirements must be obtained from the relevant governing bodies of the individual sports (such as the International Olympic Committee for athletics, or FIFA for international football competitions) and from the professional lighting institutions in various countries. In the UK the *CIBSE Lighting Guide: Sport LG4* (Chartered Institution of Building Services Engineers, 1990), plus addenda, is the essential reference. See Bibliography.

Turning from professional to private coverage, many clubs have their own video camera systems for recording games, and the lighting levels required for this are much lower than for professional coverage. A domestic video camera may pick up details at levels as low as 50 Lux on the vertical plane, which roughly equates to 100 Lux on the playing surface.

Installation design

Designing a lighting system that will achieve the above standards requires a great deal of expert knowledge, and the use of extensive computer calculations via sophisticated software. It is strongly recommended that design and installation of sports lighting for colour television (CTV) be carried out with specialist assistance.

Positioning of the lighting system should take into account the fact that television coverage of directional sports will be from one side of the stadium only, otherwise cutting backwards and forwards between camera positions will confuse the viewers.

The requirements of secondary, roving, and rail cameras should also be evaluated as broadcasters look to incorporate new camera shots to enhance the TV experience.

Floodlights are increasing in efficiency, making it both cheaper and easier to provide the quantity and quality of light that is required by colour television cameras. This has been made possible by technological advances in High Intensity Discharge (HID) lamp design. Light sources have evolved from enormous tubular and elliptical lamps fitted with large screw threads and poor alignment, into small unjacketed double-ended lamps designed for long life and high performance within sophisticated, compact, and stable optical systems.

Most old lighting towers have therefore been replaced with new lightweight mast structures using only 60 per cent new floodlights, compared with the number in the old installation, but achieving improved lighting levels and greater visual quality.

Stand-by power

Pitch lighting is sometimes supported by an emergency generator, but the latter would have to be far more substantial than that for emergency escape lighting and could only be justified if the potential financial loss from an aborted sports event were very large. Stand-by generation for pitch lighting is at present limited to major venues.

21.2 Closed-circuit television systems

Closed-circuit television systems (CCTV) may be used for two purposes in a stadium – for security and crowd control (where its use is becoming ubiquitous), and for informing and entertaining spectators, where its huge potential is not yet fully exploited.

21.2.1 CCTV for security

The need for better control of crowd movement has led to virtually all major stadia now having CCTV installations allowing management to monitor crowd densities, movement patterns and potential trouble spots before, during and after events.

Cameras have become smaller and less obtrusive, so that it is possible to monitor spectators without the latter being aware of the fact and feeling intimidated; picture quality has improved to the point where individual spectators can later be identified from a video recording, particularly if computerized enhancement techniques are applied. A striking example of the degree of miniaturization already available is a 150 mm by 25 mm camera fitting into a hollow wicket for close-up action shots of cricket matches – and no doubt even smaller cameras will be available by the time this is published.

Returning to the security aspect: it would be too expensive to place a camera in every corner of the stadium, but a general overview of all areas, plus targeted coverage of all potential trouble-spots must now be regarded as an essential feature of any new stadium design.

In the first instance control personnel should be given a clear view of all spectator approaches to the stadium so that they can identify a potentially troublesome build-up well in advance. As an example the control room of London’s Wembley Stadium is linked to cameras at a traffic junction some five miles away where many cars heading for the stadium turn off a major motorway. The police are thus able to identify supporters' coaches and take early precautionary measures if necessary.

Subsequently, they should be able to monitor crowd build-up and behaviour at all areas of dense congregation as spectators move to their seats – for instance entrances to turnstiles and vomitories, concourses, staircases and the like.

Systems integration

The monitoring facilities described above should not be seen in isolation, but in the context of an entire electronic communication system embracing the telephone, public address, crowd surveillance and recording, perimeter access control, general security, fire monitoring and fire alarm, and emergency evacuation systems. Additional aspects such as time and attendance records, parking control, elevator control and the like can also be integrated into the system.

As an example of how such integration may currently operate, an attempted illicit entry into a secure area can be detected by an electronic surveillance system which then activates a recording camera, auto-dials a message to stadium security officers and suggests what steps must be taken, issues a pre-recorded warning to the intruder, sets off an alarm, and makes a video record and computer printout of the entire sequence of events for future reference. All the correct actions can be taken and a reliable record kept with minimal risk of human error.

Ideally all the services described above should come from a single interconnected source, and it is essential to take expert advice to avoid incompatibilities between sub-systems which ought to be working together to give maximum benefit to the stadium management. For the same reason the information given here should be read in conjunction with other sections of this book such as sound systems (Section 21.3), fire alarm systems (Section 21.4) and so forth.

Stand-by power

A stand-by power system is essential for security services.

21.2.2 CCTV for information and entertainment

CCTV offers spectators the possibility of a running commentary on the game, replays and information about the players on the field, highlights from other games, and other possibilities as yet unthought of – all 'narrowcasted' on small personal TV receivers or on huge screens mounted above the pitch.

These are not just gimmicks but an essential element in managements' array of techniques to win back spectators from the comfortable alternative of watching sports events free of charge, with close-up shots, action replays and the like in the comfort of their living rooms. The proportion of events being televised increases all the time, enhanced by the spread of cable and satellite television, and stadia must struggle hard to retain their markets.

One can foresee the day when spectators will collect a small closed-circuit television receiver plus earphones, receiving only the stadium channel, as part of the ticket price. Perhaps these devices will be plugged into 'stadium television' or 'stadium radio' sockets in the seat armrest, rather as in an aeroplane, and they will offer a range of services which might include expert commentary, replays and information on the game; the ordering of purchases to be delivered to the seat at half-time; or an interactive facility allowing spectators to dial up information or statistics on a player or team, highlights from past matches, etc.

First signs of this developing process are to be seen at the Hong Kong Jockey Club, where spectators may use a key pad to find out the current odds and place bets from their seats. It can only be a matter of time before a miniature screen is added to the device, allowing the spectator to see the race from viewing angles and close-ups not available from his seat.

Turning from speculation about the future to present-day design, there are basically two technologies in current use.

Scoreboards

The provision of simple numerical or text displays above the pitch is now commonplace. They display scores, the real time, the elapsed and remaining time for games, the names and data of players and teams and the like; and even small stadia or sports halls will have scoreboards of this type. Guidance must be obtained from the governing body for the sporting type concerned, from manufacturing and installation companies, and possibly from independent consultants, to ensure correct location, positioning, size and specification. If this aspect is not considered at a sufficiently early stage it may prove impossible to install a completely satisfactory system.

Colour video displays

These are a completely different technology from the above, much more expensive but also much more dramatic. Colour video displays are like giant television sets which can screen action replays, highlights from past games or from simultaneous events at other venues, and of course commercials which are a useful source of stadium revenue.

In addition to attracting and pleasing audiences, thus increasing gate revenue, pre-programmed entertainment sequences on big video screens can also usefully slow down the rate at which people enter and leave the stadium. Keeping a proportion of the audience in their seats after the final whistle, instead of rushing for the exits, makes for a safer stadium. It can also make for a more profitable one if people are persuaded by entertaining video programmes to arrive earlier than they otherwise would do, and to stay longer, using stadium restaurants and other facilities before and after the game.

Video screens may either be permanent fixtures, or temporary ones erected in as little as six hours for a particular occasion. As these screens are very expensive to install, maintain and operate (with a capital cost of several millions for the largest sizes) the ‘rent by event’ approach may be the only feasible one for most stadia.

Very large screens are particularly apt for rock concerts and festivals; and at the time of writing the largest available size for mobile daylight screens is $48m^2$. Permanently installed screens may be up to $70m^2$ in area, consisting of 120 smaller high-resolution screens – 10 vertically and 12 horizontally. These are controlled from a console which allows the screen area to be used for one giant single image, or a mosaic of smaller images, giving great scope for exciting and entertaining effects.

Choice, positioning and operation of these very expensive facilities are critical matters which must be got right. Some requirements are obvious – for example:

- Screens must be easily visible to all members of the audience.
- Screens must not obstruct a direct view of the pitch or play in any way.
- Sunlight should never fall directly on to video screen surfaces.

However, other aspects are too technical, and too fast-changing, to describe here. Designers must get the best expert advice both from independent consultants and from companies in the field before taking decisions.

21.3 Sound systems

Badly designed or inappropriate sound systems can harm the performance of the stadium, therefore audio design must be taken seriously. There are well-documented cases in the USA where participants had to wear earplugs to allow them to concentrate on the game, and there are many instances of spectators being irritated by announcement systems which are too loud for comfort, too quiet to be heard above the background noise, or hard to decipher.

21.3.1 Requirements

The first step in designing such a system is to define as clearly as possible the results the system must achieve when in use. Matters to be considered include the following.

Specific functions

Managements require sound systems in sports stadia for as many as four different functions:

- To communicate with the spectators in the stands (general announcements, commentary on the events being staged, etc.).
- To give information and instructions in emergencies.

- To provide entertainment (music, light amusement, etc.).
- Advertising.

At times some of the above functions may be in conflict with each other, and to prepare for this eventuality a clear set of priorities must be decided at briefing stage and built into the system. A typical sequence of priorities, with the first item overriding all others, and so on down the line, might be as follows:

1 Police announcements from the police control room (see Section 19.6.2).
2 Management announcements from the events control room (see Section 19.3.3).
3 General announcements and match commentary.
4 Pre-match events information.
5 Musical and other entertainment.
6 Advertising.

Audibility

To be effective a sound system must be heard over the background noise of the crowd by a significant margin. The designers must therefore establish what the level of background noise actually is, either by measurement (in the case of an existing stadium) or by calculation (in the case of a new stadium).

Crowd noise is generally specified as an L value, which is the sound level that is exceeded for only 10 per cent of the time, and it is important to take into account the peak levels (for example, when goals are scored) when determining this value. As a guide, the sound system should be in the order of 6 dB louder than the crowd noise level as specified above.

The next step is to determine the evenness of the sound distribution in the stadium, since it would be of no use for spectators in one area to hear clearly while others could not hear at all. The degree of evenness should, as a rough guide, be in the order of $+6$ dB and -3 dB for at least 95 per cent of the spectator area, but perhaps for only 75 per cent or 80 per cent of less important areas such as entrance concourses and turnstiles.

The amplifier must be of suitable design and power capacity to maintain the above performance regardless of varying levels of background noise level, and modern systems are able to do this, adjusting automatically to the background noise level.

Intelligibility

Having enough sound volume does not necessarily ensure intelligibility (as anyone who has neighbours with a powerful hi-fi will know) and it is necessary to measure, specify and calculate sound levels in the 4 kHz octave band. Emergency messages often need to be complex and must not be misunderstood, therefore any testing of a sound system should replicate real use and not be confined to a simple reading out of ‘one, two, three, testing …’.

Reproduction of music

If a stadium is intended for multi-purpose use (which is now common) it must be suitable for hosting musical events, and music sets the most demanding criteria for sound quality. Designing the permanent sound installation to these criteria will be expensive – probably too expensive if the stadium is not often used for musical events. In that case temporary systems may have to be brought in for such events, but then very careful thought must be given as to how these temporary systems will be installed, how the stadium will perform acoustically when they are in use, and what the relationship between the permanent and temporary systems will be. Many acoustic problems arise from lack of forethought about these matters.

Provision for people who are blind or hard of hearing

An ‘induction loop’ system can be installed for certain areas so that blind and deaf people can listen to the commentary. See also Chapter 10.

21.3.2 Design

Stadium shape and materials

Acoustic design begins not with the audio system, but with the shape and materials of the stadium itself. In completely open stadia the influence of shape and materials will be small, but in fully or extensively roofed stadia, to which the following notes are principally addressed, the effects of sound reflection and of noise build-up could be severe. As an obvious example, hard surfaces that are parallel to each other (such as an acoustically reflective roof over a hard floor; or two parallel walls facing each other) may generate echoes and/or excessive reverberation which reduce or destroy intelligibility.

This is not to suggest that reflected sounds from the crowd must be totally eliminated. In Wimbledon's Centre Court the buzz of crowd excitement that is reflected back at key moments by the metal roof above contributes greatly to the sensation of a closely shared experience; and in roofed football stadia the reflected aural ambience may add similarly to the excitement.

But these aspects must be kept under control. Particularly problematic acoustic areas are the corners of the stadium 'bowl', the seats below overhanging upper tiers (where sound intensities can build up even in open stadia) and the area under the roof of a fully covered stadium. If such a roof is domed the problem may be even worse because of the focusing effect of the curved surface. Generally, the underside of enclosed stadium roofs must always have acoustically absorbent surfaces, perhaps (if the roof is solid) as panels fixed to the soffit or suspended some distance below it, or (if it is a double-layer fabric roof) by inserting an absorptive material between the two layers.

When planning fully enclosed stadia it is helpful to note that irregularly shaped plans may create fewer acoustic problems than rectangular or curved ones; that surfaces which are broken up by mouldings or irregularity probably create fewer problems than smooth flat ones; and that the careful location of acoustically absorbent materials is essential for reverberation control and the avoidance of echoes.

The above notes are of course only generalizations, and expert help should be sought.

Placement of speakers

Designing a system that will meet the performance criteria noted in Section 20.3.1 above is a matter for specialists and detailed advice would be out of place in this book. In the UK the Sports Council has published an excellent guide by the Football Stadia Advisory Design Council, which should be studied. But one aspect with which stadium designers will get directly involved is the pattern of sound distribution. There are three layouts: centralized speakers, partial distribution of speakers, and a completely distributed system of speakers.

A centralized system collects all the speakers together in one location, which makes it the cheapest of the three options. The disadvantage of this configuration is that there is less control over sound distribution if all the sound comes from one point, so that the sound may be too loud for those close to the speakers or too soft for those far away. A usual location in open stadia is at the end of the bowl, often adjoining or as part of a video display. In covered stadia a usual location is centrally above the pitch, suspended under the roof, and this may well be the most appropriate use of the centralized system – though such a central placement may exacerbate problems of reverberation time.

A partially distributed system has several clusters of speakers placed around the bowl at regularly spaced intervals – for instance, mounted on floodlighting masts. It is also called a 'satellite system' and is popular in covered stadia in the USA.

The fully distributed system, which is more popular in Europe, has an even distribution of speakers dispersed throughout the spectator areas. It is the most expensive of the three options because of the extensive cabling that is required. It may not provide good sound projection on to the playing area, so that an additional temporary system may be needed if this zone is used by the public, for example during concerts. But those disadvantages apart, this system does provide the best general sound quality of the three options and the best control. Speakers can be located on each tier of the bowl, and can separately serve each section of seating area. Good synchronization with video displays can be achieved, by fractional time delay, if necessary.

21.3.3 Control room

Whichever approach is adopted the public address system must be controlled from the stadium control room, which should overlook the pitch and have a secondary control from the police control room not far away. Other announcers using the system might be located in various parts of the ground and provision should be made for a microphone to be plugged in at pitch level for player interviews and crowd entertainment by a professional 'showman', although a radio microphone could be used for this purpose. Other control considerations are generally based around who should get what messages and what type of musical input is used, CD players now being in common use. Advertising would generally break through background music unless the advertising is co-ordinated with the video board which may make this a little difficult.

Stand-by power

As already mentioned in Section 21.1.2, a stand-by power system should be considered for major stadia so that safety announcements can be made in the event of a power failure. It is unlikely that batteries alone would be enough for a major system and therefore the emergency generator is often used for this purpose in conjunction with an immediate battery back-up system. As well as the stand-by generator and battery room, an equipment room to accommodate the sound system must be included. This can be surprisingly large and should be as close to the control room as possible. Generally the system will be housed in racks about 800 mm by 600 mm in plan and standing up to 2 m high. In addition approximately 1.5 m should be allowed on all sides of the equipment to give easy access for servicing. A network of cable trays and trunking will commence at the equipment room and spread to all parts of the stadium. Their route through the stadium and its protection should be taken into account at an early stage.

21.3.4 Typical design criteria for a sound system

A sound system for a sports stadium may typically contain the following criteria.

1 The statement should set down the basis upon which the design is undertaken and on which its performance will be judged when installed.
2 It should state the standards and codes of practice upon which the design should be undertaken.
3 The systems function should be stated as:
   a) to communicate emergency messages.
   b) to provide public address messages.
   c) to be used for other specific messages.
4 The frequency response should be stated. The following is an example.
   General public areas:
   a) Frequency response pre-equalization. Total system 100Hz–6kHz +6–3dB (essentially smooth).
   b) Frequency response post-equalization. Total system 100 Hz–6 kHz ±3 dB. Concourses, turnstiles and entrances.
   c) Frequency response pre-equalization. Total system speech only 200 Hz–6 kHz +6–3 dB (essentially smooth).
   d) Frequency response post-equalization. Total system speech only 200 Hz–6 kHz ±3 dB.
5 The intelligibility rating should be stated with a given occupancy noise.
6 Sound pressure levels and coverage should be quantified, such as the following example:
   a) Sound pressure level 6 dBA >L10 for 95 per cent of public.
   b) Coverage to be within ±2 dB for 95 per cent of public areas where L10 is sound pressure level which is exceeded 10 per cent of the time.
7 Different zones should be identified and the system should allow access to the different areas identified independently or as a group of areas. A typical range of zones is given below for guidance:
   - north side stand
   - north concourses
   - north turnstiles
   - south side stand
   - south concourses
   - south turnstiles
   - east side stand
   - east concourses
   - east turnstiles
   - west side stand
   - west concourses
   - west turnstiles
   - executive suites
   - car parks
   - restaurants.
8 A priority system should be indicated, with the police and security services given the highest priority. A typical order of priority might be as follows:
   - Police announcer in police control room.
   - Management announcer in event control room.
   - General announcer and commentator.
   - Pre-match events commentator.
   - Musical entertainment and 'Disc-Jockey'.
   - Advertising.
9 Any additional requirements should be stated.

21.4 Heating and cooling systems

Traditionally, since many sports are watched in the open air, the enclosed areas of sports grounds have also not been heated or cooled, and people have remained in their outdoor clothes whilst buying food or drink in the intervals of the event. Some areas of a stadium will however require the normal heating or air conditioning used in other building types. These might be restaurants or boxes where spectators will be sitting indoors for longer periods, or club areas, or the stadium administration offices, or operational areas.

Where the stadium is fully enclosed there is the option to heat or cool the playing arena as well as the spectator accommodation around it, though the energy costs associated with the heating of such a large volume should be considered.

21.5 Fire detection and fighting systems

21.5.1 Stadium layout and construction

Designing for fire safety begins not with the installed systems, which are a second line of defence, but with the physical layout and method of construction of the stadium. Unfortunately, building codes and regulations seldom give specific requirements for stadia, and applying those which apply to apparently similar building types will often be inappropriate, therefore we recommend early discussion with local fire and safety authorities.

The current method of design of stadia to respond to fire in many countries is to achieve a balance between the risks of outbreak, the risks of spread, the detection and control systems and the spectator exit system design. These different aspects of the fire safety design of the stadium are collected together in a ‘risk assessment’ to achieve the overall level of safety that is judged to be appropriate.

Subject to the above it may be said that the method of fire compartmentation is a key issue when the stadium layout is being evolved. Appropriate methods of compartmentation will vary depending on the location, size and layout of the stadium, but it has become accepted practice to separate high-risk spaces (for example concessions where cooking is done) from other areas by means of fusible-link fire-shutter doors. This allows public concourses and stairs to avoid the multitude of fire doors which would otherwise be necessary, inhibiting the flow of spectators and thereby causing an escape risk.

21.5.2 Installed systems

Fire detection devices, fire alarms, and fire-fighting services will be necessary in high-risk zones such as cooking areas, and in the case of roofed stadia possibly throughout the building. The latter will certainly be true of a totally enclosed stadium where the arena may be used for trade exhibitions, or other events using combustible materials.

The detection and alarm systems will probably be linked in with other electronic services as described in Section 21.2 above, and the water-borne fire-fighting systems might include:

- Automatic sprinkler systems.
- Sand-pipes and fire-hose cabinets.
- Fire protection water mains with connection points.

A thorough analysis of the stadium, its possible functions and patterns of use, its means of escape (see Chapter 13), and its materials of construction must be undertaken and discussed with the relevant authorities and with expert consultants as part of the briefing process.

21.6 Water supply and drainage services

21.6.1 Requirements

When thousands of people collect in one place for most of a day, particularly in summer, an enormous amount of liquid will be consumed and eventually recycled. We have already set out the requirements for toilet facilities but those appliances must have sufficient water to operate. Depending on the duration and type of the event water consumption in the order of 5 to 10 litres per person must be planned for if the taps are not to run dry. Equally important is the speed of distribution around the stadium to ensure an even pressure to all levels of the facility. If the stadium is planned as an integral part of the urban or rural infrastructure then it is likely that the established water mains will be sufficient to provide for this demand. It is important to be sure of this at an early stage however since water authorities are often not aware of the quantity of water required in a stadium. If the water mains is not large enough to provide sufficient pressure water storage must therefore be accommodated on site and pumped to its destination.

21.6.2 Installation design

There are a number of ways in which this water storage can be planned. Large underground storage tanks with a fully pumped circulation system or smaller storage tanks in each of the individual areas they service or a combination of both. The extent of water storage which can be accommodated in the building and therefore allow gravity feed to the outlets will be influenced by the building's design. Most local authorities require a minimum water storage to be on site and a percentage of that total to be sufficiently high to allow the outlets to be gravity fed. Another common requirement by local health authorities is that the outlets which are providing drinking water must be served directly off the mains to avoid the possibility of contamination while the water is in the storage tank. This can sometimes be a problem when the top level of the stadium is 20 to 30 m above the ground and the local water pressure is not sufficient to reach. This can be a problem when the rest of the facility is drawing off water from the same mains at its peak rate. Some South American stadia, for example Curitiba, have incorporated water towers into the general stadium and lighting installation design.

Whatever the methods used to provide sufficient water during an event the system will remain unused for much of the time. Depending on how long this is systems may require draining down between events. Drain down outlets must be provided to each storage tank and to each run of pipework if it does not drain directly to a storage tank. This requirement can usually be accommodated by the use of one drain down point per section of stadium provided it is placed at the lowest point of the system and free draining can take place. As well as being drained down between events, during the winter months in cold climates the storage tanks and pipes holding water must be protected from frost damage. This is usually done by the use of 'trace' heating to the pipework and tanks combined with the use of insulation to all exposed surfaces. If the system is inside a heated space trace heating will not be needed as long as the heating is operating on at least a minimum background setting which will stop temperatures dropping below freezing. After all this water has been allowed for and distributed to the correct areas of the stadium – including the pitch itself – a drainage system is required to take most of it away again. If the stadium is sited in an area where it can form part of a large urban infrastructure this is not likely to be a problem.

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22. Maintenance

22.1 Introduction
22.2 Pitch maintenance
22.3 Stand maintenance

22.1 Introduction

22.1.1 A maintenance policy

Just as a motor car has a planned maintenance regime which requires certain procedures to be carried out at frequent intervals, and others less frequently, so stadium planners should develop a clear 'maintenance cycle' for their building and pitch which can be passed on to the owners in the form of a *Maintenance Manual*.

To apply such a policy successfully, the stadium management will require:

- Well-trained personnel.
- Suitable equipment for these people to operate.
- Supplies of the correct quantity and quality of materials to be used.
- Adequate space allocation in the stadium grounds for storage and workshops.

22.2 Pitch maintenance

22.2.1 Maintenance of natural grass

In theory, and given proper maintenance, a natural grass pitch will last almost indefinitely in contrast to synthetic surfaces which usually must be replaced every 5 to 10 years. But in practice grass pitches can suffer irreparable damage if maltreated. The actual lifetime will depend on factors such as:

- Intensity of wear. This varies enormously: in northern Europe play is limited to a couple of months in summer, giving around 50 hours of use per annum, whilst in southern Europe play is possible all year round giving 500 or more hours of play per annum.
- Type of usage. The harder the pitch, the more use it can take.

It is essential to follow the procedures briefly outlined below. More detailed guidance will be given by the consultant and specialist suppliers who specified the pitch in the first instance, as discussed in Section 7.1.3.

Mowing

This is an important activity and should take place at the correct growth period for the particular sport involved. At the latest grass should be cut when it reaches a height of 40 mm for hockey, and 60 mm for football. It should then be mown back to a length of 20 mm for hockey, 40 mm for football, and somewhat more for rugby.

Fertilization

The adding of nutrients is required periodically and is subject to an analysis of the residual substances which will be in the grass. It is important to get the timing and quantity of application right and these factors will be influenced by the sport concerned. A fertilizer and seed spreader should be used to ensure an accurate rate and distribution of seed.

Irrigation

Depending on how much natural precipitation occurs in the region, natural rainfall should be supplemented by a centrally controlled automatic sprinkler system. Irrigation usually takes place at night as this is when the least amount of water will be lost to evaporation and the risk of 'burning' the grass is eliminated. An alternative and preferable irrigation method, if it can be afforded, is to install a network of porous pipes beneath the surface which feed water and a mixture of nutrients and pesticides to the roots from below as described in Section 7.1.3.

Many stadia are now recycling irrigation water from rainfall, using artificial pumping systems. Eighty per cent of the irrigation water used at Manchester United Football Club's Old Trafford stadium is recycled.

Drainage

A drainage system of either the 'passive' or 'active' type must be installed to ensure that excess water is rapidly removed from the pitch during irrigation and also during rain or other forms of precipitation. Systems are described in Section 7.1.3.

Repair and maintenance

Bald patches must be sown with new seed or repaired by the laying of pre-grown grass to make good damage from play. Thatch needs to be removed by aeration, perforation or slotting and sanding; and hard areas must be softened by the use of slots and holes to loosen the earth. Lawn aerators, perforators and sweepers should be used particularly where a spectator invasion of the pitch has occurred. The problem with this practice is that spectators' feet compact the earth and prevent good grass growth in the area affected.

Cleaning

Grass pitches should be cleaned on a regular routine basis just as for synthetic surfaces. See the section on cleaning below, much of which applies equally to natural grass.

Protection

Grass damage from frost and other sources of harm must be avoided. Underground heating is a useful method of protection against frost and an aid to faster snow removal, and is gaining popularity in colder climates. In Scandinavian countries metal foil sheeting is often used to protect pitches against frost.

22.2.2 Maintenance of artificial grass surfaces

Artificial grass surfaces used for hockey are predominantly non-filled but are irrigated from a pitch-side system to comply with the requirements of the International Hockey Federation (FIH). This type of surface should be kept free of dirt, leaves and other wind-blown detritus by regular sweeping, perhaps with a vacuum. The presence of large quantities of water in the pile may, in certain climates, encourage the growth of moss and algae that can only be removed by a combination of chemical treatment and water assisted suction.

Artificial grass (or synthetic turf) for sports such as soccer and rugby, is normally filled with a combination of silica sand and rubber granulate. This infill material requires to be kept evenly distributed to maintain playing characteristics and this is best achieved by brushing or drag matting. Scarification may be necessary from time to time to relieve compaction. This type of surface should also be kept free of dirt, leaves and other wind-blown detritus by regular sweeping, perhaps with a vacuum.

Play line in artificial grass surfaces may either be cut into or painted on to the surface. Painted lines are not permanent and will require to be re-painted on a regular basis.

22.2.3 Maintenance of polymeric surfaces for athletics tracks

While synthetic surfaces require less maintenance than natural grass it is wrong to assume that they can be laid and then forgotten about. Synthetic surfaces are not maintenance free.

First, it may be necessary to enforce certain limitations on their use in accordance with manufacturers' recommendations. One of the most critical is a limitation on shoe spike length for athletic events. Second, regular repair, maintenance and cleaning is essential as described below.

Repair

When maintenance is carried out the original properties of the surface must not be changed. For example, if the surface is meant to be porous then the repair material must also be porous. Repairs of polymeric surfaces should only be undertaken by experts due to the nature of the materials involved.

Track markings, if properly painted on to the surface at the time of construction, will last for ten years before re-painting is required. This life depends on track utilization.

Cleaning

Dirt and harmful materials are produced in surprisingly large quantities. They include oil and fuel dropped by vehicles, chewing gum and paper from the participants, and sand, mown grass, leaves, dirt from shoes, moss and algal growth and air pollution from the environment. All of these must be cleaned from the surface regularly by either manual or mechanical means. Manual cleaning can include rinsing with water jets, sweeping, applying cleaning agents, moss and weedkillers and pulling up weeds. Freezing agents for chewing gum, and high pressure water equipment are more specialized techniques.

General cleaning and 'house-keeping', should be carried out to a regular routine either daily or weekly; and these operations should be supplemented with a major clean on an annual basis using a high pressure suction method for in-depth cleaning. An adequate water supply for this purpose is required adjacent to the track.

Protection

It is advisable to protect the surface when it is used for activities other than sport, particularly when heavy vehicles are required to cross or move around the surface in setting up events.

22.3 Stand maintenance

22.3.1 Design factors

The stand should be designed to have unobstructed floor surfaces without fixings and nooks and crannies in which rubbish can collect, and where cleaning machines cannot easily reach. For this reason riser-fixed seats (which leave the floor surface unobstructed) are far preferable to seats with tread or nose fixings (see Chapter 12.6.2). And bearing in mind that the seats themselves will also need periodic cleaning, and perhaps snow-removal, it is best to specify the tip-up variety.

Passageways should be wide enough for cleaning machines to move about easily and quickly. Expert advice should be obtained at an early design stage about the minimum widths needed for rubbish-collecting vehicles.

Finally, there should be a generous provision of service points such as compressed air outlets, water supply outlets, drainage outlets, rubbish disposal chutes and the like. Expert advice from cleaning specialists must be obtained at an early design stage to ensure that cleaning contractors can work efficiently in the completed stadium.

The following short checklist lists the most important points to be considered from the outset of design:

1. Fixing of seats to steppings.
2. Width of seatway to allow easy access.
3. Width of seatway in front of first row to allow vehicular collection of rubbish.
4. Rubbish disposal chutes near gangways.
5. Water points at convenient point on each tier.
6. Integral compressed air system with outlets on each tier.
7. Rubbish compactors at ground level with access for heavy vehicles.
8. Rubbish containers on each level of the stadium.
9. Drains for the water used to clean the stands.
10. Openable panels in balustrades to allow rubbish to be pushed through.

22.3.2 Cleaning methods

In addition to the work required to the pitch, the stands also need to be maintained and the most important part of this process is the cleaning of the stands after every event. There is sometimes a tendency to leave the cleaning of the stands until the period immediately before the next event rather than immediately after the event just finished. This is because if the events are some time apart the stands and particularly the seats will need cleaning again. This practice should be resisted for a number of reasons, the first of which is that during the time between events the stadium will appear very dirty and untidy which is bad for the image of the venue. Second, it is usually much easier to clean a stand immediately the event is over when spilt drinks and food have not yet stained the steppings. This is not a consideration when the stadium is holding events regularly but for the majority of venues there can be a number of weeks between events and at least the seats will need to be wiped down before the next occasion.

The process of cleaning can be very demanding in both personnel and equipment and it is wise to have thought about this at the early planning stage. The careful design of steps and details at the front of the tier are important if the cleaning process is to be made as easy as possible. The inclusion of openable panels in the front balustrade of a tier are very useful particularly if a rubbish container can be positioned in front or below this opening. The use of riser fixed seats rather than tread or nose fixings are also preferred for ease of cleaning. Bearing in mind that individual seats will also need to be cleaned and sometimes snow removed it is better that these are of the tip-up variety.

The amount of time it takes to clean a stadium will depend on its design but an approximate guide is 30 to 40 man hours to clean every 10000 seats. Methods used for cleaning will depend on the equipment available and to some extent the type of rubbish to be removed. Stadia in the Far East require more use of water since less paper is used for packaging and the fast food eaten at the grounds is usually more fluid. Sweeping the rubbish together along rows and then down the tier into a single pile can be done by manual brooms and also mechanical blowers which are faster. It is then transferred to sacks and taken down the stand by hand, perhaps using a service lift if one is available. More sophisticated methods are also available, such as the building in of a compressed air suction system which allows large diameter hoses to be connected at key points on each tier and the rubbish is sucked into the hose and down into the system where it collects in large compactors, loaded on to trucks and removed. At the Utrecht Stadium in Holland rubbish is blown and swept into the moat between the seating and the pitch, where it is then gathered and cleared.

23. Operation and funding

23.1 Stadium finances
23.2 Capital costs
23.3 Operating costs
23.4 Income generation
23.5 Controlling costs and revenues
23.6 Conclusion

23.1 Stadium finances

23.1.1 Introduction

As stated at the beginning of this book stadium economics are such that it is difficult – though not impossible – for a stadium to earn a profit for its owners. The essential starting point for a viable development is therefore a comprehensive feasibility study comprising not only constructional matters but also an in-depth examination of how the stadium will operate financially.

The findings of the feasibility study will influence the design, form and content of the final project, and the study will need to address the following factors:

- Initial *capital cost* of the project.
- Anticipated *operating costs* of the stadium.
- Expected *income generation*.

The notes below deal with each of these in turn, and the advice given is necessarily 'broad-brush'. There is so much difference between countries, between various types and sizes of stadia, and costs of all kinds change so much in the space of a few years, that specific data in a book such as this would be misleading. We therefore concentrate on principles rather than specifics. In a real project, cost consultants and other specialists would be retained to give precise guidance.

23.2 Capital costs

23.2.1 Cost per element

23.2.2 Key drivers behind capital costs

When planning a new stadium it is very important to understand the key drivers behind the capital cost. Stadia are widely appraised on the internationally recognized cost per seat comparator, benchmarking one facility against another. This is shown in Figure 23.1, which suggests typical cost per seat ranges for different capacity stadia. However this data can be misleading as it gives little indication of the success of the development, with large variances occurring between facilities of similar capacity, often driven by the business needs. For example, a stadium that has been developed with the incorporation of extensive commercial facilities will carry a far greater cost/seat than one that hasn't, but may also deliver a far greater return on investment.

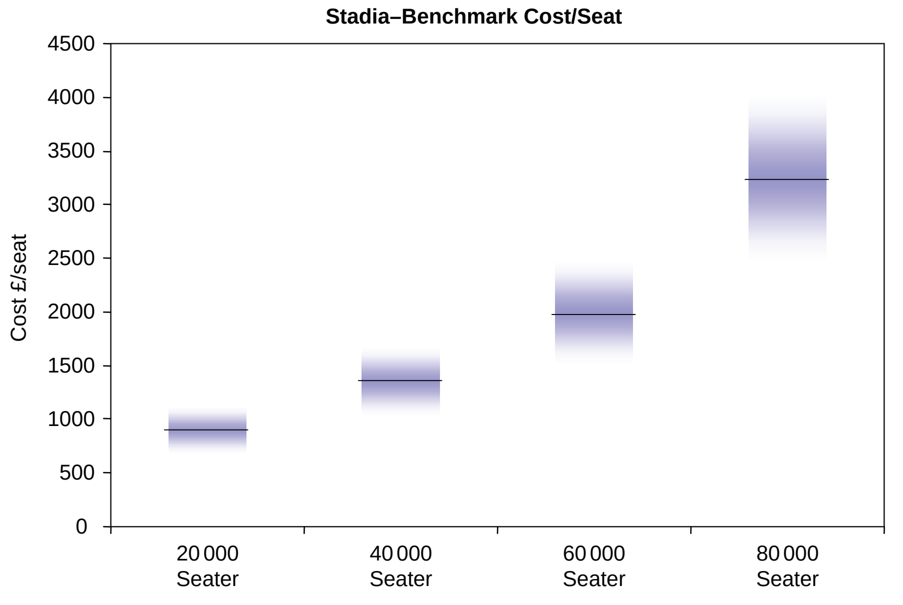


Figure 23.1 Average building costs for a large number of stadia projects have been analysed, reflecting 4Q2005 prices at a UK mean location.

The development of a new stadium will involve many costs additional to the construction costs of the building, for example land purchase, arrangement of loans if any, local authority and consultants fees. These will need to be accounted for in the overall financing, but are not dealt with here.

The capital investment cost is a complex equation and it is necessary to have an understanding of what the key cost drivers are for any facility. While site-specific issues such as demolitions, power, water and other services connections, external works, contract conditions, location and programme often account for some of the large variances in capital cost between facilities, they do not tell the whole story.

For any project, especially at early feasibility stage, it is important to have considered the primary component parts, each of which will influence the capital cost, identified as follows:

a) Event area.
b) Spectator viewing (the bowl).
c) Roof.
d) Accommodation (circulation, hospitality, toilet facilities and so on).
e) Vertical transportation.
f) Quality (internal and external façade).

The pie charts in Figure 23.2 set out the typical breakdown of these elements in percentage values for different size stadia. Each of these may affect the total stadium cost to a greater or lesser extent dependent on the drivers of the project.

In the following section Franklin Sports Business (FSB), a market leader in stadia cost consultancy, provide an in-depth review of the key influences on the cost of these primary component parts:

Event area

The event area cost will be influenced by a number of factors, including the local climate conditions and the proposed event calendar. Local climate conditions will determine the heating and irrigation requirements, but more importantly the proposed event calendar will dictate how the arena floor is constructed. A stadium designed for sports events and other activities, such as the Cardiff Millennium stadium that has a removable pitch not only has the cost of the pitch, but also the construction of a solid surface underneath. Valuable development space is also lost as an area outside the facility needs to be set aside for the pitch to ‘park itself’ whilst it is not being used.

Other factors to consider are athletics tracks, artificial turf and the growing requirements of natural turf all of which influence the overall design and cost of this element.

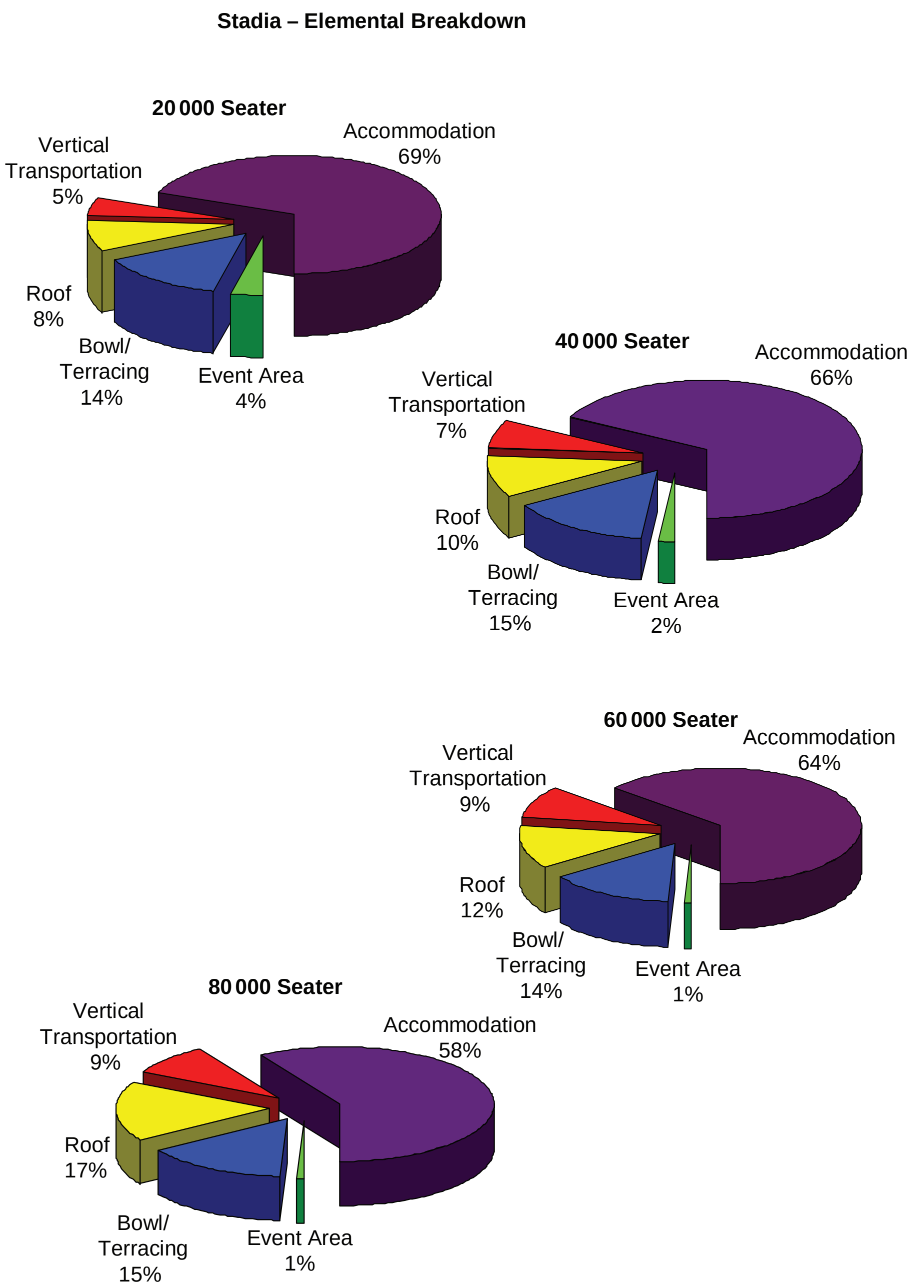


Figure 23.2 Pie charts presenting a typical breakdown in percentage values of the elements of stadia construction projects.

As a result of all these variables the cost of the event area can vary considerably with a range of between £500 000 and £10 millions not being uncommon.

Spectator viewing

The spectator viewing, or bowl as it is usually known, is probably one of the least understood cost variables in stadia and is a major factor in determining differences in facility costs. There are two main criteria to consider.

First, spectator comfort and viewing quality through seat width, row depth and 'C' value will all influence the plan area and overall height of the bowl. An example of this is the seating tiers at the new Wembley stadium, which whilst only increasing capacity from approximately 80 000 to 90 000 seats will have a seating bowl plan area one and a half times larger than the old stadium. Obviously such comfort costs considerably more money to build, however this can encourage spectators to stay at the stadium for longer which in turn means they are likely to spend more money there. In addition, the extra area afforded to each spectator will mean the viewing areas will be better suited for events that run longer than the traditional 90 minutes of a football match, such as all-day concerts or festivals.

The second influence is capacity, not just the fact that more seats cost more money but the fact that the larger the bowl gets the greater the average construction costs will be, due to additional craneage, additional support structure and increased complexity of construction.

Other influences on the cost of this element include disabled viewing requirements (see Chapter 10); quality of seats (see Chapter 11); cleaning requirements; and the extent to which the upper terracing is cantilevered to bring the spectator closer to the action.

From a cost and therefore best value point of view there are enormous benefits in lowering the pitch below existing ground level, resulting in the ability to construct a proportion of the terracing as ground bearing. This not only results in less steelwork but also means that the facility has a reduced vertical circulation element.

The roof

Roofs on the larger-capacity venues can cost considerable sums of money as the structure is asked to span longer distances and cover greater areas. The roof cost is related to the spectator viewing area for obvious reasons. The greater the spectator viewing area, the greater the area of roof to cover it and hence cost. Therefore the roof cost is influenced by some of the same factors that influence the cost of the seating bowl such as seat width, row depth etc. But more importantly the greater roof spans require proportionally greater levels of steelwork to support the roof cladding. In some instances doubling the span will require four times as much steel and therefore cost approximately four times as much to build.

Other issues to consider with the cost of the roof are the proposed material selection including areas of translucency (for both natural turf and media requirements) and the need for the roof to either permanently or temporarily close during certain types of events.

The spectator viewing and roof costs go some way in explaining why we see large differences in cost per seat between stadiums of different capacities. In fact a study carried out for these two elements shows that the relationship between capacity and cost per seat does not follow a straight line but is actually exponential which reflects the issues described above.

Accommodation

Typically football-only facilities will include accommodation behind the bowl that equate to approximately 1 m^2 of area for every spectator. However this varies considerably from facility to facility, and is probably the single largest variable in cost comparisons for stadia of equal capacity. For instance the Stade de France provides a total accommodation area equal to just under 1 m^2 per person, but the new Wembley stadium will afford an area equal to nearly 2 m^2 per person.

The accommodation areas can be broken down into five broad categories, namely:

- Spectator facilities.
- Hospitality facilities.
- Operational facilities.
- Participant facilities.
- Non-core facilities.

Spectator facilities include the areas that the general paying public use and will include areas such as concourse, toilets and concessions. Again spatial provision varies between sports grounds depending on the quality of experience to be provided. However it is clear to say that providing greater areas of concourses, bars and restaurants can encourage the spectator to stay longer and allow easier access to food and drink, both resulting in the ability to increase the average spend per head.

Hospitality areas consist of corporate boxes, banqueting suites, club concourses and the like, these spaces will usually have the greatest cost per m^2, but will also generate the greatest revenue per m^2. The extent to which hospitality areas are provided will depend on the local market for them, and will play a significant part in determining the overall gross internal floor area and outturn cost of any project. If designed correctly they can also represent a good source of income on non-event days for conferencing, restaurant and social event use. Whilst additional investment may be required this is likely to represent a significant part of the revenue stream required to make the project deliverable.

Operational facilities, i.e. the back of house accommodation that is required to make the facility ‘tick’, also vary from facility to facility. Larger stadia will require larger operational areas to deal with stadium and event management, security, servicing, waste management, media areas and the like. Whilst these areas can be designed to the bare minimum this will invariably result in inflexible and operationally inefficient solutions. On paper the capital cost of the project looks good, but day-to-day running costs are increased due to more labour intensive activities, and the building is limited on the range and frequency of other activities that can be held there.

Participant facilities, i.e. the changing rooms and other areas provided for the event participants will be defined by the proposed stadium use. Today’s venues not only have to accommodate the host sport’s changing facilities, warm-up areas and lounges, but will also need to consider requirements for pre-match events, and separate areas for female officials and participants. Whilst the total areas of the facilities do generally increase in size for larger capacity venues this relationship is not directly proportional.

Non-core facilities arise from the fact that stadia are large developments and a lot of space that is created beneath the terracing is often underutilized. Such space can be fitted out for commercial offices, casinos, shops, bars and the like which can be incorporated at a reduced cost when compared to the cost of constructing them as independent buildings. Obviously the overall area and cost of the development is increased, but adding these elements can attract separate funding, create additional revenue streams and ensure that the development remains active beyond the normal event schedule, all of which will assist in ensuring long-term sustainability.

Vertical transportation

For the larger capacity stadium an increasingly greater proportion of the accommodation is located on upper levels. This not only means that the accommodation itself will cost more to build, but will have a negative impact on the cost of vertical transportation. The design of a 40 000-seater capacity stadium can make it possible for at least 75 per cent of the spectators to reach their concourse without climbing a single step. This percentage is dramatically reduced in a typical 80 000 seater capacity stadium where it is unlikely that a percentage of 40 per cent will be bettered. As a result huge stair cores, banks of lifts and in some cases escalators are required to facilitate the safe movement of people and to ensure the effective operation of the stadiums servicing strategy.

Quality

The quality and type of materials used will influence the operational costs and it will be important to plan ahead. For instance what is the proposed design life of the project? Materials should be selected with this in mind to avoid wherever possible expensive remedial or replacement works. For instance savings can be made on the initial cost of the protective treatment applied to roof steels, however the cost of reapplying in 10 to 15 years time will be very high due to the amount of temporary work associated with the re-application process. Carrying out life cycle costing exercises is important to determine the most appropriate materials to use and ultimately the most economic whole life cost solution.

To put this into perspective, occupancy costs for a building can be as much as ten times the capital cost over a 25-year lifespan, and therefore significant whole life cost savings can be made through selective initial investment.

Quality will also influence the demand for the product, and this needs to be reviewed during the briefing process. What market are you trying to sell to? The hospitality facilities may well be adequate to generate revenue on a matchday, however to generate income during the non-event day may be harder if the facilities do not compare favourably with neighbouring competition.

Every stadium is unique

The key to the success of any project is to maximise the potential of the property asset. Focusing purely on revenue generation is not the answer and a project must find the right balance between capital expenditure, revenue generation and operational costs which will generate the greatest profit and represent a true optimum solution.

23.2.3 Checklist of significant design factors

The following checklist identifies those design factors which have a significant impact on stadium costs, and must be discussed fully with cost consultants at an early design stage:

1. Type of structure.
2. Number of seats and tiers in development.
3. Phasing of construction programme.
4. Quality of finish externally and internally.
5. Extent of roof coverage.
6. Quality and extent of car parking.
7. Quality and extent of external works.
8. Method of construction to be used.

23.2.4 Stadium conversion costs

Although not often a consideration in the USA, the conversion of standing terraces to seating is a major factor in the UK and to a lesser extent in the rest of Europe. The interest in this change from standing to seating is due not only to a sudden desire to provide comfortable viewing but a result of the Taylor Report into the Sheffield Hillsborough disaster in the UK, published in 1990, which recommended that within a set period of time most football grounds should become all-seated (see *Hillsborough stadium disaster* in the Bibliography). This policy is consistent with FIFA recommendations, but the move to all-seater stadia through all the divisions of the football league has since been modified.

A major problem in estimating the cost of this type of conversion is the extent of construction required to provide a base for the seat. At one extreme, if an existing standing terrace is sound and profiled to the correct angle to provide a good standard of view, the conversion can be as simple as fixing the new seats directly on to the existing risers or treads. The other extreme can be when the existing concrete steppings are so poor that they have to be removed, or when ground conditions are poor and have to be reinforced and a new roof must be constructed to protect the installed seats from the elements. It is therefore impossible to give a reliable range of costs for this type of refurbishment.

In new stadia it is possible to design risers and treads in a way that allows for subsequent adaptation to either standing or seating.

23.3 Operating costs

23.3.1 Running costs versus first costs

In the enthusiasm of building a new stadium the capital costs of the project are usually investigated and planned in great detail while the running costs get much less attention. This is probably because the latter are less easy to quantify at the planning stage than capital costs, and also because running costs are felt to be a problem for tomorrow rather than today.

This is a counter-productive approach because the running costs over the lifetime of any building usually far exceed first construction cost – a trend that is likely to intensify as the costs of energy and labour continue to rise in most countries. The aim should be a stadium proposal that gives value for money not only in terms of first costs, but also in terms of:

- Maintaining the playing surface and the fabric of the stadium in a safe and functionally satisfactory condition year after year.
- Keeping the stadium, playing field and grounds clean.
- The actual operation of the stadium (staffing, lighting and heating, security, etc.) – the building should be designed in a way that will encourage efficiency in these matters.

In all these cases 'value for money' does not simply mean the least cost, but the least cost to maintain a pleasing, efficient and attractive stadium – because it is only by attracting paying customers that the owners can get a return on their investment.

Maintenance and cleaning have been covered in Chapter 22 and lighting, security and other services in Chapter 21. Some notes on staffing follow below. Of necessity these can only be very general: each case must be analysed individually.

23.3.2 Staffing costs

Staffing is a significant factor in the operating policy and will consist of a number of different categories of staff from well-trained specialists to general untrained operatives. A typical list of staff categories would include:

- Administration.
- Stadium maintenance and groundsmen.
- Tradesmen including electricians, carpenters, gardeners, cleaners and general workmen.
- Auxiliary unqualified workers.
- Additional staff for event days.
- Catering staff.
- Stewards.
- Security personnel.

Adequate accommodation must be provided for all these people and the equipment they will need (see Chapter 19).

23.4 Income generation

23.4.1 Sources of funds

The stadium which is fully funded by the community is probably the most common around the world, but the significance of private finance is growing, with more and more money being generated by the top sports clubs and individuals. In the USA private financing has usually been limited to the smaller indoor venues, accommodating up to 200 events a year, to ensure their viability. Large stadia can generally attract only around 20 to perhaps 75 event days a year and therefore are hard pressed to justify the significant financing necessary. This limitation on event days is largely due to the fact that most stadia have an open roof making them vulnerable to the elements and also that there are a limited number of events which can attract an audience of 50 000 to 100 000 spectators. Pop groups these days prefer to book a venue for three nights at an arena of 20 000 than one night of 60 000 because if all three nights are not sold out they can always cancel the last night rather than go on stage to a half full stadium lacking atmosphere. Completely covered or domed stadia are able to achieve in the order of 200 event days a year and there have been studies done which show that up to 250 or even 300 is possible with the increased multi-purpose use the enclosure provides.

Stadium funding nowadays is usually a combination of both private and public money using a number of different methods balance their finances. We set out below several of these methods and explain the usual form they take, though in practice many variations will be encountered.

Sponsorship

Private companies justify the injection of capital into a stadium development for a whole range of reasons from loving the sport with no need for a return on the money invested, to a planned commercial investment in return for some form of franchise. A major drinks company may inject millions in return for their drink being sold exclusively in the stadium. This can also be true for other fast-food products.

Advertising

The greater the number of event days a year at the venue the more spectators will attend and the greater the value of the advertising rights. If the events are televised this will also significantly increase the revenue generated. A combination of advertising positions is available around any stadium from fixed display boards on the perimeter of the ground to fixed or movable strip boards around the outside of the pitch. Front edges of roofs and upper balconies can also be utilized but the aesthetic balance of the stadium can be ruined if this is not carefully judged. Video display boards and colour matrix score boards can also be used to show advertising before and after play.

Seating

The most obvious area of revenue generation is selling the seats themselves and a range of standards and positions is important to maximize the return. Private hospitality areas and club enclosures are all part of providing this range of seats to everyone wanting to attend the event and have the advantage of usually being paid for in advance. These more private facilities can be a deciding factor in the viability of a new development. In Europe seat sales tend to account for the major proportion of stadia income but in the USA income from seating ranks lower than income from concessions.

An increasingly popular form of financing is the pre-sale of seats, particularly in the more expensive seats of the stadium, for 3, 5, 10, or 20 years. With guaranteed income for a fixed period the stadium owner can borrow money for reconstruction from banks against pre-sold seats. This long-term season ticket or licence can be mixed with equity in the stadium company to make it more saleable in some circumstances.

Named stadia

There have been a significant number of stadia around the world which have been largely funded by a company in return for naming the stadium after that company. This can be another form of advertising but not necessarily. The Carrier Corporation in the USA contributed several million dollars to the construction of the domed stadium at Syracuse University now known as the Carrier Dome.

Concessions

Selling concessions in a stadium is effectively letting space to the food and beverage industry to sell their goods and merchandise at the grounds. It can be the source of significant revenue but the concession areas must be well planned at an early stage to ensure they are attractive to the prospective competing concession holders. A percentage of the sales made is often part of the deal but this will vary with the venue.

Parking

Car, bus and bike parking is often limited at a stadium and therefore the demand can be exploited by charging for this facility. Depending on the number of vehicles accommodated the revenue generated can be substantial as parking charges are often a quarter to a half of the actual ticket price for the event.

Club funding

If a stadium is not actually owned by a club but by an independent organization then the club which uses the facilities can support the venue by injecting initial capital. In return the club will usually expect some part of the equity of the grounds or a return of the income generated.

Land deals

An increasing number of football clubs in the UK are finding this method to be suitable to their situation where they lack the funding to improve their grounds but own the land on which it sits. Provided their land is of sufficient value they can often pay for a new facility on less valuable land by the sale of their existing site. Land swap can also include the local authority where an area of land surplus to the local authority's requirements can be sold to the club so that they move from their original location.

Syndication

This is simply where a group of companies or individuals come together to fund the development. Their motives can vary and are not important provided certain similarities exist in their expectations of the new facility.

Land donation

A public authority may feel that there is sufficient benefit to the community in retaining a facility in its area to justify providing land for its use. Often this method of donation is done because it is the only asset the city owns and the least difficult to administer.

Tax reductions

In countries where the control of local taxes is within the jurisdiction of the authority it can reduce these taxes to benefit certain developments. This method is not possible in the UK but in the USA a city authority which would like to assist in the development of a stadium can reduce or defer its local taxes on the development.

Tax increase

The converse of the above approach and one which can also only operate under similar conditions is where a city uses revenue from a tax or introduces a new tax in order to pay for a stadium development. A popular method in the USA is the tourist tax where a percentage is added to hotel and motel bills so that people coming into the city help pay for the facility.

Government bonds
A range of different types of bonds are used in countries where local authorities, as well as central government, are allowed to raise them. These bonds can vary from General Obligation Bonds where the city sells bonds to finance the construction of a facility and these are paid back from the general city revenue funds, to the Revenue Bond which is sold and then paid back from the revenue generated at the facility when it is operational.

Television
It is most common for the television rights to an event to rest with the event organizer, not the stadium; but in some instances the stadium can also be paid to allow certain televising rights in the venue.

Club debentures and bonds
A quite different type of bond is often used in the UK to fund new development and that is where members of the public are offered the right to buy a seat for a fixed period of time. The period can be from a few years to 125 years which is a period used recently by a number of football clubs. This method of funding allows the club to finance new development and still maintain their future income from seat sales.

Grants
By far the most attractive method of funding as far as the developer is concerned is the direct grant from a city or local authority. A grant may be offered for a number of reasons and can be very substantial. Florida in the USA for example is reported to be offering $30 million for a professional team to move into the state. Grants can also take the form of specific financial assistance with such things as road systems, drainage and general infrastructure which can be significant at the early stages of development.

Betting revenue
Sometimes this is a politically sensitive subject, but the betting revenue which accrues from sport is enormous. Although largely generated from horse racing, all sports promote some degree of betting. In countries where it is possible to reinvest a proportion of the profits the sports facilities will benefit. In the USA betting on American football and baseball is illegal but it is not in the UK and a number of other countries, and it is not uncommon to find betting outlets at soccer stadia.

Outside income
Income can be generated to help finance a project from outside the main operating area of the development. This usually involves the joint development of the stadium with other, perhaps more financially viable activities. Other developments can range from those directly related such as sports and health clubs to completely unrelated activities such as offices and workshops.

Non-event day activities
Although they are unlikely to be a major contributor to overall financing, the letting of the stadium's club areas, restaurants, boxes and the like for conferences, weddings, parties, or whatever else they are suitable for, can assist the whole financial picture.

23.5 Controlling costs and revenues

23.5.1 Typical headings
If the feasibility study indicates that all the above factors can be balanced to give a viable project, the next step is to ensure effective financial control in all parts of the facility. This includes the careful recording and checking of all transactions for both income and expenditure. It is important that the individual sources of income and expenditure are identified to allow their assessment at a later date.

We list below typical headings for these individual categories. They should be read subject to the proviso that some carry very much more weight than others. The outgoing cost of financing the capital can account for as much as 70 per cent of the total.

Income
1 Spectator attendance.
2 Visitors to the ground on non-match days.
3 Club income from membership.
4 Advertising revenue.
5 Television revenue.
6 Ground rental for events.

Expenditure

1 Staff costs.
2 Administration costs.
3 Maintenance expenses.
4 Public relations.
5 Operation costs.
6 Fuel and energy.
7 Machinery and repairs.
8 Events costs.
9 Taxation (if applicable).
10 Financing and depreciation.

23.5.2 Club participation policy

An important aspect of operational policy relates to the players who use a stadium owned and run by a club. The skill of the players, managers and trainers largely dictates the success of the team, and the success of the team in turn determines the financial strength of the club. A significant factor in this equation is the cost of 'buying' players in professional sport and the cost of training them. The league system is ideal for training as it gives all clubs a chance to find new and promising players who they can train to their financial benefit, but the North American college system is probably even better as it effectively pushes the cost of training on to the educational system. The cost of training players in American football and baseball is therefore relatively low.

It also benefits the financial stability of a sport to limit the number of teams who can take part, although this is against the principles of most amateur sports since they believe in as wide an involvement as possible. Rugby Union in the UK for example has something in the order of 2000 registered clubs whilst at the same time the Football League in the UK is having a hard time preventing their league reducing from approximately 60 clubs. The theory is that if the number of top clubs is reduced and the number of spectators at least stays the same there will be more spectators at the clubs who do survive. Eliminate your competitors and so increase your market share, obviously it is inevitable that sport becomes a market place when the financial risks and profits are so high.

One of the reasons for the perceived success of American sport is because the governing bodies of American football and baseball limit the number of clubs they allow to play in their competition by not granting playing franchises to new clubs. This has increased demand for the clubs who do have a playing franchise among the cities of the USA since they value the recognition and financial advantages a major league club brings to their community. The asset they believe they acquire from a team being based in their city can vary from the extra cultural perspective to the community to the secondary spending from out of town fans on restaurants and hotels in the city. This situation puts the sports club in a very strong position to negotiate the terms of their moving to a city or their continued presence in a city. It is not uncommon for a club to have a new stadium built for it by the city authorities and even a cash payment for the move.

23.6 Conclusion

Stadia must be designed to an exacting set of financial controls in terms of both their initial capital cost and their ongoing operating costs by building into the design the maximum potential for generating revenue. This is the beginning and the end of all developments but for stadia the sums are often more difficult to 'make work' than other forms of development and therefore there is less room to make mistakes in their financial planning as many organizations have found to their cost in the past. Modern, safe, efficient and beautiful new stadia are possible, but if they are to survive anywhere near as long as those our ancestors have handed down to us they must also prove themselves on the balance sheet.

24. Sustainable design

24.1 What is sustainable design?
24.2 Environmental considerations
24.3 The Olympic Movement and the environment
24.4 Energy use
24.5 Lighting
24.6 Water heating
24.7 Space heating
24.8 Ventilation and cooling
24.9 Life cycle cost analysis
24.10 The environment friendly stadium

24.1 What is sustainable design?

Sustainable design, also referred to as environmentally sustainable development (ESD for short), has become an increasingly important consideration for buildings of the future. It is one of the dominant issues of our time.

The most widely quoted definition of sustainable development is from the Brundtland Commission of 1987: 'development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs'. Sustainable design recognizes the interdependence of the built and natural environments; seeks to harness natural energy from biological processes and eliminate reliance on fossil fuels and toxic materials; and seeks to improve resource efficiency.

It is the responsibility of designers to create buildings which protect and potentially enhance the environment both physically and in other ways. The following are some of the key considerations.

24.2 Environmental considerations

24.2.1 Electricity generation

Traditionally electricity is generated in huge centralized power stations and then fed into the national grid for distribution, but this is in many ways an inefficient and environmentally harmful system.

New thinking indicates that generating electricity close to where it is needed (for instance, a large sports complex could generate its own electricity on site) is the way of the future. Decentralized Energy (DE) is claimed to be cleaner; to have lower carbon dioxide emissions; to be cheaper in both the costs of construction and costs to the consumer; and to be more secure than centrally generated energy. According to Greenpeace it is already mainstream in countries like Denmark, Sweden, and the Netherlands.

Combined Heat and Power (CHP) is a system in which the waste heat from the electricity generation process is used for space heating, instead of being discharged into the atmosphere as waste (which is largely what happens under the present centralized generating system). This process too can be decentralized to local areas or even to an individual stadium complex. The total efficiency of CHP systems could be in the region of 85 per cent, compared with less than 50 per cent for conventional centralized power generation.

In all cases energy from renewable sources – wind, waves, and boreholes, etc. – should be used where possible, whether generated on site or taken from the grid.

24.2 2 Energy efficiency

Approximately half of the annual carbon dioxide emission of most industrialized nations, including the UK, is generated from buildings. More energy-efficient buildings could substantially reduce this harmful effect.

Building designers should deal with the matter in two parts – the amount of energy used in the construction of the building; and the amount of energy that is required for its use. Both should of course be minimized, and in view of the scope and complexity of the subject it is dealt with separately in Section 24.4.

24.2.3 Use of materials

The selection and assessment of the source of materials used in the construction of buildings should be carried out on the basis of life cycle cost analysis (see Section 24.9) and likely environmental impact. Practically this may suggest where possible the use of natural materials, e.g. wood from renewable sources instead of steel and concrete, and/or recycled materials. In addition, consideration should be given to factors such as energy used and pollution generated during extraction, processing, manufacture, transport, treatment and disposal of these materials. It is a good idea to consider the life of the materials to be used in construction in order to extend the period before replacement is needed.

Materials which are produced using toxic substances should be avoided, whilst those performing a similar function should be selected on the basis of least toxicity, e.g. water-based rather than solvent-based paints. Components containing CFCs and HCFCs such as extruded polystyrene, should be avoided along with materials that emit volatile organic substances such as formaldehyde, toluene etc. Even the use of PVCs is under re-examination and future research may help to give further guidance on this.

24.2.4 Water conservation

Water is a valued resource and methods for conservation should play an integral part in service design. Consideration should be given to water saving initiatives such as collecting and storing rainwater, and then using it for purposes such as cleaning and toilet flushing. More importantly, it can be used for watering the grass pitch, as at the Manchester United Ground. Grey water recycling is another method of conserving water, whilst economies can also be made by using water restrictors, cistern control, vacuum toilets and leak detectors. Figure 24.1 shows in schematic form the rainwater reclamation systems of the Sydney 2000 Olympic Stadium. Another example of a stadium in which similar principles have been applied is the City of Manchester Stadium (see the Case studies at the end of this book).

24.2.5 Waste reduction

Strategic waste management is the key to reducing costs, not only in the use of materials but in their disposal and the related environmental impact. Waste should be evaluated from the raw material source rather than just the demolition process, and

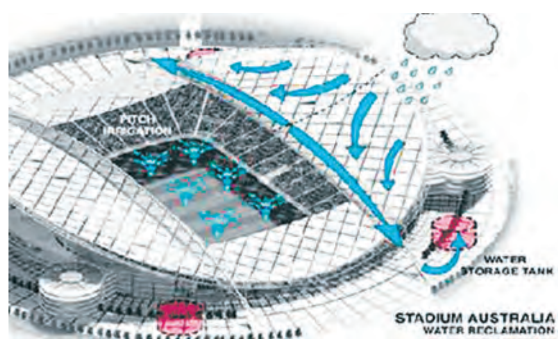


Figure 24.1 Rainwater collection in the Sydney 2000 Olympic Stadium (now called the Telstra Stadium Sydney) – See also Appendix 3. *Architects: Hok Sport Architecture.*

purchasing and recycling strategies are therefore important components to incorporate into waste management.

Because of the function of stadia, designers also need to take into account problems such as the packaging and type of consumer goods which are likely to be brought into the building, bearing in mind whether they are produced from recycled materials and designed to be recycled. The quantity of waste produced by spectators is enormous and although this is largely a management problem, it is not without its implications at the design stage. Athletes and spectators should be provided with food and drink, but in a way which minimizes the effect on the environment.

24.3 The Olympic Movement and the environment

24.3.1 Introduction

All the above matters are engaging the attention of the International Olympic Committee (IOC), which has added care for the environment to its objectives of Sport and Culture. The following notes, taken from the *IAKS Journal S & B,* April 1995, explain the IOC position and objectives, following the first World Conference on Sport and the Environment.

> *The idea that 'future generations should not inherit an environmental capital inferior to that bequeathed to the present generation' has progressively been accepted as an element of sustainable development.*

The Olympic Movement

As an integral part of society, the Olympic Movement is also concerned with the environment. The history of sports practice amply shows how it has developed, become more sophisticated, and modernized over time. Large stadiums with a communications network and extensive car parks are now necessary. Every large-scale sports event implies the gathering of a crowd of spectators who must be welcomed, seated, fed, entertained, informed and looked after. The result is often an impact on the environment that should not be ignored.

Sport and the environment are factors in the well-being of humanity, and both are linked in the sense that one influences the other and vice-versa. The Olympic Movement is a universal one, almost all of whose members are young athletes and voluntary officials. As an integral part of society, they aspire to live in peace in a non-polluted world where the fauna and forests, rivers and lakes, plants and animals are protected for the well-being of mankind.

The International Olympic Committee (IOC), through its Sport and Environment Commission, has therefore published the Olympic Movement's 'Agenda 21: Sport for Sustainable Development'. This is a theoretical and practical guide for members of the Olympic Movement, and for sportsmen and women in general, and promotes the playing of an active part in the sustainable development of our planet.

The Olympic Games

The IOC wants the Games to be an exemplary event in this respect. One of the first initiatives has been to include in the list of specifications of the cities bidding a file relating to new requirements in terms of the environment. These requirements are as follows:

- Supply an official guarantee from the competent authorities stating that all the work necessary for the organization of the Games will comply with local, regional and national legislation and regulations regarding town and country planning and the protection of the environment.
- Indicate whether impact studies have been carried out with a view to the harmonious and natural integration of the Olympic Games into the environment and whether they have been established by official bodies or bodies recognized as authoritative and scientifically competent.
- State whether the ecological organizations in the city, region or country have been informed or consulted. If this is the case, state their opinions and attitudes regarding the candidature. Indicate the size of these organizations and their representivity.
- Describe the plans for waste treatment and energy management, particularly for the Olympic Village, competition venues and media sites.
- Indicate whether the staging of the Games will give rise to advanced technology being developed in the area of environmental protection and if so, describe this.

- Indicate the efforts to be undertaken regarding transport, particularly with a view to minimizing atmospheric pollution.

It is vital that all studies relating to infrastructure take environmental parameters into account from the outset, and be geared towards avoiding, or at least minimizing, any damage to the environment. These criteria are merely minimum standards which the cities are called upon to develop and expand. The current trend is actually in this direction, as environmental measures are occupying an increasingly large place in the candidature file and are of particular importance in the choice of the host city. The IOC commission responsible for evaluating the candidatures now includes an environmental expert.

24.3.2 Olympic facilities

The facilities for the Winter Olympics in Lillehammer were the first live demonstration in built form, of energy and environmentally conscious buildings. The successful Sydney bid for the Olympics in the year 2000 featured a major case for environmental issues and this was one of the main reasons for the success of their bid. (See Fig. 24.1 and Appendix 3, page 291)

24.4 Energy use

Having briefly surveyed the main environmental considerations in sustainable building design, we return in greater detail to the most important of these – the sensible use of energy.

24.4.1 Design aims

There are three main aims for the use of energy in stadia: firstly to minimize the demand for energy; secondly to supply as much of the reduced demand for energy as possible from energy resources which are renewable; and thirdly to meet the remaining energy demand with efficient use of the cleanest possible non-renewable fuel.

In order to achieve the aim of minimizing the amount of energy used, energy efficient appliances are needed in the stadium, including good control and information systems as well as educational policies to help raise user awareness.

The second issue of using renewable energy sources has become a stated aim of the International Olympic Committee and is applicable for all Olympic stadia (see Section 24.3). The IOC uses the phrase 'widest possible use of renewable sources of energy' in its documentation to bidding cities for the Olympic Games. Energy usage should be based on a detailed 'load profile of the venue' to match its needs with available renewable resources of the area. The designer needs to develop a clear understanding between the relationship of base energy loads and peak energy loads, particularly where the value is to be multipurpose. There will also be considerable differences in energy usage between event days and non-event days when only the ancillary facilities will be in use with relatively low energy demands.

The third aim recognizes that different fuels have different levels of environmental impacts. Cost cannot be the only factor that influences a decision when choosing an energy source for a stadium because the market does not currently reflect the true environmental impact of conventional energy sources. One criterion must be to reduce CO_2 emissions which will call for new standards of energy production. This has already taken place in some parts of the world where all new developments, including stadia, require the use of improved energy sources such as solar water heating.

Energy standards must therefore respond to the needs of the whole community for improving performance and cannot be judged on cost alone, in the same way that fire safety issues would not be assessed solely on capital cost criteria. The single greatest impact of energy use in the latter part of the twentieth century is the greenhouse effect, which is largely the result of the growth in CO_2 emissions since the Industrial Revolution. A number of countries around the world are committed to a programme of reducing CO_2 emissions and this should, therefore, be a clear aim in stadia design. It is imperative to aim to minimize the CO_2 emissions throughout the complete life cycle of the building, from construction through use and eventually to its demolition. A large part of this third objective is to attempt to reduce the dependence on mains electricity supplied from the national grid.

24.4.2 Saving energy

To many people electricity appears to be a 'clean' fuel in use but it has a significant environmental impact at its point of production. It is interesting to note that electricity generated in coal-fired power stations, which emit high levels of CO_2, allows only 35 per cent of the energy generated in many cases to be distributed to the actual socket as usable power. The remaining 65 per cent of energy is lost through the heat from the cooling towers or through the transmission in the grid. Heating water by gas can produce around 70 per cent less CO_2 emissions than by electricity, and solar water heating, supplemented by a gas back-up, can achieve a 90 per cent reduction or more in certain parts of the world. Certainly self-generation of energy in stadia using photo-voltaic cells, which is the conversion of sunlight into electricity, is becoming more viable. Cladding panels are now being manufactured with built-in photo cells which not only clad the building but also generate its electricity. As a guide, a photo-voltaic array in a stadium of around 2500 square metres could produce up to 40 per cent of the venue's energy requirements. The roof of a stadium is a very large area which can be used for such a purpose.

Energy can also be recovered from waste water by heat exchange, with the possibility that where there is a suitable nearby river or water area, heat can be recovered. Wind fans are another possibility which could be considered, along with recycling waste energy from plant systems and the use of CHP, which should be examined.

24.4.3 Energy load profile

In order to develop a true load profile for a stadium it is necessary to look at each of the energy consuming components of the venue.

Figure 24.2 shows a typical load profile for a stadium which represents a starting point against which future stadia projects may be compared. The exact values of each of the energy components will vary between venues but by starting to set down this type of data we can build up a stock of knowledge on the subject for future comparison and analysis.

24.5 Lighting

24.5.1 Use of daylight

An overriding aspect of stadia design should be to allow as much daylight as possible into the building, thus avoiding the use of artificial lighting as much as possible. Translucent roofs can provide daylight to the spectator areas and this is not only beneficial from an energy point of view but is also preferred by spectators, providing a more pleasant outdoor 'ambience' for the user. The stadium is, after all, a building which has its origins in outdoor sports.

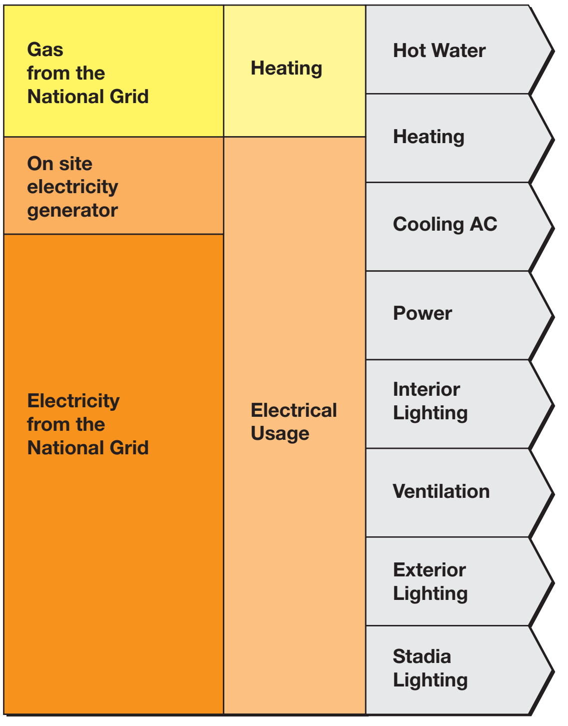


Figure 24.2 A typical energy load profile.

24.5.2 Artificial lighting

Floodlighting

The first and perhaps the most obvious energy using component is the floodlighting for the event area. The lighting of this space requires a huge amount of energy, perhaps to the order of 100 to 150 Mwh/y, which means that there are considerable savings to be made in this area through more efficient light fittings, rationalized lighting levels, improved distribution, maintenance and control systems. Light fittings for pitch lighting are gradually improving in their efficiency but really major leaps forward in technology could be just around the corner. Microwave sulphur lamps which produce light by the microwaving of argon and sulphur gases achieve a greatly extended life. Microwaves convert the gas into a plasma which produces a pure white light with a continuous spectrum very similar to natural daylight, which is ideal for arena lighting. There are a number of current prototypes which indicate that they will be 10 per cent more efficient than metal halide lamps. This technology is developing and improving rapidly. See in this context also Chapter 21.

Indoor lighting

In addition to the lighting of the actual event area, indoor lighting is also a significant factor in stadia design because of the large public areas involved. There are, of course, minimum lighting levels, laid down by local authorities, required for all buildings, but a stadium which is designed to achieve ESD should take into account a number of factors which can minimize the amount of artificial indoor lighting necessary. Natural daylight should be used as much as possible and taken into account when designing the building structure. This can be achieved either by using light 'shelves' at the perimeter of the building to reflect natural light into internal spaces, or perhaps through the use of light wells to bring daylight into the building.

The support areas of accommodation in a stadium are often buried deep under the spectator areas and those who work in and operate the building will benefit from more naturally lit spaces. Similarly, restaurants and social spaces will also benefit. Light wells and atria are two devices for achieving this.

Light control

Artificial light fittings should be low-energy fittings with an efficient control method, perhaps using photocells to control when lights need to be used and movement sensors to switch lights on and off in infrequently used spaces.

The illumination of external spaces is another major user of energy and is required for both security and public safety. Significant improvements are also evolving in this area in lamp and control technology and when combined with careful distribution of fittings around the exterior of the stadium can minimize the amount of energy required in this zone of the complex.

24.6 Water heating

In order to minimize the energy demands for water heating, the distribution of hot water through a stadium should be carefully considered at the design stage, particularly where hot water is required to all public toilet outlets. Experience shows that hot water taps in public toilets in stadia are rarely used and their installation can be minimized where possible. The energy and water efficient design of appliances should also be considered, using mixer spray taps and water efficient shower heads in the players' changing areas. Solar energy can be a significant contributor to water heating in some parts of the world. However, a major problem in stadia is the intermittent use of hot water and the consequential inefficiency due to its loss in storage. An instantaneous gas water heating system could provide overall efficiencies and may be considered for peak loads.

24.7 Space heating

In temperate climates some form of heating will be required in many of the ancillary areas of a stadium, but in calculating the heating needed with an aim to reducing the energy necessary to achieve those heat levels, the thermal mass of the structure itself must be taken into account. This thermal mass, together with the secondary heat gain from spectators and the appliances in the venue, must be calculated as these will have quite an effect on the extent of energy consuming heating required in the stadium. In the same way as the extent of external fenestration and its orientation is a major factor in cooling, so it is with heating. Heat radiation build-up from the sun's energy can be a significant contributor to reducing the extent of artificial energy required to achieve comfortable temperatures. Carefully positioned insulation to avoid cold bridges in the external fabric of the structure can improve the perceived comfort levels within the space.

From studies we have conducted on recently designed stadia, it is interesting to note that although the large spectator events create considerable peaks in the overall base load of energy consumption, the energy demand from general administration and operational functions, together with that required for security lighting through the year may have a total energy demand of half of the stadium's total annual energy use. A total annual energy usage for a major multi-purpose stadium could be in the order of 4000 to 4250 Mwh/y (megawatt hours per year). The total energy usage for the Melbourne Cricket Ground in Australia, for example, was 4200 Mwh/y and it had an annual attendance of around 2.93 million spectators. Some interesting comparisons can be derived from this type of information as regards the energy usage per spectator.

24.8 Ventilation and cooling

24.8.1 Natural ventilation

Although the primary focus of any stadium is the event area, the off-field activities also play a significant role on both event days and non-event days. If a stadium is to be used for a range of functions it must be commercially successful and therefore these spaces must provide an acceptable level of comfort in terms of temperature, air quality and humidity. The energy used in cooling and air-conditioning can be significant and, therefore, areas that require this type of environmental control must be carefully considered. Comfortable conditions can be achieved in many parts of the stadium, including public concourses, through the use of natural ventilation using 'stack' effect ventilators and venturi effect extract supplemented by extract fans without resorting to artificial cooling (Figure 24.3).

This type of approach must be considered at a very early design stage as its use will fundamentally influence the stadium's planning and sectional layout. This is the case even in the more tropical areas of the world where good air movement and the removal of hot air can be facilitated by the use of thermal chimneys throughout the structure. A good example of this approach is the Royal Selangor Turf Club grandstand in Kuala Lumpur, Malaysia, where the central atrium acted as a large 'chimney' to the warmed air and induced a through ventilation in the spaces leading off this central core (see Figure 24.4).

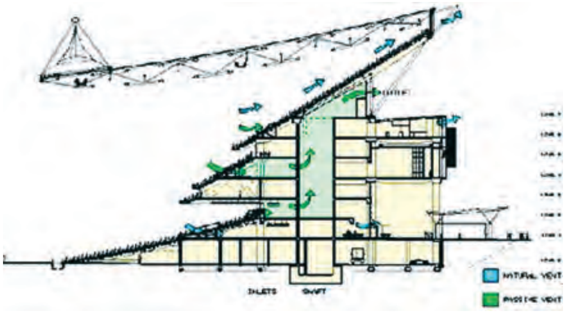


Figure 24.3 The use of natural ventilation in the Sydney 2000 Olympic Stadium to give a comfortable microclimate and save energy.

24.8.2 Temperature

The position of glazing on a stadium should also be controlled to ensure minimum solar radiation build-up within internal spaces and perhaps protected at certain times of the day using sun awnings. Insulation from both heat and cold is also an important element in ensuring the minimum possible energy usage, although it must be borne in mind that conditions for watching sport and many other events don't need to be the same as for sitting quietly in an office or at home. Because of this a more flexible approach to the environment parameters to which stadia are being designed must also be taken into account. A typical temperature range for an office building may be from 20 to 22 degrees, whereas an acceptable temperature range for sitting in a stadium to watch an event may be between 18 and 26 degrees. This decision on its own may significantly reduce the energy demands on a venue. It is also important to remember that air movement itself can reduce perceived temperature to quite a large degree. For instance, it can be shown that ventilation rates of around five air changes per hour, with a typical speed of say 0.23 metres per second, can in fact reduce the temperature by around 1 to 1.5°C.

24.9 Life cycle cost analysis

24.9.1 Long-term costs

Some technologies will not only reduce running costs but are likely to reduce capital costs as well. Others may be initially more expensive in terms of capital cost but because they reduce the running costs of a stadium, they will prove to be cheaper in the long term. Natural ventilation and daylighting options may well lead to cheaper stadia than conventional equivalents so it is important to analyse the energy usage of any stadium, not just in terms of its initial capital cost but also its long-term life cycle costing. This life cycle cost analysis (LCCA) takes into account not only capital cost but also running, maintenance, and replacement costs over the stadium's life cycle. It is a design tool to ensure best value, typically including capital or investment cost (first cost); utility costs (energy); water use; waste

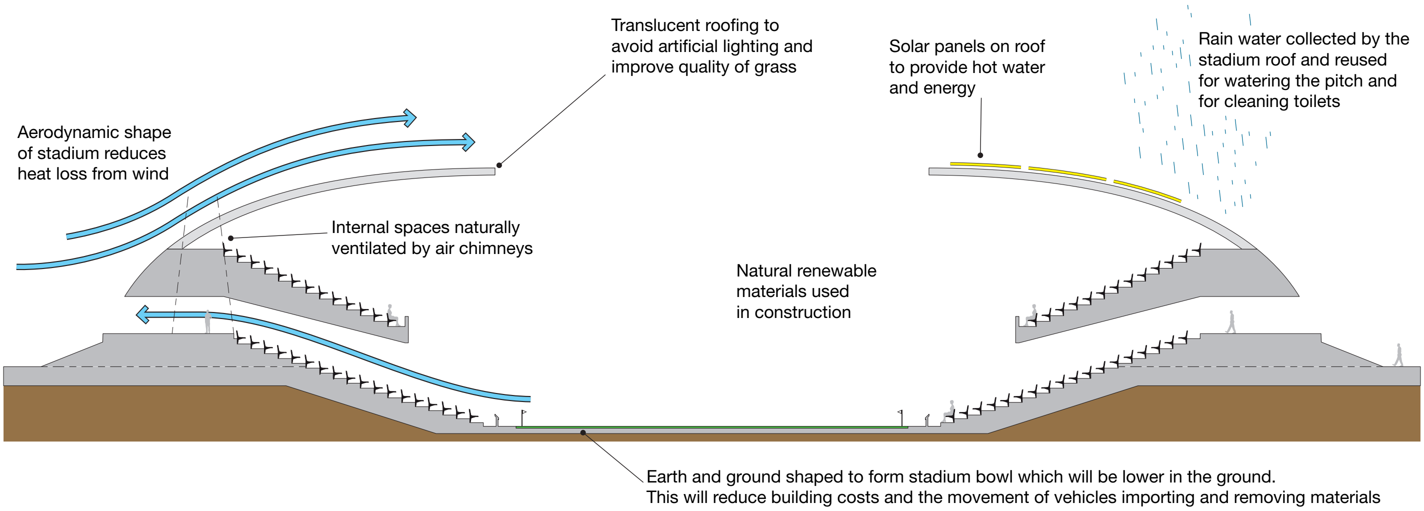


Figure 24.4 Environment-friendly design incorporates all the factors noted in this chapter.

water disposal; operation and maintenance costs; and periodic replacement costs. Life cycle assessment has been described in the past as 'from cradle to the grave' accounting of the inputs and outputs of the energy usage of a building.

24.9.2 Aspects to consider

LCCA examines all the energy and raw materials used, as well as the emissions to air, water and solid waste over the entire life cycle of a product or material. This takes into account the extraction of the raw material through its production, distribution, use and disposal. We suggest that the full life cycle assessment of a stadium should be taken into account at an initial design stage. Unfortunately there is very little historical information available to be able to establish rules of thumb or good practice, or even best practice examples. It is only by applying our minds to new developments, quantifying these factors and publishing the results, that we will start to achieve truly environmentally sustainable stadia.

24.10 The environment friendly stadium

So far, examples of environmentally responsible stadia, in which all the factors discussed in this chapter have been fully taken into account (Figure 24.4), are few and far between. This short selection may help to heighten awareness of what can be done.

Arsenal: the new Emirates stadium, London

Rubbish is to be separated for recycling. Timber from renewable sources will be used. Harmful PVC products will be avoided. Rainwater will be stored and reused. Access for spectators will be by public transport.

The new Wembley stadium, London

The building was designed so that the 'cut' and 'fill' of the stadium's foundations were balanced thus avoiding vast quantities of earth being moved by road. Refuse will be separated for recycling. All electricity will be generated from green power resources. Daylight conditions in the stadium bowl will be excellent. Access for spectators will be by public transport.

Sydney Telstra stadium

Materials were carefully selected to avoid those that generated pollution in their manufacture or installation; rainwater was stored and used for the flushing of toilets; and some areas had cooling systems using natural draughts. A life cycle energy use analysis was carried out to inform the selection of building materials.

25. Stadia and tourism

25.1 Introduction
25.2 Stadia and tourism
25.3 The stadium as an attraction
25.4 The wider potential

25.1 Introduction

Stadia have a role in helping to create a vibrant image for a town or city, and at their best can be used as part of the tourism infrastructure and appeal of a city. The actual events in the stadium attract tourists but also these landmark buildings themselves can act as magnets and draw visitors to them. In addition the emergence of the sports visitor attractions, museums and halls of fame in the stadium are increasing its market appeal. A good example is Barcelona's Noucamp Stadium which attracts a huge number of visitors each year. The success of the Galpharm Stadium in Huddersfield, with its blue roof and exciting shapes, had a major impact on the city itself. Similarly the Toronto Skydome has clearly become part of the image of that city. Images of these venues appear in tourist brochures as an attraction of the city or town. Television coverage of major events such as the World Cup in football or rugby and the Olympic Games have brought images of dramatic and often aesthetically memorable stadia into the living rooms of millions of people. The tourism impact of such coverage for a city is immense.

A considerable amount of research has been carried out on these stadia tourism concepts, with some of this work in North America reviewing the interdependency between the stadia and city redevelopment. The impact of the Olympic Games and the legacy of the facility provision and the implications for urban areas is a favourite subject for discussion. It has been suggested that many cities are 'clamouring' for new stadia and arenas because of their potential as 'flagships' in urban regeneration and in the development of entertainment districts. It has been asserted that the mass popularity of sports and the close relationship between civic identity and local teams makes the construction of sports facilities an important tool for promoting public and private spending aimed at solving the problems of civic development.

25.2 Stadia and tourism

The concept of multi-purpose utilization can help to stimulate wide economic regional regeneration as has been the case in the USA, and proposals for many new stadia are particularly notable as regenerative projects, in which there is an important potential for tourism. Sports stadia are becoming more readily integrated and accepted as a fundamental component of the leisure industry in general. As well as the benefits that accrue to the owners from successful operations, local authorities, regional and

Figure 25.1 Oriole Park at Camden Yards, Baltimore, USA, is an example of successful down-town regeneration, encouraging visits, shopping and tourism (see also Figure 5.16). *Architects: HOK Sport.*

national governments are increasingly realizing that stadia and arenas can play a vital role in creating a vibrant image and contributing to the economic and social wealth of the community in which they are located.

An essential feature of a city's ability to host a major league sports team, or indeed a primary sporting event or festival, is the provision of modern, high capacity stadia and arenas. The economic rewards inherent in major sporting activities have stimulated considerable development in facilities, particularly throughout the USA. The public sector has recognized the added value of investment in stadia and accepts that they can rarely be expected to make a profit and that the political risk involved is outweighed by wider economic gains for their community.

A good example of a new stadium being integrated into the wider urban planning of a city is in Baltimore, USA, where Oriole Park (Figure 25.1), designed by HOK Sport, was sited to anchor the south side of the city's waterfront regeneration scheme. This effectively turned the derelict Camden Yards docklands into an extension of a thriving entertainment and tourist centre, creating a landmark in destination marketing. The high-rise buildings of downtown Baltimore can be seen towering over the stadium creating a view for its 46000 visitors of the city's commercial and economic centre. The economic impact of this development clearly shows the potential of stadia to generate tourist visits with 1.6 million fans (that is 46 per cent of all fans) coming from out of town, with 24 per cent of those coming from outside of the Washington DC area, with many staying overnight in the Baltimore area.

Venue	Percentage increase
Sheraton Inner Hotel	21
Tremont Plaza Hotel	20
National Aquarium	8
Maryland Science Centre	3.2
Baja Beach Club	15
Babe Ruth Museum	110
Ball Sports Bar	50 (on game days)

Table 25.1 Increase in trade resulting from Oriole Park at Camden Yards, Baltimore

This ability to generate secondary spend in and around the stadium is a critical factor. Spending on merchandise inside the facility, together with spending on hotels, restaurants, petrol stations and in the local shops outside the facility will not only have a marked effect on operating profits, but will reverberate around the local economy with a multiplier effect typically five or six times the original level of spend (Table 25.1). The potential to generate additional spending outside the stadium largely depends on being able to develop synergy between the stadium or arena and the central business district, or commercial centre. In the case of Baltimore, for example, more than 40 per cent of all fans going to the ballgame combine their trip with other downtown activities such as 'pleasure travel', 'work downtown', a 'business trip' or 'attending a convention'. Consequently, spending exceeded expectations by as much as 300 per cent with increases in hotel, restaurant and other trade. Moreover, when compared with the previous Memorial Stadium, 80 per cent of fans indicated that they were more likely to spend time in the stadium area before and after games. As the Baltimore example suggests, stadia are also potent landscape features contributing to positive destination imagery, considered so essential in tourism destination marketing.

25.3 The stadium as an attraction

The commercial and cultural potential of a successful stadium has been likened to a sleeping giant, capable of making a powerful contribution to its neighbourhood, city or region through development as an all-year-round visitor attraction.

As an example, Cardiff's 72 000 capacity Millennium Stadium (Figure 25.2 and Case study 10) has, since its opening in 1999 to host the Rugby World Cup, become a recognized driver of tourism to the capital of Wales. The stadium hosts international team sports, world championship speedway, rock concerts, and was the venue for a Super Special Stage of the Wales Rally of Great Britain in 2005. In addition, following the closure of Wembley Stadium for its rebuild, Cardiff's Millennium Stadium has hosted FA Cup Finals, as well as the league play-offs. These matches have yielded in excess of £25 million to the city's economy and attracted over half a million visitors a year to Cardiff.

More narrowly, stadia attract large numbers of people to the regular sporting events that they are host to. Even when allowance is made for visitors that come from local areas, it is likely that the number of day visitors and those from further afield could exceed the most popular of other forms of visitor attraction.

The potential for sports stadia to be developed as all-year-round visitor attractions is closely linked to the growth in the day visitor market and in special interest tourism, as well as urban tourism marketing, which includes travelling to watch sport. In the UK, recent strategic documents from the English Tourist Board, the West Country Tourist Board of England, and the Wales Tourist Board establish the policy link between tourism and sport. In the US, the remarkable transformation achieved by the Indiana Sports Movement translating 'Indiana-no-place' to 'the star of the snowbelt' is testimony to an integrated tourism and leisure strategy featuring world-class sports facilities.

The emergence of successful tourism programmes centred upon stadia and arena developments can be seen in St Louis and Chicago in the USA, Calgary in Canada, and Melbourne in Australia. Cities such as Sheffield (World Student Games), Barcelona (Olympic Games) and Vancouver (Commonwealth Games) have also restructured their tourism product based upon their stadia infrastructure. New dome facilities for example in Atlanta (Georgia Dome), in Toronto (Skydome) and in Japan (Fukuoka Dome) extend this concept by providing real multiple-use options, especially for convention and conference markets. Consequently, there should be a much closer relationship between sport, the stadium and tourism.

Photograph: Patrick Bingham Hall

Figure 25.2 Cardiff's Millennium Stadium has, since its opening in 1999 to host the Rugby World Cup, become a recognized driver of tourism to the capital of Wales.

The potential of stadium location has been exploited particularly well in the case of FC Barcelona (Spain), where the museum attracts 500 000 visitors each year, mostly on day trips from the resorts on the Costa Brava.

The introduction of commercial activities is now essential as stadium owners search for innovative ways to secure new sources of revenue. Perhaps the most significant potential exists in the development of stadia as sports-based visitor attractions, especially since the attractions industry is dynamic and anxious to find new applications and settings in which to create exciting visitor experiences. The inherent appeal of stadia as special places where heroes played and legends are made, captured so vividly in Alden Robinson's 1989 film *A Field of Dreams,* gives them the type of attributes upon which more recognized visitor attractions are based; atmosphere, sense of occasion, evocation and emotion. It is therefore surprising that, since sport makes a significant contribution to cultural identity and heritage, there are very few sports-based visitor attractions outside the US. In the UK, for example, these are limited to museums at Manchester United, Liverpool, Aston Villa, and Arsenal football clubs: the Wimbledon Tennis Museum, the Newmarket Horse Racing Museum and the British Golf Museum that opened at St Andrews in 1990. Elsewhere, many stadia now operate 'guided tours' but few have the same level of sophistication expected from other forms of visitor attraction.

Examples from North America illustrate the most advanced application of the visitor attraction concept i.e. 'the sports hall of fame', which uses sport as the dominant theme. Even here the attractions are often very staid, with traditional museum style presentations. There is considerable scope to develop and apply techniques, designs and technologies from the wider leisure industry (especially theme parks) to create a new generation of sports attractions offering exciting visitor experiences. Few sports 'Halls of Fame' have been located to optimize market potential and generating significant and commercially viable levels of attendance. This does not appear to have been an important consideration; the genesis for their location tend to be non-market related criteria, such as location of administrative offices or the owners desire to convert a lobby into a public display. Most are located outside the main metropolitan areas, and when compared to the geography of major league franchises, and hence major stadium developments, it is apparent that the opportunity to physically link sports stadia with sports visitor attractions has largely been missed. Consequently, only a handful of the sports halls of fame have visitor attendance figures in excess of 150 000 per annum.

A new generation of sporting visitor attractions are now emerging. For example, at Turner Field (Atlanta) the 'Home of the Braves', which is an interactive plaza, entertains fans before games and at other times. A similar concept has been deployed to a lesser extent in the designs for Chelsea Village at Chelsea, London and in the master plan concepts for a number of other stadia.

In fact, interactive visitor attractions and associated stadium tours are now becoming commonplace. These facilities generate visitors who will readily pay an admission charge and use retail outlets and cafés in the stadium. Examples of this type of year-round tourist facility include club museums such as the one in Arsenal's new Emirates Stadium; the 'World of Rugby' at Cardiff Millennium Stadium; Newcastle's Helix Centre; the Dallas Cowboys' Experience; and the Olympic Spirit in Munich.

Particular sports attractions include the Speedway Museum at Daytona, and various sports Halls of Fame, such as Eden Park in Auckland.

At the MCG (Melbourne Cricket Ground) a new single, large museum and entertainment complex is being created to replace five separate displays – the Australian Cricket Hall of Fame; an Extreme Sports Exhibition and Australian Rules Football Exhibition; the Australian Gallery of Sport; the Olympic Museum; and the MCG Museum. The new museum will be located below one of the main entries and take up an area of 5000 m^2.

Elsewhere a number of clubs are exploiting the potential of their fan base by creating visitor events built around the stadium. Benfica, for example, hosts an annual fiesta attracting 30 000 visitors drawn from the Portuguese diaspora, whilst at Croke Park in Dublin the Gaelic Athletic's 80 000 capacity Stadium and Museum has become a cornerstone for many tourist visits to Ireland's capital city.

These examples are forerunners of a new and exciting trend in the role of sports stadia in city development.

The stadium as a potential host venue is a logical proposition to meet the criteria for a new sports visitor attraction and should be reviewed positively as a potential venue for development. The infrastructure is generally in place; space, facilities and services are available, the site is an appropriate setting, often steeped in history, given the desire amongst owners to achieve optimum use, the current momentum to build and rejuvenate stadia could embrace the potential to include wider, year-round visitor attractions. It does not automatically follow however, that the location is capable of optimizing visitor markets and the emphasis must be on identifying locations likely to achieve high levels of attendance (150 000 per annum) and where the public's awareness of the attraction is underpinned by exposure to large numbers. At the same time, schemes must build upon the physical and psychological sense of place essential to creating the right environment to enhance the visitor experience.

The 'real' potential of a stadium or arena depends much more on the inter-relationship between other factors such as: location; catchment; the nature, structure and organization of the sports that are played in them; the characteristics and demands of spectator and market trends, and the stage of stadium development. For stadia owners in this position the basic objectives will be to secure good core attendance at regular sporting fixtures, efficient operational and commercial management in relation to the facility's primary use, and maximizing secondary spend and alternative revenue streams by involving the local community and businesses in activities such as corporate entertaining, product launches, and meetings and conference business.

25.4 The wider potential

The potential of a facility is generally determined by the interaction of market and socio-economic variables. In the USA the 'real' potential is usually great. Assisted by the fact that the USA population has a narrower range of sporting interest than the UK and Europe and with a wide cross-section following and participating in fewer sports, the economic rewards inherent in major sporting activities have stimulated considerable development of new facilities over the past 20 years. The public sector has recognized the added value of investment in stadia and accept that they can rarely be expected to make a profit. Moreover, there is increasingly recognition amongst municipal and state governments that new facility development, or refurbishment to upgrade an existing facility, is essential in attracting and retaining major league sport and that the political risk involved in not investing in facilities is outweighed by wide economic gains to the community.

As markets mature, new technology being developed for the leisure industry in general, and for theme parks in particular, is likely to provide the main vehicle that will allow stadia to be fully exploited as venues for a wide range of leisure activities and as significant entertainment venues. In the USA the phenomenon of pre-match entertainment and the associated 'Fan-Fests' have been a prominent feature of pro-football and major-league baseball games. Pre-match and half-time shows at major football events have given this concept a new dimension. Inventive multimedia shows combine the best of theme park technology with live entertainment, pyrotechnics, and lasers, turning the stadium into theatre, stage and film set at the same time.

Of particular relevance to the realization of this potential are associated technologies: simulators, photography, interactive exhibits, participation equipment, laser and pyrotechnics, sound systems, video and information panels. If contemporary and new stadia are to realize their potential, management becomes as critical as the original design. The economic survival imperative requires stadia designers and operators to understand user demands, and to optimize and create revenue opportunities. This is reflected in a shift towards the privatization of the management of facilities. Management interests are now involved in the conceptual and design process. This is an essential prerequisite if the enormous capital and real estate asset of the facility is to be realized. Stadia and arenas must be regarded as a microcosm of the hospitality industry, reflecting trends in the socio-cultural leisure environment and rapidly becoming multi-faceted complexes hosting a diversity of events that involve a wide range of hospitality services and management skills.

Stadia, whether locations for great sporting events, host venues for visitor attractions, or 'cathedrals' with inherent architectural appeal, are a fundamental part of a destination's tourism infrastructure. Just as great heritage properties have become icons of place promotion, so stadia will join them. These are the 'sleeping giants' of tourism.

Appendix 1

Stadia briefing guide

General design information		
Status of commission	Feasibility study Outline design Full design Working drawings Supervision	Previous studies Board requirements Local authority needs
Finances	Financial constraints Maximum costs Revenue potential	Present income Projected income
Programme	Planning timetable Building start date Target completion date Close season consideration	Determine phasing Determine financing
Project objectives		
Compactness	Provide good visibility Minimum viewing distances	Running track included Additional sports
Catering	Participants Spectators Family provision Private boxes Hospitality suites Club facilities Administrators	
Convenience	Accessible to transport Location in city	
Comfort	Inviting environment Easily understood Clear signposting	
Flexibility	Arrangement of spaces Juxtaposition of spaces Relationship of spaces	
Economics	Initial capital expenditure Annual maintenance costs	

(*Continued*)

Project parameters		
Client's requirements	Accommodation schedule	Participants Spectators Administrators
Traffic movement	Car, bus, pedestrian, rail	Public and private vehicles Inside and outside stadia
Ground capacity	Seated and standing	Consider trends Design to be convertible
Site services	Present and future	Service phasing
Phased development	Options with flexibility	Pattern of use Phased financing
Safety and control	Police and stewarding	
Site considerations		
Investigation and survey	Old or new stadium site	Previous land use Mining survey Land contamination
Accessibility	Access and egress Crowd safety	Convenience Safe segregation zones
Constraints	Boundaries Buildings Roads and rights of way	Property deeds Planning restrictions
Orientation	Sun aspect Prevailing winds Micro climate consideration	Pitch maintenance Player comfort Spectator preference Solar panels Wind fans
Unusual difficulties	Identify special problems	Sub-soil stability Water table
Unusual advantages	Shared use of site Unique location	Sports and leisure Commercial considerations Hotel consideration
Vehicle parking	On the site Near the site Remote from the site Parking for spectators Parking for VIPs & players Coaches for visiting spectators & teams	Planning requirements
Fire brigade	Access for vehicles	
Neighbours	Visual implications Construction implications	Consult local authority Local services
Spectators		
Capacity of ground	Proportion of spectator types Number of standing	Flexible arrangement Range of quality
Entry and exit of stadia	Fill time for events Timed exit analysis	Legislative requirements Follow good practice
Seating areas	Gangway location and size Radial or longitudinal Vomitory arrangement	Legislative requirements Minimum travel distance Sized for convenience
Toilet facilities	Proximity to spectators Near catering outlets	Male female ratios Toilets for disabled people Numbers required

(*Continued*)

Catering outlets	Good range of quality & types	Food distribution policy Alcohol/no alcohol
First-aid centre	Central or dispersed Operation methods	Ambulance park nearby
Concourses	Adequate width Access to toilets Access to catering	Unrestricted to full length Adequate signposting Act as reservoir space
Provision for disabled people	Wheelchair access Ramps, lifts or escalators; not stairs	Legislative requirements Numbers to be accommodated Dispersed location to be considered
Participants		
What events envisaged	Football Rugby American football Australian football Events for disabled people Concerts Multi-purpose use	
Size and type of play area Protective measures Practice area, equipment	Warm up facilities Club requirements Weather protection	
Trainers and reserves	Seats at edge or in dugout Not restricting view	Protection from spectators Access to team rooms
Team rooms	Changing and washrooms Treatment areas Kit storage and lounges	Manager requirements Trainer requirements Comfortable temperature
Access to field	Tunnel access Protected route to field	Separate routes for teams Join before exit to field
Referee, umpires, linesmen	Changing and wash rooms Lounge area and store	Adjacent to team rooms Access to management
Media		
Press	Location and number Seats for reporters Positions for photographers	Local requirements National requirements International requirements
Radio	Location and number Cabin for announcers Cable servicing	Local requirements National requirements International requirements
Television	Location and number Cabin for announcers Interview studios	Local requirements National requirements International requirements
Media support facilities	Catering and rest areas Interview and briefing room Media vehicles Television van parking	Servicing requirements Access from administration Exterior location & connections
Management		
Administration	Scale and location	Stadium management Team managers Accounts section Secretarial facilities
Directors	Lounge and entertainment Box for viewing	Board and guest rooms Access to viewing/directors' seating

(*Continued*)

Sponsors and club area	Lounge area Box for viewing	Access to directors' area Good quality areas
Ground staff	Changing and toilets Equipment stores	Vehicle access for loading Safe storage of chemicals Access to pitch
Private viewing areas	Number, location and type Range of quality	Well catered and serviced Well located in tier
Restaurants	Size to suit regular usage Close to main kitchen Banqueting/dining to be generally used outside event days	Catering strategy Vehicle access for loading
Private vehicle parking	Television van parking Directors, VIPs & team park	Size dependent on stadium Close to management areas
Control rooms	Stadium management Police control	
General services		
Type of system	Central or local units Emergency back-up plant	Short distribution runs Plant near load centres
Plant location	Basement, ground or roof Individual plant areas	Access for venting Duct access
Fuel type	Gas, oil, coal, electricity Alternative solar use	More than one system Running costs
Space requirements	Fuel storage and equipment Workshop areas	Vehicle access
Thermal considerations	Building insulation Zoning energy control	Zone control for efficiency Non-event day control
Security requirements	Consult police & other authorities	
Fire requirements	Sprinklers, alarms, hoses Emergency lighting	Stand-by generator Start-up time
Cleaning	Water and power supply Materials storage	Cleaning policy Man power requirements
General installation	Power and lighting Telephones and facsimiles Public address and CCTV	Location and servicing Visible video board
Ancillary areas		
General	Any special areas Time and duration of use	
Floodlighting	Standards for play Standards for viewing Television standards	Colour television demands Discuss with TV company
Video or indicator board	Viewing location Adequate sizing	One end or both ends
Pitch heating	Electric cabling Hot water or hot air	Alternative economics
Stand heating	Under seat radiation Slab warming	Seat price economics
Concourses	Lighting and ventilation Environmental control	Often unheated or cooled
Telephones	Management requirements Media requirements	Depends on standards
Communications	Crowd control by police Management and police	Discuss with police

Appendix 2

Video screens and electronic scoreboards

Since publication of the first edition of this book there have been huge developments in giant screens and electronic scoreboards. Indeed, they have become a necessary feature in modern stadia and technology in this area is rapidly developing. They are also discussed in the Chapter on Services, Section 21.2.2.

Larger stadia will often use the Large Screen Colour Video Display (LSVD) but there are options for stadia with more modest budgets to use limited video capability, providing text information and high-quality graphics. For those stadia considering investing in this type of technology, early dialogue with manufacturers and suppliers is advisable. The following notes offer brief guidance:

The Large Screen Colour Video Display (LSVD) can represent a major capital outlay and should be carefully selected to suit the needs and light conditions of the stadium as well as the budget the client has available for such a purchase. Considerations also need to be given to the integration of the scoreboards, the video production room and the LSVD, as the specification and performance of one of these elements can have an effect on the others.

Certain systems are sold with some accompanying video editing software, but in other cases an editing suite may be required to provide the content shown on the screen.

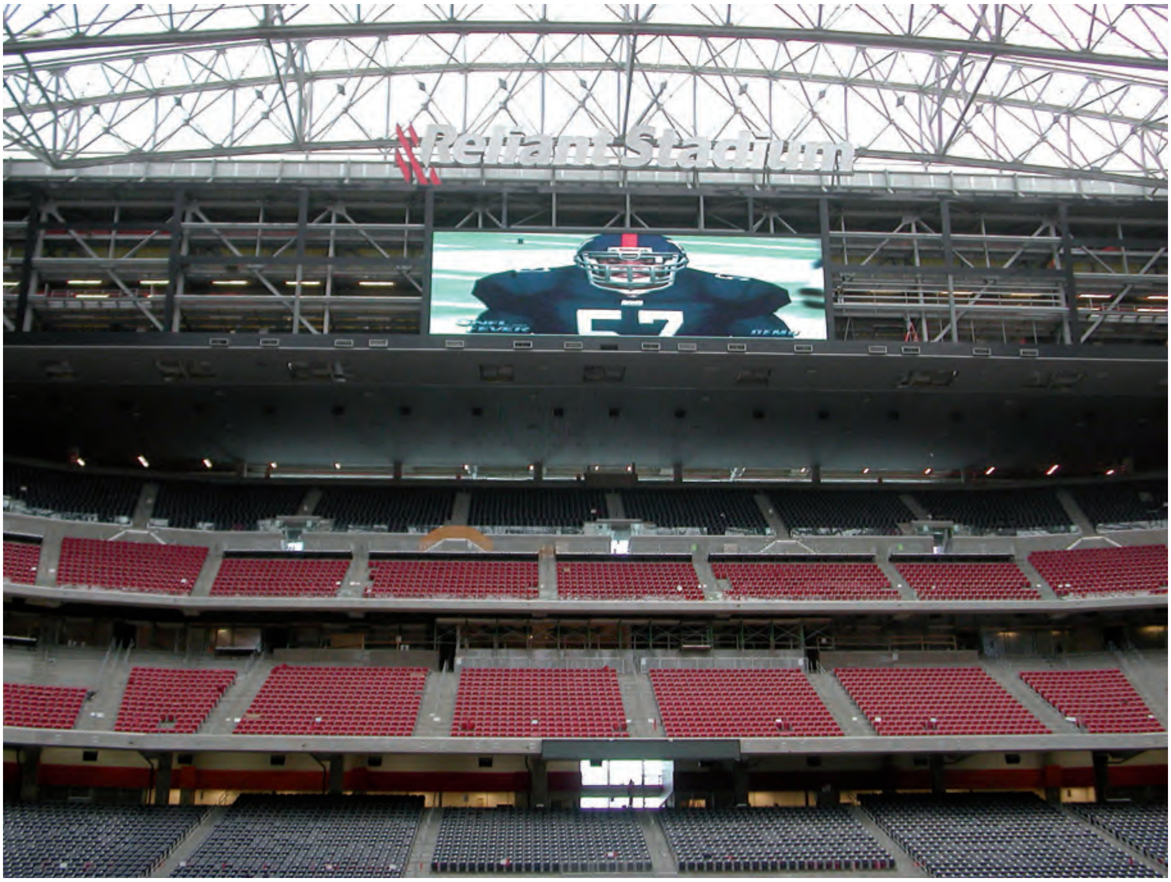
The expertise of the simple scoreboard companies is usually not applicable to the LSVD companies and vice versa. In order to secure the best value for each particular stadium, consideration will need to be given to whether or not high definition (or even very high definition) is required. For example, scoreboards need relatively low-tech lightbulb solutions whereas to use the same technology to replay action from a cricket match would be inappropriate.

Technology

Four main types of technology are presently used in screens. They are as follows:

Cathode ray tube (CRT)

This technology has been the market leader for some years, but it is being overtaken by LED systems not only in terms of image quality, but also because LED screens take up less space and use less power.



Photograph: HOK Sport Architecture

Figure A.2.1 Video screen at Reliant Stadium, Houston, Texas. *Architects: HOK Sport Architecture.*

Fluorescent discharge tube

This produces a similar quality to the CRT technology, and the comments in the previous paragraph also apply here.

Base matrix

This is the simplest of the technologies in current use. It is also probably the cheapest in capital cost and is widely used.

Light emitting diode (LED)

This technology has advanced greatly in recent years. Screens are now being produced that offer high resolution, fast refresh rate, and sufficient strength for viewing in sunlight.

All of the above technologies achieve the images required of them by the use of the three base colours, red, blue and green. These three colours when combined in various ways can produce the theoretical 16.7 million colours possible.

Life cycle

While the life cycle costing of screens is important, their longevity is less important in a stadium situation. Most stadia will only use their screen for around 250 hours per year and since most LED screens will have a lifespan of approximately 50 000 hours this is not a major consideration. The cost of maintenance, refurbishment and operation is, however, a key component in the life cycle analysis; a decision has also to be made about how long the screen will remain at the ‘cutting edge’ and how long it will be before it needs renewal, not because it is worn out but because it is out of date.

Quality

The quality of the screen image is mainly determined by the brightness of the pixels and the pixel pitch of the screen. Generally the smaller the pitch (i.e. the closer together the pixels are to each other) the better will be the image. A typical matrix screen may have a pitch of around 50 mm, or in some cases more. But the Sony JumboTron Screen JTS35 has a pitch of 35 mm while the JTS17 has a pitch of 17 mm, and Barco now offer LED screens with pitches of 14 mm and 10 mm.

Screen size and position
The size of a screen for any given location is determined in the ideal circumstances by its height, which should be 3 per cent to 5 per cent of the maximum viewing distance from the screen. The screen itself should have a proportion of four wide by three high or preferably sixteen wide by nine high. Therefore in a stadium where the maximum viewing distance is 200 metres, the screen should be 6 metres high and 8 or 10 metres wide. This would produce a screen of 48 square metres or 60 square metres, which would weigh around 5.0 tonnes for a CRT screen or 3.5 tonnes for a LED screen. It should be noted that screens also have minimum viewing distances, with a viewing distance of around 8 metres being a good minimum. It is obviously necessary for the screen(s) to be visible to all spectators.

Other ways of showing moving images are becoming available with the production of LED in strips or curved screens, and the development of more powerful projectors.

Cost
After all considerations have been taken into account it is the available budget that will be the main determinant in the selection of a screen. Manufacturers should be contacted about prices, but it is important to note that comparative costs should include the supporting structure, electricity supply, and control software. Some manufacturers have, in some circumstances, offered deals for the supply of large screens together with other electrical equipment, or set against advertising revenue.

Screen companies
It seems that there are over 4000 screen companies currently in existence but probably only twenty to thirty who could be considered to be major players.

Programme
The procurement strategy may consider a hire arrangement which can be very attractive if the utilization is low, perhaps as a single package or split into two or three packages. Lead times are of the order of one month for the development of an invitation to tender, a month for tenderers to respond, with a further four to five months for manufacturing and a final month for installation.

Appendix 3

Case studies

Allianz Arena
Amsterdam ArenA
Arizona Cardinals Stadium
Ascot Racecourse
AT&T Park
Auf Schalke Arena
Aveiro Municipal Stadium
Braga Municipal Stadium
BritOval
City of Manchester Stadium
Emirates Stadium
Estadio da Luz
Heinz Field
Melbourne Cricket Ground
Melbourne Telstra Dome
Millennium Stadium
Nanjing Sports Park
Oita Stadium
PETCO Park
Reliant Stadium
RheinEnergie Football Stadium
Salzburg Stadium
Soldier Field
Stade de France
Statteg Sports and Leisure Facility
Telstra Stadium
Wembley Stadium
Westpac Stadium
Wimbledon AELTC: Centre Court

The following case studies are examples of stadia design from all over the world. They are listed in an alphabetical sequence. The examples have been chosen to illustrate different responses to the design challenges, which reflect location, climate and circumstance. They also reflect different uses: some are multi-purpose, some are sport specific. Many incorporate technical innovation, and some have opening and closing roofs. Most of the examples are large in scale: it is felt that these produce the real design challenges for the designers. Some respond to their site situation, but all have something interesting to say about stadium design.

Allianz Arena

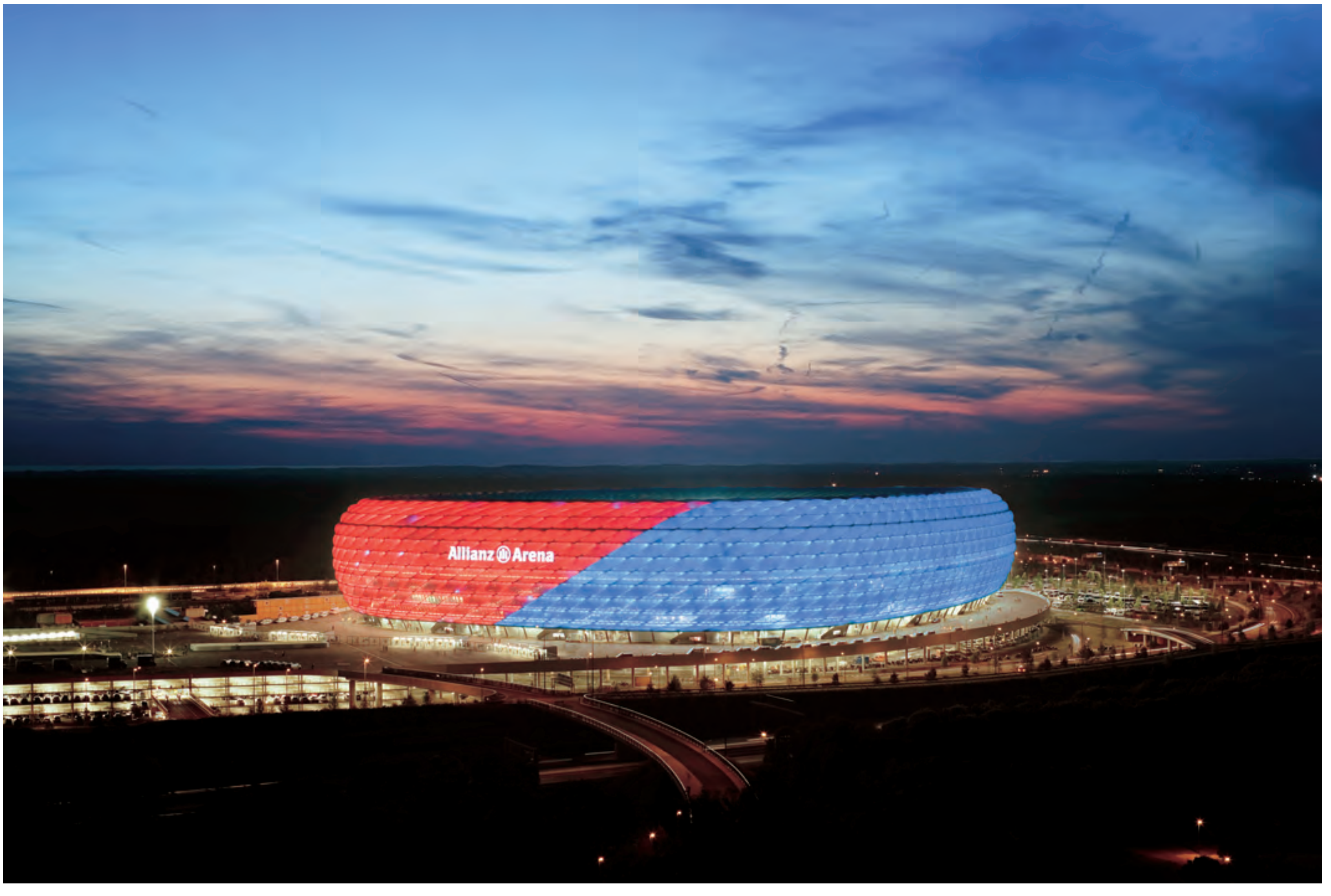
The Allianz Arena, in Munich, Germany, completed in 2005, was designed by Herzog & De Meuron to host the Opening Game of the FIFA World Cup 2006. It is home to two local football clubs, FC Bayern and TSV 1860. The architecture of the 60 000-seat stadium is distinguished, above all, by its unique skin. This is a translucent luminous body consisting of large shimmering white, diamond-shaped ETFE cushions, each of which can be illuminated separately in white, red or light blue, the colours of the two clubs. The colours of the cushions can be controlled digitally so that the home team playing in the stadium can be identified from the outside. The outer enclosures of the stadium are multilayer, pneumatic structures. At every corner a pumping station maintains the internal air pressure within the pneumatic elements. The changing appearance of the stadium enhances its attraction as an urban monument even for people who are not interested in football.

The design concept is based upon three principles; firstly, the presence of the stadium as an illuminated body that can change its appearance; secondly the development of a procession-like arrival of fans, in a landscaped area; and thirdly, to develop a crater-like interior of the stadium itself.

Both the shell and the structural skeleton of the stadium are designed throughout to implement these three key concepts. Hence, the main stairs along the outside of the shell follow the line of greatest slope underscoring the procession-like approach of visitors to the stadium. As a huge luminous body, the stadium marks a new location in the open landscape to the north between the airport and downtown Munich.

The car parks are laid out between the underground station and the stadium so as to create an artificial landscape for the arrival and departure of the fans. Since only football will be played at the stadium, the seating is directly adjacent to the pitch and each of the three tiers is as close as possible to the action.

Architects: Herzog & De Meuron



Photograph: Duccio Melagambo-fotografia de arquitectura S.L

Amsterdam ArenA

Amsterdam ArenA, completed in 1996, was the first European stadium to be built with a retractable roof. It opens and closes within 25 minutes. The state-of-the-art 52 000-seat stadium, which can be increased to 68000 seats for concerts, is the home of the Ajax Football Club, as well as host to a range of very successful entertainment events. The stadium hosts more than seventy major events each year, and more than half are concerts, dance parties, religious meetings, product presentations and other sporting events such as international games of the Dutch national team, and American football. The Amsterdam Arena has a wide range of corporate facilities including a Royal Suite, VIP lounges and suites and 16 hospitality rooms, which can seat 2500 as well as 2000 business seats.

The stadium is located in the east of Amsterdam and is accessed by several metro and railway stations.

There is also a large car park for 2000 cars under the stadium, and 12 000 car parking spaces within walking distance of the arena. The arena is continuously upgrading its facilities including an updated sound system and the introduction of more escalators and elevators as the ascent from the underground parking

to the second tier is the equivalent of an 11-storey climb. The roof is based on two large arches to which two longitudinal beams are fixed which correspond to the playing field's rectangle. Semi-transparent panels are connected to the arch and it is these panels which open and close to provide the retractable roof.

The arena has two large video screens and an internal pay system with smart cards acting as an electronic purse. Supporting facilities include a museum and fan shop.

Architects: Robert Schuurman & Sjoerd Soeters

The state-of-the-art 52 000 seat stadium, which can be increased to 68 000 seats for concerts, is the home of the Ajax Football Club, as well as host to a range of very successful entertainment events

Photograph: Visions in Photography

Arizona Cardinals Stadium

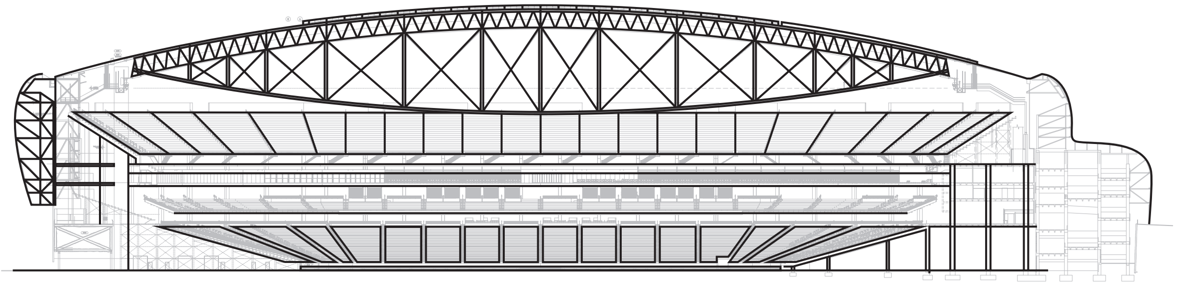
The Arizona Cardinals Stadium is a 65 000-seat stadium located in the Phoenix suburb of Glendale, Arizona.

The project sports an openable roof to shelter spectators from the desert sun. Additionally, as a first for North America, the stadium contains a moveable playing field. The field will reside outdoors most of the time, rolling into the stadium on rails for use during football games and other sporting events. This provides the grass with the sunshine it needs to grow, and also allows the building to function as a venue for tradeshows, concerts or other events on non-game days.

The basic form of the stadium is a 'nod' to its surroundings, taking the shape of a barrel cactus. The outer skin features dramatic vertical slots that alternate with large, smooth panels, creating a beacon whose colour and light reflect the brilliant colour of the Arizona desert sky. This mixture of steel decking, glass, stucco and a fabric roof create sweeping lines and a sense of texture in the design.

In addition to housing the Arizona Cardinals football team, the new stadium has already been selected to host the 2008 Super Bowl.

HOK Sport Architecture in collaboration with Eisenman Architects



Photographs on this page: Hutton-Crown

Ascot Racecourse

Top class thoroughbreds and world-class jockeys compete for some of the highest accolades in horse racing against the stunning new backdrop of this grandstand, completed in 2006. As elegant as the fashions on the field and as exciting as the action on the track, the new Ascot Racecourse embodies the essential requisites for a satisfying racegoer experience – attractive, stylish, tasteful, cleverly simple and clear.

The new 30 000-seat grandstand is perched on the brow of a hill with panoramic views of the course to the north and Windsor Great Park beyond. The 480 metre Grandstand takes the form of a shallow-arched hyperbolic paraboloid, conceptualized as 'a building between trees'. A slight curve on plan embraces the racecourse.

The new stands with their lofty, elegant and structured architecture form a backdrop to the parade ring, the outdoor public spaces and social activities. The combination of large-scale dramatic new stands and retained buildings at the site edge, with major public outdoor lawn spaces distinguished by mature deciduous tree specimens, provides the racegoer with a variety of different spatial experiences. This much-loved characteristic experience of the Ascot Racecourse has been preserved to enhance the uplifting spaces created in the new buildings.

Running the length of the building, the internal galleria both separates and connects the viewing and dining functions. The design of the southern elevation to the galleria brings natural light into the covered concourse providing even-tempered environmental shelter at the heart of the building.

The grounds of Ascot Racecourse have numerous superb trees, and the soaring steel structure of the cathedral-like galleria was inspired by the forms of these trees. The large atrium acts as an 'environmental lung' for the grandstand, which is topped by a lightweight glass and steel roof. Sailing over the whole are the dramatic form and lines of the roof's light, sweeping canopy.

Architects: HOK Sport Architecture

The 480 metre Grandstand takes the form of a shallow-arched hyperbolic paraboloid, conceptualised as 'a building between trees'.

The ballpark takes every advantage of its spectacular location

Photograph: Joel Avila

AT&T Park

The site for AT&T Park has it all: San Francisco's skyline, the hills of the East Bay and vivid ocean sunsets over the Golden Gate. The ballpark takes every advantage of its spectacular location, creating a seamless relationship with the city and turning the Bay into an inimitable design feature. The San Francisco Chronicle called it 'reassuring proof that cities can still glow.'

A transit-first ballpark, spectators commonly arrive using public transportation. The journey becomes part of the experience, from a lively streetcar ride to a scenic ferry trip, or an invigorating amble down Second Street. Upon arrival visitors are greeted with a composition of steel, concrete and brick. Heroic in scale and proportion, the ballpark's rugged face recaptures the spirit of the grand old game and the South of Market context. Flanked by clock towers, this face engages the city street network and the neighbourhood's scale.

Recalling the language of the ubiquitous waterfront pier buildings, larger than life portals allow the public to glimpse the verdant playing field without a ticket. This gesture of owner and architect collaboration is perhaps the most compelling example of the effort to make the building, the game and the city as one.

Designers: HOK Sport Architecture

Photograph: Patrick Bingham Hall

Photographs on this page: Jochen Hette

Auf Schalke Arena

The 58 000-seat Auf Schalke arena, in Gelsenkirchen, Germany, was completed in 2001, and is designed primarily for football, but its key is its multifunctionality. The arena hosts a wide variety of non-sporting events including concerts, opera, festivals, trade fairs and conferences, which can all be held irrespective of the weather. The arena is in the shape of a rectangle, with steeply banked stands that are very close to the pitch on all four sides, a sliding roof and an adjustable playing field.

One of the main reasons for the arena's versatility is the mobile pitch, which can be moved in or out in six hours and is only used when a football match is being played. During the week the pitch is stored outside the arena, enabling it to recover after the game, with proper exposure to light, air and water. It is laid on a mobile, reinforced concrete trough (118 by 79 metres) which is about one metre high and weighs 11 000 tonnes. It is filled with a layer of sand into which the under soil heating is installed. Top soil is then added for the turf, as well as pitch watering and drainage systems. The tray itself is attached to sixty-centimetre high sliding shoes. The secondary floor is 1.5 metres below pitch level and serves as a platform for all other sporting and non-sporting events.

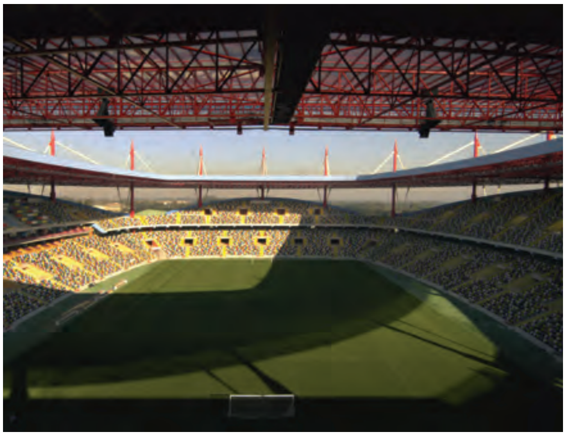
The electronically driven sliding roof, weighing 560 tonnes, can be opened or closed within 30 minutes. The stadium remains open immediately above the pitch, but spectators are under cover whatever the weather. The sliding roof is not only technically advanced but also spectacular in appearance; with translucent, Teflon-coated fibreglass fabric stretched over the steel roof structure. The stadium is also environmentally attractive, with water recycled from the roof and drained into a nearby wetland habitat, as well as natural ventilation of the arena and concourse levels.

Designers: HPP International Planungsgesellschaft mbH

The roof has a 'flat' design, supported by a line of pillars and beams.

Aveiro Municipal Stadium

The colourful and elegant Aveiro Municipal stadium is located on the outskirts of Aveiro in Portugal. It is one part of the sports park planned for the site, and other facilities include a golf course, Leisure Park and several hotels. The 31 500-seat stadium was designed, initially, for the 2004 European Football Championships, and comprises the football pitch, two tiers of spectator seating, back-up spaces underneath and one level of underground parking. All seating is covered, but the roof is open over the pitch.



The base structure of the stadium, a set of frames in concrete, is an imperfect 'circumference' because of an economy of space and to allow the border line of the stands to be sinuous, enabling better ventilation of the grass. At floor level the frames are bordered by transverse beams around the circumference, and the curved shape of these concrete panels gives the design a unique image. Access to the stands is through eight staircases peripheral to the stadium as well as elevators. The roof has a 'flat' design, supported by a line of pillars and beams.

The VIP area is separate from the rest of the building, and although it is integrated into the stadium, it only seems to be 'coupled' and is treated with different materials and forms from the rest of the stadium.

Parts of the exterior of the stadium are made of ceramic tiles, a traditional Portuguese material, which also lasts longer, is washable and more environmentally friendly than paint.

The stadium, on top of a hill, has been variously described as looking like a huge spaceship, or the segments of an orange with several colours, and already it has become an architectural landmark of the city, attracting tourists and publicity.

Tomas Taveira – Arquitectos

Photograph: Luis Ferreira Alves

Braga Municipal Stadium

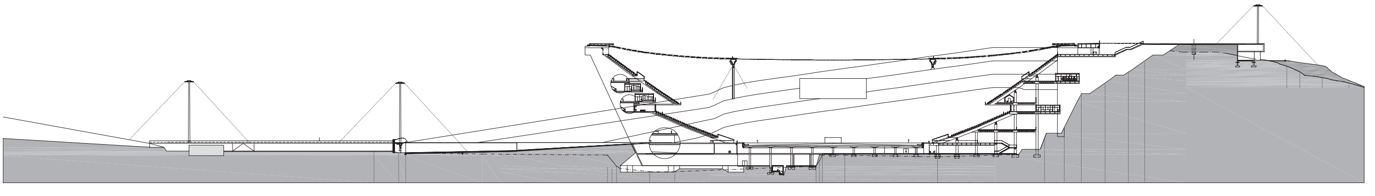
Braga Municipal Stadium is situated within the Dume Sports Park on the northern slope of Monte Castro in Portugal. The stadium, built for the European Football Championship 2004, has two unusual features. The first is that it has been integrated into its rocky surroundings and the second is that there are only two stands, located along the sides of the pitch.

The location was chosen to avoid making a dam along the water's edge in the Valley. The two stands, each accommodating 15 000 spectators, are very different. The West Stand was literally 'dug into' the rock after one million cubic metres of granite were removed from the hillside within a year. It is accessed from above at a height of 40 metres. The entrance offers expansive views across the stadium and the surrounding countryside. Inside there are spacious access and concourse areas as well as extensive VIP areas, including a two-storey underground car park beneath the pitch, a separate entrance and catering facilities.

The East Stand is a free-standing, solid reinforced concrete building and is accessed from eight ramps, which lead to an ambulatory serving the lower tier, with stairs leading to the upper tier.

Both stands are fully covered with strongly projecting roofs, connected together with ropes, and modelled on the Peruvian Inca bridges.

Souto Moura – Arquitectos



Photographs on this page: Hufton & Crow

BritOval

Surrey County Cricket Club had an ambition, in 1995, to preserve the status of the 125-year-old BritOval (formerly known as the AMP Oval) as one of the finest cricket grounds in the world. In June 2005, this ambition was realized when the BritOval opened after an eye-catching facelift to host the final Ashes Test where England was at last victorious.

The BritOval has been transformed, boasting a brand new 4-tier 23 000 capacity structure, known as the OCS Stand. Geometrically bold with futuristic curves in white steel, the stylish new stand is truly iconic, elegantly harmonizing with the imposing Victorian appearance of the Pavilion. The dramatic sweeping form of the new roof has been composed to act as a foil to the gasometers which have historically formed the backdrop at this end.

The OCS Stand has been designed to dramatically improve the match-day experience; spectators are brought closer to the action than ever before, and presented with the added luxury of more legroom. Acoustic consideration was also important and now the stand will reflect the noise back into the ground to create a more vibrant atmosphere; perfect for the sport that is fast becoming one of the most watched around the world.

A further feature of the redevelopment is the 600 ft (183 m) external ‘Living Wall’, which will support a variety of climbing plants, adding to the summer ambience of the external concourse, bringing the seasons into the urban fabric of the area. The tapering timber louver screen will also help to restrict overlooking from the adjacent residential accommodation and help to dissipate the traffic noise from the main end.

The new BritOval is a stadium fit for the twenty-first Century, providing spectator terracing, a press centre, broadcasting suite and corporate hospitality facilities. With a usage for 365 days a year, the stadium will host everything from conferences and board meetings to weddings.

HOK Sport Architecture provided the Concept Design for the BritOval. MillerSport provided Detailed Design

Photographs: © View Pictures Ltd

City of Manchester Stadium

The City of Manchester Stadium was designed to host the 2002 Commonwealth Games and became the home for Manchester City Football Club in August 2003.

Manchester City Council held three ambitions for the project. The stadium should be central to the urban regeneration of east Manchester. It was to be a high-profile venue that would reflect Manchester's aspiration to become a regional sporting centre. It also had to have a sustainable future. The first of these ambitions was embodied in the selection of a contaminated brownfield site at Eastlands.

The architectural expression and landmark identity of the design responded to the aspirations for a modern civic stadium. Within this ambition, the overriding design aim was to create the best possible environment for players, spectators and broadcasters. The masted roof structure integrates with the spiral circulation towers. These provide urban scale, orientation, and a safe, stepless access. The saddleback seating bowl geometry combines optimum sightlines with in-the-round intimacy. The bowl is dug into the ground to reduce bulk and improve spectator access.

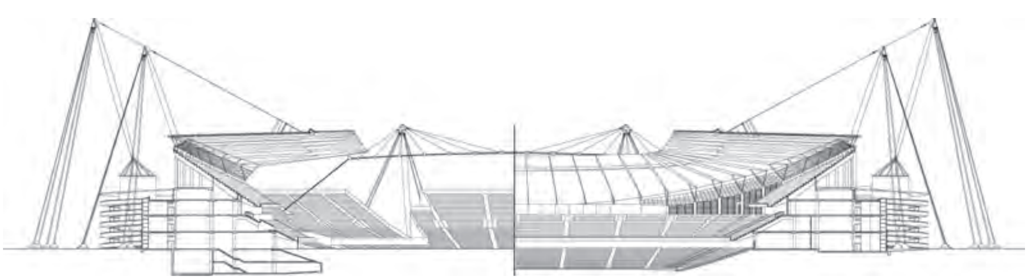
A continuous, flowing roof plane mirrors the bowl profile to provide maximum shelter whilst admitting sunlight and air to the playing surface. Variable façade ventilation controls the micro-climate within the stadium, and the translucent roof edges modulate daylight to improve broadcasting conditions.

Following the Commonwealth Games a long-term future for the stadium was secured by its conversion to a football stadium that can also host rugby matches as well as other performance and community events. This conversion was achieved by the completion of the northern segment of the bowl and by digging down to create the lower seating tier, increasing the seating capacity from 38 000 to 50 000.

The City of Manchester Stadium has won many awards including the IOC/IAKS Gold and IOC/IAKS Special Award 2005, RIBA Inclusive Design Award 2004, The Institute of Structural Engineers, Special Structural Award 2003, Structural Steel Design Award 2003 and the Building Services Awards, Major Project of the Year 2003.

Arup Associates

The architectural expression and landmark identity of the design responded to the aspirations for a modern civic stadium.



Section: Left shows the original athletics profile, right shows the altered profile for football.

Photographs on this page: Lance McNulty

Emirates Stadium

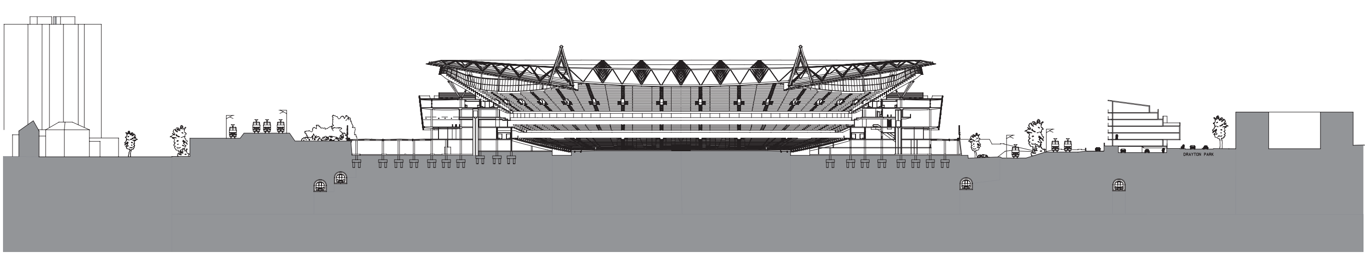
Emirates Stadium is a striking addition to Islington's civic architecture and an excellent example of a stadium acting as a tool for urban regeneration. On a former brownfield site defined by railway lines on 2 of its boundaries this 60 000 m^2, 60 000-seat state-of-the-art Stadium replaces the revered Highbury Stadium. The design reflects the demanding nature of the site and rises dramatically behind Victorian terraces, revealing itself in unusual, unexpected vistas creating a striking juxtaposition of scale, while 2 new bridges link the Stadium with the adjacent neighbourhoods.

An elliptical form with eight cores around the circumference, steel tripods support the two primary trusses resulting in a clean-edged roofline. The materials give a clear reading of the building's function, with toughened glass plank façades at podium level responding to the more robust environment of large crowds and overlapping glazed and woven steel mesh screens articulating the exposed concrete of the vertical circulation cores at higher level. A metallic under-clad roof seemingly floats above the exposed concrete seating bowl and undulating glazing sheltering the rear of the upper tier.

The Stadium provides an upper and lower tier of general admission seating, with a range of positions for disabled spectators. In between these levels are located Corporate Club and Executive Box facilities. The Club level provides a unique mix of Restaurant and Network Bar spaces, together with dedicated bowl seating, with 150 Executive Boxes and an exclusive Private Members Club above.

Emirates Stadium was the catalyst for an integrated urban planning exercise to regenerate a deprived, underutilized area stretching west from the existing stadium. One of Britain's largest regeneration projects, it will see the construction of over 2000 new homes, including key worker and social housing, and create over 1800 new jobs. By adopting a series of green measures integral to the design, for example, using passive environmental systems to heat and cool the building, the stadium also helps to redevelop the area in a forward-looking and sustainable way.

Architects: HOK Sport Architecture



Photographs on this page: Patrick Bingham Hall

The new stadium has been designed to incorporate a range of facilities that can be used both by the club and local community

Estadio da Luz

The 65 000-seat Benfica stadium, affectionately named Estadio da Luz or Stadium of Light, is the most prestigious of the ten new stadia developments built in Portugal for the Euro 2004 Championships. This centrepiece for the UEFA competition was built on a site adjoining the old stadium, and since its completion in 2003, has led the way in the regeneration of the Luz district. The new home for the multifarious sporting institution that is not only the Lisbon and Benfica Sporting Club but also the default International social club for the Portuguese Diaspora, blends harmoniously into a romantic landscape, surrounded by a site which holds an extraordinary place in the public imagination.

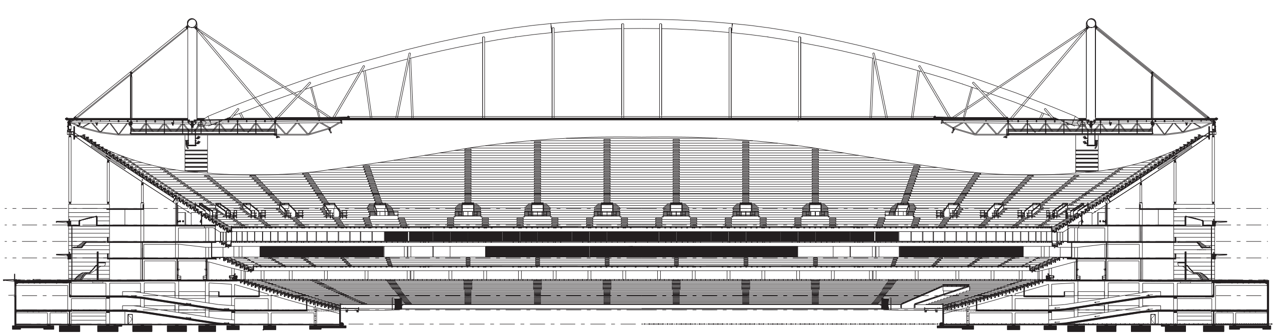
The new stadium has been designed to incorporate a range of facilities that can be used both by the club and local community on non-match days – bringing life to the area throughout the week.

In determining the form of the new stadium the shape and position of the bowl on the site was of great importance. The elliptical bowl was chosen as it had minimal impact on the existing stadium and fitted in well within the parameters of the available site. It also enabled the creation of external landscaped areas connecting to the existing transport infrastructure.

The plan form was one of the key factors in determining the design solution, but the arched structural solution was instrumental in the creation of a visible landmark and individual identity to the stadium. The four arches allowed a phased construction sequence to minimize disruption to the existing stadium and its environs.

This elegant sweeping form is visually separated from the roof and minimizes the height of the bowl in the corners of the stadium. Minimum structure at the edges of the roof and the introduction of glazed elements in these areas lightens the overall appearance, giving expression to overriding criteria for the stadium – the recreation of the Stadium of Light.

Architects: HOK Sport Architecture



Photograph: Ed Massery

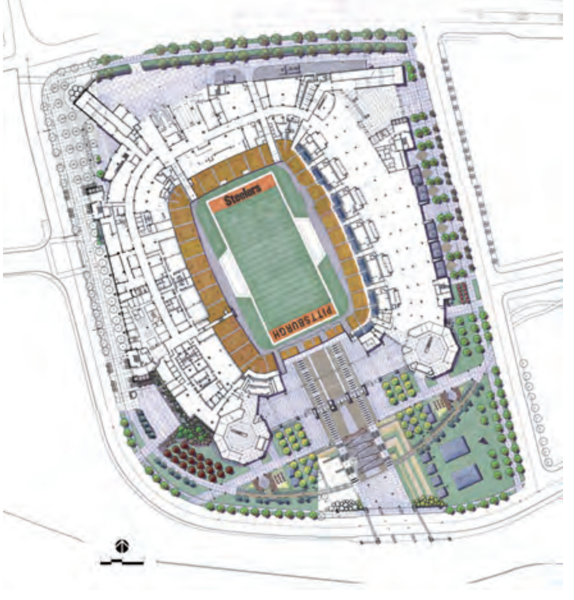
Heinz Field

The design for Heinz Field is inspired by elements integral to Pittsburgh and its people. The Steelers football team takes their name from Pittsburgh's history in the steel industry. Reflecting that legacy, steel is a primary building material in Heinz Field. While respecting the heritage of the city, the stadium's design conveys a contemporary image that looks to the future.

Two towers create a frame, or doorway, to the stadium, and the stadium's stonelike masonry is inspired by the stone and steel buildings that once defined the city's skyline. Progressing up the stadium façade, the building gradually changes from steel and stone into transparency. Glass allows fans to see and be seen. Views in and out of Heinz Field convey how the building works and how fan activity enhances every event. With seats starting just 60 ft (18 m) from the field, Heinz Field gives fans in every section a great view of the game.

Heinz Field's horseshoe-shaped design takes full advantage of the stadium's riverfront site. The open south end frames Point State Park, Mount Washington and views of the rivers. The northeast and northwest corners of the bowl are also open, and the stadium's upper concourses offer dramatic views of downtown and the city's urban skyline.

Architects: HOK Sport Architecture



Photograph: HOK Sport Architecture

Melbourne Cricket Ground

The Melbourne Cricket Ground (MCG) is 153 years old and one of the largest capacity sporting venues of the world. It has great historic and spiritual significance as the home of Australian cricket and Australian Rules Football. It was the main venue for the 1956 Olympic Games and in March 2006 hosted the opening and closing ceremonies and the athletics for the Commonwealth Games.

The MCG has undergone a number of transformations and the latest AUD $435 M remodelling, completed in March 2006, involved a 60 per cent redevelopment of the ground, transforming the stadium into a modern world-class facility. HOK Sport Architecture was commissioned to provide full architectural services as part of MCG5 Sports Architects*.

The new stadium is open and transparent, with views back to the city and into the Yarra Park. The design took care to ensure patrons feel the connection to the city which is within walking distance. Each of the three new entrances features a grand glass atrium, serviced by escalators taking patrons to the upper levels, and the new hybrid roof is constructed of metal and glass. Sightlines from all 100 000 seats are uninterrupted and the new structure is much closer to the field of play than the stands it replaces. 80% of the seats are under cover.

Another major feature of the redevelopment is the relocation and expansion of the stadium's heritage facilities with a museums and entertainment precinct, open seven days a week, featuring interactive devices. The museums include the Australian Gallery of Sport and Olympic museum, the Sport Australia Hall of Fame and the Australian Cricket Hall of Fame.

**The MCG 5 is a joint venture between HOK Sport Architecture, Daryl Jackson, Hassell, Cox Architects and TS&E, provided full architectural services*

The integrated urban stadium development has been designed with event flexibility as a key component

Photographs on this page: Patrick Bingham Hall

Melbourne Telstra Dome

Telstra Dome, formerly Colonial Stadium, is set in the redeveloped Docklands precinct immediately adjacent to Melbourne's CBD. The AUD $430 M integrated urban stadium development, which opened in 2000, has been designed with event flexibility as a key component in the design, allowing the stadium to attract a full range of sports and entertainment events.

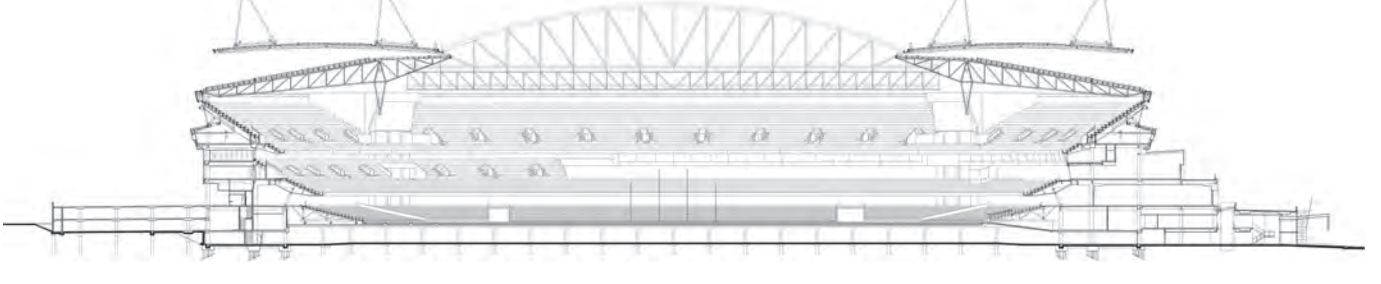
The multi-functional 4-tier stadium features a fully closing roof, moveable spectator tiers and a natural turf playing surface. It provides uncompromised sightlines and proximity to the playing surface from the 52 000 seats for oval based sports, and over 49 000 for rectangular pitch based sports.

Sophisticated moving tier technology allows the lower section of the stadium seating to be reconfigured, drawing spectators up to 18 m (60 ft) closer to the action when hosting soccer or rugby.

The roof, in its retracted position, provides an opening of 160 metres × 100 metres, while still maintaining roof protection to 98 per cent of the patrons in the spectator stands. The roof can be closed in 20 minutes.

Another key feature is a Ring Road located at basement level connecting all back of house facilities and allowing independent servicing without disruption to match-day patrons. There is a 4-tier spectator bowl, 67 luxury suites, and 12 500 membership seats with separate dining and bar facilities overlooking the playing surface with views back to the city.

Architects: Telstra Dome was designed by an HOK Sport Architecture joint venture, Bligh Lobb Sports Architecture and Daryl Jackson Pty Ltd



Photographs on this page: Patrick Bingham Hall

Millennium Stadium

The Millennium Stadium was the first to be built in the UK with an acoustically insulated retractable roof and the largest capacity of its kind in the world. It accommodates all types of sports, leisure and cultural events to take place year-round and at all times of day. The new stadium was a catalyst for the regeneration of Cardiff city centre.

The stadium interior has a three-tiered profile, the middle of which club and corporate seating, with hospitality boxes to the rear overlooking the arena. It has a seating capacity of 73 000.

Stadium user accommodation is arranged over six levels and includes food and beverage concessions, ranging from fast food to reserved table restaurants, merchandising franchises and retail outlets, a museum of sports and childcare facilities. Spectator accommodation has been designed with degrees of flexibility which allow the stadium to adapt and compete in a rapidly changing environment.

The city centre siting of the stadium allows easy pedestrian links with existing transport terminals.

Architects: HOK Sport Architecture

Photograph: Patrick Bingham Hall

Nanjing Sports Park

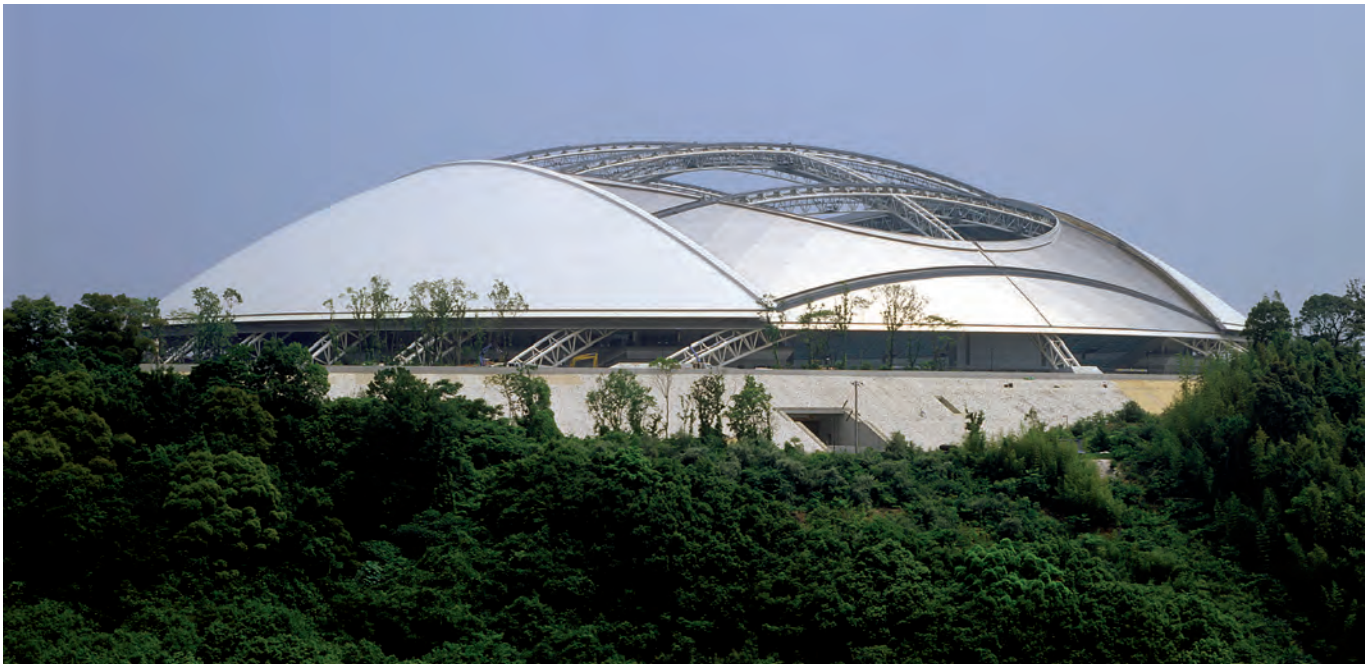
The Nanjing Sports Park, one of the largest athletic venue projects ever completed in Asia, was designed and built for the 10th China National Games, held in the ancient Chinese capital in October 2005. HOK Sport was the architect for the master plan and all buildings, designing all stages from beginning to completion of the project.

The US$285 M sports park includes a 60 000-seat stadium, 11 000-seat arena, Natatorium, Tennis Centre, Media Centre and outdoor facilities for Baseball, Softball, Hockey and Basketball.

The sports park forms the centrepiece of a new downtown precinct development to the West of Nanjing, and marks a new generation of stadia, illustrating the significance of sport as a catalyst for urban development. The Chinese Government used the National Games as a precursor to the Beijing Olympics to gain as much experience as possible about how facilities work for a major event. The primary concept of the Sports Park was to create a 'people's palace', a multifunctional environment, a combination of world standard sporting facilities with the main stadium as the centrepiece within a recreational park. The sports buildings are grouped closely together and 35 per cent of the precinct is made up of Park space.

The sports complex incorporates a number of new design features and represents a leap forward in interconnectivity. All facilities were designed concurrently and in record time to allow the greatest possibilities for interconnection and design harmony, and also enabling maximum efficiency for both major event and everyday use. Access to the buildings is by an elevated podium so the park can be used regardless of events occurring in the sports buildings. Spectators can circulate between the facilities, via the podium, without needing to enter the park area.

Architects: HOK Sport Architecture



Oita Stadium

The Oita Stadium, in South West Japan, was built for the 2002 Football World Cup. It was designed by Kisho Kurokawa and the Takenaka Corporation and is affectionately known as the 'Big Eye' because the stadium is shaped like a big eye looking upwards that can open and close its eyelid.

The stadium is extremely versatile. As well as providing a home for soccer and rugby, it can host international athletics and a range of entertainment events such as rock concerts, because of the closing roof and a movable seating tier which can be installed in the front section to create maximum atmosphere.

Oita Stadium is designed as a simple geometric sphere, based on ancient Japanese symbolism. The gentle curvature not only blends in with the surrounding landscape, but the shape also provides a perfect base for a retractable roof. The ellipse shape at the opening portions of the roof, has a north/south axis, and is designed to allow maximum sunlight into the rectangular natural grass pitch. The use of Teflon in the movable roof panels also allows sunlight to reach the grass when the roof is closed. When open some main beams remain exposed over the central area.

The Oita Stadium is part of a large-scale, versatile, sports park for the people of Oita Prefecture. The total land is 255 ha, and as well as the stadium, the master plan includes an arena, training centre, pool, and facilities for soccer, rugby, softball, baseball, tennis, gate-ball as well as large parklands.

The use of deliberate gaps between the seats and the roof enables natural ventilation of the stadium; it also means patrons do not feel enclosed and it allows them to look out on the mountains beyond. The Oita Stadium installed the world's first mobile camera, which meant images could be sent around the world.

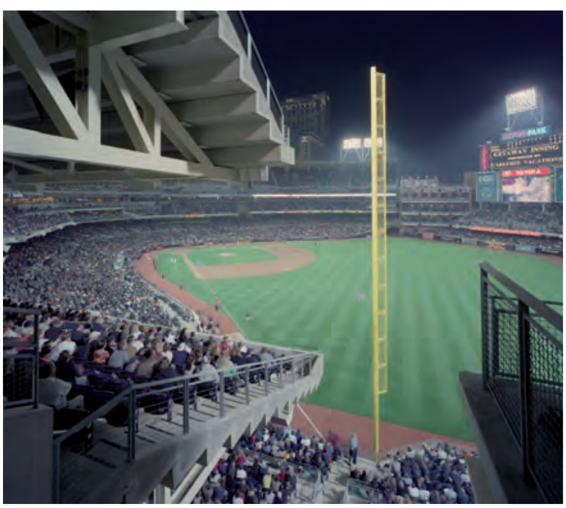
Kisho Kurokawa architect and associates

The design opens the space between the seating bowl's steel structure and the surrounding buildings

Photographs on this page: Timothy Hursley

PETCO Park

PETCO Park embraces California's climate and beauty and serves as metaphor for the area's natural splendour. Labelled by the Press Enterprise as "the hub of the city's renewal," the facility also joins a distinguished list of ballparks that have positively impacted the urban core. In fact, PETCO Park advanced the movement by including neighbourhood master planning from the onset.



The ballpark brings to life San Diego's canyons, coasts and cliffs. The design opens the space between the seating bowl's steel structure and the surrounding buildings to create spacious valleys. Just as bridges link the area's valleys, this space connects the bowl to garden buildings wrapped in stone and stucco, and landscaped with indigenous plantings. White steel reflects the nautical atmosphere and creates a striking silhouette against the sky.

The near-perfect climate allows for an exceptionally open and airy layout that diffuses light throughout the ballpark. The impeccable weather also makes the grassy, tree-lined area known as the 'Park at the Park', an appealing option. It extends the ballpark experience beyond the facility's walls, offering fans a place for relaxation and recreation during a game and serving as a public park during non-event times.

Architects: HOK Sport Architecture and Antoine Predock

Photograph: Aaron Dougherty

Reliant Stadium

Houston is an epicentre of technology, industry and space exploration. Reliant Stadium is designed to embody the city's visionary spirit and the uniquely Texan sense of pioneering and adventure.

Photograph: Patrick Bingham Hall

The 70 000-seat stadium features a retractable fabric roof, which combines with expansive areas of glazing to provide a sense of transparency. The stadium's sliding roof panels are made of steel hinged frames wrapped in translucent Ultralox fabric, which allows in natural daylight. The bright, open-air feel of the facility's concourses and gathering spaces generate the feel of an outdoor stadium with the comforts of climate control necessary for Houston's extreme weather.

Home of the Houston Texans NFL franchise, Reliant Stadium offers an intimacy and compactness similar to a large indoor arena. All seating levels are designed to be as close to the field as possible. A palletized natural grass field provides the optimum playing surface for football and soccer, while allowing flexibility for rodeos and other events.

The interiors of the facility also have been designed with the region in mind. The careful use of frosted glass and brushed aluminium with stained woods, rich leathers and cattle brands evokes the blend of Houston's sleek modernism and Texas' rugged sense of history and heritage.

Architects: HOK Sport Architecture

RheinEnergie Football Stadium

The RheinEnergie Stadium, is an integral part of the Cologne Sportpark, in Germany, situated within the city's green belt, close to the city forest as well as part of the city's sports and leisure facilities. It is the third stadium to be built at the same site in the Sports Park, dating back to 1923. From the north the visitors are guided through a cordon of lighting steles towards the new stadium, nestled between two tree-lined avenues.

The clear design of the rectangle stadium geometry is maintained in plan and elevation

Photograph: Juergen Schmidt

Four light towers, 60 metres high, form a landmark that is visible kilometres away. Their function is to support the lightweight roofs of the stands, which have two distinctive levels. The pre-cast, untreated concrete stands, above the box level, are positioned as independent circles between the four lighting towers and are supported by an open concrete framework. They provide a total capacity of 45 000 roofed seats offering a column-free view across the playing area. The roofs, too, have two distinctive divisions. The exterior is metal and the interior is transparent and UV permeable, ensuring optimum growth of the grass. The individual roofs are suspended along their central line, their system designed like a traditional suspension bridge. The main stand is reserved for VIPs and the Press, providing 52 boxes on two levels. The south stand accommodates a congress and conference centre, restaurant and a separate approach road. The entrance gates and ticketing areas to the ground floor concourse ring are situated at the four open stadium corners.

The clear design of the rectangle stadium geometry is maintained in plan and elevation and emphasized by the choice of materials as well as the structural system. All the steel components are coated in dark iron mica paint and the façades of the box and office level have storey-high glazing and the steel structure is painted black.

Designers: gmp-von Gerkan, Marg und Partner-Architects

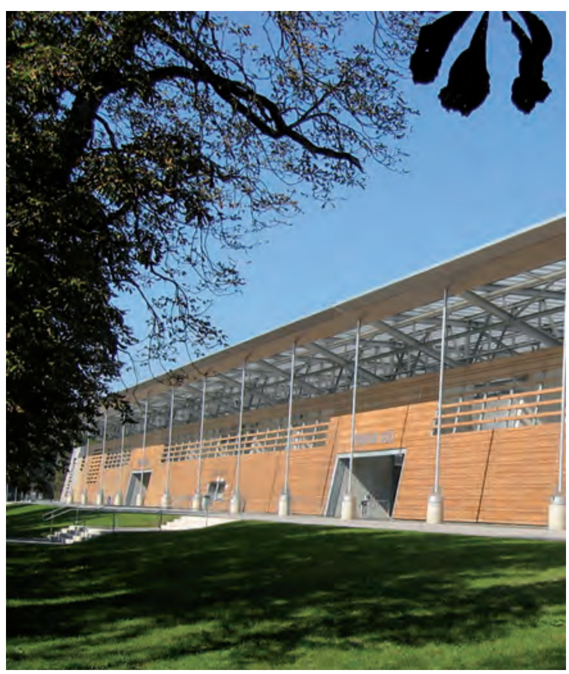
The soccer field was literally dug into the topography

Salzburg Stadium
The Salzburg Stadium, in Austria, opened in 2003. The 16 500-seat stadium, designed mainly for football, has been integrated into its surroundings in the immediate vicinity of Klessheim Castle designed by Fischer von Erlach in 1694. This has had a significant impact on the design of the stadium.

The heights of the surrounding buildings and the fact that the stadium is so close to the Castle has resulted in a design concept in which the building height of the stadium has been kept to a minimum. As a result, the soccer field was literally dug into the topography. Hence, what is seen from the outside is the shape of a slightly slanted, uniform building, with a semi-transparent light roof, supported by an intricate steel frame structure.

The low building height has created great atmosphere inside the stadium, enhanced by the design of a continuous seating bowl. The concourse has been positioned at entrance level. The stadium was designed to be multifunctional and has already been used for a range of events including concerts and motocross meetings. It has been designed to be expanded to 32 000 seats for EURO 2008.

Architects: Schuster Architekten

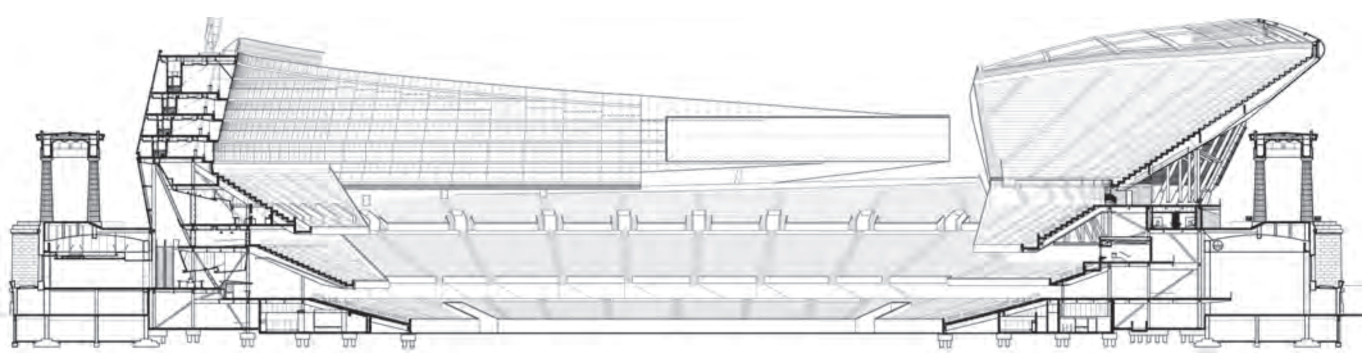


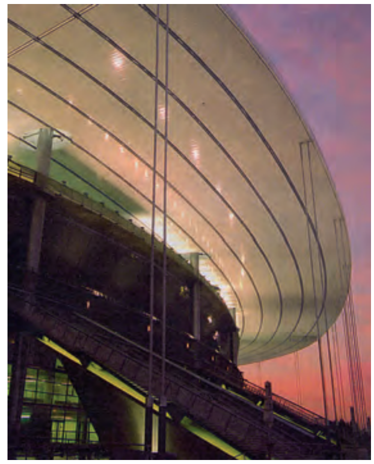
Photograph: © David B. Seide, Defined Space, Chicago

Soldier Field

After years of political wrangling, the Chicago Bears, the fans and visitors are finally enjoying their brand new state of the art 63 000 seat stadium. Named the 'Best Damn New Stadium, Period' by GQ magazine, this stadium and its 17 new acres of parkland, is changing the face of sports architecture. W+Z working in close collaboration with the team's owners, developed a scheme that saves the classic colonnades of Soldier Field, while providing one of the most exciting luxury skybox configurations in football, with 120 luxury suites, 9000 partially covered club seats, and two cantilevered LCD video boards, one in each end zone. The regular seats each offer a superior view of the playing field, due to their closeness to the field, and also offer the fans incomparable views of both downtown Chicago and Lake Michigan.

Designers: Wood + Zapata. Lohan Caprile Goettsch Architects





Stade de France

The cities of antiquity have demonstrated that stadiums were, and still are, magnificent urban objects. The Stade de France, built in the heart of Saint Denis, a district close to Paris, provides public open spaces for the local inhabitants with a roof that seems to offer shelter to the neighbouring districts. From the very top it offers panoramic views over the town, with, in the distance, the monuments of the Sacre Coeur and the Saint Denis Basilica.

The imposing Stade de France, is distinguishable by the spectacular view of a great elliptical disc, the hi-tech roof of the stadium, elevated 43 metres into the air. The disc is supported by 18 steel masts, placed at 45 metres from each other and following the curve of the nearby Saint-Denis Canal.

The multi-functional 80 000-seat stadium, built originally for the 1998 final of the Football World Cup, is designed for both football and rugby, because of the elliptical shape of the tiered seating. It naturally provides a convergence of the spectators' view towards the pitch, and more particularly, towards the goals. But it is also adaptable to a wide range of athletic events. The 25 000 seats of the first ring terraces are mobile, and can be mechanically pulled back 15 metres, rolling on a cushion of air, steel and Teflon rollers.

The roof has a total surface of more than six hectares, weighs as much as the Eiffel Tower and houses all the lighting and acoustical functions. Its interior edge of glass also works as a filter of natural light, and can be used as a backdrop for a variety of special lighting effects.

Designers: Aymeric Zublena, Michel Macary, Michel Regembal & Claude Constantini

The Stade de France provides public open spaces for the local inhabitants

The project is the combination of a wooden module system with versatile rooms

Stattegg Sports and Leisure Facility

Stattegg sports facility on the outskirts of the town centre, at Graz/Styria, Austria, is a model complex, built on the basis of a study on multi-functional leisure and sports facilities with an integrated energy strategy. The project is the combination of a wooden module system with versatile rooms that can be used in a number of different ways.

Because of the difficult topography, poor access to, and orientation of, the existing sports ground and the incorrect position of the clubhouse, the site was completely reorganized. The new two-storey stadium with solar panels on its roof is now situated along the southwest side of the pitch. The stand is triangular in shape, reflecting the wedge shape of the site: wide at the entrance area that all visitors have to pass through, and narrower towards the rear. The façade facing away from the pitch resembles a residential building and blends in with the surrounding architecture.

The players' changing rooms and toilets are located on the lower floor, and the upper floor has been designed so that virtually all functional units have at least two uses. In the centre is the restaurant area, which takes the form of a free-standing red cube inserted beneath the large stadium roof. The kitchen, serving hatch and toilets of the sports bistro, can also be used during matches, while the football clubroom is also available as a restaurant extension. The two offices adjoining this and the associated infrastructure are shared by several different sports clubs.

Simple, confidently used, and often brightly coloured materials make the building an inviting new village centre. The good looking, cost-effective facility has been extremely well received by the Stattegg community.

Designers: Hohensinn Architektur

It is a powerful icon on the Sydney landscape with both durability and adaptability

Photographs on this page: Patrick Bingham Hall

Telstra Stadium

Telstra Stadium (formerly Stadium Australia) was the largest Olympic stadium ever built and during the main ceremonies of the Sydney 2000 Olympic Games, hosted 110 000 people. It is a powerful icon on the Sydney landscape with both durability and adaptability. It has since been reconfigured to 80 000 seats, and a rectangular pitch added, to suit rugby league, rugby union and soccer. It is also used for concerts, exhibitions and public gatherings. The philosophy behind the stadium is to provide a flexible, multifunctional and economically viable venue with widespread appeal.

One of the main design features is the translucent saddle-shaped stadium roof which is 58 metres (or 16 storeys) above the arena. It is a hyperbolic parabolid, which not only offers protection to twice the number of spectators when compared to stadiums with cantilever roofs of a similar form, but allows rainwater to be siphoned off into tanks to irrigate the pitch. The roof slopes down towards the pitch, enhancing the intense atmosphere and optimizing stadium acoustics. The roof is supported by the seating structure and two 295 metre long trusses.

Spectators have access to the stands via 4-helical ramps, escalators and lifts. The stadium's circulation routes for spectators, athletes and services personnel were designed to never cross for reasons of security, convenience and efficiency.

The stadium is environmentally sustainable. Passive design measures include ventilation, natural cooling and heating. Rainwater is recycled from the roof and used to irrigate the pitch.

Telstra Stadium was designed by an HOK Sport Architecture joint venture, Bligh Lobb Sports Architecture.

Rising 133 metres, the Wembley Stadium arch provides London with an iconic landmark

Wembley Stadium

The new 90 000-seat state-of-the-art Wembley Stadium, opening in summer 2006, has built upon its past heritage to become the world's most dynamic stadium. Designed to the highest specifications, using the latest technology and offering every fan who visits an unrivalled match-day experience, the stadium will continue its renowned status as the 'Venue of Legends'.

Photograph: HOK Sport Architecture, CGI Image

Replacing the famous Twin Towers is a wonder of modern architecture. When our first sketches of an arch hit the tracing paper, we could all see the magic in that form. Rising 133 metres, the Wembley Stadium arch not only provides London with an iconic landmark, but holds a crucial function in supporting the 7000 tonne steel roof structure, eliminating the need for pillars.

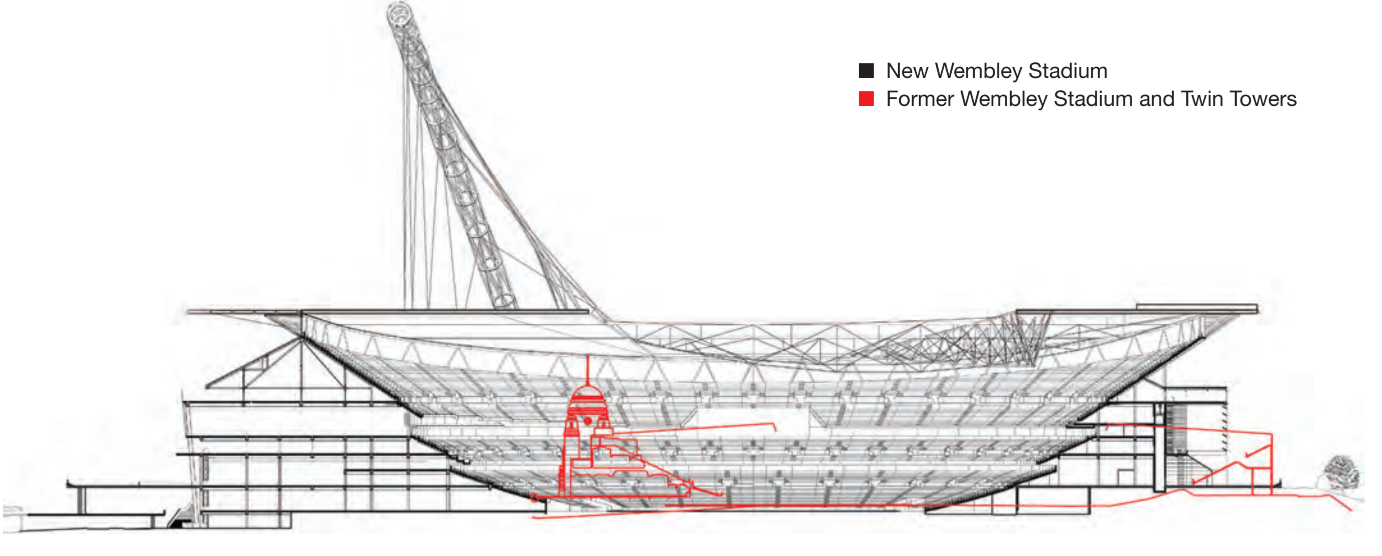
The roof has retractable panels to allow light and air onto the pitch, maintaining the quality of the famous Wembley Stadium turf. Between events, the roof can be left open, but can be moved to cover all the seats within 50 minutes, ensuring fans are sheltered during an event.

Stadium facilities have been designed to maximize spectator comfort and enjoyment; the quality of seats and the space allowed has improved dramatically. Seating provisions for disabled spectators have been greatly improved, increasing from 100 to 310.

The geometry of the seating bowl, designed as a single form rather than 4 separate stands, ensures that spectators have an unobstructed view from each of the 3 tiers. Careful attention has been paid to the acoustics which will enhance the noise from fans on match days and create a legendary atmosphere. The Wembley Roar has not been forgotten.

Although designed primarily for rugby, football and concerts, the new Stadium Is capable of hosting world-class athletics events, by means of a platform adaptation. With the platform in place, the stadium seating reduces to 67 000.

Wembley Stadium has been designed by the World Stadium Team (WST), a joint venture between HOK Sport Architecture and Foster & Partners



Photographs on this page: Patrick Bingham Hall

Westpac Stadium

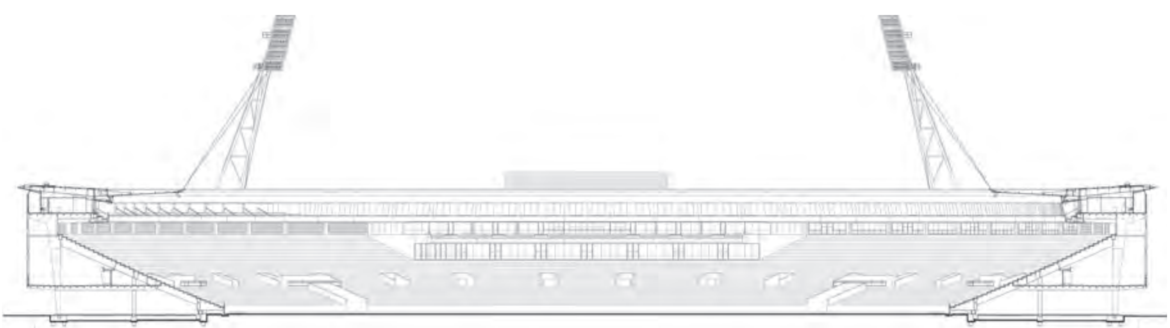
Sited on disused railway yards on the edge of Wellington Harbour, the 34 500-seat Westpac Stadium is this modern purpose-built cricket ground. It is also the home of New Zealand's other main sporting code, rugby and the stadium has taken a leading role in the redevelopment of the surrounding area.

The project provided a unique opportunity to develop a world-class cricket venue as a whole entity rather than adding to an existing facility in a piecemeal fashion. The design demonstrates a minimalist approach, with the cricket arena cut back to the tightest possible configuration allowing the stadium to also accommodate rugby games, without placing the spectators too far from the pitch. The bowl design includes a complete oval lower tier with separate box level seating for 2600 to the underside of the roof giving dramatic and unobstructed views of the whole arena. The complete enclosure of the field with the oval seating bowl provides an ideal amphitheatre for the action of the sporting arena.

The building's external skin of horizontally-striated reflective metal cladding has created a large sculptural landmark on the northern edge of the CBD. The concourse areas include gallery spaces providing seven day a week entertainment, cultural and exhibition space serving the community. The stadium also includes offices, a sports medicine facility, cricket academy and a cricket museum.

It opened early January 2000 and has been awarded the New Zealand Institute of Architects (NZIA) Resene National Award for Design and the Royal Australian Institute of Architects International Building Award.

The stadium was designed in an HOK Sport Architecture joint venture, Bligh Lobb Sports Architecture, in association with Warren and Mahoney.



The design of the innovative hydraulically operated roof evolved after a scientifically demanding process.

Wimbledon AELTC: Centre Court

Wimbledon is one of the world's most recognizable and evocative of sports arenas, with a past of more than 120 years. Almost every summer however the prestigious outdoor grass court Grand Slam tournament has to deal with the frustrations of the occasionally inclement British weather.

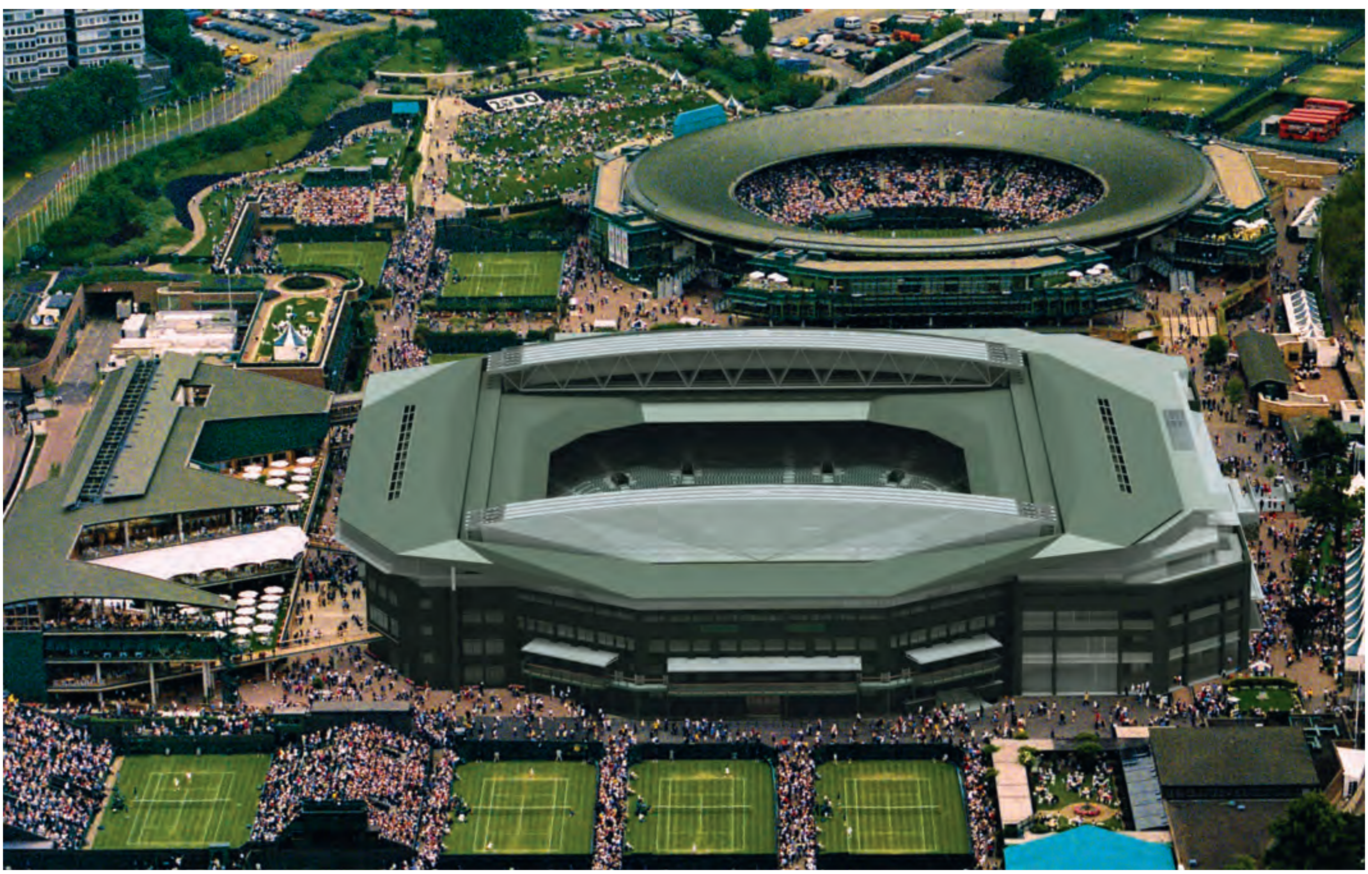
Until now, the Australian Open is the only one of the Grand Slam events that has had a retractable roof. It is important that Wimbledon moves with the times and protects its position at the top of world venues; to make sure its huge television audience has tennis to watch and to ensure its long-term financial viability. The Centre Court will stay where it is; is simply being remodelled to bring the 1922 building into the twenty-first century.

The design of the innovative hydraulically operated roof (a 'folding fabric concertina') evolved after a scientifically demanding process. Measuring 65 metres × 70 metres the structure works on a principle similar to an umbrella, with metal ribs supporting a translucent fabric.

A key element of the design has been to allow natural light to reach the grass, while an airflow system removes condensation from within the bowl to provide the optimum internal environment for the comfort of spectators and players when the roof is closed.

The addition of six rows of seating to the upper tier on three sides will enable increased capacity at Centre Court from 13 800 spectators to 15 000 spectators. New wider seats will be installed as well as extra stairs and lifts to provide greater spectator comfort. To allow for the new seating, new media facilities and commentary boxes will be built to replace those currently in the upper tier. They will be located in a similar position to the one they have at present at the back of the seating bowl.

Designers: HOK Sport Architecture



Photograph: HOK Sport Architecture

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