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Kosovo’s national football Stadium

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Personal motivation

The breathtaking atmosphere, the feeling of being part of a larger whole, and watching the favorite team write a piece of history are the main motivations for me to visit a stadium. It's the Stadium as a big structure, which fascinates and inspires me since my teens. For me, stadiums are more than pure utility buildings, they are landmarks and places of worship and an integral part of every sightseeing tour. Is also the sport of football in itself, which motivates me for this topic because in addition to my general enthusiasm for football I play since my youth in a club and know the feeling of audience with his teammates to compete against other teams. It is the result of these Aspects, but above all the timeliness of the topic, which confirms my decision.

Concrete considerations for my country in the recent past, to make a little contribution for people of my country with new design of Stadium, finally gave the impulse, to treat this topic and in one Implementing a design. It's not just a matter of heart opportunity for me, but also fills me with pride to design a stadium for my country in the course of my diploma thesis.

Abstract

In May 2016, UEFA's annual congress voted to accept the Football Federation of Kosovo's application for membership, paving the way for teams from the country to enter European club competitions.

The UEFA decision was made despite strong opposition from Serbia, which opposes any recognition of its former province's statehood.

Until then, Kosovo teams were unable to compete internationally, although two years before, FIFA agreed to allow the national team to play so-called friendlies with other countries under special conditions.

With its stadiums not meeting UEFA requirements, Kosovo's national team embarrassingly has been forced to play World Cup Qualification host matches in neighboring Albania.

However, at home the situation isn't too good, with funding insufficient at all fronts. There is no stadium meeting all UEFA and FIFA criteria at this point, while the national team is conditionally allowed to use two grounds: in Pristina and Mitrovica.

Fig.1 Fadill Vokrri, director of football federation of Kosovo

The "Prishtina City Stadium" in Prishtina is one of the most traditional sports grounds in Kosovo and used to be stage for many highlights and important matches in history. However, in spite of permanent modernizations the 40-year-old arena cannot cope with the high requirements of nowadays modern soccer sports. Time has left marks and the stadium seems to be far from getting permission for international matches of

the UEFA or the FIFA. Therefore the located club "FC Prishtina " has decided to rehabilitate, renew and expand the stadium. Modernizing infrastructure, premises and grandstands and increasing capacity are essential points of the conceptual plans of the club.

The Prishtina municipal stadium has been under reconstruction since the dark days of the Kosovo war in late 1990s. The main stand's roof remained without any covering sheets until as late as 2014 and despite gradual works in recent years the venue still lacks in infrastructure.

As a result of all this, the government of Kosovo has proclaimed international partners for the new project of stadium of the Kosovo's national football team. This thesis deals with these concrete intentions and includes a design based on these guidelines and specifications. Additionally, the new Stadium should have approximately 30.000 seats.

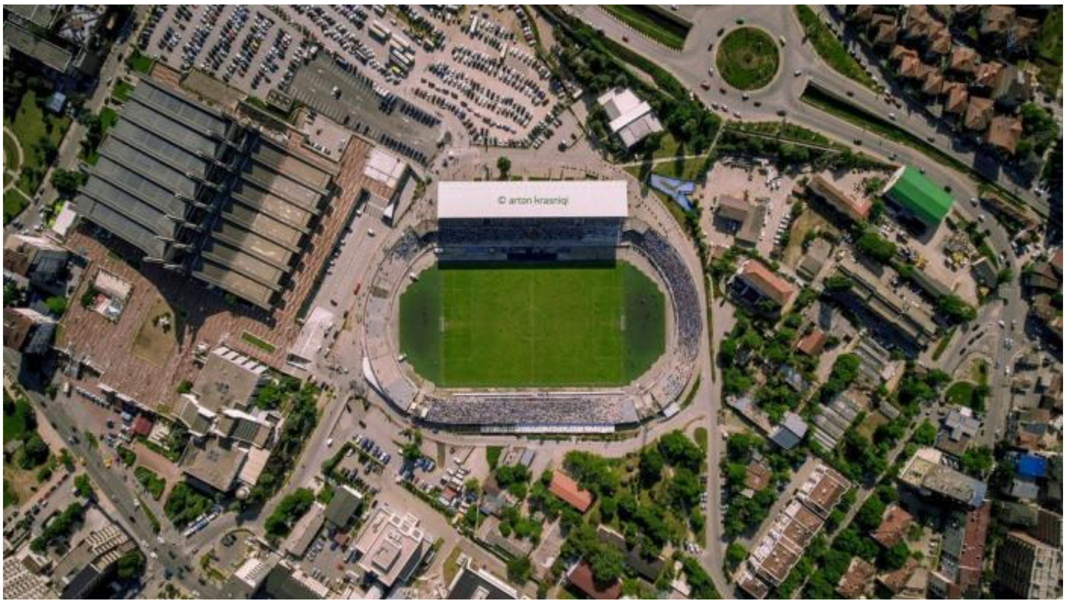


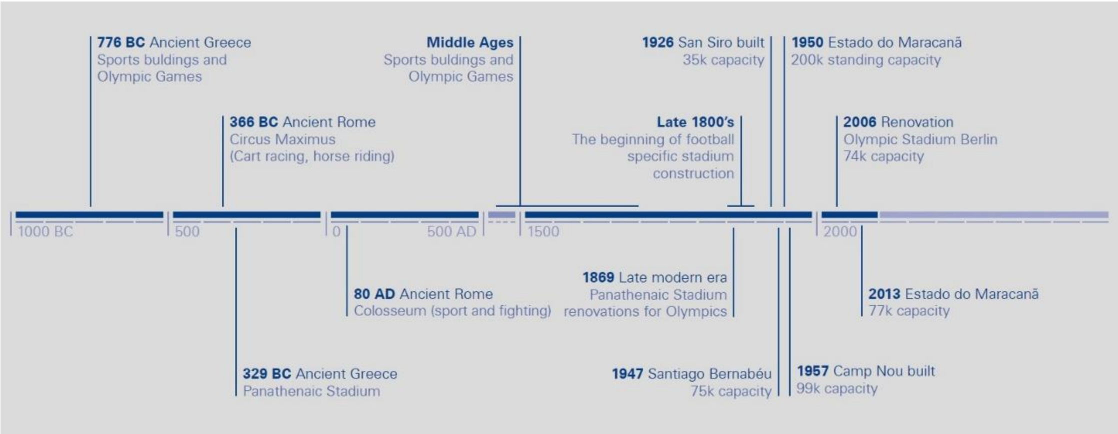
Fig.2 Prshtina's old Stadium

1. Short historical development

1.1 The development of stadium construction

Where Stadiums began: In Antiquity, sports were not only an entertainment for the people, but more a way to gain political support and pay homage to the Gods. At this early stage of civilization, man sought for an arena to perform in, a place where crowds could gather and become a part of something bigger than themselves. Hence the first stadiums were born. The events held in these early stadiums were either of a sporting nature or gladiator 'shows', where slaves and free men battled each other in front of tens of thousands of spectators. One of the most iconic early arenas used for sports was, of course, the Coliseum in Rome The Coliseum is one of the most recognized ancient stadiums in the world, and has been the building block for future stadiums. Even in 80 AD, with a capacity of 50,000 in three tiers, 80 entrances and exits were key to the safety of all spectators. There was a strict class system employed in the Coliseum, with the more important and influential citizens seated in the front rows, with the lower class and poor housed in the top rows, echoing to a degree today's ticketing system and corporate hospitality offerings. There are a number of characteristics from Antiquity, which are still used in stadium design today notably the bowl concept, roof concept and the circulation around the venue

Timeline of stadium development:



Other periods of time contributed to conceptualizing modern stadiums, for example, during the Renaissance, horseback competitions required the construction of temporary stands specifically built for these events, much like mega events of today. The first stadiums of the modern era started emerging in the late 19th century, such as the excavated and restored Panathenaic Stadium in Athens ready for the Olympic Games in 1870 and 1875 and the first Modern Olympic Games in 1896. Hampden Park, in Scotland, was conceived in the 1860's for football club Queen's Park. The club moved to its current site in 1903, and built the largest and most advanced stadium of its time, with a capacity of over 100,000 seated and standing. Crowds in ancient Greece and Rome embraced the retainment factor within an event, be it sport or fighting spectators spent days, if not weeks, travelling to and leads these sporting events. Today, stadiums and arenas are no longer be places to spend 90 minutes watching our favorite football team and then leaving the ground. They become places of (family) entertainment, providing entertainment to keep visitors engaged for longer periods before and after the event.

Fig. 3, Colosseum, Rome

1.2 Fifteen centuries of suspension

During the IV century AD, the importance of sports practice was considerably reassessed all over the ancient world, which unavoidably affected the development of sports facilities.
After Christian cult was legitimized by Constantine Edict, the Council of Arles held in 314 imposed a ban on the circus charioteers, actually banning the pagan practice of chariot racing and thus speeding up the conversion of circuses into non-sports public facilities. Similarly in 394, when Greece had been under the Roman rule for a long time, an edict promulgated by the emperor Theodosius who accepted the request made by Milan bishop Ambrose led to the abolition of the Olympic Games, which were regarded as a pagan rite contrary to religious rites.

Fig. 4 Firenze in Piazza Santa Croce

Therefore shifted to new building typologies such as churches and cathedrals, castles, fortifications, towers and municipal palaces which became peculiar elements of Medieval towns and of their development. Sports activities were seldom and limited. The ancient Greek and Roman sports buildings were progressively abandoned. Many of them were converted into markets or houses, others were fully pulled down to reuse building materials.
Sports practice was given a new boost during the Renaissance when running events and equestrian events were reintroduced. However they did not take place in specific facilities, but usually in areas serving other purposes, in large open spaces or in the squares, which were often provided with wooden tiers and small temporary roofs for the most important spectators.
Piazza del Campo in Siena and its Palio horse race are the most important case that is still popular nowadays, while in Firenze in Piazza Santa Croce the forerunners of modern football used to play in teams made up of 27 members each without any rule, but the one to throw the ball into the goal of the opposite team.

Sports were properly defined a few centuries later, in the second half of the Nineteenth Century, which also saw the setting up of the first clubs and sports federations. The enthusiasm for the new sports, football and rugby in particular, quickly grew in Great Britain, where in the cities in which population had dramatically grown due to the urbanization process resulting from the Industrial Revolution people soon felt the need to build new facilities that could welcome a high number of fans.
In the same years the revival of the Olympic Games, proposed in 1894 by the French baron Pierre de Coubertin, sanctioned the final importance of sport in the modern age and symbolically marked the start of a new age of stadia.

1.3 The modern age

Modern Olympic Games were inspired by Greece and by the model of stadium, this time Panathenaic Stadium in Athens, which was brought to light by the excavations dating back to the Eighteenth century and which was rebuilt keeping its elongated "U" shape prior to the first Games held in 1896.
The models of the Greek and Roman sports facilities rediscovered in the Neoclassical age turned into the reference prototypes for the first modern stadia, triggering off an evolutionary process that starting from Great Britain at the end of the Nineteenth century and still under way, spread in all continents in parallel with technological innovations and often linked with Olympic Games and Football World Cups.
So far the technological evolution is almost one century and a half long. On the basis of the peculiar aspects that have marked the different stages, partly drawing on the theoretical analysis made by Rod Sheard (read note 1), five "generations" of stadia can be identified. These are generations marking the steps of a faster and faster development with many stadia, fully renovated or rebuilt over time, that have gone through more stages of this evolutionary process.

1.4 The first stadium

First-generation stadia were like huge hotchpotches whose purpose was basically to host a large amount of spectators in an age when there was no television and sports events could be watched just live.
Particularly in the first years, they were facilities with no architectural value, uncomfortable and the provision of facilities was basic. Tiers were made of concrete or just with the arrangement of embankments standing and often crammed into the stands, with the exception of some small seating stand, sometimes also provided with a small roof for the most important spectators. Their extension was usually disorderly and non-homogeneous, in order to satisfy the increasing demand for seating areas by the spectators.

Fig.5, White City Stadium (London)

This model was introduced in Great Britain as football facility with the typical rectilinear stands running parallel to the sides of the pitch and was soon adapted to the model of the Olympic stadium with continuous tiers running along the perimeter of the athletics track. The White City stadium, now pulled down, was the first example during the Games of London 1908.
Alongside with the passion for football, these models were exported from Great Britain to the rest of Europe and to South America. They often featured the Marathon Tower, which made them easily identifiable in the city environment. This first generation of stadia took different forms until the end of the Fifties, when they had to be confronted with a sudden reduction in the number of spectators.

2. Project references

Apart from examples of the historical development of stadium typologies, there are also specially selected reference projects which are important for the design of this diploma thesis. Although it is not necessarily a prime example of modern stadium construction, it is above all similarities of certain aspects of the Arena da Amazônia, Willemote Alliany Rivera and Universiade Sports Center, which provide clues in the planning of the new Stadium of Kosovo.

2.1 Arena da Amazônia, Manaus, Brazil

- Architects: gmp Architekten
- Location: Arena da Amazônia, Manaus - Amazonas, 69050-010, Brazil
- Architect in Charge Volkwin Marg and Hubert Nienhoff with Martin Glass
- Project Year: 2014
- Seats: 43,500

Fig.6 Arena da Amazônia, Manaus, Brazil

With the design of the new Manaus stadium, the aim was to come up with a very simple but highly efficient stadium that would at the same time specifically symbolize the location, particularly the fascination and natural diversity of the tropical rain forest. The roof structure is made up of mutually supporting cantilevers, whose steel hollow core girders function simultaneously as large gutters to drain the immense run-off of tropical rainwater. The fields of the roof and façades consist of translucent fiberglass fabric, whose low emittance coating reflects heat radiation and thus has a cooling effect.[1]

This stadium design was based on the idea of creating a simple but highly efficient stadium which also makes reference to the special location, to the fascination and natural diversity of forms in the tropical rainforest. Designed for 44,400 spectators, the stadium is located at the central traffic axis that links the airport with the inner city. The new building was integrated into a sports park with Sambadrome, field and track facilities, multi-purpose halls and an aquatic center. The project was developed in cooperation with the gmp partner practice STADIA from São Paulo and the structural engineers schlaich bergermann und partner.

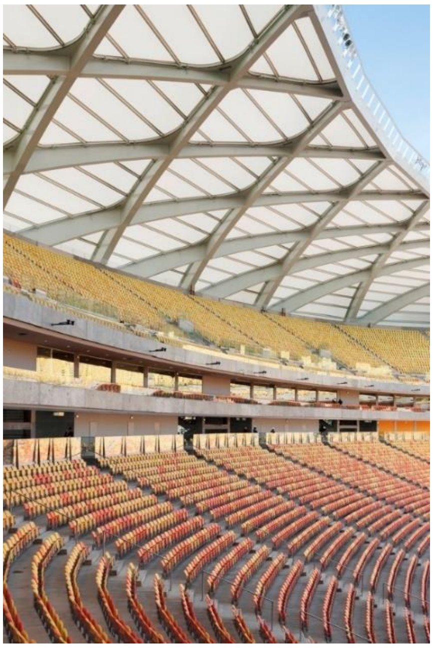


Fig.7 Arena da Amazônia, Manaus, tribune

Making best use of the topography with its gentle slope in the terrain, the stadium has been placed on a base which provides space for VIP access, the media, the players and parking spaces. A ring including spectator boxes, offices and a restaurant sepa- rates the upper tier from the lower tier, which is recessed in the base. The roof structure is composed of mutually bracing cantilever elements in the form of hollow steel box girders which also serve as large gutters for the discharge of the enormous quantities of water expected during tropical rain events. In view of the hot and humid climate at the Amazon, the roof extends into a facade which provides shade to the spectator balconies and vertical access routes. The roof and facade panels consist of translucent glass fiber fabric.

[1] https://www.archdaily.com/527272/arena-da-amazonia-gmp-architekten

2.2 Willemote Allianz Rivera

- Architects: Wilmotte & Associés Sa
- Location: Boulevard des Jardiniers, 06200 Nice, France
- Area: 54000.0 m2
- Project Year: 2013
- Seats: 35,000

Fig.8 Willemote Allianz Rivera outside view

In December 2009, the city of Nice launched an international competition for the construction of a new 35,000-seat stadium capable of hosting large international competitions. The stadium would sit at the heart of the Eco Valley in the Plaine du Var, named an 'Operation of National Interest' (OIN) in March 2008, and was to be the first flagship project in the new district.[2]

The competition program – the product of a public-private partnership – included three projects to be built in a seismic zone, each with a different completion date:

• a stadium with 35,000 seats, multi-purpose facilities (sports and concerts), UEFA approved, well-integrated with its urban environment, and in line with sustainable development principles
• the Musée National du Sport (National Sports Museum)

[2] https://www.archdaily.com/431938/willmote-allianz-rivera-wilmotte-and-associes-sa

• a real estate development plan (PIA) including 29,000m² of retail space designed to animate the area

Fig9. Willemote Allianz Rivera, roof structure

The intervention included a development plan based on retail, leisure, and food service. This plan was designed to work symbiotically with the stadium to create a coherent complex able to generate urban synergy, use, and energy. The plan provides more than 29,000m² of retail and leisure-related spaces on one side of the stadium. On the east side, there is a pedestrian mall with direct access to future tramway opening up to the future Eco Quarter.

The Plaine du Var Eco Quarter, adjacent to the stadium, - spans over 10.6 hectares, 44% of this is designated as residential. This new quarter is inserted within the Plaine du Var landscape. Originating in the Alps and flowing to the Mediterranean, the Var River winds along the valley bottom. The urban plan is reminiscent of the river’s meandering north to south course through the valley. This is complemented by a swathe of greenery running from east to west. A ring around the central park creates a ripple in this green swathe, offering a breath of fresh air to the offices and residences that will integrate seamlessly with these green spaces in the years to come.

2.2 Universiade Sports Center

- Architects: gmp Architekten
- Location: Shenzhen, China
- Area: 870.000 m²
- Project Year: 2007-2011
- Seats: 60,000

Fig.10 Universiade Sports Centre, outside view

Faceted glass triangles create glowing crowns around a trio of stadiums for the World University Games currently taking place in Shenzhen. The
three Universiade stadiums were designed by German studio GMP Architektenand surround an artificial lake.

The design for the Universiade Sports Center in the city of Shenzhen is inspired by the surrounding undulating landscape and generates a formal dialog that references Chinese horticulture and philosophy toward the land. The roof structure projects up to 65 m, and is designed as a steel prismatic shell on a basis of triangular facets. The crystalline shape of the three stadia is additionally emphasized by the illumination of the translucent facades at night. An artificial lake connects the stadium with the circular multifunctional hall in the north and the rectangular swimming hall west thereof.[3]

[3] https://www.dezeen.com/2011/08/16/universiade-2011-sports-centre-by-gmp-architekten/

Fig.11 Universiade Sports Centre, facade view

The main stadium is planned to be multifunctional, meeting the requirements of international sports occasions and events. Total capacity is 60,000, seated in three stands. The total diameter of the roof is 310 m lengthways and 290 m across. The indoor sports complex is designed as a circular multifunctional arena for indoor sports competitions as well as for ice-skating and other events. The overall capacity is approx. 18,000 spectators. The swimming complex forms the third module of the Shenzhen Universiade Sports Center. The overall capacity is approx. 3,000 spectators, the seats are arranged on two stands.

3. Stadium uses

3.1 Playing Surfaces

In the past, informal sport had been played on open fields, city squares, or anywhere large enough to hold a gathering of people. Once rules were specified, organized sporting events required specific playing surfaces. Sports that depend on the interaction between the ball and the playing field would require natural grass fields. The issue with natural grass is that it is considered a small ecosystem that responds to changes in the environment; weather, temperature, and other environmental factors. Natural grass requires the right amount of sunlight and water to stay healthy and practical for use. For this reason, stadiums were originally built without roofs, as seen by stadiums of early history.

Once a stadium is equipped with a roof, the grass doesn't receive the nutrients needed and therefore doesn't grow. A perfect example of this would be the 1996 Houston Astrodome, an influential structure in the study of stadiums because it led to the invention of 'Astroturf'- a plastic material used to make artificial playing fields. A detailed case study of the Astrodome will follow in the "Case Study" chapter at the end of the thesis, and will describe why it is one of the most influential structures in stadium history.

Technological advancements have made artificial grass fields popular, but some sports still require natural grass for play. Structural engineers have used innovative techniques to remedy the situation and provide stadiums with both natural grass surfaces and keep them fully enclosed.

3.2 Natural Grass Surfaces

Although artificial fields have been gaining popularity, coaches and players still prefer natural grass for its playability. In fact, national federations for major world matches have yet to approve artificial grass as an acceptable option. Natural grass has numerous advantages, most of which are aimed towards the athletes themselves. First, it provides the perfect amount of speed and resistance for most ball sports when wet or dry. Grass also is less injurious when a player falls and has a firmness that is good for running. Other benefits to natural grass are that it is aesthetically appealing and can self repair itself when given the right amount of water and sunlight.

With that being said, the major disadvantage to natural grass is that if not given the proper water and sunlight it could become aesthetically unappealing and unsatisfactory for play. Natural grass fields require daily maintenance and care. This in turn limits natural grass stadiums to being open roofed. E ven when transparent material is used for the roof, as will be seen in the discussion of the Astrodome, the grass still does not receive the right nutrients. As a means to facilitate this problem, designers began installing partial roofs on stadiums, but finding the right size aperture for the grass to survive naturally has been a difficult task.

3.3 Artificial Surfaces

The obvious advantage to using some type of artificial surface is that it requires much less maintenance and has less of a limitation on the stadium structure. "In completely enclosed stadiums artificial grass will almost certainly be chosen in preference to natural grass".[4] Artificial surfaces are not always the perfect choice though. They have a high initial cost associated with them and are not everlasting. Depending on the material and use of the surface, there is a life expectancy of six to eight years. Artificial surfaces can be made of a variety of materials, and this will have an effect on the required maintenance and repair. The man-made material looks a lot like natural grass, as seen below in Figure 9.

Fig. 12 Artifical Turf

One option for an artificial surface is non-filled turf. Composed of nylon, polypropylene, or polyethylene, this surface consists of a turf-carpet and an underlying shock-absorbing layer. This material comes in various densities and thicknesses and can therefore be suited for nearly any sport.

[4] (Geraint, Sheard and Vickery 2007, 82)

3.4 The Spectators

Nowadays if a stadium is uncomfortable, overcrowded, and doesn't provide some food/drink outlets fans would stay home and watch the event on their television. Technological advancements have allowed for live broadcast of sporting events so that people can stay in the comfort of their own homes and watch the games from a closer view than if they were at the stadium. However, a home does not provide the same atmosphere as seeing a game live in person. In order to meet the needs, and wants, of the spectators, designers need to ask themselves the following question at the start of the design process: "Who are the spectators, what are they looking for in the facility, and how can their numbers be maximized?

Ideally, the playing area of a stadium should be free of any barriers between spectators and the playing field. FIFA has decreed that its final competitions will only be played in fence-free stadiums. However, it is essential that players are protected against intrusion by spectators. This could be accomplished in a number of ways, including one or more of the following:[5]
The presence of police and/or security personnel in or near the playing area is the ideal situation.

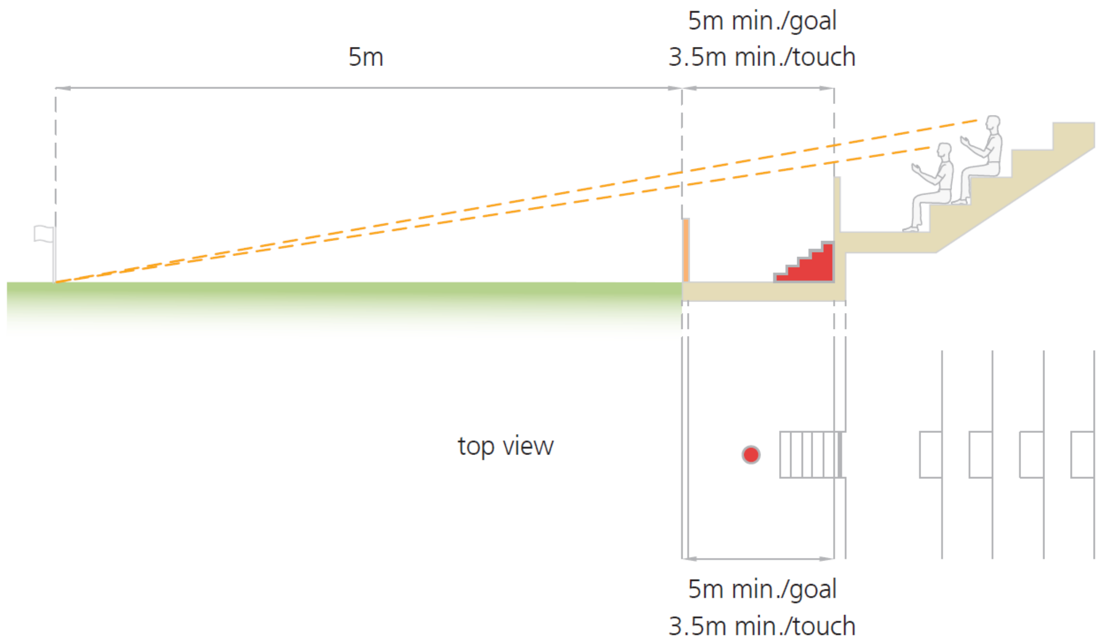


Fig. 13 Exclusion of spectators

[5] FIFA Football Stadiums

3.5 Viewing Distances

Once the use of the stadium is specified, the designers must decide the best way to organize the seating around the playing field. It is the designer's job to make sure the stadium can accommodate the number of spectators required in the project's program and that these seats have a clear view of the event. Determining maximum viewing distances and viewing angles is a purely mathematical problem. According to Stadia, the "calculation of maximum viewing distance is based on the fact that the human eye finds it difficult to perceive anything clearly that subtends a angle of less than about 0.4 degrees"[6]. Using these distances, an optimal seating section can be determined, which usually takes the shape of a circle about the center of the field. Figure 11 shows the optimal and maximum viewing distances for a football field. The right side of the image shows possible seating orientations and how they overlap with the optimal seating area of the dashed circle.

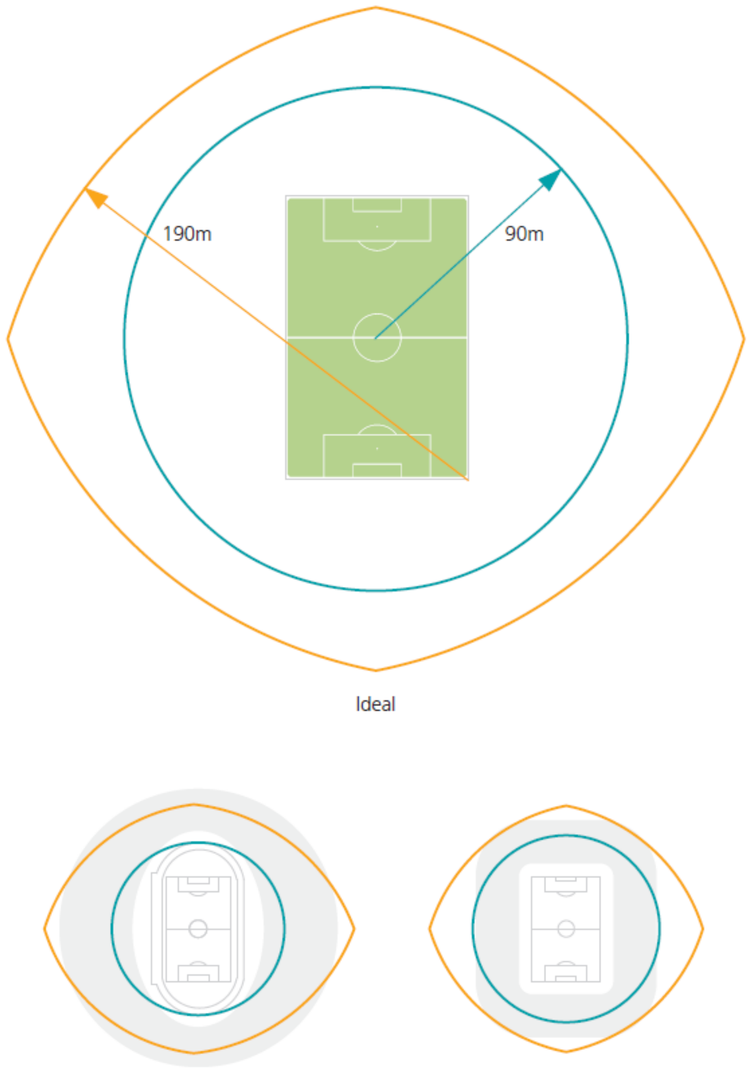


Fig.14 Spectators' distance

[6] (Geraint, Sheard and Vickery 2007, 128)

3.6 Sightlines

Viewing distances was the first step in determining the shape of the stadium but in order to transform this into a three-dimensional plan the viewing angles need to be determined. Like the distances, optimal angles, or sightlines, can be determined mathematically. The term sightline 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".7 Optimal riser height can be calculated using the equation below, which takes into account the sightline and other variables in the stadium design.

$$N = \frac{(R + C)(D + T)}{D} - R$$

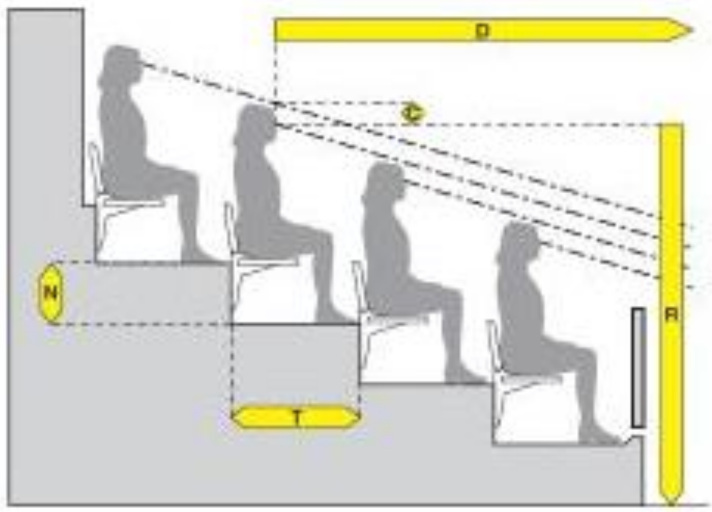


Fig.15 Calculate Optimal Riser Height

Figure 12 defines all the variables that affect the riser height, N. C is the sightline values; R is the height between the eye and the 'point of focus' on the playing field; D is the distance from the eye to the 'point of focus' on the playing field; and T is the depth of the seating row.

While this method seems simple, in order for it to be accurate and actually influence the design it needs to be calculated many times over for each individual row. For this reason computer programs that test different scenarios to find the optimal solution are often used by top design firms. After determining the riser height, designers need to check the rake, or slope of the seating. A general rule is to limit the rake to 34 degrees, which is the approximate angle of stairs, because anything steeper could make spectators feel a sense of vertigo as they descend.

[7] (Geraint, Sheard and Vickery 2007, 132)

4. Structural Systems for the Roof

4.1 Post and Beam Structure

Post and Beam is the simplest structural system and is comprised of two elements: columns and beams. Columns are set up in a grid pattern and large beams, called girders, connect the columns. Smaller beams are then placed between girders and support the roof structure above.
Compared to more complex structural system, the Post and Beam system is cheaper and simpler to construct. A major downfall of using a Post and Beam structure is that it limits the geometry of the stadium to a shape with linear edges. Lastly, depending where columns are placed, they could cause obstruction to spectator views.

4.2 Goal Post Structure

A Goal Post structure is very similar to a Post and Beam structure, except it only has columns at the perimeter. This means that the each section of the roof is supported by a single girder.
Because the girders are much longer, they are also much deeper; typically, the girder depth is about one twelfth of the length. Like Post and Beam, stadiums built with Goal Post structure are limited to a rectangular shape. Another disadvantage to this system is that regular inspection and maintenance in necessary since the entire roof is dependent on a single girder. An example of the Goal Post structure is Ibrox Stadium, seen below in Figure 13.

Fig.16 Ibrox Stadium

4.3 Cantilever Structure

Cantilevered roof structures are supported at the exterior end and hang freely over the stands. Like a simple cantilevered beam, the load is carried to the supported edge where it is resisted by moment and shear stress. A major benefit of a cantilevered roof is the unobstructed views it guarantees spectators. Unlike the Goal Post system, cantilevered roofs are not restricted to rectangular shapes; in fact, they are often incorporated into circular and elliptical stadiums.
Cantilevered roofs can cover any length and is generally kept to depths around 45m. Because of the dramatic look cantilevered roofs have, architects often incorporate them as a highlight in the design. The structure supporting the hanging roof is also often exposed as a way of broadcasting the design. One example of a cantilevered roof can be seen at the University of Washington's Husky Stadium in Seattle (Figure 14). These roofs have unique acoustics that tend to trap the noise of the fans below making for some of the loudest and most intimidating college football games in the country.

Fig.17 Husky Stadium

Like any other structural system, cantilevered roofs do have their disadvantages. One issue many designers have is the cost factor; when the depth of the cantilever becomes too large the cost of the structural members becomes very expensive.

4.4 Concrete Shell Structure

Concrete, as pointed out earlier, is a plastic material that can be shaped into various curves and geometric forms. Since engineering advancements have increased the strength of concrete, it has been used to create concrete shells, which are thin surface structures that curve in one or two directions. The strength of these shells comes from the geometric shape and not the thickness of the material. This concept can easily be tested with a sheet of paper: if a sheet of paper is held at its end it immediately bends down, but if it is held with a slight upward curvature it can support additional weight.

Fig.18 Zarzuela Hippodrome

The example of the covering is Zarzuela Hippodrome (Figure 15), a racecourse in Madrid, Spain.
Eduardo Torroja designed this roof in the form of a hyperboloid of revolution. It supports a 43 ft cantilevered span and the concrete is only 14 cm thick at the edges. Concrete shell roofs are most notable for their aesthetics and ability to push the envelope of structural engineering. To help enhance their visual elegance, shell structures often have selffinished surfaces on the top and bottom.

4.5 Compression/Tension Ring

A roof structure suitable only for circular/elliptical stadiums is the compression/tension ring system. Such a roof consists of a compression ring around the exterior and a tension ring on the inside, creating a doughnut shape. These two rings are connected with radial members that carry the roof covering. Roofs using this structural system can span large depths with ease, such as Vienna Prater Stadium at 48 m and the roof added to the Olympic Stadium in Rome (Figure 16) which is 52 m. This roof type also achieves a weightless appearance from both the inside and outside and doesn't interfere with the designers' attempts at making beautiful architecture. An additional benefit of the compression/tension ring system is that it can be used to add a roof to an existing stadium without taking away from the original design, as seen with the Olympic Stadium in Rome which had the roof added in 1990. As with all properly designed roofs, this system provides a completely column-free interior with no obstructions whatsoever to the spectators.

Fig.19 Olympic Stadium in Rome

Modem stadiums have modified the simple compression/tension ring system to achieve more unique designs. This has been done by adding fabric as the roof structure, creating various geometries with the radial members, and by placing the rings out of plane with one another so three-dimensional roofs are created.

4.6 Cable Net Structure

Cable net structures consist of two parts: the structural three-dimensional steel net made of steel cables and the fabric covering. The covering tends to be some form of plastic: acrylic, PVC, or polycarbonate. Glass and other fabrics have also been used since material scientists invented new materials that can better withstand the forces.

Munich's Olympic Stadium complex has the world's largest tent-like roof with cable net structure (Figure 17). Covering the main stadium, gymnastic arena, indoor pool, and connecting paths, the translucent Plexiglas roof system covers a total of 74,800 square meters.

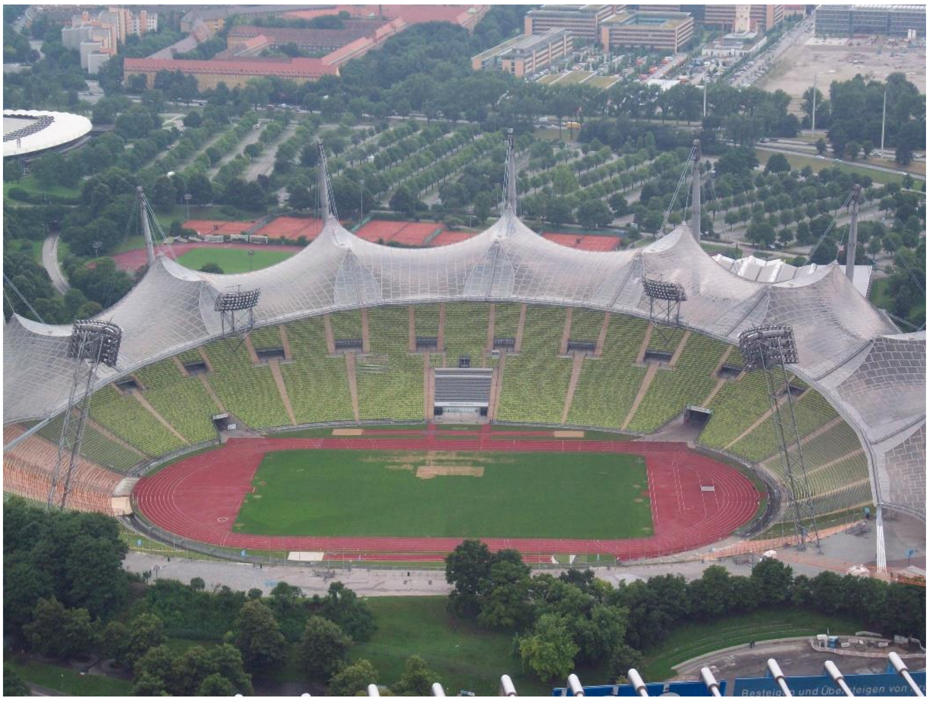


Fig.20 Munich Olympic Games Tent

Each section of the roof is supported by either cable-stayed towers or cable trusses. The stadium roof is supported by eight cable-stayed towers that reach 76 m and tensioned by a curved cable.
Gunther Behnisch, a German Architect, and Frei Otto, a German Architect and structural engineer, designed this roof structure with the intension of imitating the Alps and create a lighter feeling to counteract the Berlin Olympics.

4.7 Membrane Structure

Unlike the cable net structure, the roof covering of a membrane structure provides both the structure and the enclosure. This system "provides the opportunity to design a beautiful form, with large uncluttered spans thus creating exceptional lighting characteristics often not achievable with conventional materials and systems"[8]. Two of the most popular material choices for the membrane are PVC-coated polyester fabric and Teflon-coated glass fiber fabric (PTFE-coated glass fiber fabric). The later is the more expensive option but has a much longer lifespan. The PVC coating tends to get sticky with time and requires frequent cleaning while Teflon provides a somewhat self-cleaning surface for the second material. Some countries have banned the use of PTFE-coated glass fiber because it produces toxic fumes if a fire occurs; for this reason expert designers and fire engineering is required for such roof systems.

A major benefit to membrane structures is that they can be applied to any geometry and do not dictate the shape of the stadium. They also provide a more airy and open appearance because there is no need for a dense skeleton of steel below the fabric. Depending on the material choice, there are also natural and artificial light benefits that come with membrane structure. Given a translucent material, typical daylight transmission is between 9% and 18%, thereby eliminating the need for artificial lighting.

Fig.21 Olympiyskiy Stadium

[8] (Structurflex 2010)

A stadium equipped with a membrane structure is Olympiyskiy Stadium in Kiev, Ukraine (Figure 18). Originally built for the 1989 Summer Olympics, the stadium was renovated in 2011 for the final soccer match of Euro 2012. A s part of the renovation a 48,000 square meter membrane roof was added to cover all the stadium seats. The membrane is a glass cloth coated with Teflon on both sides and has a 12% transparency. Weighing only 1 kg per square meter, the membrane offers strength of up to 13 tons per square meter.[9]

[9] (Membrane Roofing of Olimpiysky Stadium in Kiev 2012)

5. Prishtina, Kosovo

5.1 A piece of history

Prishtina is the capital and the largest city of Kosovo, it and its suburbs have a total population of over 400,000. It is the administrative, economical, and cultural center of Kosovo.[10]

Fig.22 Kosovo map

The area in and around Prishtina has been inhabited for nearly 10,000 years. During the Roman period, Prishtina was part of the province of Dardania and nearby Ulpiana was considered one of the most important Roman cities in the Balkans. Prishtina developed as an important mining and trading center thanks to its proximity to the rich mining town of Novo Brdo, and due to its position on the Balkan trade routes. The Old Town stretching out between the Vellusha and Prishtevka rivers, which are both

[10] http://ask.rks-gov.net/en/kosovo-agency-of-statistics

covered over today, became an important crafts and trade center. Prishtina was famous for its annual trade fairs (panair) and its goat hide and goat hair articles. The first mosque was constructed in the late 14th century while still under Serbian rule. In the early Ottoman era, Islam was an urban phenomenon and only spread slowly with increasing urbanisation. Economic life was controlled by the guild system (esnafs) with the tanners' or the bakers' guild controlling prices limiting unfair competition and acting as banks for their members.

Fig.23 View of Prishtina

In 1912, Prishtina came under Serb rule, then briefly under Bulgarian occupation before reverting back to what then became the 'First Yugoslavia. The inter-war period saw the first exodus of Prishtina's Ottomanised (Turkish-speaking) population. Under German occupation in the 1940s, a large part of Prishtina's already small Jewish community was deported. The few surviving families eventually left for Israel in 1949. As a result of these wars and forced migration, Prishtina's population dropped to 9,631 inhabitants.[11]

The communist decision to make Prishtina the capital of Kosovo in 1947 ushered in a period of rapid development and outright destruction.

[11] Vgl. Bradt: Warrander & Knaus 2007, 86-88.

5.2 The development of football in Kosovo

The first ball in Kosovo was brought by a student from Grenoble in 1919 but it is said that in 1914 football was played by Austro-Hungarians who served in Kosovo at that time. Football in Kosovo was played very early but the first football clubs were formed in 1922 in Gjakova and FC Prishtina in Prishtina and later on there were formed other clubs. Competitions were not regular because of unstable situation prevailing at that time.

Fig. 24 Prishtina vs Rijeka, 1984

This period begins after the Second World War from 1945 until 1991. At this time the football in Yugoslavia makes a rapid progress and together with it also the Kosovar Football when the Football Federation of Kosovo was formed in 1946 and associated as a branch of Yugoslav Football Federationin 1948. In the first Yugoslav league, FC Prishtina was distinguished the most and for one year, FC Trepça was a member of that first Yugoslav league. The second state league continuously used to have 3 to 4 Kosovar football clubs. Within these two Federal leagues, there were competing Slovenia, Croatia, Bosnia & Herzegovina, Serbia, Montenegro, Vojvodina, Kosovo and Macedonia, all of them in a unique league.

Kosovo used to have its own first league, the first one from which directly played in the second Yugoslav league. It used to have also its own second and third league.

Kosovo at that time had its own Football Federation associated to Football Federation of Yugoslavia (FSJ), representatives in Assembly of FSJ, federal referees and many employees of the highest level.

In the time of Yugoslav disintegration, exactly in 1991, the Kosovar football was in its zenith and continuously used to have 4 to 5 clubs in the first two Federal leagues. However, deterioration of the political situation reflected also in the sports. It was almost impossible to play football notably in Kosovo. Because of that in August 1991 the best Kosovar football club Prishtina with a bright tradition in the first Yugoslav League abandons the Yugoslav professional league because there were no more guarantees for the security of players and other officials and neither for the Kosovar funs.

The first game was played in the Flamurtari stadium in Prishtina on 13 September 1991, which marked the start of the first independent championship in Kosovo. The first league counted 20 teams while other leagues depending on regions but playing on only improvised fields, in very difficult conditions.

Throughout the football stadiums in Kosovo, then there used to play only 8% of the total population, Serbs. Tortures, beatings were present in any lap but football in Kosovo survived and was played until January 1998 when the Serbian military campaign began against the civil population of Kosovo. Also during this period (1991-1998) in Kosovo, football was played according to UEFA and FIFA rules and any amendment of their rules immediately applied in the system of our competitions.

Another Stage of football in Kosovo began immediately after the end of war in Kosovo in 1999 when the Football Federation of Kosovo was reorganized. Its Assembly was constituted, its Statute was passed, clubs were confirmed, Commissions, associations were appointed etc. The First League counted 18 teams, Second League in two groups with 14 teams each.

From 1991 to date, it was played continuously under the UEFA and FIFA rules.

Presently, in the new 2009/2010 season, Kosovo has its Super League with 12 teams, First League with 16 teams, Second League – in two groups with 15 teams each League, Women League, Futsal Competition in four levels, Juniors League and all age's groups who compete according to FIFA and UEFA system.[12]

[12] http://www.ffk-kosova.com/en/?page_id=4516

5.3 The Location

The location, which the Government of Kosovo has determinated for construction of the new stadium of Kosovo is located in the west of Prishtina.

Fig. 25 the border map of Prishtina

The stadium is situated in a location which is sufficiently large to provide spacious and safe external public circulation/activity areas and marshalling space for service vehicles and functions. The Stadium is located in the area of 23.000 m^2 which is an area that completes all requirements that are necessary for a Stadium.

Large sites reduce the probability that the site may have to be abandoned in the long term, or even in the short term, because of its inability to accommodate some unforeseen development requirement. Larger sites also increase the possibility of providing adequate on-site parking areas – a requirement which will probably remain for the foreseeable future.

As a site becomes more suburban and isolated from public transport, it will have to become larger to accommodate the required additional parking. In this situation, convenient and multiple access to major roads and motorways is essential.

Fig. 16 Black and white plan of Prishtina

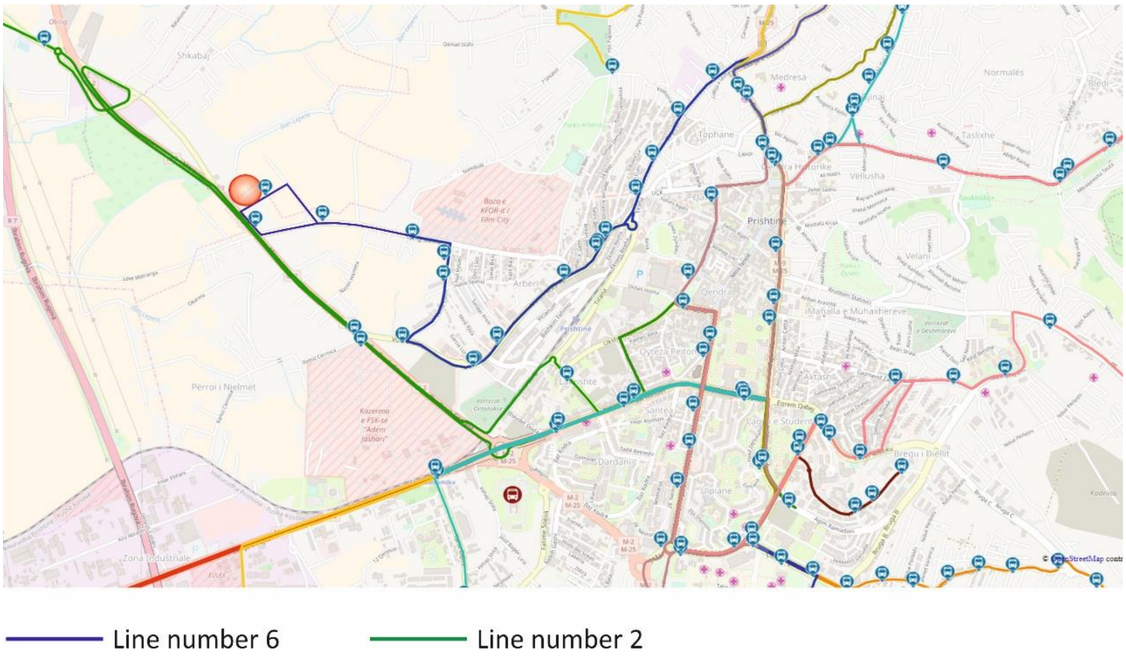
5.4 Traffic connections

At first sight, the location offers an ideal transport connection in every aspect. The access to this location can be made from two roads leading from the city of Pristina. One which is the higher categories of road, leading to the city of Mitrovica as well as the second low street link directly to the city.

However, just the seemingly good transport links is a problem of the construction site. The traffic areas of the surrounding streets are already brought to the limit by the traffic volume that is now available. According to City und transport development Prishtina, the traffic situation in this area must be included in every project that could increase traffic. These include, inter alia, extended traffic areas, improved entries and exits. Furthermore, the concept should pay attention to the greatest possible reduction of traffic.

Public transport

The offer of public transport connections is very good. Bus line 6 connects the construction area directly. Furthermore, the bus line 2 is not far away and can be reached quickly on foot. There are further connections with the regional bus lines which connect the city of Prishtina with city of Mitrovica and goes around the location.

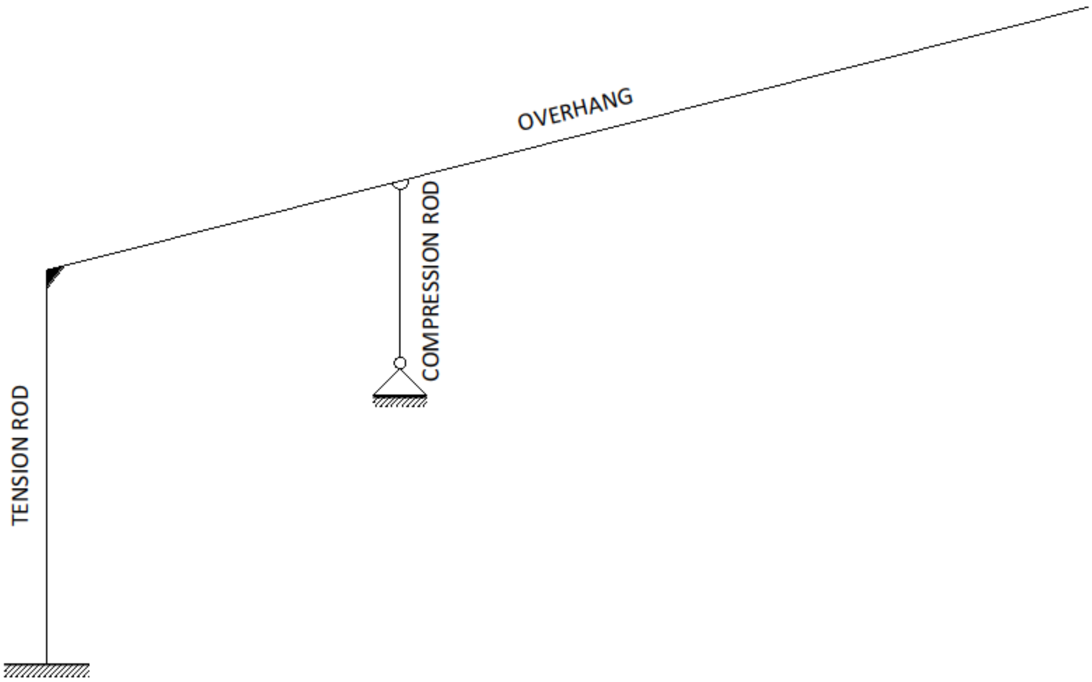


The distance between the location and the center of the city is approximately 4 km, this means that the people can reach the location not only with car but they can reach it by bike and why not by walking.

6. Structure

6.1 Static system

A single-span beam with a projection of 27m, which is rigidly connected to a tension rod and hinged to a compression rod. The tension rod is clamped to the ground and the pressure rod hinged to concrete construction.
Maximum clamping length between the beams is 15,4m and the minimum clamping length is 6.10m

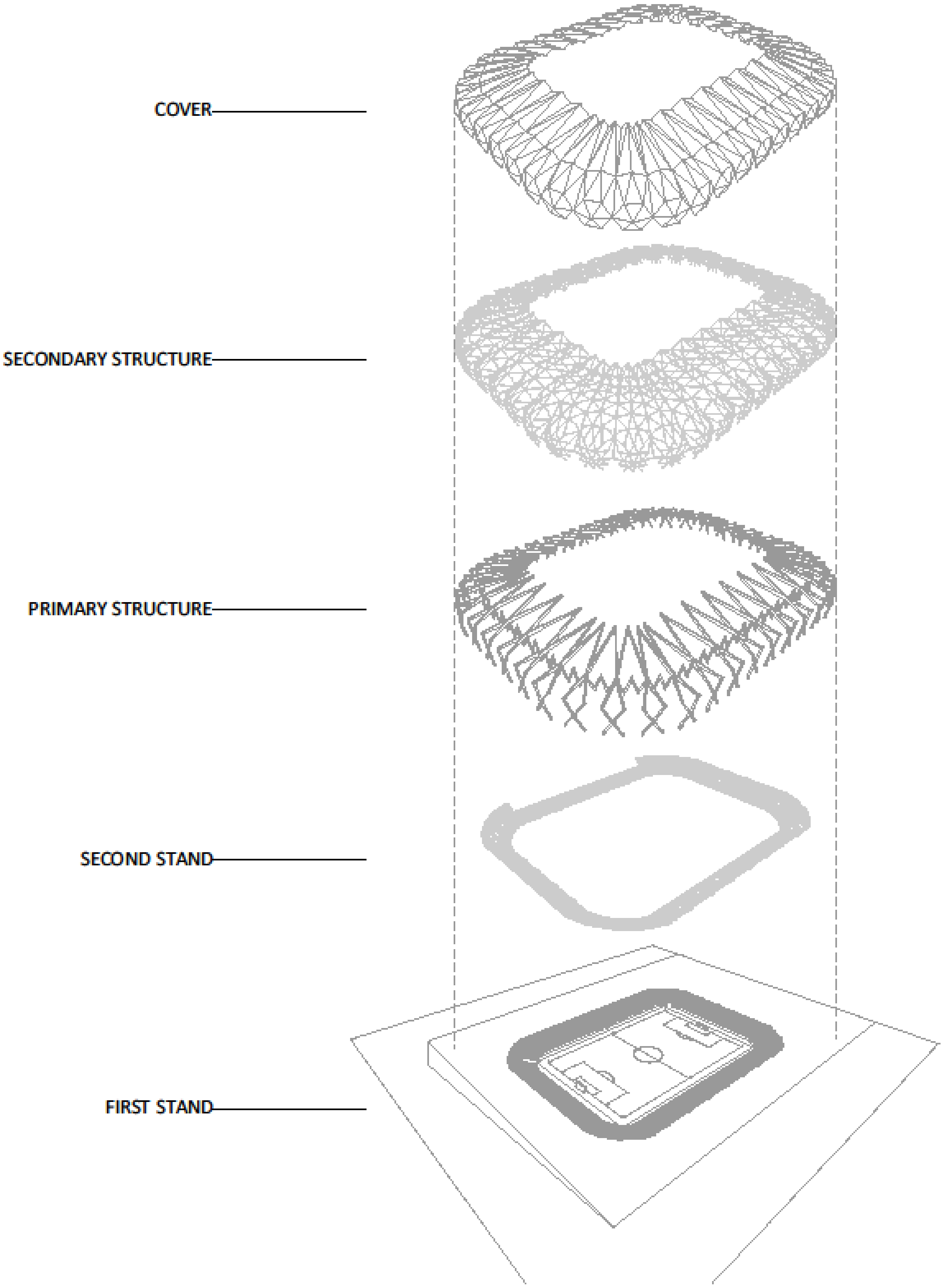


6.2 Construction

The roof construction of the stadium forms the conclusion of a system with a clear design language. The roof gives the arena by its formulation a certain peace and ease and summarizes the stadium complex into a single unit.

The stadium consists of a primary tract structure and a secondary structure of steel beams that have a rectangle profile and variable height. Variable height affects the reduction of the weight and the aesthetics of the construction.
The pillars, tension and compression rods have a dimension of 60/60 cm. The secondary structure consists of round steel profiles with a diameter of 30 cm and 20 cm. The stadium cover is partly from glass and partly from translucent tissue.

The arrangement of the beams and columns is divided into a system that repeats around the hall. There are always 4 radially arranged beams between a pair of beams forming the exits from Stadium.
The interiors walls in the 1st floor contribute to torsion bracing and the floor slab forms a stiffening level for the supports and beams, the position of the assembled-on site precast parts is fixed immovably and stable.
The beams have a 14-degree slope, which prevents water accumulation from rainfall.


COVER
SECONDARY STRUCTURE
PRIMARY STRUCTURE
SECOND STAND
FIRST STAND

6.3 Static analyse

For the analysis and pre-designing of the static system the steel construction of the roof has been visualized and designed in the Finite element software RFem.

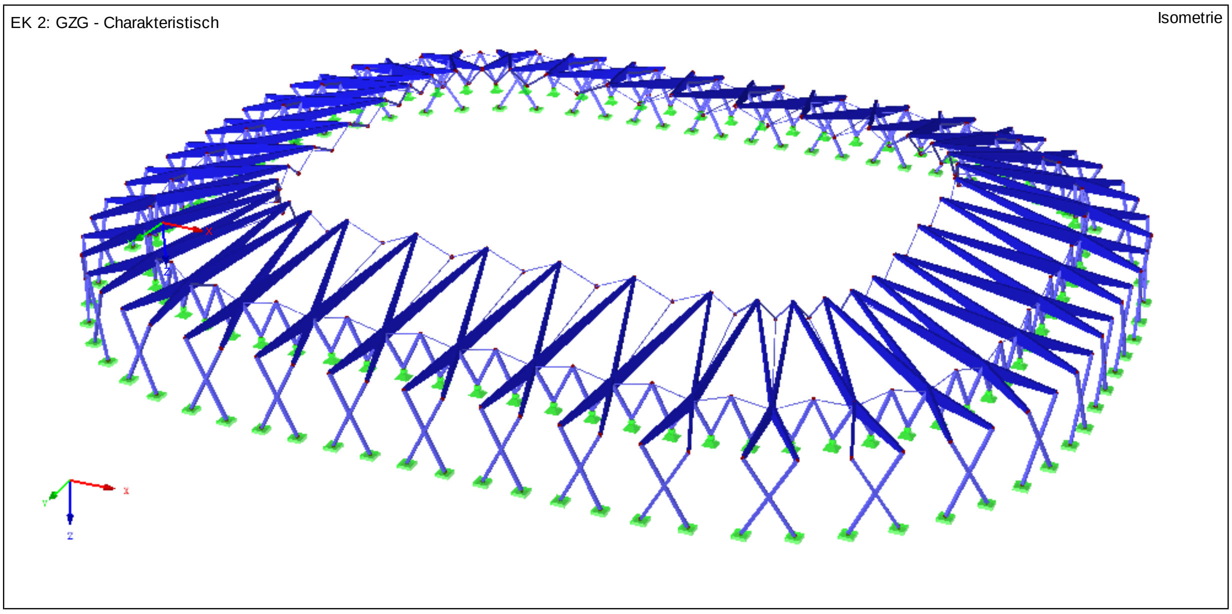


Fig. 27 Overview out of RFem

- Loading

Type	Characteristic value	Shape function	Partial safety factor γ
Self-weight	$\rho_{steel} = 7850$ kg/m³	-	$\gamma_G = 1{,}35$
Snow	$s_k = 2{,}0$ kN/m²	$\mu_0 = 0{,}8$ $\mu_2 = 1{,}6$	$\gamma_S = 1{,}5$
Wind	$q_{b,0} = 0{,}26$ kN²	$c_{p(z)} = 0{,}23$ $c_{pe,max} = 0{,}8$ $c_{pe,min} = -1{,}5$	$\gamma_W = 1{,}5$

The self-weigt of the construction is considered automatically in the software.
The snow- and wind loads has been distributed as an assumption for the pre-dimensioning.
This leads to the maximal distributed characteristic loads of:

Snow: sk = 2,4 kN/m²
Wind pressure: $w_k^+ = 0{,}1$ kN/m²
Wind suction: $w_k^- = 0{,}35$ kN/m²

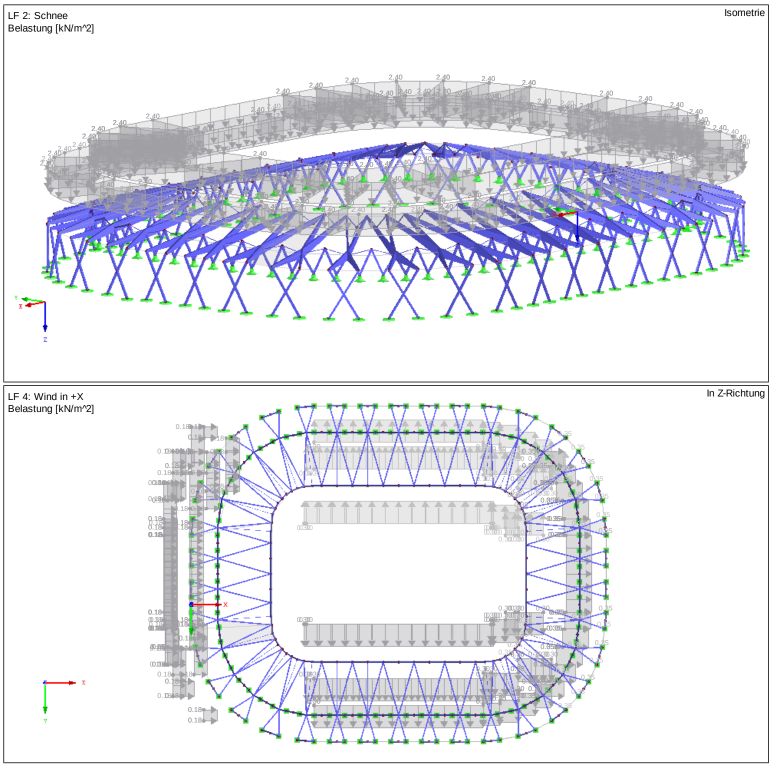


Fig. 28 Distributed snow- and windload

- Material:
  All parts of the steel construction should have a material class of:
  S235 J0
  f_{yk} = 235 N/mm²
  ductility: 27J at 0°C
  Execution class: EXC 3a

- Cross Sections
  The cross sections of the cantilever beams and the columns are welted rectangular hollow profiles which are torsion stiff to avoid stability problems like lateral torsional buckling.
  The cross sections are of class 3. So, they had to be protected against local buckling with welted bracings.

- Design
  a) Ultimate Limit State

  Internal Forces:

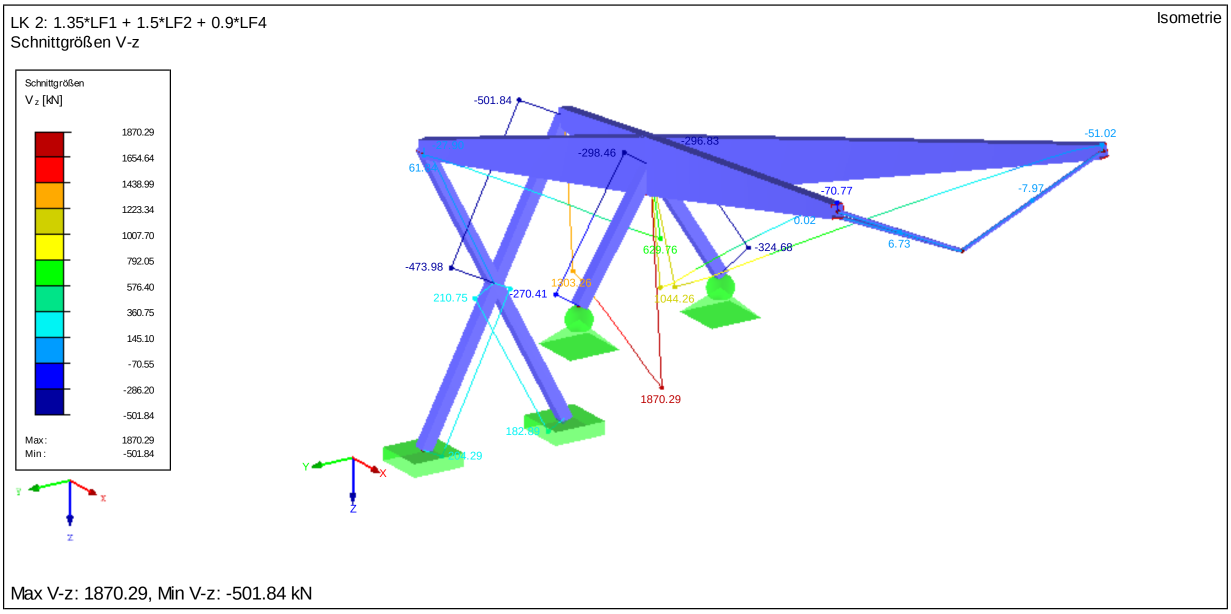


Fig. 29 shear force

The maximal shear force in the cantilever beam is at the front column. There had to be bracings to initiate the force from the column in the beam.

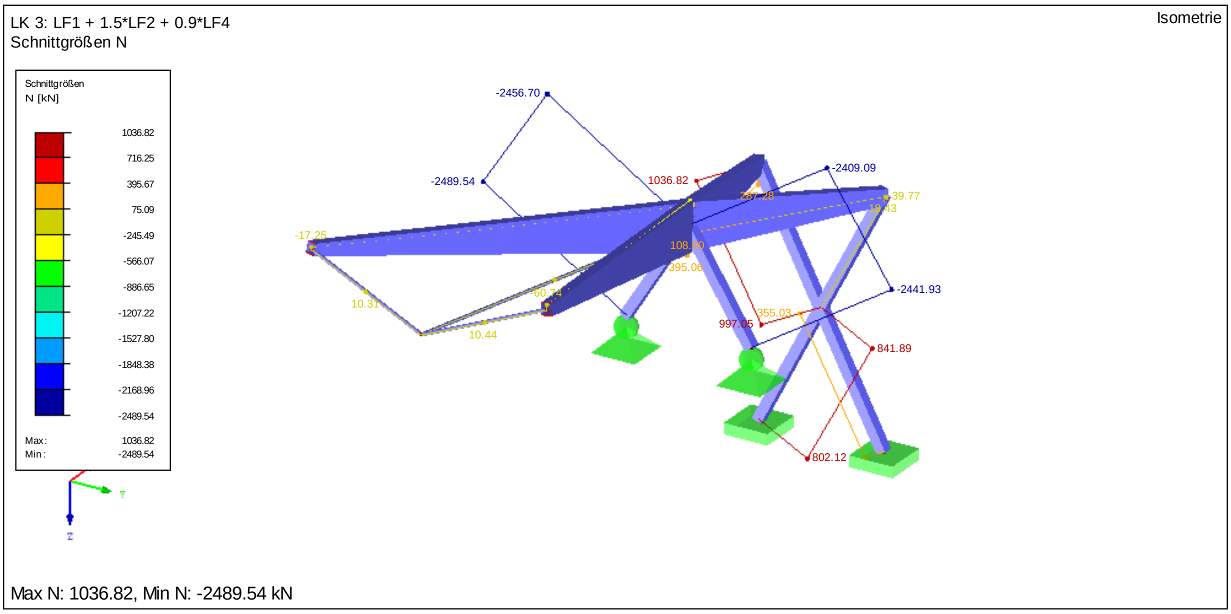


Fig. 30 Normal force

The maximum of the normal pressure is in the front column (compression rod), the maximum of the tensile force in the back column (tension rod)

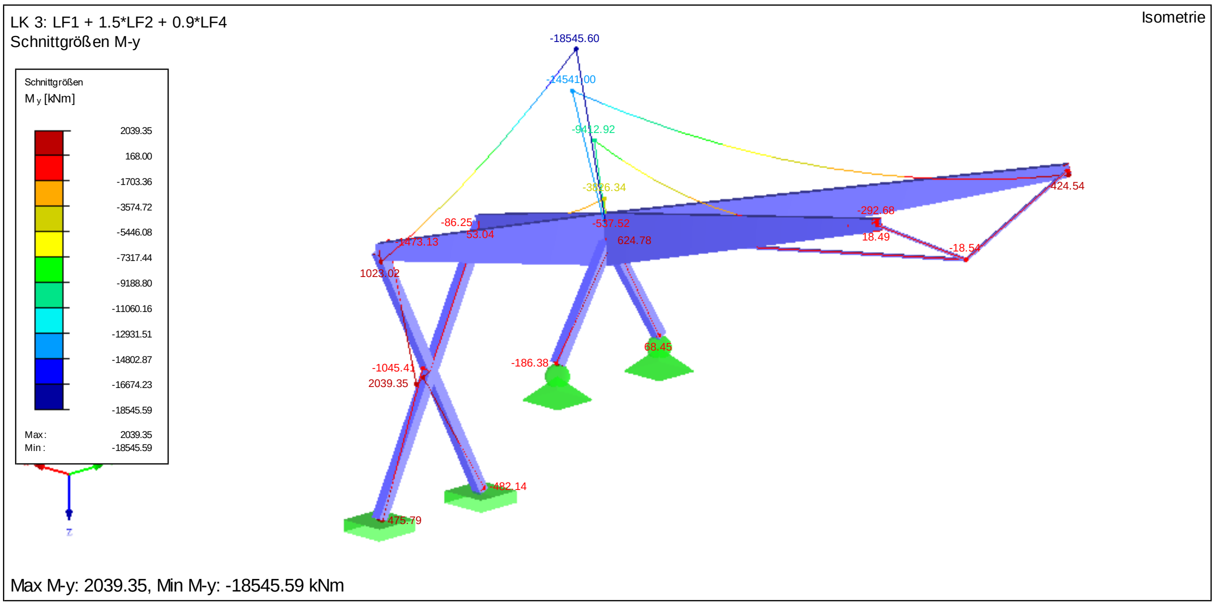


Fig. 31 Bending moment

The maximum of the bending moment is expectedly the hogging moment over the front column. The cross section at this point is 2,8m high to cover the big forces.

The design of the cantilever beams considering all forces from above leads to the cross section of the most loaded point (over the front column) of 2800mm Hight and 600mm width, which leads to a utilization factor of η = 0.92 (92%). In the ULS combination al partial safety factors are considered.

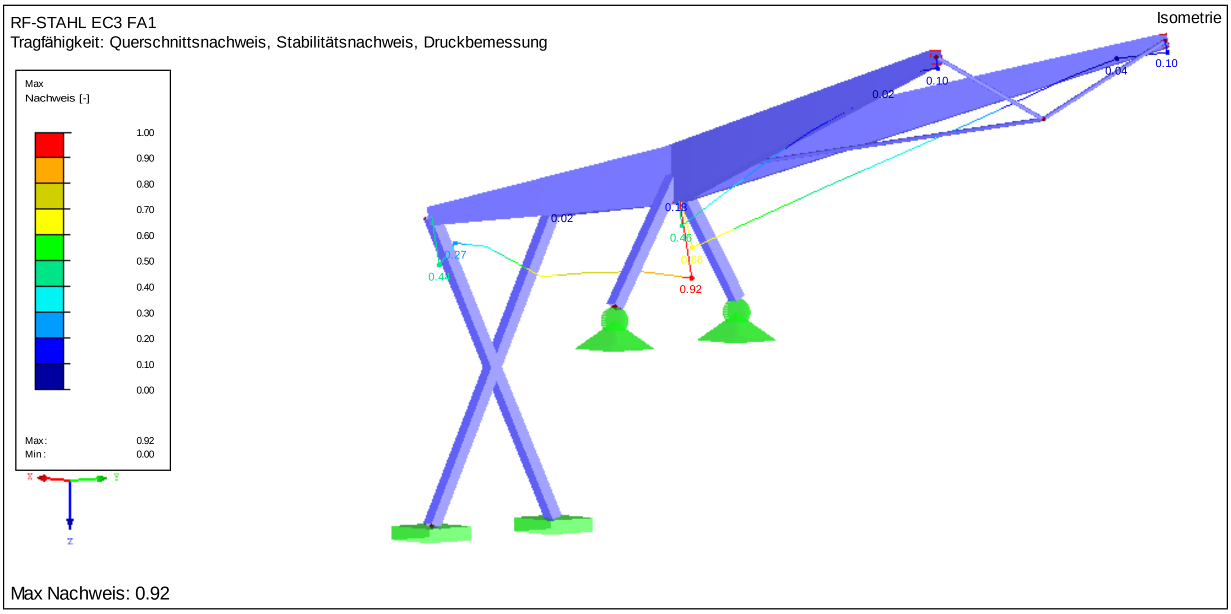


Fig. 32 Utilization factor

b) Serviceability Limit State

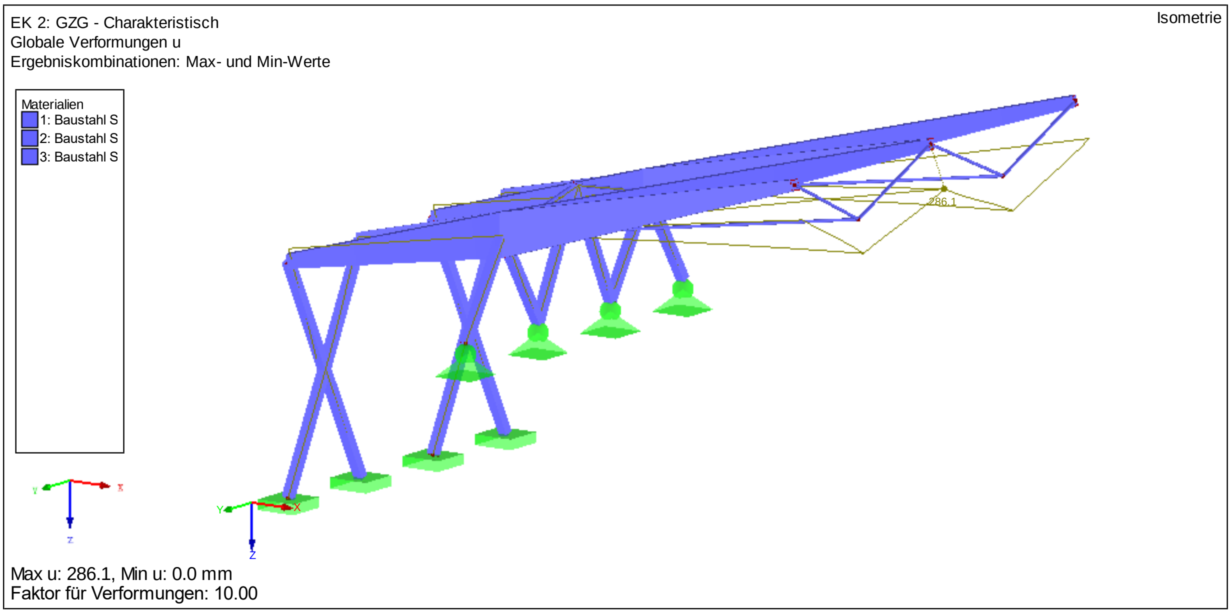


Fig. 33 Utilization factor

The maximum of the deformation in vertical direction is 286 mm. The suggested deformation for cantilever beam according to Eurocode 3 is l/150.

L = 27m => 27000/150 = 180mm

The deformation passes over the suggested value about 50%. To handle it the length of the beam should be reduced.

7. The concept

7.1 Design concept

The basic goal of the design is the creation of a multifunctional stadium complex with a simple and clear design language. At the same time, the arena is to meet the requirements of modern football sports and to fill viewer capacity.
Above all, the new development concept forms a very fundamental aspect of the design. A distribution level around stadium stands allows for easy and flexible access to the sectors.

The clear emphasis on the entrance areas through large, massive supports and openings creates important clues for orientation and, at the same time, ensures clearly defined assignment of the spectators.

In addition, reorganization and expansion of the substandard space will enable improved and smooth use of the various areas of the press, VIP, business, gambling, academia, administration or infrastructure. These additional uses create a multifunctionality of the stadium complex and provide the basis for flexible use of the facility around the Stadium.

In the context of a future-oriented urban development and a fictive project, I would like to assume that in the hypothetical case of an actualization of the project, this development would give way. This project will be essential for a rational urban design in this area.

7.2 Staircase design

A key factor in ensuring stadium safety is the development of sectors and, subsequently, seating. A coordinated orientation and structured allocation of crowds ensure a smooth and uniform filling of the stadium and thus prevent conflicts even before kick-off. Through a new development level at the level of the first rank there is the possibility to reach all sectors via a tour around the stadium in an easy way. At the same time, the massive supports create clues for a simple orientation and mark the clearly defined entrances to the respective sectors.

Spectators are able to move up or down the stadium bowl in order to get to and from their seats. The staircases are distributed in equal proportion around the stadium in order to adequately serve every section of the bowl, allowing easy access to the upper tiers and vomitories. They are correctly dimensioned to fully and safely handle the volume and flow of spectators allocated to a given section of the stadium. The dimensioning of the treads and the handrails are fully complying with all national and international safety regulations. A separate entrance and reception area it's available for those VIPs arriving on foot. The VIP car park and entrance has a separate staircases and lifts that provide direct access to the VIP lounge area and enclosure.

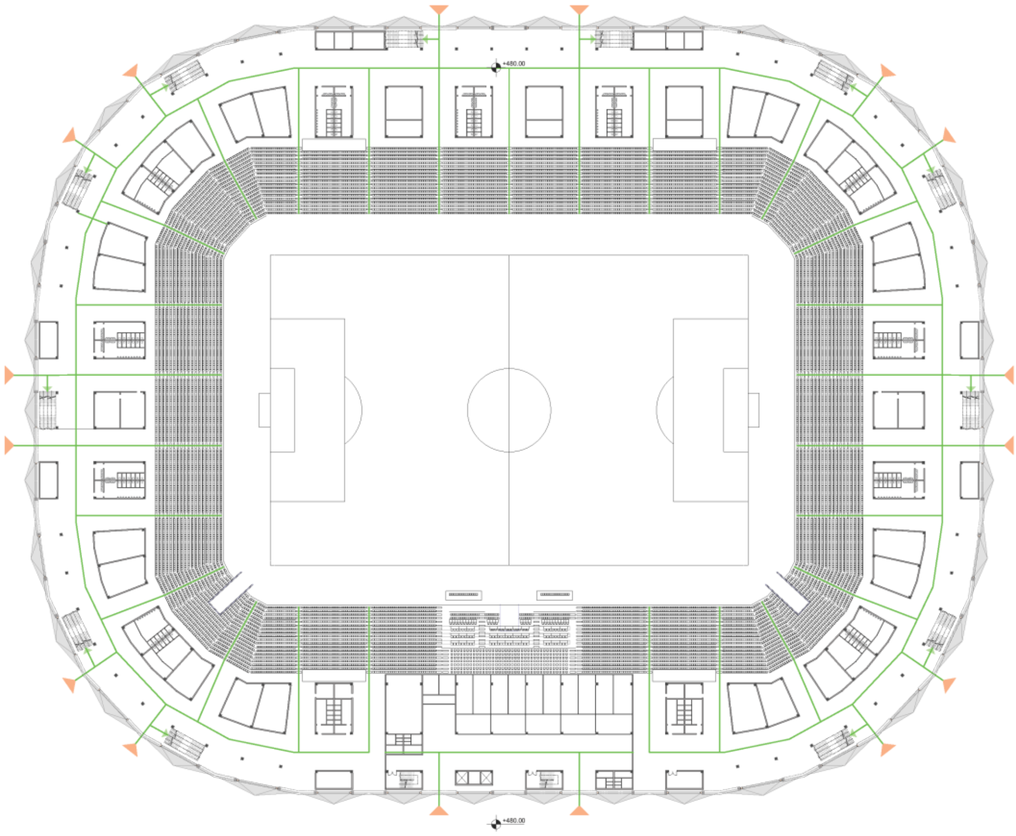
In order to prevent conflicts with the local fans, the visitors reach their seats via a separate entrance, whereby an alternative access possibility on the same level is possible. Internal advances to the second ranks within the sectors complete a clearly defined and structured development concept.

7.3 Movements lines (evacuation)

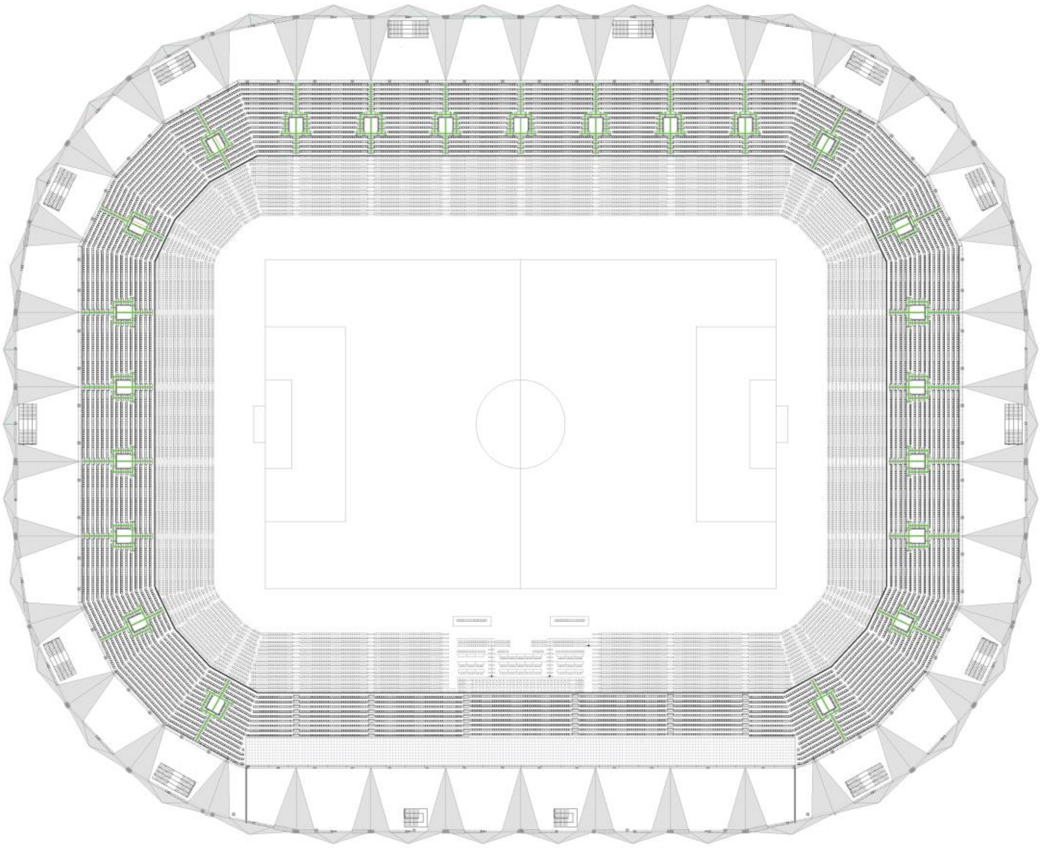
A much bigger challenge than the smooth filling of a stadium it is the emptying of it. Large crowds want to leave the arena at the same time and in the short time. Therefore, it is absolutely necessary to provide sufficient outputs.

Adequately sized up and down ranks, as well as access routes inside and outside the arena complete an escape route concept, which ensures a smooth and above all safe emptying in emergencies and after the final whistle or the end of events.

The concourses are the passages inside the stadium through which spectators get from the main entrance to their seats. The concourse areas are wide enough to allow a smooth flow of people before, during and after the match and also, of course, allow for the safe evacuation of the stadium in the event of an emergency. Even at times where crowd flow is at its peak (i.e. before and after the match and during the half-time interval), spectators able to circulate freely within the concourse areas, so that they can access the general exits, staircases, concessions and welfare facilities with minimum fuss.



Level 01: Movements lines



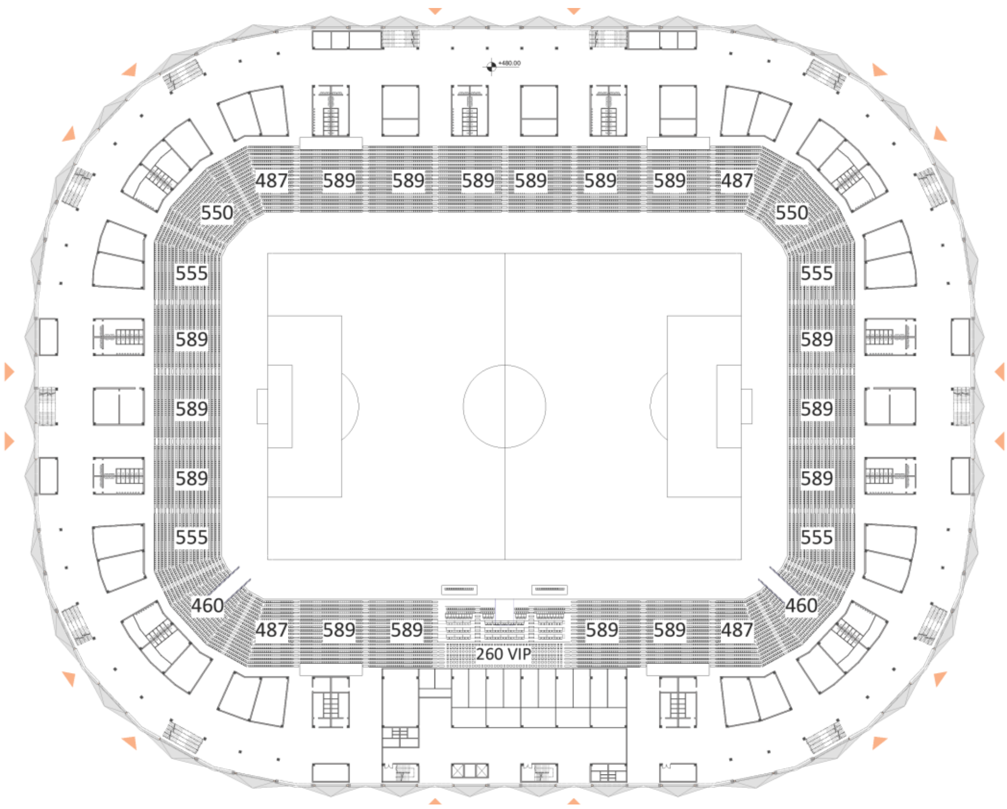
Level 02: Movements lines

7.4 Stadium capacity

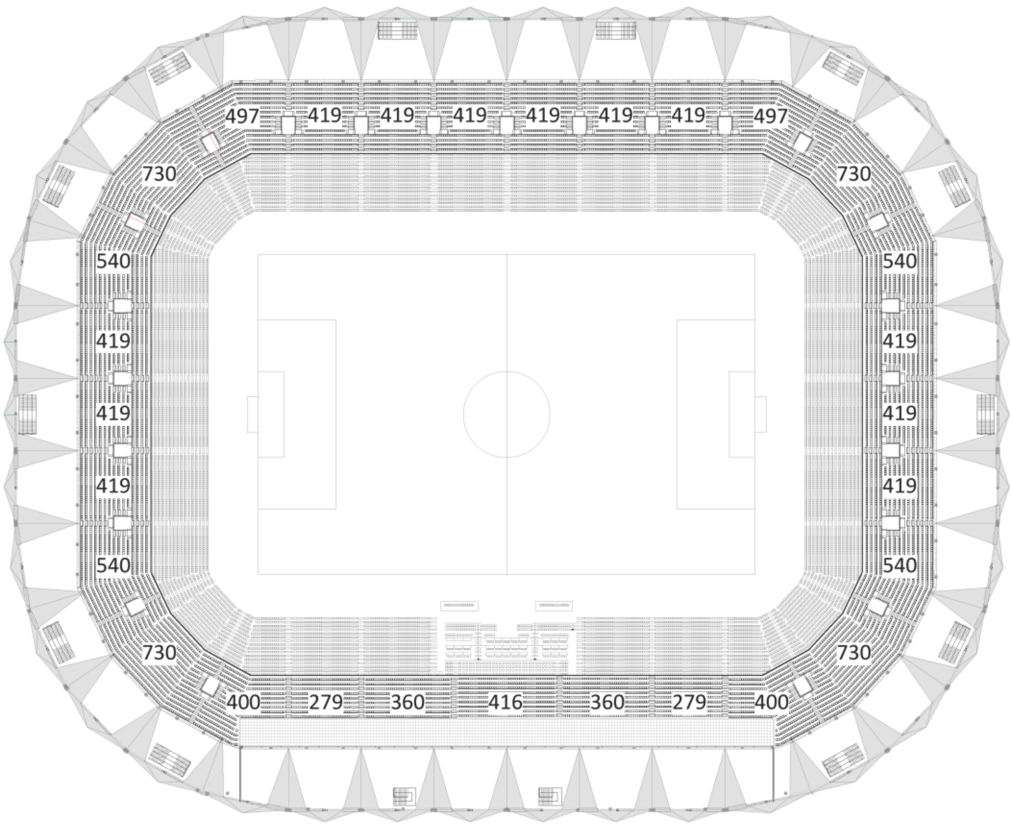
Capacity is, of course, one of the primary considerations for any stadium design project. The stadium needs to be big enough to accommodate all those fans who wish to attend matches, yet not so big that there are lots of empty seats, as this will detract from the visual impact and overall atmosphere. There is no set formula for determining the optimal capacity. This will depend on a variety of factors, including the status and popularity of the club/national team, the location, and any plans for alternative uses of the venue.

Apart from various other uses such as concerts or public viewing events, this stadium capacity description deals exclusively with the utilization possibilities for football matches. Of course, by sharing the lawn or other areas of the stadium, it would be possible to accommodate significantly more viewers, but for the main use as a football stadium these scenarios are irrelevant. Nevertheless, on match days, the arena may have different requirements, and capacity differentiation generally distinguishes between national matches and international UEFA or FIFA competitions.

international games are not allowed in international competitions due to the high security requirements of UEFA and FIFA. These restrictions mean that the stadium can accommodate around 28,000 spectators, placing it in category 3 of the UEFA Classifications.



Level 01: Stadium capacity

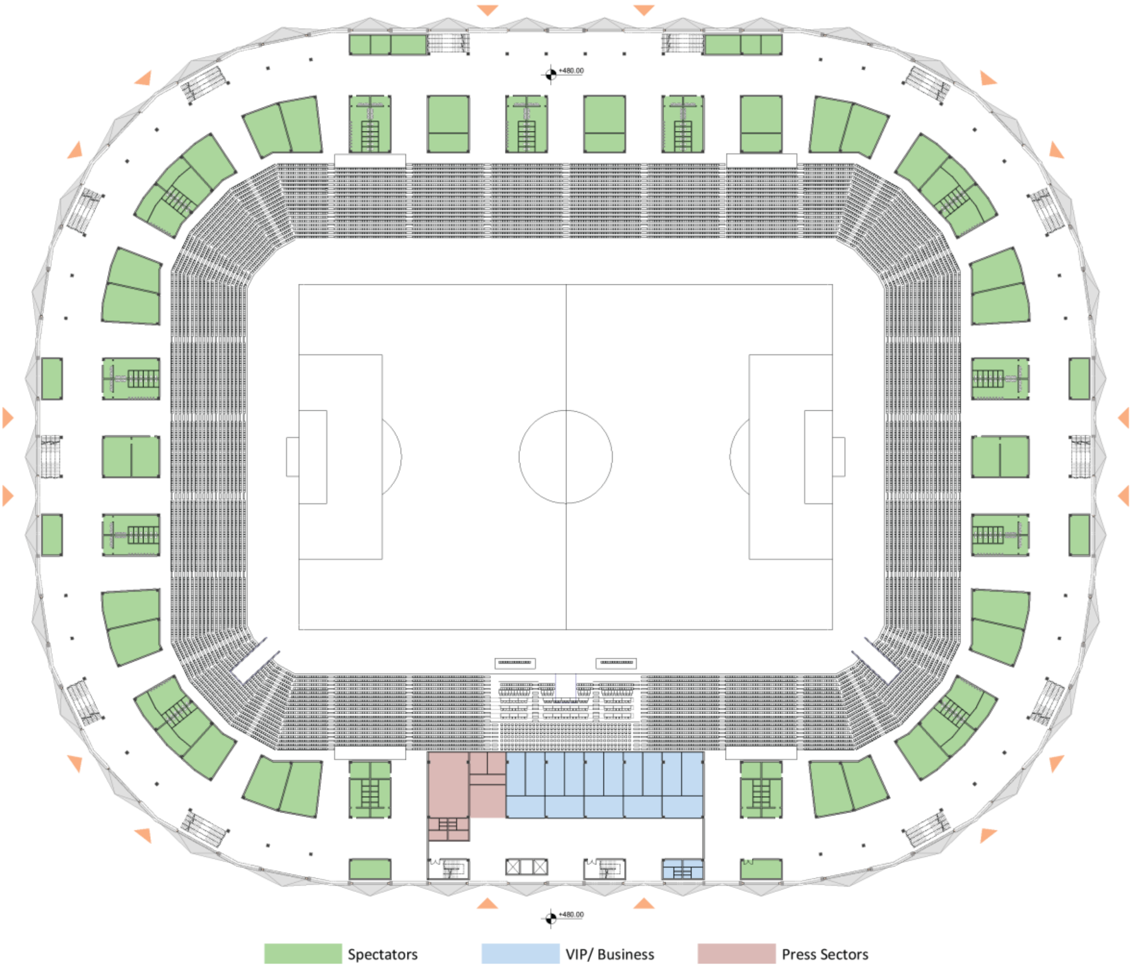


Level 02: Stadium capacity

- Total capacity: 28 000
- VIP/Business Sectors: 1690
- Accessibility places: 60
- Press: 50 Tables (150 seats)

7.5 Zoning

Today, modern multi-functional stadium buildings include many differently used areas that need to be coordinated. In particular, interfaces and transitional areas such as flash or mixed zones between the press area and the players' cabins require a controlled structuring and assignment. Due to the different requirements of the differentiated user groups, however, it is sometimes necessary to ensure clear separation between the individual areas. For example, VIPs and sponsors need separate entrances and lounges, while game management and security monitoring must always have the ability to gain insight and access to all sectors.



Level 01: Zoning

Level 02: Zoning

7.6 Ground floor

Ground floor zone, above all, the right allocation and coordination of the different areas plays an important role, since at this level very many access routes superimpose and intersect, separate entrances for players and supervisors. the press. VIPs and sponsors, as well as administrative and security personnel, enable a clearly structured and easy orientation and breakdown. The use of all the space under the stands creates a multifunctional stadium complex that can be used by all user groups around the Stadium. At this level there are all the necessary rooms for both teams and the other accompanying rooms. At this level there are also entrance for media and VIP.

7.7 First floor

First floor, in contrast to the ground floor zone, this area serves mainly to supply all spectators during a football match or event. A clear zoning allows a smooth, internal development of the business lodges as well as the media rooms and the associated press tribunes. Catering areas and sanitary facilities, both at the level of the first and the second rank, guarantee uncomplicated and short access routes within the new supply concept for the spectators.

First floor and the second floor in contrast to the ground floor zone this area mainly serves to supply all spectators during a football match or event. A clear zoning allows a smooth internal development of the business lodge as well as of the associated press tribunes. and sanitary facilities, both at the level of the first and the second rank, guarantee uncomplicated and short development paths within the new supply concept for the spectators.

7.8 Stadium sectors

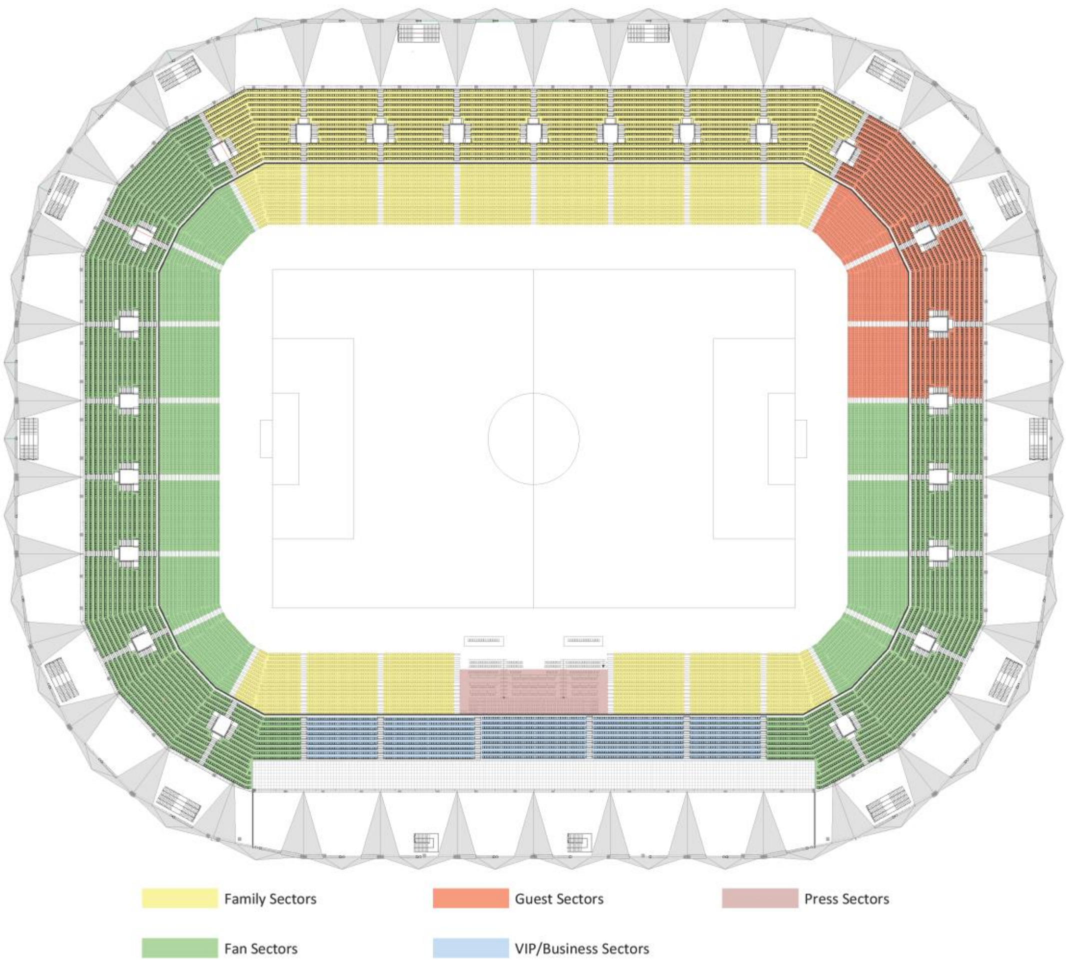
The stadiums tribune can generally be divided into five different categories, which in turn have an impact on the respective admission prices: family sectors, fan sectors, guest sector, VIP / Business and press. Evenly subdividing these sectors into more compact bleacher sections allows easy viewer orientation and easy access to the seats.

Family Sectors - these are located on the grandstands and thus provide very comfortable and well-arranged seats. Above all, they are available to the general public and usually convey a familiar and rather peaceful atmosphere.

Fan sectors - placed behind the gates, these sectors make up the home of the supporters of the home club. Loud songs and enthusiastic crowds lead to a breathtaking atmosphere in the stadium, especially in this sector.

Guest Sector - In order to avoid conflicts between home fans and supporters of the guest team, the guest fan sector has a separate access and is fobbed off by the local fan sector. These are flexibly designed to adapt the respective capacity to the size of the followers of the guest club.

VIP/Business - the grandstand sections of the VIP area are accessed via the internal business area. In addition to the boxes and the corresponding seats, these sectors also have an optimal location directly at the center line.
Presse- Positioned in second place, the press sector allows reporters a centralized and clear processing of the games. Tables with the required equipment connections also provide a professional and modern working environment for the media.



Stadium sectors

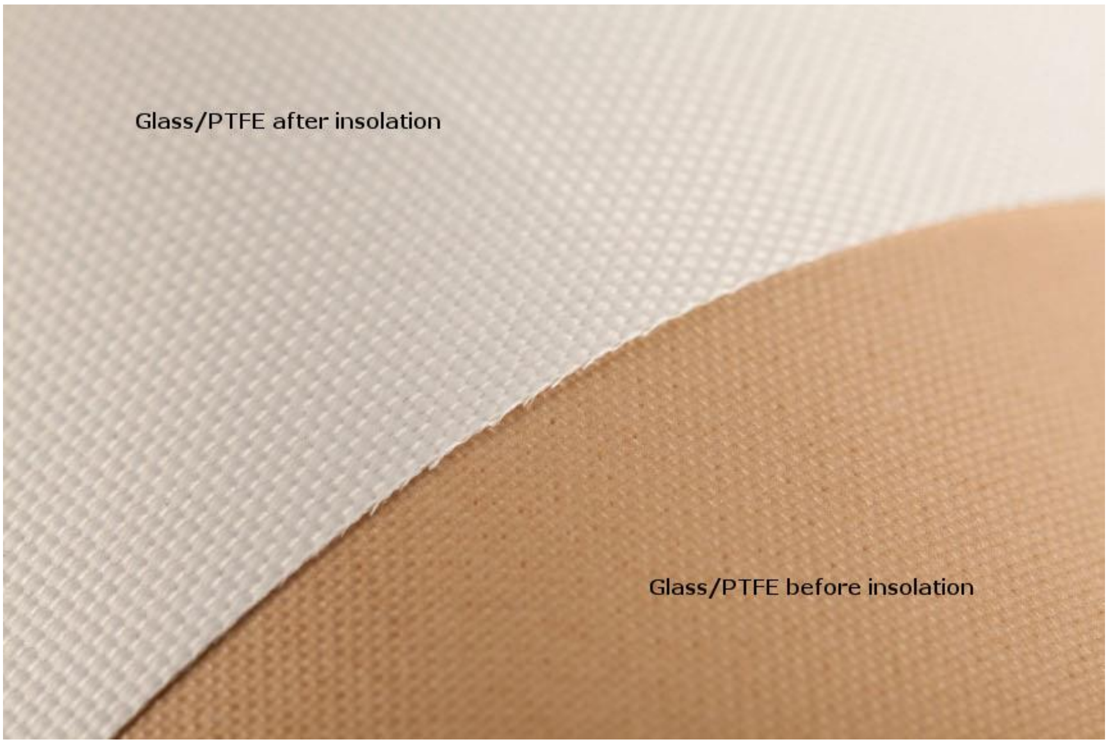
7.9 Roof structure / material

The roof structure is composed of cross mutually bracing cantilever elements in the form of hollow steel box which also serve as large gutters for the discharge of the quantities of water during rain.

In view of the hot and humid climate, the roof extends into a facade which provides shade to the spectator balconies and vertical access routes. The roof and facade panels consist of translucent glass fibre fabric. PTFE-coated glass fiber fabric is used whenever as extensive a self-cleaning material as possible is requested or a non-combustible material is specified by the building authorities.

The woven fiberglass gives the PTFE coated Glass Fiber its mechanical strength. These filaments, known as beta glass, are the smallest diameter available and provide the membrane with maximum flexibility. The fibers are drawn from hot melt glass through platinum dies into continuous filaments, and are then twisted and plied into yarn bundles. The yarns are woven into a wide structural fabric, which is then coated with PTFE to complete the process.

PTFE coated Glass Fiber is a Fabric which is coated with PTFE, which is chemically inert, therefore it can withstand temperatures from -73°C to +232°C (-100°F to +450°F). Because of this characteristic, PTFE coated Glass Fiber can be installed in almost all climates zones, ranging from the Deserts to the Artic and still has a life span of more than 30 years.



Textile Structures of PTFE-Fabrics

8. Imprint

8.1 Thanksgiving

Shortly before the final whistle I would like to thank all those who accompanied and supported me during my studies. I especially want to thanks Assoc.Prof. Dipl.-Ing. Dr.nat.techn Andreas Trummer for the advice and support of this thesis.

A big thank goes to my parents for their moral and financial support during my entire study period. I am very grateful to you for making this study possible! Also, with my siblings, friends and colleagues I would like to thank for the great and exciting study time! Thank you for your time.

Finally, I would like to thank Shpresa for the wonderful time together - without you all this would never be possible anyway.

8.2 Conclusion

Football is more than a game and the stadium is not just any type of building. The preceding chapters have given us diverse insights into events in and around the stadium. It has become clear that football stadia are ideal for socio-diagnostic analyses: social trends are condensed within them, as if under a magnifying glass At the same time, football stadia also function as places of refuge, since behaviour possible inside their gates is not (or no longer) acceptable outside them. In this concluding chapter, we first refer to the findings of the chapters of this thesis in the light of this particular double-sided nature of the stadium. Subsequently, we expand on our thesis outlined in the introduction, namely, that the cause of this double-sided nature can be found in the very specific spatiality and materiality of the stadium. What constitutes the built and social space of the stadium in all phases of its history is its introversion and clear structural demarcation from the outside world, the spatial separation between active participants and spectators, the direction spectators' gazes onto a central point, and the spatial process by which of the conscious of themselves the are made visible and reflexively conscious of themselves.

Modern stadiums are much more than just playfield areas. Through their urban significance, they create new symbolism for the affected urban area. Particular attention is paid to the stadium forecourts. They are both important parts of the overall design and should offer both functional traffic areas and space to stay.

In the development of the stadium structure, different variants were initially considered, in which the structure forms an integral part of the overall design and meets the special requirements, such as the large coverage areas.

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