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Stadiums



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Executive summary

This paper deals with risk-management and insurance issues related to the construction of stadiums. These objects can be considered to be one of the most exotic and attractive ones in today's world.

Stadiums amaze by their diversity, multifunctionality, architectural and technical solutions.

During the 20-th century the stadium has become not just a sport facility, the purposes of its use has become quite unlimited and universal in terms of holding mass events. They have become various in their function, design, capacity, type of the roof, covering of fields, etc.

Significant development of all the above mentioned characteristics means that underwriters cannot consider structures of this type as model ones but instead must adopt an individual approach to each project.

Stadiums are being built in different regions and countries which, taking into account the existence of significant dynamic loads, both internal and external, require a detailed personal assesment. Stadiums can accommodate up to 150 000 people. Thus the additional attention is required not only to the consequences for the construction itself, but certainly to the possible consequences for people inside and outside it as well.

For the purposes of a clear understanding of the risk components of stadium construction and the simplification of the decision-making practice and analytical conclusion, this paper presents an anatomy of a stadium which shows the elements of the construction that needs a special attention.

Options for both the construction of new stadiums and reconstruction of old ones are considered.

Both internal and external risk factors: in the course of construction, reconstruction are analyzed:

- In terms of geographical approach and climate factors;
- In terms of soil conditions;
- In terms of adopted architectural solutions;
- In terms of hazards, connected with specialties of internal systems and transformation systems of multifunctional stadium;

A relatively new factor for analysis of possible major losses — «robustness» is explained and considered on specific examples of construction and engineering practice;

The role of Parties, participating in the project implementation and interested in its realization, but having different insurance interests and carrying different unique risks is examined.

The opinion of independent expertise/surveyors, up to physical control during the high-risk operations, should be taken into account when considering these elements and accepting

them for insurance. Their advice given during the monitoring of risks are very important, especially taking into account the coverage of defects and designer's risks.

The usual types of insurance coverage which can be used in stadium construction insurance and the underwriting philosophy for each of them are presented and described in this paper. A list of basic technical and economic information which should be used in underwriting of the project together with recommendations for loss minimization and the means of management of the coverage are also presented.

As in many other similar works, we could not ignore the question of losses and lessons learned. The examples of accidents shows that they do not have a specific geography. The vast majority of them are connected to faulty design and defects of construction. Consequences can be catastrophic taking into account the number of people the object can accommodate.

In this paper we have collected major aspects and, although some of them may be well-known, they are nevertheless still relevant today for the purpose of stadium construction insurance.

We hope that this paper will become a tool for a deep understanding of the specifics of stadium construction and its place in a range of major engineering projects insurance for the members of our community.

1. Definition of the stadium. History of stadium construction. Role of a stadium in a modern world.

1.1. Definition of the stadium

A stadium is a place or venue for sports, concerts, or other events and consists of a field or stage either partly or completely surrounded by a tiered structure designed to allow spectators to stand or sit and view the event. "Stadium" comes from the Greek word "stadion" (στάδιον), a measure of length equivalent to 600 human feet.

Modern Olympism, the revival of the Olympic Games and the construction of modern Olympic Stadiums find their origins in the ancient Greek era with the world famous Olympia (1st stadiodrom, Hippodrome, gymnasium, Palaestra), as well as in the era of the Roman Empire: the Roman Colosseum - a prototype architecture modern stadium.

The world most famous ancient greek Stadium is located on the northeast side of Mount Olympus, set in the steep slopes of the hill. That was the site of the original Olympic games.



Figure 1 Ancient Stadium at Olympia. Source: http://en.wikipedia.org/wiki/Stadium_at_Olympia

1.2. History of stadium construction

Because of a great popularity of the Olympic Games, stadiums and racetracks were widespread throughout ancient Greece. The largest of them were designed for 45,000 spectators. Many stadiums in Delphi, Ephesus, Athens, etc., with varying degrees of preservation, have survived to our time. The most famous among them, the Athens Stadium (built in 331 BC), was restored by the time of the first modern Olympic Games in 1896. This later building was reconstructed for the Olympic Games in Athens in 2004.



Figure 2 Panathenaic Stadium in Athens. Source: http://en.wikipedia.org/wiki/Panathenaic_Stadium

During the medieval period churches, cathedrals, castles, fortresses and municipal courts became for a long time the main attributes of medieval towns and ancient stadiums, theaters and amphitheatres were abandoned, turned into the market or demolished and used as a source of building material.

A new impetus was given to sports practice during Renaissance. However, competition were usually held in open urban areas. Temporary wooden platforms were constructed for the spectators. The typical examples of such constructions were: Piazza del Campo in Siena (constructed for annual horse races) and the area of Santa Croce in Florence (constructed for sport competitions).

The beginning of mass stadium construction is connected with the popularization of the Olympic Games (started in 1896) and the Football World Cup (started 1930). Pierre de Coubertin, founder of the modern Olympic Games played a prominent role in the scientific substantiation as well as the introduction of the principle of decentralized venues for the Games as set out in the Olympic Charter. This led to the games being held alternately in different cities around the world, and was a unique phenomenon in the process of urban development in some of the largest cities around the world.

The Arena stadium takes its final form from the standard size and design parameters of a football field (104x69 m); a closed running track in an oval shape, a length of 400 m and athletics sectors for jumping and throwing. Set around this arena is a grandstand for spectators with a capacity generally of 50 to 100 thousand places, rationally planned and designed to meet the optimal conditions for observing sports activities from all positions, ie it has an optimum profile in cross section.

1.3. Role of the stadium of the modern world

Up to the 1980's the construction of stadiums was mostly boosted by the preparation for the Olympics/ Football World Cup or other sporting events and so the construction was based on public funding.

Now we can clearly see the tendency of private funding (especially in Europe, USA, UK).

Furthermore, the modern stadium is no longer solely a sports building, but a kind of multi-purpose recreational complex, consisting of an arena itself as well as a wide range of other facilities - shopping malls, restaurants, technical facilities etc.

There are a lot of types of stadium projects, which can be classified based on different criteria:

- 1) purpose of use: universal stadium for athletics competitions/ olympic stadiums/ football stadiums
- 2) type of design: colosseum type, bowl type, stadiums with dynamic moving structure giving the possibility to transform in accordance with changes in the sports technology, varieties of mass entertainment, and weather conditions.
- 3) type of roof: with/without roof, with retracable roof
- 4) capacity of stadium
- 5) type of field cover (artificial, natural)
- 6) new project/reconstruction

Now multi-purpose stadium projects can include:

1. The Stadium (arena) itself with roomy, comfortable stands/seats and a whole set of specialized sports facilities that are usually on a compact, well-landscaped area sports park, creating an optimum ecological environment for sports
2. Separate sports facilities for training nearby
3. Residential and hotel complex
4. Service center: shopping mall, restaurants, etc.
5. Technical facilities and transport facilities of the city (motorway junction at different levels) with the required capacity
6. Parking and underground parking

The following trends can be underlined in modern stadium construction:

- different types of climate control inside the building
- multi-purpose use, varying from open air arenas for sports which could be transformed into multi-functional halls / arenas
- standing sectors/ transforming capacity
- high tech equipment including LED facades, huge screens inside the building as well as radio and television transmission
- environmental friendliness

As sporting competitions and programmes change, modern stadiums will need to be constantly adapted, using the latest achievements in architectural thought, construction technology and materials in order to accommodate a more varied useage.

2. Risk description**2.1 Different elements of a stadium**

To understand and assess the risk and to provide the insurance coverage that meets the requirements of their clients, insurers need to carefully examine the stadium project. Below this paper tries to focus on those elements of Stadium projects connected with the highest exposures and which should therefore be the main focus for underwriters when assessing the risk.

2.1.1 Anatomy of a stadium

Important decisions need to be made in advance regarding the location, capacity, design and environmental impact of a stadium in order to ensure that the facility continues to meet the demands of a rapidly changing market.

Once these decisions are made, a stadium design will include the following main areas:

- Playing area: also called pitch. Dimensions and types of accepted pitches are defined by the standards of different sports organizations e.g. FIFA for football.

- Spectators area which includes grandstands and seating
- Hospitality area including the VIP lounge and other reception facilities
- Press and media area
- The envelop which may include the (movable) roof, a covering membrane and the facades designed to ensure protection from weather as well as to reduce noise disturbance
- Access and parking areas that can be located under the stadium or close to it.

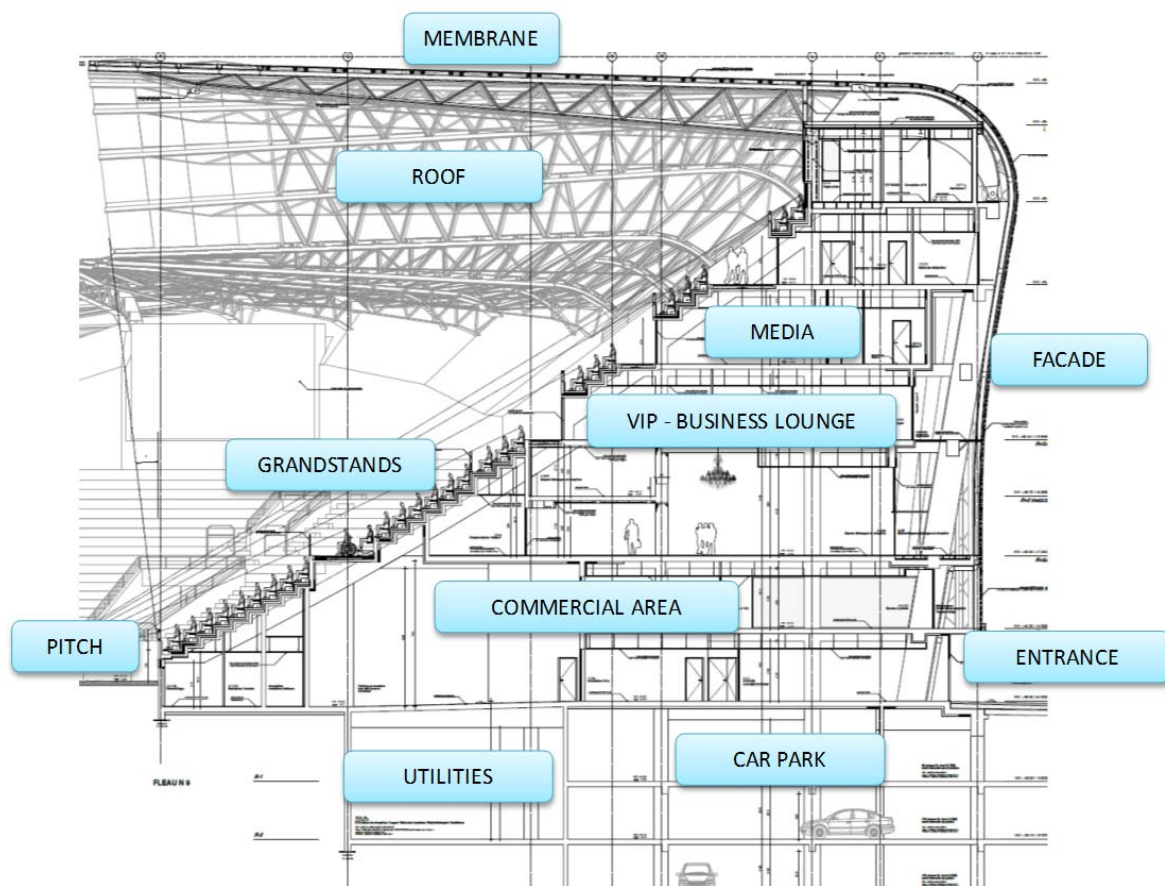


Figure 3 Typical cross-section of a stadium

2.1.2 The roof

Covered seating is not mandatory. However, roof coverings provide protection from the rain and wind in northern countries, while in southern countries they offer shade from the sun and heat. In certain conditions, a retractable roof may be the best solution. This will enable the stadium to be used in extreme weather conditions and will also make it more viable as a venue for other events such as concerts. Roof design also needs to take into account the shading of the pitch and adequate exposure to sunlight.

Covering a stadium inevitably requires complex structural solutions because of the need to eliminate all visual impediments from the seating. Very large structural spans will be necessary, and these are both costly and technically challenging.

Roof support structures are generally made of metallic elements like trusses, beams or tridimensional tubular elements. The choice of the structure material and type depends of many design criteria like the span of the beams, the geometric form of the roof (i.e. plane or waved), the maximum weight that is allowed and of course the loads and effects of the environment.

Trusses beams are widely used because the fabrication and assembling methods are more commonly spread. In some projects, architectural constraints may impose very large spans and thus, trusses design becomes unique and difficult to achieve.

The pictures below show the mega beams of the Lille Stadium¹ in France where the span is of 205m. The Beam has a height of 16meters and weights as much as 1800 tons! The whole weight of the roof structure is more than 7200 tons i.e. more than the Eiffel Tower!



Figure4 Lille stadiummegabeams. Source: <http://stadelille.prod.stadelille.zeni.fr/index.php>

On other projects, the use of tridimensional mesh structure is required in regards of architectural and engineering constraints. The Nice stadium² in south of France, recently delivered, has a composite 3D structure of metallic and wood elements combined with a single layer ETFE membrane. The specificity of the project lies in its complex geometry and structure. The roof is a continuous surface enveloping all seats, starting at floor level and going up as a façade then cantilevering over the tiers. The timber is located on the inside of the truss, where it is the most visible and structurally efficient³.

This design protects from environment but also responds to sustainability objectives.



Figure 5 Nice stadium 3D composite roof. Source: <http://www.allianz-riviera.fr/>

¹ Lille Stadium is an ELISA project built by EIFFAGE and designed by architects Valode and Ferret – 2012

² Nice Stadium also named Allianz Arena was built by VINCI and designed by Wilmotte& Associates – 2013

³ Source : Nice stadium: Design of a flat single layer ETFE roof – EGIS Concept

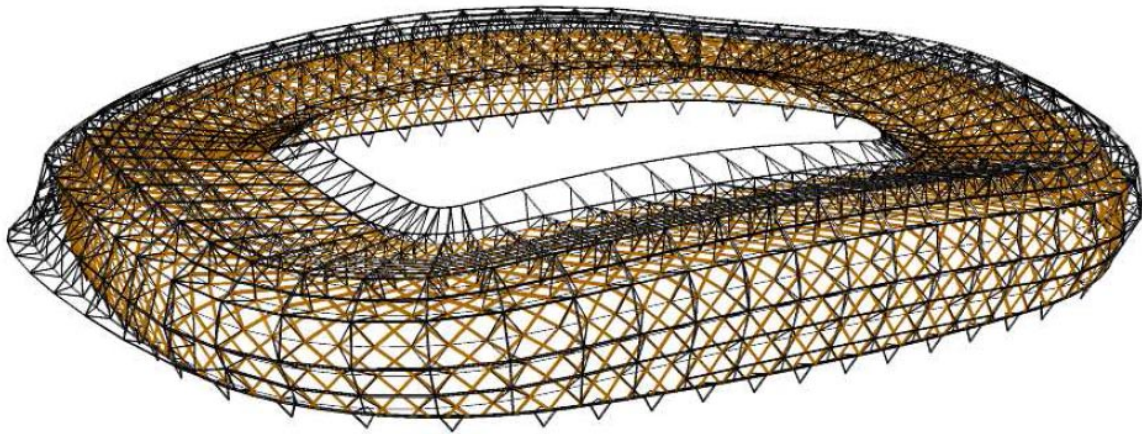


Figure 6 3D view of structural model. Source: EGIS

2.1.3 The bowl structure/stands

Given that stadiums are formed of large spaces with substantial structural spans, concrete tends to be the simplest and most cost effective structural material. In those countries where concrete is locally produced and steel has to be imported, it is certainly the most cost effective option. The choice of construction methods is often the contractor's decision factoring time, cost and experience.

In many cases prefabricated concrete structures are used especially for the grandstand frame to gain time and money compared to cast in situ structures. In that case, the dimension of the elements is a balance between transportation conveyance constraints and the weight and availability of lifting engines on the construction site. Temporary support and shoring is of big importance to insure the stability of the prefabricated elements once mounted in place.

The design of the bowl and determination of the levels of the grandstand are conducted to insure perfect viewing for the spectators. Recommendations as from the FIFA or other organizing associations, define the metrics to satisfy perfect viewing in regards of distance from the pitch, level of the seating and also safety metrics for crowd movement.

Theoretically, the ideal configuration for a football stadium is a curved bowl that is situated as close as possible to the playing surface, providing all spectators with a similar quality view, unobstructed along the entire length of the pitch.

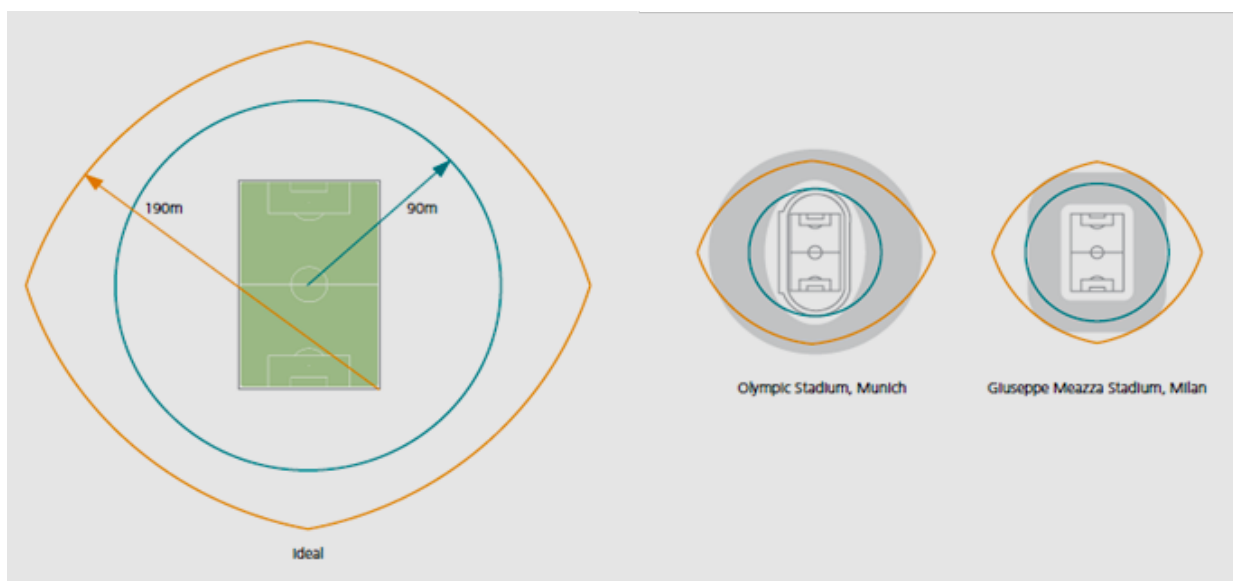


Figure7 Distances of spectators from the field of play. Source: FIFA technical recommendations

2.1.4 The pitch

The playing field can be of natural grass, or artificial turf or a mixture of the two of them being known as hybrid turf. With natural grass, it should have an efficient watering system for use in dry weather. In cold climates, the playing field should be equipped with an underground heating system to prevent it from freezing in extreme winter conditions.

The primary characteristics of a good playing field should include proper underground and surface drainage to allow play during rain and to rid the surface of water during extremely wet conditions. There should be no patches of water logging and/or ponding.

Planning for the pitch is very important as it takes into account time for seeding and growing the grass to be at the required quality before transplanting it into the stadium. Other important issues for the natural grass is the quantity of sunlight which reaches the pitch as well as natural ventilation.

2.1.5 New developments in building service systems

Increasingly, sustainable and environmentally friendly design and construction schemes enjoy political, public and financial support. Incorporating such initiatives into the stadium project may not only be beneficial in the long term, it can also help project an image of social and environmental responsibility.

Green Goal

UEFA embraces the FIFA Green Goal programme, which strives to encourage and support sustainable and environmentally responsible stadium design and construction. The main specific objectives of the Green Goal programme are to reduce water consumption and waste generation, to create more efficient energy systems and to encourage increased use of public transport systems. In order to satisfy Green Goal benchmarks, “green” strategies and initiatives such as environmentally responsible water and waste disposal management systems should be adopted wherever possible.

Solar panels

Solar panels installed in the stadium façade and roof provide a simple and environmentally friendly means of generating electricity (like at Cornellà El-Prat in Barcelona). The power produced can even be sold back into the main electricity grid. While solar panels are still an expensive option in the short term, and the economic benefits will only be felt over a period of time, many countries now have grants and subsidies that make them a viable and even attractive proposition over the longer term. And they will invariably help to reduce conventional energy costs.

2.2 Prototypes and challenging structures

The following part of the paper is focused on the prototype stadium structures/projects. To estimate the risk and to design an appropriate insurance protection for such a projects is a most challenging task for the insurance industry .

2.2.1 Moving pitch: Lille stadium

The Lille stadium is unique in its kind as it has a built-in arena where the northern half of the pitch is designed to lift up and slide over the southern half to reveal a «Showcase» with

terraced seating located under the pitch, providing a total capacity of 29,500 seats. Concerts and indoor sporting competitions will be hosted in this arena⁴.

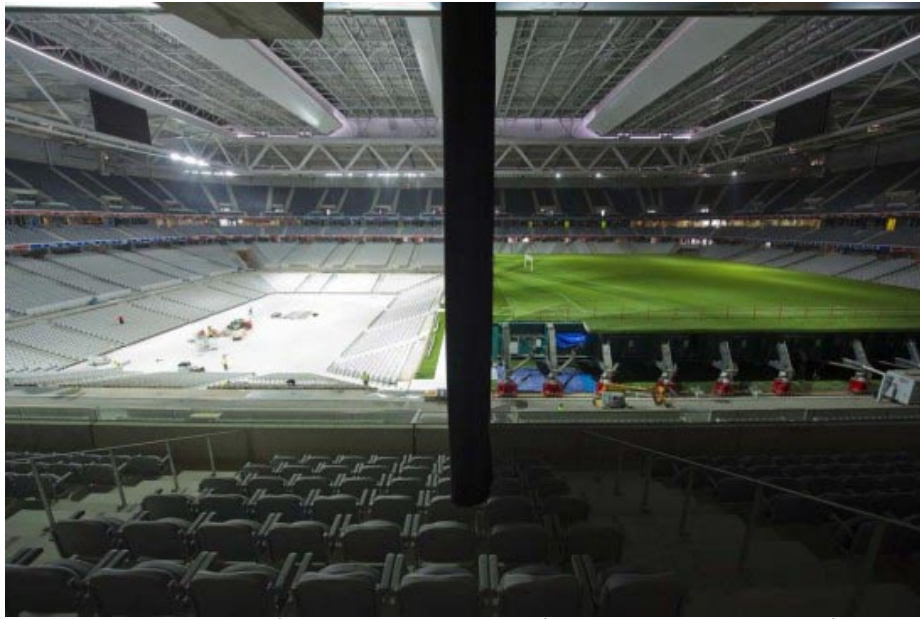


Figure 8 Lille showcase - © Elisa / Valode&PistreArchitects / Atelier Ferret Architectures / Max Lerouge

The moving pitch is built on a metallic frame of 72m x 55m and weights 4,500tons. To allow translation of this mega structure, 12 hydraulic cylinders were especially designed to lift the pitch up to 6m and each having a capacity of 900tons. Depending on water content in the pitch, the load can easily vary of more than a 100tons. Any uncontrolled displacement during the lifting operation could be fatal to the structure and thus special control systems allow data analysis and coordination of the cylinders. Once lifted, the structure is translated on two mega rails situated on each side of the pitch. Telescopic seats are deployed for extra seating. This whole operation can be done in as little as 24hours.

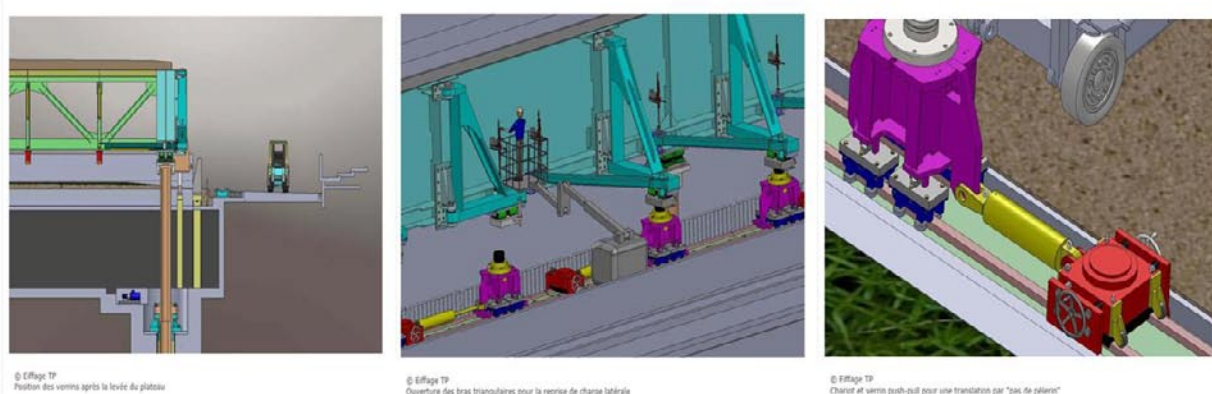


Figure 9 Hydraulic cylinders - ©EIFFAGE TP

2.2.2 Renovation of existing stadiums: Athens Olympic Sports Centre

The project of the Aesthetic Integration of the Athens Olympic Sports Center, was executed within a 16-month period and encompassed remarkable venues and structures. The three most famous of these are The Olympic stadium roof, the Velodrome and the Agora.

The Olympic Stadium roof constitutes a world renowned attraction for Athens interms of its architectural appeal, its size and its amazing construction achievement (technical features

⁴ Lille Stadium Press Pack 2009 – ELISA

and time of completion). It is the stadium with the biggest free span in the world (304m). The overall weight of the steel structure rises to 19,000 tonnes, covering an area of 25,000 m².

The Velodrome was originally constructed by Aktor in 1991 while its steel roof was added for the purpose of the Olympic Games 2004 when the existing facilities were renovated.

The Agora consists of a series of repeated elements of large sharp top arches by steel cross sections. Agora is curve shaped, its axial length is 475m and its total surface is approximately 12,000m²



Figure 10 Complex reconstruction of Athens Olympic sports Centre. Provided by N. Gavrilis& Co. insurance **Brokers**

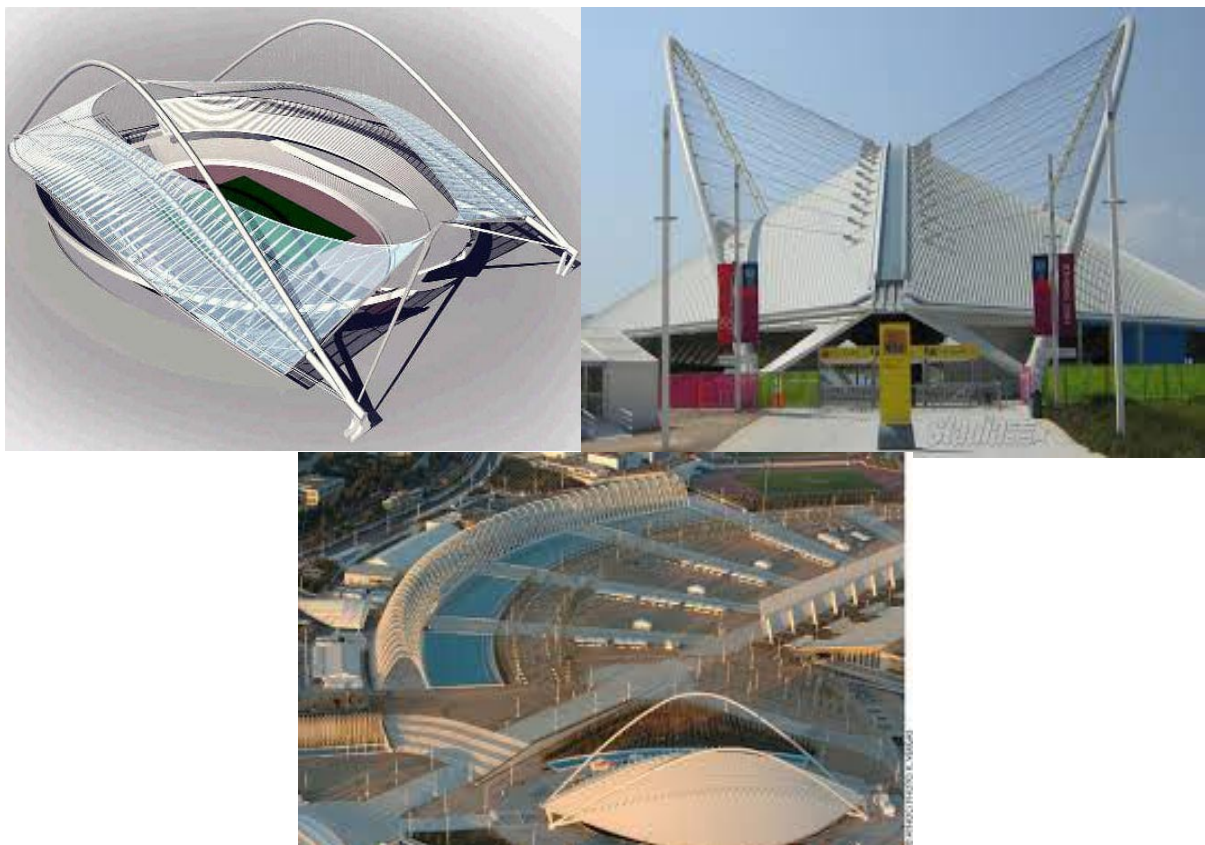


Figure 11 .Olympic stadium, Velodrome and Agora. Provided by N. Gavrilis& Co. insurance **Brokers**

3. Risk Analysis:

The main structures of Stadiums can be built of steel or of concrete or a mix of both. Some of them can include large elements suspended by cables. This wide range of possible materials and structures leads to a large variety of potential risks. These can be classified by the risks linked to the nature of the stadium as well as the external risks, deriving from the neighborhood and local factors. One factor which should not be forgotten is the soil risk itself. This may have consequences on the choices of construction method and may even lead to changes in the initial design of structural works. It is also an major elements of the civil works.

Usually stadiums are fitted with main structures and secondary structures. Furthermore a third structure can be necessary to support the cladding and secondary elements such as aluminum cladding and insulation materials. Complementary equipment can be fitted for HVAC (Heating, Ventilation and Air Conditioning) and other specifications depending on climate requirements. Heating in the northern countries and cooling in sunny and hot climates. The size of this equipment can lead to a real challenge in terms of design and architectural trends, as the structure must be adapted to cope with the weights, the static loads and dynamic loads. The standards used for the design after the general architectural concept may have a large impact on the internal risks analysis. The roof must be insulated for noise just enough to maintain the good acoustic sensation for people, but at the same time must be adapted for climate. Such decisions will affect the weights and stresses that are applied to the structure.

In addition new equipment such as geothermal systems and or photovoltaic systems can also be fitted, which are inherently part of the structure and their failure can lead to an inconsistency in the overall operation of the stadium.

In the following sections we describe in more detail both categories of risks, starting with the external risks.

3.1. External Perils

a) Vicinity and location consequences:

A stadium can be built in different types of areas. Some of them are old industrial zones, where the pollution risk can be considerable and should be carefully studied and analyzed. Such analysis may lead to a limitation of cover or perhaps to the exclusion of such peril.

The location in populous suburbs can increase the exposure to human related risks such as arson, third party liability exposures, strikes riots and civil commotions, or theft.

Even where the abovementioned risks may be reduced in respect of more isolated construction sites other perils remain. e.g aircraft risk if close to airports.

b) Climate conditions and natural events:

A Stadium reaches its final resistance against climatic conditions and natural catastrophic events with the completion of the outer skin. During the construction phase the structures are weak not well secured and may not yet be able to resist even normally expected wind speeds or other types of overloads, such as the weight of ice and snow. Such risks should be carefully considered even if the calculations and design are such that the completed structure is expected to withstand such loading.

Seasonal conditions can be crucial when the phasing of certain construction activities are planned and the works programme and works method statements should be considered carefully when assessing the risks related to climate. Special protections or provisions may be required for some erection activities and it may be necessary to introduce specific protocols which limit the circumstances under which certain activities can be performed. e.g. maximum wind speed.

c) Soil conditions:

To discover potential risks arising from the soil, a properly carried out soil report forms the basis for a proper design of the foundations. The following subsoil perils should be taken into account - different layers of soil, cavities, liquefaction, old inconsistent soil, filled soil, water table, etc.

The foundations shall be those which shall be anticipated by the nature and quality of the soil. The main consequences of inadequate soil exploration are settlement and differential settlement should be anticipated and taken into consideration in the design plan .

Foundations should be designed to cope with the future use of the building. The potential complementary loads, (static and dynamic loads) must be anticipated and the foundation constructed considering such parameters. The choice of the method, piling, micro-piling, reinforcement, have a strong impact on the future limits of the stadium, including any possible changes in use.

A classical problem for example can be design and calculation of micro piling. The method of calculation of total loadings or of additional loading method, can have major consequences such as the differential settlement of slabs due to different compression rates.

3.2 Inherent Perils

a) Design and architectural view:

Stadiums are very often conceived as a brand or a remarkable monument. Their design must respond not only to the external overview of the site but also the investors vision. As a consequence, and like some skyscraper around the world, they are subject to an engineering challenge for both structural design and construction methods. For example specific designs may be required to allow a complete transforming of the Stadium from a football sport arena to a motorcycle race circuit or a music concert exhibition, with huge vibrations and noise.

The numbers of people to be accommodated in stadiums is always increasing; in our century they are increasingly used to accommodate spectacular events and exhibition shows rather than just sports and Olympic games. In consequence the design is completely changing to that of an “arena” (a name originally used by the Romans).

The design is very complex and each construction is unique, although not always should it be considered as prototype (as in many cases the general design method and rules applied to steel or concrete structures are of well proven technology), but a careful design study by engineers during the risk analysis is always recommended, and items which are not usual or not previously put in place on an earlier project should be studied in detail.

The number of people to be accommodated and their activities are factors which should also be taken into account, not only for the weight but also for the dynamic loads and vibration which can be a consequence of the activities.

Another inherent peril can be some defects due to bad waterproofing of the slabs. The defect itself may not be considered as damage, but it can be a cause of cracks or more important consequences.

The roof of the stadium can be constructed using textile material. This kind of roof should be carefully calculated with an adapted coefficient for winter weather, as the weights of snow and ice can have a wide impact and lead to major loss.

Other buildings are often constructed in the stadium vicinity or linked to it, such as training facilities. There may also be ramps, on which sometimes cars truck and lorries can circulate. The weight of such vehicles and also the effect of vibration on the structure should be considered in the design.

b) Robustness of the roof structure

A characteristic feature of a modern stadium roof is a large span and a high-rise structures. Such designs are performed mostly from metallic elements with modern composite materials, glass, fibers, etc. Some designers tend to minimize the volume of materials (and therefore the price of construction) by taking into account the work of spatial structural system and redistribution of stress due to geometrically nonlinear operation. This leads to an increased sensitivity of such structures to the static/dynamic overloads. Therefore there should be special requirements for design of such objects to ensure their robustness. Such overloads can lead to a "progressive" (avalanche, cascade) collapse. As a result - there are recommendations on excessive increase (1.5-2 times) of the carrying capacity of the key elements of the structure. Unfortunately these requirements are not applicable to the minor elements of the structure in every design project. And of course this can lead to the "zero robustness" of the whole construction of a building during both the "in construction" or "operational" phases.

To assess this risk can be a real challenge for the underwriter. Sometimes the use of independent expertise is the only possibility to understand the risk. In addition risk monitoring during the different phases of construction and during the guarantee period could be useful to understand the sensitivity of structure elements..

c) Building service systems

Specific service systems can be split in two categories; proven and unproven. Some devices may be considered proven, and commonly used, such as photovoltaic systems and geothermal, or solar. The challenge for the underwriter here is to understand the size or capacity of the equipment compared to the standard design. Furthermore careful consideration should be given to the implementation of these systems in the structure and the ability of the stadium to receive such an item without any risk. In another words has the stadium been properly designed to receive such equipment.

The installation of photovoltaic units on a roof is a relatively recent exposure, as the fire risk from such items is not negligible.

d) Transformations of the stadium

Another category relates to issues concerning the transformation of the stadium itself such as:

- removable grading and/or annular race field where the grassed area can be removed or reduced to enlarge the number of seats for a show;
- Retractable roof.

These items shall be risk assessed carefully, as they are usually (like the stadium itself) unique, with a specific machinery. Necessary preliminary tests should be performed and quoted accordingly



Figure 14 .Retractable roof. Source: www.tekla.com

e) Risks connected with the construction process

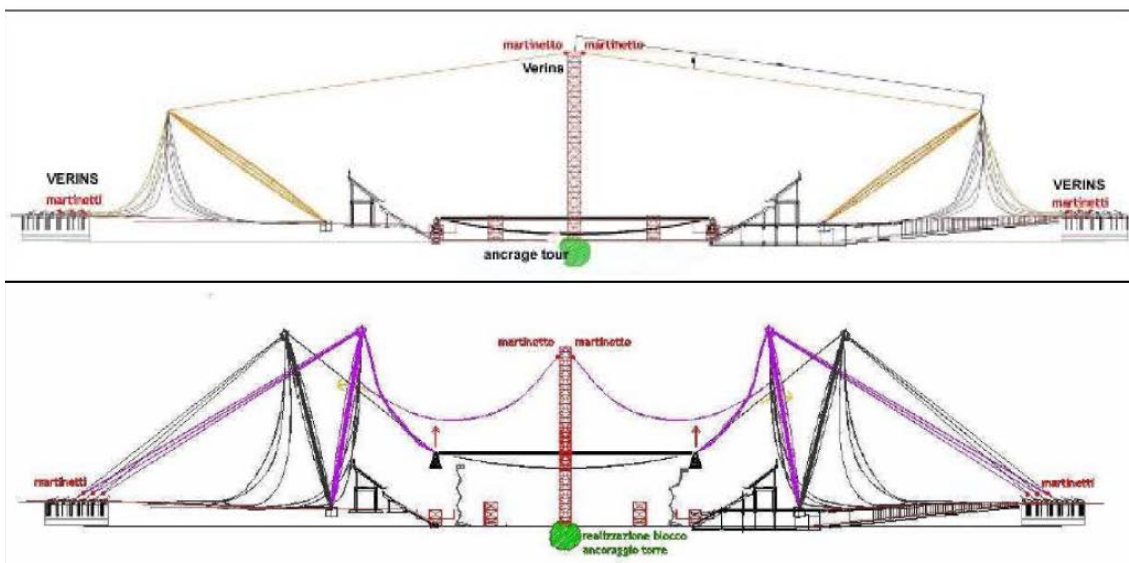


Figure 13 .Construction of the stadium roof. Source: www.tekla.com

The Construction method for a stadium often requires specific devices and heavy cranes. According to the method, the weights themselves can be very important, if the method is to lift the complete erected structures of the roof for example, and to put it in place in only one process. This can involve very wide spans when putting in place important beams. One of the challenges is also the cover of the attached Construction Plant and Equipment, which is sometime unique and their damage can lead to very significant delays in construction.

It is evident that the main peril is the risk of collapse during the lifting following a mistake by the technician in charge or a fault in the lifting process. The main cause of such damage is as very often an accumulation of smaller mistakes and or discrepancies concerning the usual operation. An example can be the lifting of weights very close to the cranes limits; lack of experience concerning the erection engineer; attempts to

accelerate the erection in order to reduce the duration time; bad weather condition (at the limit to stop the works). Any one of these causes can lead to physical damage and a serious claim.

Another challenge can be the lack of space for erecting carefully the elements. This requires very detailed analyses and early consideration in the project design in order to anticipate the requirements of a particular lift.

Risk monitoring can be very important in such cases and sometimes the presence of an independent surveyor during the critical path of construction works can decrease the possibility of large loss.

f) Risks connected with pitch (playing field)

Most Principals developed uniform requirements for contractors for warranties for all stadiums. They include requirements to provide a guarantee for all work performed, including grass cover of the football field. As the playing field is subject to wear and tear this can pose some problem for insurers. This part of scope of the risk should be considered separately. Modern field with natural grass is a rather complicated multi-layered structure. On the one hand, it is difficult to separate the risk of damage due to operation of the errors or omissions of the contractor. However, grass cover, as well as other property is exposed to sudden external influences, not related to wear and incorrect operation, - for example natural hazards.

Considering the case of loss or damage to the playing field coverage, Insurer will have to answer a few questions:

- How to determine what exactly (what type of defects, which detected fact) is damage to the turf, the contractor is responsible for proper performance of works and he should bear the warranty?
- What is the normal wear and tear role combined with climate exposure found in loss or damage to grass cover?
- What are the possible faults in construction works during installation / assembly (for example, errors during construction of the drainage system, the accuracy of the materials used, etc.)?

As a summary of risk analysis we provide a Risk matrix for exposures in Appendix 1.

4. Available insurance coverage and underwriting considerations

Effective risk management and risk transfer insurance solutions are critical elements in securing the financing of a Stadium project and its future success.

4.1. Risk Management Process

In order to assess the available coverages from the perspective of the different parties involved with the ownership/ construction of Stadiums, the various stakeholders need to be identified and managed:-

For Principals/Financiers/Investors – the various risks that are identified are as follows:-

- Timely completion of the project
- No deviation from the budget

- Securing the collateral during the investment period
- Generating forecasted revenues
- Minimising the risk during the operating phase

For Operators/owners

- Protecting the assets from property damage
- Loss of income/ profit

For Contractors/ Sub-contractors (during construction period)

- Protecting the assets from any damages until handover
- Containing any ancillary costs related to the damages
- Liability arising from any third party damages
- Political risks
- Risks during maintenance

For Designers/ Engineers/ Consultants

- Liability arising out of professional negligence

For Suppliers/ Manufacturers

- Keeping up with agreed delivery Quantity/Standards/Time as per contract requirements

4.2 Risk monitoring

Risk monitoring is very effective for the different stages of the project realization:

- during the design phase - the independent surveyor can give some recommendations to change the design/specification and help to reduce the risk of collapse of the building due to design error and to assess the possible PML scenario;
- during the construction phase - the surveyor can be present on the construction site during the critical path of the construction and may assess how the process of the construction corresponds to the design and usual construction practice. He can give recommendations how to improve the level of risk management on the site
- there can also be occasional visits by the independent surveyor after the completion of construction and during the maintenance period. A good example of how these visits can reduce the risk are shown below (Section 6.1 – Krylatskoe ice palace)
- The use of web-cameras on the construction site also could be an additional instrument of risk monitoring.

The international importance of the sporting events and the scale of these projects explain the ultimate importance of the quality of risk monitoring for the stadium construction. Risk monitoring is an essential consideration before granting any of the insurance coverages for stadium construction which are described below.

4.3 Available coverages

The types of insurance, suggested for these projects by the international engineering market are rather traditional. Below this paper describes them trying to focus on the essentials which are very important for stadiums.

4.3.1 Construction All Risks Policy (CAR)

CAR cover is normally arranged by the EPC (Engineering Procurement Construction) main contractor; however, in some cases the Owner of the property will procure and administer a CAR policy covering all aspects of the project. A classic example would be the OCIP (Owner controlled insurance programme).

CAR Insured Parties:

- i) Principal and any subsidiary or affiliated companies:
- ii) Sponsors/Financiers/ Investors

- iii) The main contractors
- iv) All other contractors, subcontractors and agents of any tier.
- v) Consultants, suppliers and vendors, all of any tier, while carrying out physical work associated with the Project on or about the Project Site or caused by their physical presence on or movement about the Project Site.
- vi) The employees, directors or officers of any of the above.
- vii) Including all such parties, whether named hereunder or not, or whether appointed prior to inception of this Contract of Insurance or subsequently.

Each for their respective rights and interests in connection with the relevant project.

CAR Cover Description: This is an all risks cover provided for damages to a **Stadium** during its construction, testing & commissioning and maintenance. Such Policy includes extensions of cover such as removal of debris, professional fees, public authorities, inland transit, offsite storage etc.

Underwriting consideration/ information:

Project details:

- Detailed scope of works
- Contract value
- Breakdown of the sum insured
- Bar chart
- Work method statement
- Geotechnical investigation reports
- basic design criteria
- details of offsite storage/ laydown area
- Nat Cat exposure
- Location / Site layout plan
- Retractable roofs – structural & non-structural
- Any prototype technology involved
- In case of reconstruction: report on the existing property, recommendations on preservation, info on price

Contractor details

- Contractor's experience in similar projects
- Project personnel qualifications and experience
- Site security
- Fire protection and/or prevention systems/ procedures

U/W check-list:

- Is there any prototype design used?
- Is the cost of engineering equipment included in the TSI?
- Will there be any surveyor presence on site during the critical path?

4.3.2 Delay in Start-up Policy (DSU)

Insured Parties: This cover is provided to the ultimate owner of the project. The Financiers to the project require the purchase of DSU cover where finance is on a limited recourse basis to ensure protection of their investment. Accordingly, this Policy is only beneficial for financing and/or co-financing parties of the Project.

DSU Cover Description: DSU, as the name suggests, covers the financial consequences of delay (beyond the scheduled business commencement date) to the completion of a construction project following the physical loss or damage caused by an insured peril. The cover should be purchased in conjunction with the CAR policy.

The indemnity could be based on:

- Gross profit (loss of anticipated revenue, including debt service costs, fixed operating costs as well as anticipated net profit, less variable costs).
- Debt service and fixed costs, or
- Debt service only

Nonetheless, that the indemnity under this cover shall not extend to any expenditure incurred solely to have the project completed at an earlier date than would have been the case had no physical loss or damage occurred. Fines and penalties for late completion or non-completion is excluded.

DSU cover is purchased for a maximum indemnity period which should ideally not be less than the maximum period envisaged to rebuild the stadium. It is typically 12-24 months for a Stadium.

Underwriting Consideration/ information:

In addition to the information requested for the CAR, the following is required:

- Details of projected revenue/ Sum Insured
- Debt service/ fixed cost details
- Critical Path of the project
- Contingency plan
- Project risk monitoring report
- Details of partial hand-over and partial payment provision (if any) in the Contract
- Redundancy in the equipment ordered for the project

U/W check-list:

- Do the underwriters have the clear understanding how the project revenue is forming?
- Can the underwriters divide the revenues that depend on delay covered by the policy?

4.3.3 Third party Liability (TPL)

TPL Insured Parties: Normally the same entities covered as under the CAR section for their respective rights & interests.

TPL Cover Description:

The Insured will be covered against all sums which they shall become legally liable to pay as damages (whether contractually or otherwise) in respect of or consequent upon

- (a) death or Injury suffered by any person
- (b) loss of or damage to Property
- (c) obstruction, interference, loss of amenities, nuisance, trespass, stoppage of traffic, infringement of light, easement or quasi-easement or denial of access arising in connection with the Project.

Underwriting Consideration/ Information: Policy limits will be determined by the contractual obligations and the needs of the Insured parties.

- Details of third party surrounding properties
- Accessibility of the site by the public/ third parties
- The underwriter should be very careful about the TPL coverage during the maintenance as the risks too high because of the lots of people inside the building. Usually it is not recommended to cover the TPL during the maintenance phase.

U/w check-list:

- Will there be any possibility of presence of a public on site during the last stages of construction?
- Is only the liability in tort covered under the policy?

4.3.4 Liquidated Damages (LD)

LD Insured Parties: EPC Contractors and subcontractors

LD Cover Description: EPC Contractors and subcontractors may be exposed to large penalties in the form of Liquidated Damages reaching up to 20% of the contract value for the non-achievement of their warranties regarding contractual completion date and/or guaranteed performance during the demonstration period. An LD Cover can improve the financial stability of the EPC contractor and subcontractors backing up their contractual liabilities.

The Insurer's liability follows very closely the liability of the EPC Contractor in the EPC contract. On top of that there will be additional required standard exclusions as well as a reasonable deductible and a proportional loss participation of the insured in order to align the interest of both parties. This is not a standard cover offered by the insurance market but only by few insurers to selected insureds.

Underwriting Consideration/ information: Apart from the requirements specified under CAR, underwriters require to know the Contract provision detailing LD clauses along with an in-depth understanding of the parties involved and their history with LD.

There are papers on LD Cover on the IMIA website that may be of interest for readers:
<http://www.imia.com/wp-content/uploads/2013/05/GP08-2008-Liquidated-Damages.pdf> and
<http://www.imia.com/wp-content/uploads/2013/02/IMIA-WG-7712-Entrepreneurial-risks-31.pdf>

4.3.5 Inherent defects insurance (IDI)

IDI Insured Parties: This is a first party Policy; owners are insured with an option to add waiver of subrogation against the Contractor.

IDI Cover Description: cover of material damage to premises caused by an inherent defect in design or workmanship or material which was undiscovered at the date of Practical completion and which affects structural works. The Insured interest will be a completed stadium, accepted by the Owner/ Principal and checked by an independent inspection company. This inspection company is a crucial element of the cover without whom underwriters will not agree to write the risk. The Sum Insured will represent the total cost of rebuilding the Stadium, at the date of inception of the Policy.

Underwriting Consideration/ Information: apart from the information required for CAR, the following is mandatory

- General arrangement drawing including plans and section for each structure
- Preliminary report issued by an independent inspection company
- Individual cost of each structure.

5. Lessons learned from claims. Recommendations

5.1 Claims examples

If we look at the global view of stadium damages, we could divide them into 3 groups according to the cause of damage:

- Acts of God,
- Errors during assembling
- Design/manufacturing errors.

The Working Group of this paper tried to analyse the details of stadium failures connected with construction and design but such risks as overcapacity, crowd issue and similar were not considered as this is a field of operation policy coverage.

Here are some claims examples:

Date of accident: June 4, 1979

Stadium: Kemper arena

Capacity: 17 600 in 1979, 19 500 – now

Located: Kansas City, USA

Built: 1973–74 (in 18 months)



Figure 14 .Kemper Arena collapse. Source: http://www.capretzer.com/html/kemper_arena.html

Cause of accident: AoG/ design errors

The roof of the Kemper Arena was designed to slowly release the rainwater as to reduce the chance of flooding, but during a storm the water collected on the roof and caused it to sag from the excessive weight and it collapsed. It was also investigated that the strengths of the bolts used to uphold the structure were miscalculated.

Water couldnot run off the roof fast enough, bolts holding supports to the roof weren't strong enough for the load, and the roof cashed to the stadium floor on a day when, thankfully, the facility was closed.

Two major factors came together to cause the collapse.

- First, the roof had been designed to gradually release rainwater as the sewers in could not adequately handle the rapid runoff because of the nearby confluence of the Missouri River and Kansas River.
- Second, there had been a miscalculation on the strength of the bolts on the hangers when subjected to the 70 mph (110 km/h) winds while supporting the additional rainwater weight as the roof swung back and forth. Once one of the bolts gave way there was a cascading failure on the south side of the roof. Although the bolts were enormous, the media was to make much of the fact that "one broken bolt caused the collapse."

Date of accident: July 14, 1999,

Stadium: Miller Park

Capacity: 41 900

Record attendance: 46 218

Located: Milwaukee, Wisconsin , USA

Built: 1996 – 2001

Cause of Accident: Failling crane - construction error



Figure 15 ._Miller park Source [http://en.wikipedia.org/wiki/Miller_Park_\(Milwaukee\)](http://en.wikipedia.org/wiki/Miller_Park_(Milwaukee))

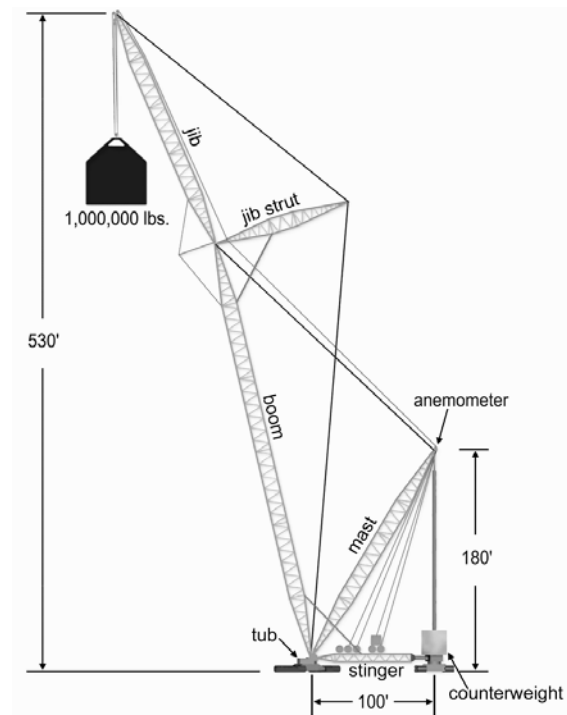
A 567-foot crane lifting a 400-ton section of a retractable roof bent in half and collapsed inside the new Miller Park stadium being built for the Milwaukee Brewers' professional baseball team. The roof that was damaged in the crane's collapse was made from special high-strength steel, designed and produced in Luxembourg, which will take seven to eight months to replace.

An investigation revealed that although the effects of side winds on the crane itself had been calculated, it had not been considered for the load the crane was lifting.



Figure 16 .Source:

<http://www.simulia.com/forms/world/pdf2006/Kenner.pdf>



Date of accident:
December 11, 2010

Figure 17 Metrodome of the Minnesota Vikings Source:
<http://en.wikipedia.org/wiki/Metrodome>



Stadium: Metrodome of the Minnesota Vikings

Capacity: 64 121

Located: downtown Minneapolis, Minnesota, USA

Cause of accident: design errors

Four of the five incidents occurred within the stadium's first five years of operation:

On November 19, 1981, a rapid accumulation of over a foot of snow caused the roof to collapse, requiring it to be re-inflated. It deflated the following winter on December 30, 1982,

again because of a tear caused by heavy snow. In the spring following that same winter, on April 14, 1983, the Metrodome roof deflated because of a tear caused by a late-season heavy snow. On April 26, 1986, the Metrodome roof suffered a slight tear because of high winds.

A severe winter storm arrived on December 10–11, 2010, with over 17 inches (43 cm) of snow accumulation. On December 12 at about 5:00 a.m., the roof had a catastrophic collapse as three panels tore open.

The roof was again reconstructed, but the stadium was closed December 29, 2013 and demolished during the 2014.



Figure 18.

Source: <http://www.constructionweekonline.com/article-10470-in-video-stadium-roof-collapse/>

Date	2011
Stadium:	FC Twente stadium Grolsch Veste (Enschede -NL)
Capacity:	30206
Located:	Enschede, Netherlands
Built:	1997–1998. Expanded during the summer of 2011



Cause of accident -
engineering errors

Figure 19. GrolschVeste. Source: http://en.wikipedia.org/wiki/File:Grolsch_Veste_1.jpg

During the renovation work at the Grolsch Veste, the roof of the building collapsed.

The Grolsch Veste was expanded during the summer of 2011. On 7 July, when working on the construction of the stand, the roof suddenly collapsed, killing two workers and injuring 14 people. The collapse was probably caused by too much weight on the unfinished roof. After an investigation of a month, the roof was taken away and work continued. FC Twente played the first few competition matches partly without a roof. The new stadium was officially opened on 29 October with a competition match against PSV Eindhoven (2-2). A year after the accident, a monument was revealed.

The investigation examined both the technical and human factors that contributed to the failure. The investigation concluded that the technical causes of the failure was the insufficient stability of the incomplete roof structure. And on the technical side three following key factors played a role:

- Elements required for stability were missing from the roof structure. The last of these cables was taken away on the day of the failure.

- The incomplete roof was subject to excessive loading. The experts identified that this additional loading was enough to collapse the incomplete structure.
- Dimensional deviations in the concrete structure lead to a mismatch between the concrete and steel structures.

Human factor was the time pressure. The stadium associated with 'football-ready'. That's why the main original construction sequence of the work were abandoned and allowed it be undertaken simultaneously.



Figure 20. Source: <https://www.engineersaustralia.org.au/sites/default/files/shado/Divisions/Quee>

Date	May 27, 2013
Stadium:	Itaipava Arena Fonte Nova
Capacity:	51 708
Located:	Salvador, Brazil
Broke ground:	2010
Opened:	April 7, 2013



Figure 21 Arena Fonte Nova. Source: <http://www.odebrechtproperties.com/pt-br/itaipava-arena-fonte-nova>

Cause of accident: partial roof collapse after heavy rain/ design error

The stadium which is due to host Confederations Cup matches has suffered a partial collapse of its roof, after an apparent build-up of rainwater.

Workers at the Arena Fonte Nova stadium in Salvador had to bail out water from another section to try to prevent it from collapsing.



Figure 22 . _ Source: <http://www.bbc.com/news/world-latin-america-22685180>

Date	November 27, 2013
Stadium:	Arena Corinthians
Capacity:	47 605
Record attendance	63 267
Located:	Sao Paulo, Brazil
Built:	30 May 2011 – 15 April 2014
Cause of accident:	A crane collapsed hitting the roof



Figure 23. Arena Corinthians. Source:

[http://stadiumdb.com/pic-projects/estadio_da_itaquera/estadio_da_itaquera14.jpg](http://stadiumdb.com/projects/estadio_da_itaquera/estadio_da_itaquera14.jpg)

The crane that hoisted the last module of the structure of the metal roof collapsed causing the fall of the part of the circulation area of the east building.

On December 12 2013 officials were still probing the causes of the crane collapse, and there is no evidence that the company building the stadium, Odebrecht SA, committed any wrongdoing. Odebrecht said in a statement that construction "has followed rigorous planning and respected the appropriate speed.



Figure 24. Source: <http://www.ibtimes.co.uk/world-cup-2014-brazil-stadium-corinthians-arena-525642>

Date	14/02/2004	Located:	Moscow, Russia
Stadium:	Largest water park in Moscow, built in 2002.	Built:	2002
Capacity:	2000	Cause of accident:	Design error

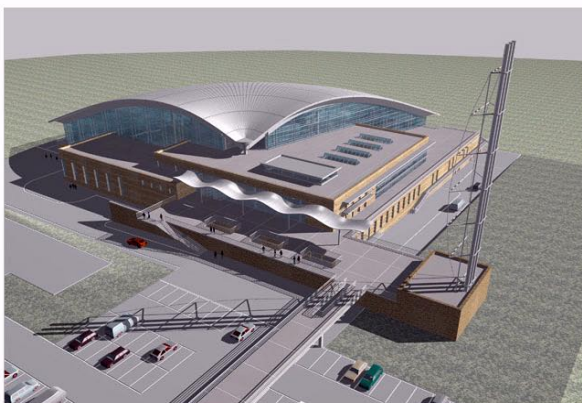


Figure 24 .Transvaal Park Picture sources: http://www.newsru.com/arch/world/17feb2004/transvaal_baturina.html

February, 14, 2004 the roof of aquapark "Transvaal" collapsed. About 400 people were inside at the time. The accident killed 28 people, injured 193.

Examination revealed that the cause of the collapse was the fall of one column and engineering mistakes made in course of a water park erection.

The dome of the water park, which is a segment of a sphere with an angle of 108 degrees at the base, supported by an administrative building in the center and 22 columns along the arc.

Each of the columns — a round hollow metal construction height of about 8 m and a diameter of 450 mm, plastered with cement mortar. Columns were not rigidly attached to rest of the structure. At the bottom, they were just standing in petri-glides, and sharpens the top (tapered) and is connected to the roof using a small hinge compensates for the temperature expansion of the dome.

"Pencils" (as these column were called by designers), had a margin of safety that can withstand another 15 set top water parks, but only if the burden falls on the static compression. The horizontal load could give way the "pencil" falling.

It is now established, that as a result of system "shell — columns with constraints" design solution fault, just a load applied to the seventh column, was the cause of the collapse.

Date	22/11/2007
Stadium:	Krylatskoye Ice Palace
Capacity:	10 000
Located:	Moscow, Russia
Built:	2004
Cause of accident :	Manufacturing error/defect

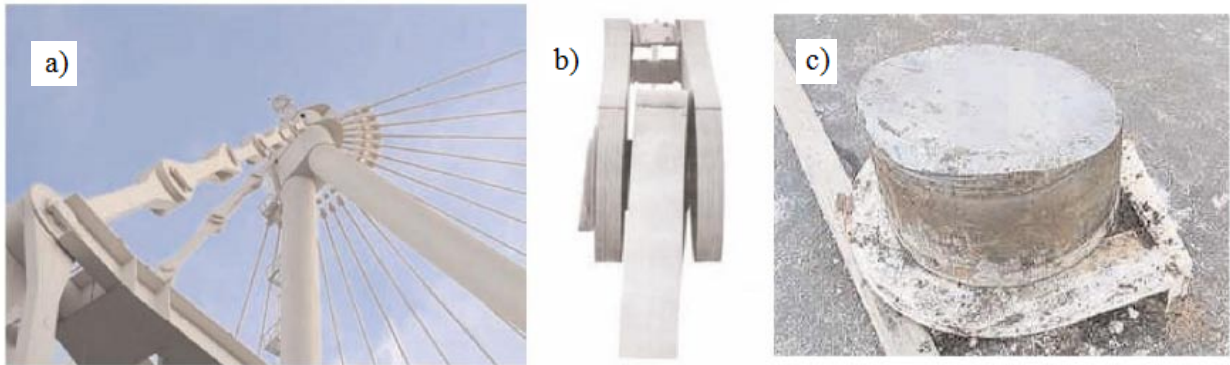
The building has a prototype roof design - semi-circular segment with a suspension cables.

In course of the technical structures checking, it was noted that cable system has "zero robustness ": it contains several key design elements — damage to any of them leads to complete destruction the entire structure. November 22, 2007 one of the metal elements (units) with the function of cable-braced fastening roof has burst. Structure collapse was avoided but staff and visitors were evacuated.



A fragment of the building calculation model.
Elements # 3,4 and node # 5 are key

Figure 25 Picture source: [Moscow State Construction University Journal, 2009, page 117](#)



Hazardous precedent: a) undamaged backstay b) damaged backstay
c) dropped "finger" frame

Figure 26 Picture source: [Moscow State Construction University Journal, 2009, page 118](#)

There was a very high probability of collapse of the Ice Palace roof. In the element of the cabling structure, which provides a counterbalance to the roof, there was a brittle shear of bushing "fingers" (all-metal huge rod diameter 528 mm), which is mounted on a hinge and provided a link to the cabling system counterbalance.

"Finger" broke into two halves. One third has fallen, and the second part is continued to provide work of the entire cable system.

The investigation has shown the cause of incident — the finger manufacturing error. All at the stadium was installed 16 same fingers.

It was decided to repair the building, the total duration was about half a year.

Repair consisted of the following major steps:

- Mounting of the ring beams temporary supports for unloading braces around the perimeter;
- Installation the temporary belaying device on the damaged unit procrastination;
- Replacement of damaged fingers;
- Installation of two new permanent cables that are unloaded and topologically duplicated braces;
- An annular beam gain;
- Implementation of the horizontal detents in supporting reinforced concret tower.

Figure 27 - Picture source: [Moscow State Construction University Journal, 2009, page 118](#)



5.2 Lessons learned, conclusions and recommendations

There are some lessons we can learn analysing the accidents:

- The more stadium span - the higher the risk. Especially if there are structural components which bridge the considerable span because they tend to be massive, heavy and difficult to handle;
- It's negative for the project, if there are any elements which takes half a year or more to produce it again and replace it in case of accident.
- When the time pressure exists - the risk increases greatly, because often there are a lot of changes in the order of work without any consultation with the engineering professionals.
- The last days of construction are very important. In that period the errors during assembling risk still exist or sometimes is higher than before.
- A new type stadium has its own unique construction challenges for the constructor. The better way to low the risk is to ask both of the consultants – architect and engineer - to estimate stability of the structure and possible corrections in the further work according to current purposes.
- When using the labour intensive methods of construction work, workers should be given a good grounding in the basic work method, the skills need to be improved to produce quality work on sites, then the quality of engineering design will meet specifications and possibility of damage is lower.

In the most of above examples, the incident that damage the stadium was the collapse of roof due: designer fault/ manufacturer defect/ construction error in some cases combined with the storm/heavy rain/snow.

That's why insurers has to be very careful with granting a wide coverage including defects coverage (LEG2 / LEG3, DE4, DE5)

The most important issue for these type of construction is large spans exposure and insufficient information about the whole structure design.

An independent examination of the calculations on the robustness of structure, including the consideration of the scenario of failure of one of the "key elements" (domino effect) should be requested.

The Working group recommends:

- to obtain adequate proof of the ability of key elements to perform their functions in accordance with the project. For this purpose it is possible to study:
 - the results of laboratory investigations of "key elements" materials of the construction;
 - the results of survey of manufacturing compliance with the technologies used, quality management standards requirements for quality and reliability of the final product;
- require the independent expert's participation to monitor the execution of work / key elements installation and providing documentary evidence/validate the installation. This method is widely used in the offshore construction. Marine warranty surveyor issues a certificate when certain operations are carried on the sea, after rechecking corresponding to the actual fulfilment work performed design and estimate documentation, as well as the very design estimates checks for errors and vulnerabilities.
- Preliminary testing of materials should be done and according to the test results they can be used in case if they meet specifications and design requirements.

- Coordination, communication and cross- checking is very important in construction structural safety and these processes should be being developed all the time.
- Any alternative design proposals provided by main contractor should be adopted with integrated checks.

Possible, and even desirable, if the insurer recommends the inclusion of some of these conditions to the construction contracts' insurance requirements.

Appendix 1- Global risk matrix for exposures

Hazards	MPL Scenarios	Frequency			Severity		
		H	M	L	H	M	L
Natural hazards (6)							
Earthquake	Total loss for projects within 50km from the epicentre.	1)			X		
Ice and snow accumulation	Large part of the works can be affected by the same event resulting in roof collapse on seats and structures.				X		
Wind storms	Large part of the works can be affected by the same event resulting in roof destroying or collapse on seats and structures.				2)	X	
Flood	Partial loss of structures plus possible collapse, in case of violent flash flood.					X	3)
Landslides	Possible collapse.						X
Lightning	Lightning storms usually affect limited parts but with possible risk of total fire following.				X		
Subsidence	Effects depending on subsoil conditions affecting foundations and structures in case of construction on filled areas (also as consequence of EQ).can lead to destroy and rebuild						X
External Hazards							
Aircraft impact	Large part of the works can be affected by the event resulting in roof destroying or fire following then collapse and total loss.			X	X		
Bush fires	No great exposition			X			X
Terrorism & SRCC	Great exposition with wide risk of collapse or fire following which will lead to complete loss. This may happen during end of work or standby/silent risk period.			X	X		
Theft	Theft of minor to moderate quantities of valuable goods (bulky items) stored at the construction site or partially assembled along the line.	X					X
Nearby man-made hazards	Yes for low intensity and attritional level (5)	X			X		
Project intrinsic hazards							
Fire	The most exposed items are internal systems and PML usually refers to the largest fire unit.		X			X	
Faulty design and workmanship	Clearly depending of the architectural novation. If the structure is very well known the risk is rather low, if the structure is complete new one calculation, with specific raw materials and bad quality checking chain system then become it with high intensity	X			X (4)		
Construction operations	Lifting, erection operations are intrinsically risky given special equipment and high rise structures	X			X		

- 1) Frequency is not included for Natural hazards as it depends on the location of the project.
- 2) Wind storm severity have to be increased to High in case of projects located in areas subject to heavy snow falls/freezing rain or hurricanes/typhoons. A layer of ice 1 cm thick means an additional weight of almost 100 kg per 100 m².
- 3) Flood severity can be considered Low where morphology allows to clearly separate different flood areas/chat basins.
- 4) Faulty design severity has to be limited in case limits are included in the policy wording.
- 5) Natural hazards:
 - a. *Earthquake*: High exposure during the execution of works.
 - b. *Windstorm*: producing losses over the whole project.
 - c. *Ice&Snow*: Combined effect of ice and wind could change the aerodynamic conditions as a consequence of the higher charges produced by the deposit of ice and snow.
 - d. *Wild fire*: producing damages in the substation and stored equipment.

- e. *Lightning*: basically affecting structure.
- f. *Flood*: Direct and indirect damages.
- g. *Soil conditions*: affecting to excavation works and foundations but complete settlement may occur.

6) Manmade hazards:

- Terrorism: Higher exposure
- SRCC: damage can be large (fire).
- Theft: in case of absence of security measures.
- Operational Errors: no exposure
- Aircraft collision: Depending on location.