

RISING TO THE CHALLENGE

Mosaic Stadium
Image credit: Nic Lehoux

Sports venue developments present complex and unique engineering challenges, as Bart Miller of Walter P Moore and Geoff Wilks of TRP Consulting explain to John Sheehan.

Architects and engineers of modern sports venues face a myriad of challenges as they look to complete projects on time, on budget, and which meet the specific needs of their client.

The design of new 'iconic' venues with complex feature aspects also add to the demands faced by stadium and arena designers and builders.

The rise of multi-purpose venues and the requirement to be able to convert them quickly from sporting venues to host concerts and other events also heightens challenges.

Bart Miller, Principal/Structures at **Walter P Moore**, told *PS&AM* that the company is currently working on a number of high-profile projects, each with a unique set of challenges.

He said: *"The real speciality and value we bring on a lot of these projects is our experience with long-span, and particularly lightweight, structures and retractable roofs.*

"Right now we're working on the new Los Angeles Sports and Entertainment

District in Inglewood, California, which we believe will be the largest stadium roof in the world – covering more than 1.2 million square feet – when it opens in 2020.

"It is an ETFE-clad, cable-supported roof over a stadium in an extremely high-seismic region and very close to LAX airport. It is a very high-profile and visible location for a spectacular project; the type of project that has never been done before."

Miller said Walter P Moore is the structural engineer-of-record for the entire building, working alongside architects **HKS**.

The companies have teamed up on a number of projects including **AT&T Stadium** in Arlington, TX, **Lucas Oil Stadium** in Indianapolis and the new **Globe Life Field** for the **Texas Rangers**, also currently under construction in Arlington, TX.

"Los Angeles Sports and Entertainment District is being designed with multiple uses in mind, and will even feature a separate, 6,000-seat entertainment

venue below a single, clear-span roof," Miller added.

GLOBE LIFE FIELD

Miller said work was also underway on a new retractable roof ballpark for the Texas Rangers in Arlington, TX.

"That's another very exciting project. It's not only a retractable roof, but also has some ETFE elements as well to create a more open feel and bring natural light inside the stadium. There are all the challenges you have in a ballpark – including long cantilevers and very little symmetry or repetition – combined with all the challenges of a retractable roof.

"With any retractable roof, the main challenges from a structural design standpoint have to do with the interaction of the structure and the mechanisation, as well as the delicate balance between the stiffness and flexibility of the rails and the moving panels that ensure that the mechanisation functions properly. Spans are typically very long and that

Marlins Ballpark
Image credit: Christy Radecic



impacts our design as well, obviously, but mechanisation, in general, will drive a lot of the structural design of a roof.

“What we’ve found on these projects is that the least weight solution in terms of structural steel quantities very often does not equal least cost.

“You have to think about constructability, fabrication, and absolutely you have to think about the integration of the mechanisation into the structural design. Mechanisation often drives how we approach the structural design.

“In addition to that, because the roof moves, theoretically there is an infinite number of different positions that roof could be in, so there are a lot of different scenarios we need to consider, and the amount of analysis increases by orders of magnitude.

“The fact that these panels move creates dynamic forces, especially when the roof panel stops abruptly in an emergency stop scenario. That is equivalent really to a mild seismic event, an earthquake-type of loading being distributed over the entire roof structure.”

Hurricane winds also need to be taken into consideration in cities like Miami and Houston, Miller said.

“At Minute Maid Park in Houston, the roof is designed to be closed and strapped down during a hurricane event.

“At Marlins Park in Miami, however, the roof is actually designed to be left partially open in a hurricane, in order to reduce internal pressure on the inside of the building. These intentionally planned and strategically located gaps between panels saved a significant amount of structural steel and money by leaving that roof open a little bit and designing the rest of the building accordingly.”

The need to keep the playing surface healthy and grass growing is also a major concern for designers.

Miller said: *“There’s a lot of talk about trying to find ways to grow natural grass under a roof by using transparent materials. Stationary, opaque canopies and even partially transparent roof structures make growing natural grass nearly impossible below.*

“Connected to that is also shadowing on the field during a game. We think about shadowing caused by the density and positioning of cable-supported structures required to support transparent roofing materials, for example, impacting the ability of an outfielder to catch a fly ball.”

MOSAIC STADIUM

At the **Mosaic Stadium** in Regina Canada, home of the **Saskatchewan Roughriders**, a particular challenge was around the roof and the weather patterns in the area.

“That canopy is a PTFE fiberglass fabric stretched across a cantilevered structural steel frame. Beyond the complex, curving geometry, the biggest structural design challenges are associated with snow and ice prevalent in that climate.

“We’re designing not only for the weight of snow and ice that can drift and pile up on top of this roof, but also the possibility that the fabric can be punctured or torn and the resulting unbalanced horizontal loading that can create on our structure.

“So we’re designing for a lot of different scenarios for both gravity and lateral loads associated with a combination of those two factors. We also spent a lot of time working on snow and ice guards that keep those elements from sliding off the roof and onto the people below.”

Miller said environmental factors are a major driver of the design, shape, materials, and the aesthetic of modern sports venues.

“Where we have high seismic activity, hurricane-prone regions, or high snow and ice loading, those things have to be taken into consideration along with the functional requirements of a stadium roof.

“Lucas Oil Stadium from the very beginning was designed to be truly multi-purpose. It’s not just a football stadium that you can try to host some other events in.

“It’s a football stadium that is also designed specifically for basketball, concerts, and conventions with full rigging capacity, catwalk access, and lighting capabilities that function for any of those types of events. So truly a multi-purpose type of facility.”

MULTI-PURPOSE VENUES

Miller said the majority of arenas are now being built to be truly multi-purpose venues that are not just intended for basketball or hockey, but for concerts, circuses, ice shows, and conventions.

“Being able to easily convert these buildings from one function to another quickly is really important to make sure that facilities maximise their event dates, revenue, and return on investment.

“Right now we’re working on a new arena for the NBA’s Milwaukee Bucks. Populous and HNTB are designing the building and we’re the structural engineer for the roof in addition to serving as consultants on the façade.

“The roof is very complex geometrically as most of these buildings are. It’s curving in plan and in section and these multiple, curving surfaces have >>

« to merge seamlessly to create a very dynamic shape that emphasises the very iconic building that it's going to be; one of the most recognisable buildings in Milwaukee.”

He said the roof is designed for maximum flexibility with the rigging grid spread out across the roof.

“The rigging grid in Milwaukee is both large in terms of area or coverage, but also in terms of its load carrying capacity.

“It's going to be capable of handling anything that these performers are going to throw at it.”

ROOFING TRENDS

Miller said some of the major trends in terms of sports venue roofing in the U.S. are towards lightweight structures, membranes, and cable-supported structures.

“If you've followed Major League Soccer (MLS) expansion talks over the last year, nearly every design concept proposed from each of the 12 cities that were vying for a franchise incorporated some type of ETFE or

transparent membrane solutions, either on the roof, or façade, or both. So the industry is clearly headed that way.

“I think another trend in design is the types of digital design and fabrication tools that are now available. They significantly improve the design process, especially when tackling complex geometric forms that architects are envisioning these days and addressing the added complexity that tension structures introduce.

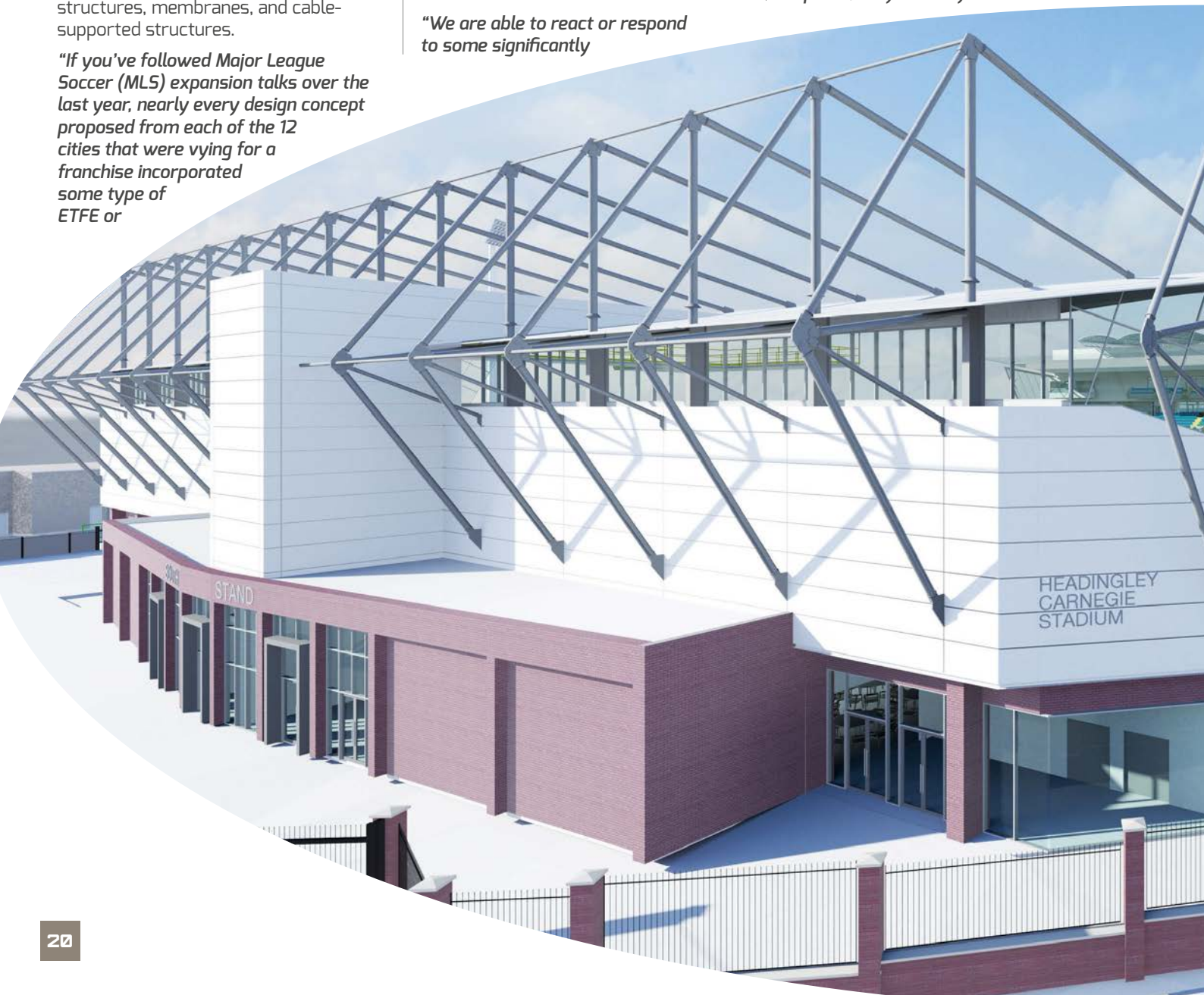
“We're doing a lot with advanced computational tools. Parametric modeling specifically allows us to study a lot of these different geometries, multiple roof configurations and options. A very diverse set of design scenarios for very complex shapes over a much shorter amount of time than we used to.

“We are able to react or respond to some significantly

compressed design schedules with the use of innovative technologies.

“The other thing that we have to keep in mind when we're talking about lightweight structures is the limitations of the material itself. We're not dealing with a metal deck, we're dealing with perhaps a very thin ETFE membrane which has a different set of design criteria and of capabilities, but also a different set of limitations on what it can really do, the type of load that it can support.

“One thing we're looking forward to is continuing innovation in these materials in terms of their ability to provide greater strengths that can span longer distances and improved thermal and acoustic performance. And as these materials continue to improve, they're really



going to open the door to a vast amount of additional design possibilities from both an architectural and an engineering standpoint.”

HEADINGLEY REDEVELOPMENT

Complex projects are taking place across the world and one unique scheme is underway at **Emerald Headingley Stadium** in Leeds, England.

Leading structural engineering specialist **TRP Consulting** is part of the team that is delivering the £40 million redevelopment.

Its engineering experts are working with the Emerald Headingley design and construction teams to turn the vision for two impressive new stands at the historic sporting venue into reality.

Emerald Headingley is home to **Leeds Rhinos** rugby league club and **Yorkshire County Cricket Club**. It also hosts **Yorkshire Carnegie** rugby union games and is a Test cricket venue.

The proposed major redevelopment includes a new rugby South Stand and a replacement for the 90-year-old joint rugby and cricket ground stand that overlooks both sides of the iconic sporting complex.

The new combined stand will have 4,200 seats for cricket and 3,800 facing the rugby pitch. The new South Stand for the rugby ground will have a capacity of 7,700 with 2,200 seats.

TRP Consulting has been appointed by **Caddick Group**. The new stands are being designed by **DLA Architects**. Construction work will be carried out by Caddick Construction.

TRP Consulting director Geoff Wilks said: *“Emerald Headingley is well-known globally as a fantastic venue and this redevelopment will ensure that it continues to be the scene of great sporting dramas in the future.*

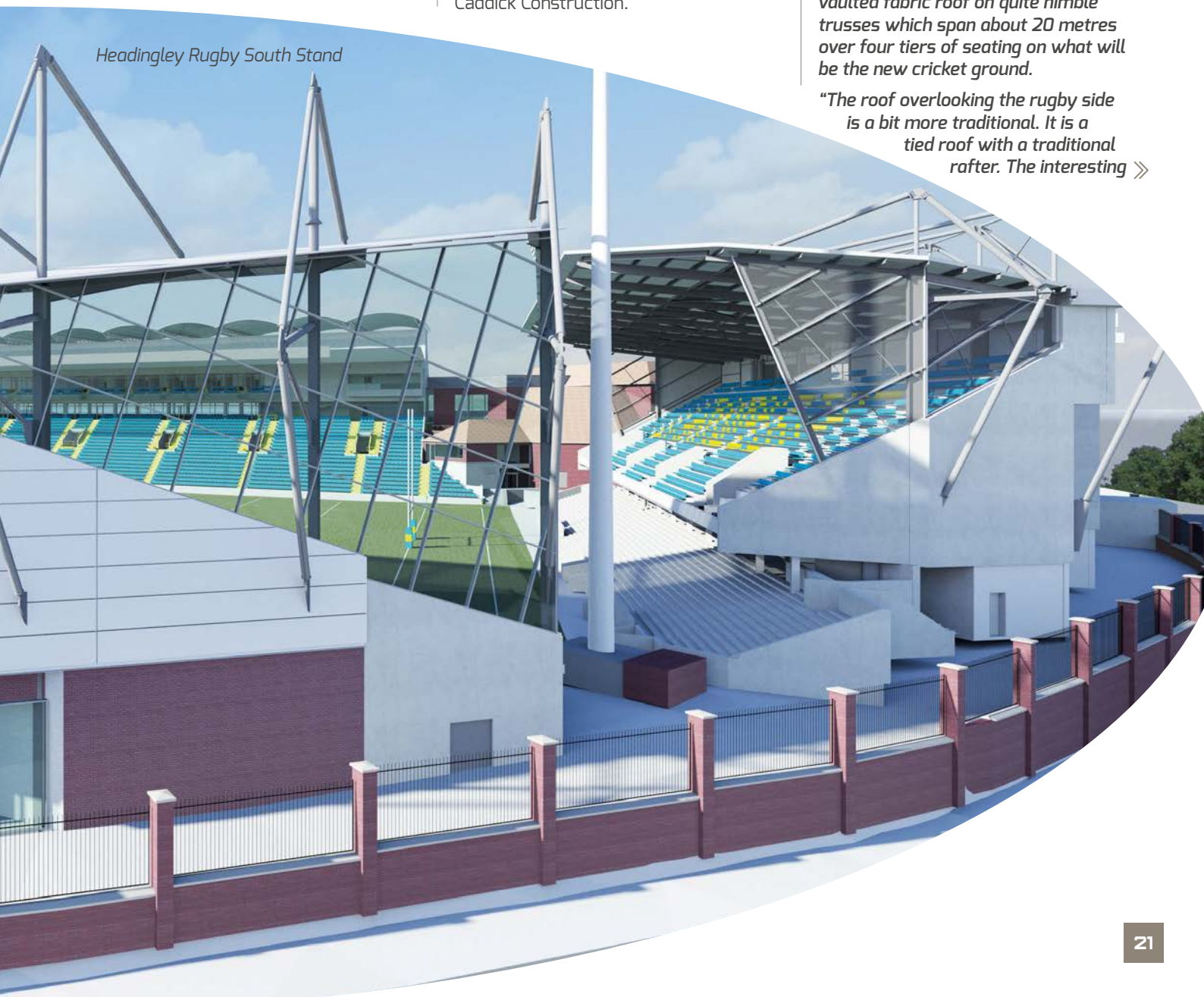
“This new facility at Headingley is an unusual sports development. I bet there aren’t many places in the world which have constructed a new state of the art stand which looks south over a rugby field and north over a cricket field.

“There’s perhaps a potential for something like that to happen in Australia where they’re big lovers of both cricket and rugby but I’m not sure it does exist.

“It’s appearance from the cricket side is a bit more related to the cricket vernacular with quite a nice barrel-vaulted fabric roof on quite nimble trusses which span about 20 metres over four tiers of seating on what will be the new cricket ground.

“The roof overlooking the rugby side is a bit more traditional. It is a tied roof with a traditional rafter. The interesting »

Headingley Rugby South Stand



« elements are the interaction of the crowd loading on this frame which is loaded on both sides, which is not what you normally see on a sports stadium. That is an interesting design and an interesting approach.”

TWIN TERRACING

Wilks said the South Stand is well underway and the main frame is currently being erected and is about 50% complete.

He added: “The North Stand foundations are well advanced and the steel frame will be constructed in due course. That will of course be taking shape from both sides, rather than a normal, traditional sports stadium.

“There’s a lot of activity on the front of it where you’ve got your terraces and the vomitories and all the bits which

are sports specific. Whereas the rear elevation of most sports facilities is just normal commercial space, this one’s a bit different as it has sports interface on both elevations. There will be quite a lot of activity around that for quite some time to get both terraces in on both sides.

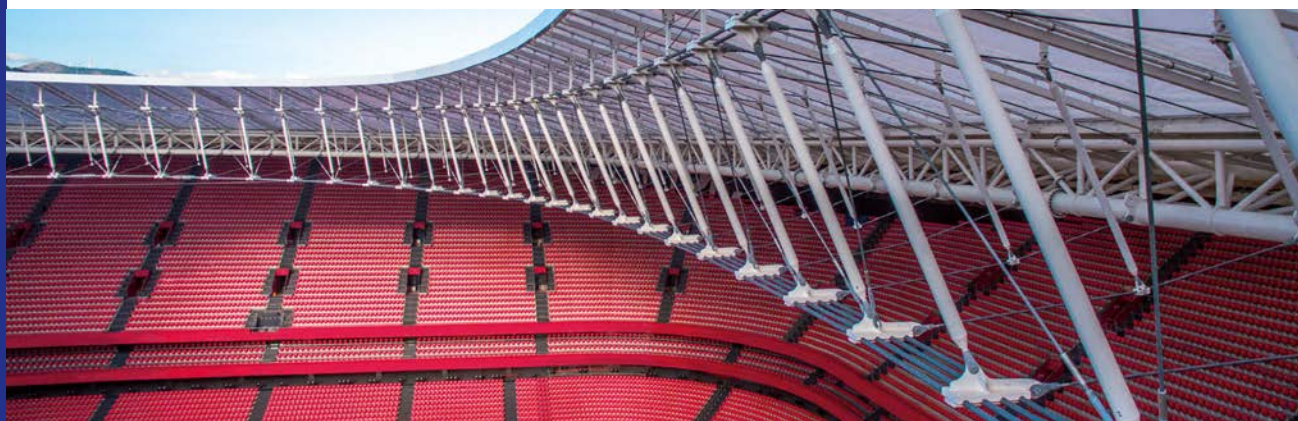
“The site in itself is quite tricky because there are elements of it that have to be brought in to use sooner to be able to service the rugby. Some temporary seating arrangement is being put in to replace the stand which was demolished a few months ago to make way for the North Stand. So there’s the typical licensing challenges of getting temporary seating in, getting safe access and safe egress, having the crowd support systems in place while you’re actually trying to construct a stand behind it.

“The real challenge on this one is that it faces both ways – north and south.”

He said that ordinarily, the terracing units could be built along with the roof but in this particular case, there has been a need to think about the stand in a partially complete state. “With construction more advanced on one side than it is on the other, it’s been necessary to introduce temporary bracing and the like into the frame to give it some temporary stability during construction.

“The challenges are unique both from an operational point of view as far as the club is concerned, from a construction point of view as far as the contractor is concerned and from a design point of view from our side. It’s an interesting and complex scheme.” ■

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