France's stadia go into overdrive as the time nears to host UEFA's flagship football competition.

Cedric Dufoix, general secretary, Olympique de Marseille

"The staging of the tournament matches will be much more demanding than hosting Champions League games but will raise the profile of the club and stadium. For the city, it will have an important economic and media impact."
THE FIFTH FAÇADE

By investigating the roofing developments of recent and future facilities, Stadia examines a new generation of truly sustainable architectural innovations that meld, form and function like never before.
Aided and abetted by advances in production techniques and materials science – and further driven by architectural demands for enhanced aesthetics, design freedom and a better spectator (and TV viewer) experience – the stadium roof has essentially become the ‘fifth façade’ in many observers’ eyes.

As well as serving as a visually striking architectural element (see Olympique Magnifique on page 26, for example), the right roof not only vastly improves the fan experience but can also facilitate a guaranteed revenue stream for a multipurpose venue regardless of the weather.

As such, the range of materials that are used to construct and support these behemoth structures are of vital importance. The requirements for a satisfactory roof covering include the need for the material to be lightweight, tough, water-tight, incombustible, aesthetically appealing, cost-effective and durable.

Material gains

The rise of ethylene tetrafluoroethylene (ETFE) plastic and polytetrafluoroethylene (PTFE) fabric (think Teflon) has started to offer diversity in selection, both for engineers and designers. Originally developed for the aerospace industry, ETFE is a weather-resistant thermoplastic. This polymer is just 1% the weight of glass, with the ability to bear 400 times its own weight, but it still lets 90% of sunlight reach the turf. That translucency, along with the ability to play with the opaqueness of the material, makes it an excellent choice for venues wanting the feeling of the outdoors, the light from sunshine when it comes, and none of the rain or snow.

AGC Chemicals Europe, one of the world’s largest producers of both glass and ETFE, has placed its Fluton ETFE coverings on venues such as Brazil’s Itaipava Arena Pernambuco in Recife, Beijing’s National Stadium, Sochi’s Fisht Stadium and the Forsyth Barr Stadium in Dunedin, New Zealand.
One of the next largest stadia that will employ ETFE was awarded 2018's Super Bowl. Minnesota's new 65,000-seat NFL stadium – now under construction and set to open in 2016 – will feature a sharply pitched transparent ETFE roof.

Bryan Trubey of HKS, the building's designer, calls 'transparent' the next 'retractable' when touting the design. The roof of the cold-weather venue will enable the Vikings to ward off wintry weather, and the heavy slant will serve as a snow-defense measure. By moving snow off naturally and choosing an ETFE roof, HKS is able to use a single, large steel truss running the length of the roof, removing the need for a network of overhead beams. This is helping Trubey's design to be one of the lightest hard roofs in snowy Minnesota.

"The sunlight will create the look and feel of an outdoor stadium, with the advantages of an indoor stadium," Trubey says.

In the winter, drawing in the warm sunlight will help heat the building and the venue's energy system will push that air toward the fans. In the warm summer, that same ventilation system will pull the top layer of warm air out of the building. Plus, to go with van Sluijs' point, Trubey has designed in 95ft-tall pivoting glass doors – the largest in the world – to help open up venue ventilation.

ETFE can also help to keep heat out by diffusing direct sunlight with printed white-silver dots or added-in color. However, ETFE isn't for everyone, points out van Sluijs. He says the material proves valuable for transparency and low weight, but its high capital cost and ongoing operational cost can make it prohibitive for some owners.

"ETFE film is chosen for stadia as it is lightweight so needs few supporting structures that would cast shadows, and architects like the imaginative shapes they can create with the material," AGC's product manager, Susie Claridge, tells Stadia. "It is strong and UV-resistant and keeps clean due to the non-stick surface."

ETFE made its in-stadia debut at the 2006 FIFA World Cup at the Allianz Arena in Munich, Germany, home to FC Bayern Munich and TSV 1860 München Bayern. From there, its popularity has grown. "More people started to get to know about ETFE film after it was used in this high-profile stadium," Claridge says.

Forsyth Barr Stadium, the only permanently covered natural turf stadium in the world, employs the film for its roof. The 30,000-seat rugby venue made its international debut during the 2011 Rugby World Cup, taking cues from the Populous-designed retractable roof built for Wimbledon's Centre Court.

"We were clear that natural light on the playing pitch was essential, so we wanted to create a transparent fixed-roof structure," says Richard Breslin, Populous senior principal and designer of Forsyth Barr. "The grass keeps growing but the fans are protected from the elements, whatever the weather."

Coryn Huddy, Dunedin Venues' chief operating officer and overseer of Forsyth Barr Stadium, says the ownership team completed trials before fully enclosing the natural grass turf to make sure it was achievable, while rigid maintenance of the turf inside the stadium has helped it along.

Ron van Sluijs, associate principal at Populous, says that, with Forsyth Barr a success, he thinks more applications of a similar nature will be seen in the future, along with the ability to go larger. While ETFE is a small module in the bigger structural span (ETFE is often installed as a double-sheet pneumatically inflated cushion system) and isn't able to span the full distance over a stadium pitch, he believes that breaking up the structural elements in which the ETFE modules can be fixed will allow for a much larger fully enclosed natural grass turf stadium.

Whatever the weather
According to van Sluijs, though, it is important to keep in mind that enclosing a stadium in ETFE works like a greenhouse. To prevent overheating inside the venue, a fixed roof ETFE venue is generally not suitable in a moderate-to-hot climate. If the roof is operable or the façade allows for ventilation, that reduces the heat load of ETFE and makes its use possible in warmer climates.
Future proof

Another application on the rise is PTFE fabric, and Michael Lussier, a manager with Saint-Gobain Performance Plastics, says the industry is seeing a trend toward open stadia, whether in retractable roofs, such as the ones his company helped install in the AT&T Stadium in Dallas and NRG Stadium in Houston, or with transparent materials. In Vancouver’s BC Place, the PTFE fabric pulls back with the combined help of structural steel cables to hold the fabric open to the sky. Use of structural steel cables has grown in popularity in Europe for PTFE fabric and other stressed-skin elements, says Serge Dussault, vice president of engineering at Structal-Heavy Steel Construction.

CLEANING THE OUTSIDE

Saint-Gobain’s EverClean surface has gained traction as a de-polluting feature of a stadium roof, all while keeping the surface clean. The surface, a photocatalytic TiO₂-based material uses organic substances to self-clean. In the presence of UV light, and through a chemical reduction process, both nitrogen oxide and sulfur oxide pollutants, two atmospheric pollutants mainly found in exhaust fumes and smokes, decompose.

Used on two FIFA World Cup 2014 stadia – Mané Garrincha in Brasilia and Estadio Mineirão in Belo Horizonte – the roofs will stay cleaner, whiter and brighter, helping to de-pollute, Lussier says. Plus, when attaching photovoltaic panels to the roof, as seen in Brazil, the cleaner surface better captures the sun.

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Mané Garrincha, Brasilia
And though the same cannot yet be said in North America, the 60,000-seat BC Place, for example, features 22 miles of 5.25in-diameter cables, and is one of the world’s largest cable-supported retractable roofs. Expect to see plenty of roof combinations in the future too, from steel cables to fabrics to ETFE. The Singapore Sports Hub, completed in June 2014, is a modern example displaying ETFE’s retractable abilities. In New York, the USTA National Tennis Center wanted a retractable roof over Arthur Ashe Stadium on a foundation that cannot handle substantial added weight, so opted for a traditional retractable steel feature with PTFE fabric stretching across the supports. The addition is planned for 2017.

Steels with tensile strengths reaching 70ksi have also gained in popularity as they enable structural elements to span further. Structal-Heavy Steel Construction’s work on Marlins Park in Miami, which opened in 2012, allows for a 338,000ft² roof with three movable structure steel panels weighing 8,000 tons. 

Lussier says the continued push toward openness is first and foremost about aesthetics. “ Owners want to have a unique look and different appearances,” he says. “They also tie it very closely with the fan experience. That openness enables the fans to feel they are outside.”

Claridge says that openness continues to enable architects to be more creative, as they use these films to curve shapes. “It gives architects freedom of design as ETFE film can be bent or shaped more easily than other rigid materials,” she says.

Also expect more personalization of a team’s brand, as color – either through additives or light – creates new aesthetics. In Sochi, Populous welded the clear ETFE sheets together, giving an illusion of arched panels and gaps in the roof. “Creative use of the material has resulted in a clever balance of light ingress, shading and architectural interest within the application of a single material,” van Sluijs says.

Architectural features of a roof have turned into signature elements, believes Dussault – something owners have proved more willing to heavily invest in. “We are looking at ways to create the next generation of materials that can provide for the dramatic, iconic looks we’ve seen over the years,” says Lussier, “while improving the fan experience and the environmental impact of the stadium.”

Finally, Dussault, who is working on the Arthur Ashe project, says new computer software is enabling ever-increasing complexity in roof design. Working with designers and engineers, roof creators can efficiently produce ‘unique concept’ roofs, in any material, pushing the boundaries of the ‘fifth façade’.

**AUTHOR**

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