Building with ETFE polymer

ETFE fluorocarbon-polymer, a durable adaptable plastic, is emerging as an exciting and innovative building material for architectural applications around the world.

Originally developed by DuPont for NASA as insulation for the space race in the 1970s, Ethylene Tetra Fluoroethylene (ETFE) is now finding its place as an effective building material in many buildings designed and constructed today.

Though a sheet of ETFE film has a look-and-feel like a transparent plastic, it provides many unique features and functionalities. Asahi Glass Co. Ltd. is the largest manufacturer of ETFE films with the brand name as "Fluon® ETFE FILM" in terms of worldwide production volume and sales.

Given its superior properties, such as heat, chemical and weather resistance; anti-adhesion; excellent electrical characteristics; and transparency, the film has been used since its launch in 1975 in a wide range of fields, including electronics, aviation/space, photovoltaic cells, sound insulation bags and green houses.

Today, ETFE is having a major impact on the use of membranes in architecture, and ETFE cushions inflated with low air pressure are being used in major projects worldwide.

Another advantage is that the material is available in different finishes, colours and prints and can be lit from within using LED lights or decorated with projections. The material is also recyclable.

The appealing property of ETFE is that it can be spun into a thin, durable film and can be used in structured sheets or inflated into "pillows".

What makes ETFE different from glass and plastic is that it is an extremely versatile material to include in any architectural project. Although relatively a new material in architectural applications, ETFE has become increasingly popular, especially in Europe. Since the 1980s, the product has been successfully used in several commercial, educational and medical facilities in UK and Germany.

One of the best examples is the Allianz-Arena football stadium in Munich, Germany. One of the most unique features of the design is its exterior facade. The film has some special features, such as transparency with high light transmittance; light weight enabling the light structure; long durability; flexibility for the design; developing the design by printing on the surface of the film especially for the stadium.

More recently, ETFE will be used for the 2008 Beijing Olympics, where it is an important part of the designs of both the Beijing National Stadium and Beijing National Aquatics Center. National Stadium, which is called as "Bird's Nest" because of the shape of its structure, will use about 50,000 square metres of Fluon® ETFE FILM. "Beijing National Aquatic Center", which is called the Watercube because of its shape, will use about 300,000 square metres of Fluon® ETFE FILM.

Other large projects include the Khan Shatyry Entertainment Center in Astana, Kazakhstan. Held by a mast, the vast tent-like cable net structure will be clad in ETFE.

The use of ETFE for building projects around the world has proven the ability of the material to achieve innovative aesthetic, experiential and functional solutions.

On the following pages, we look at how ETFE film has been utilised in buildings around the world.

Beijing National Aquatic Center. Image courtesy of Shenyang Yuanda Enterprise.

BEIJING OLYMPIC PROJECT, CHINA

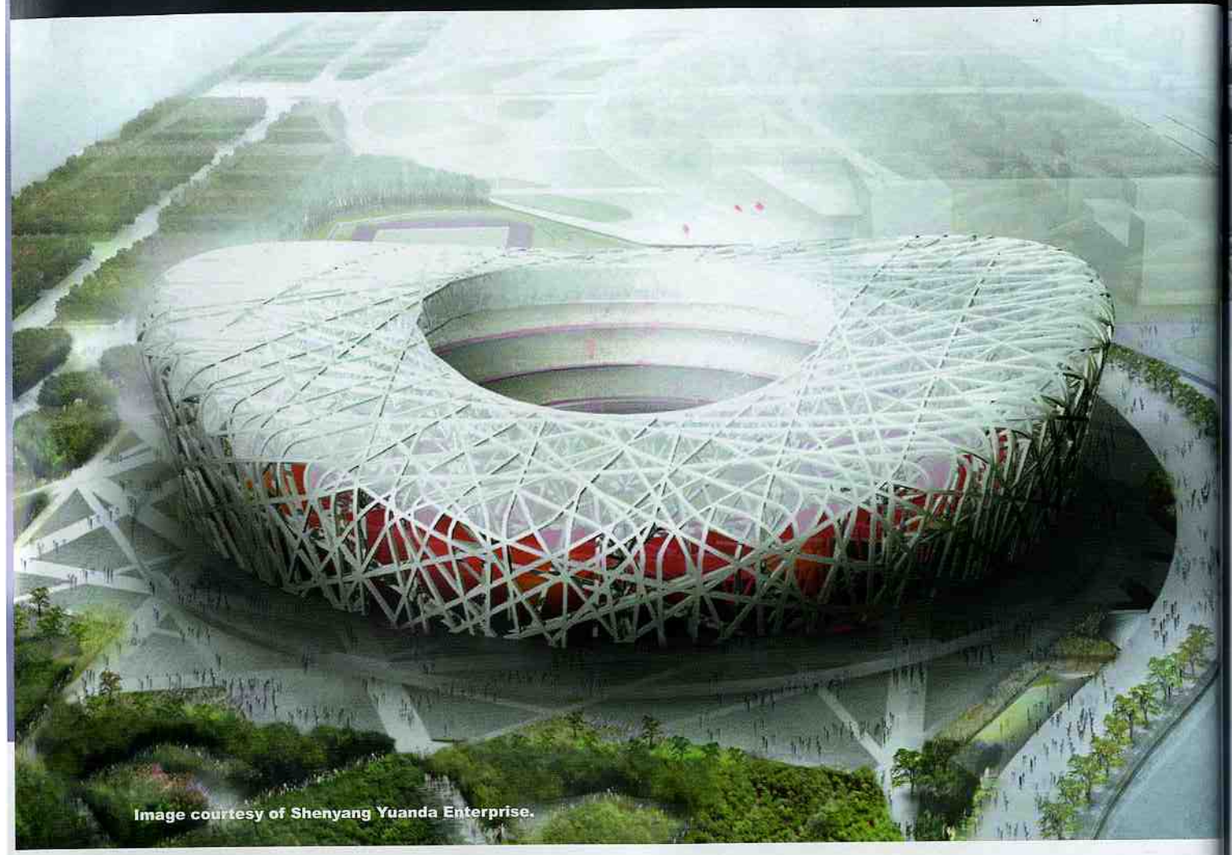


Image courtesy of Shenyang Yuanda Enterprise.

The National Stadium – "Bird's Nest"

The National Stadium, commonly called "Bird's Nest", is located inside Beijing Olympic Park, east side of northern part of middle axis of Beijing, and is the main stadium for 2008 Beijing Olympic Games.

The stadium has a built-up area of 258,000 square metres and a covered area of 204,000 square metres for main body of the building, its major axis is 332.3 metres, minor axis 297.3 metres, vertex 68.5 metres and nadir height 40.1 metres. The length of its roof opening is 185.3 metres and the width is 127.5 metres. The major structure of the stadium adopts the bending and twisty box shaped steel beam, which surround the red ochre coloured and bowl like seating area in spoke-wise form, and also rotate, interlace in slope direction.

The membrane structure of the National Stadium consists of roof enclosing structure; acoustics suspended ceiling and internal ring elevation cladding membrane structure three parts. The upper chord of roof system adopts single-layer stretching membrane system as maintenance structure of roof for wind and rain resistance and sunlight shading, the transparence ETFE membrane material with the glaze point is selected and disposed on comparatively flat roof and the adjacent area between the elevation and roof. The acoustics suspended ceiling of lower chord for roof system adopts white translucence PTFE membrane system as denoise layer and sunlight shading layer at stand area, which is hung beneath the lower chord of main frame and substructure, meanwhile extends downwards from back of upper story stand, functions as screen. The elevation of the interior framework of roof opening (internal ring surface) is sealed with PTFE membrane for good waterproofing quality.

The single-layer ETFE stretching membrane structure of roof consists of 1,038 membrane units, with total area about 38,500 square metres. On the roof, the drainage gutter is set up along the inside of lattice unit constituted by interwove steel beam, the ETFE membrane unit is fixed on the border of gutter after stretching.

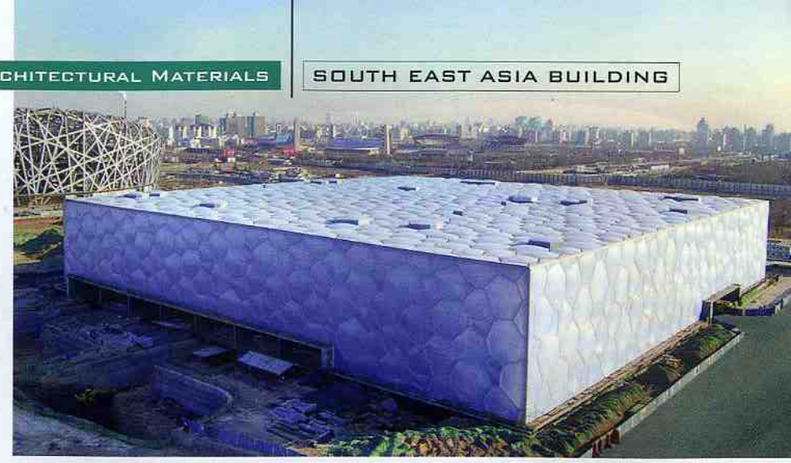
The National Swimming Center

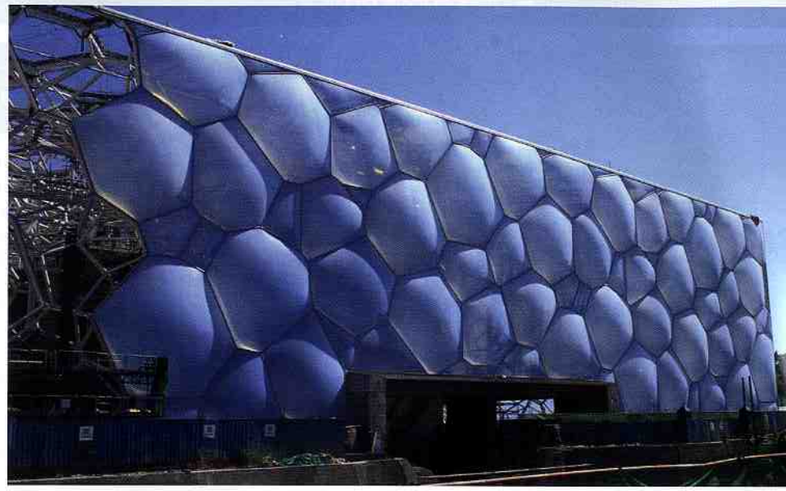
All images courtesy of Shenyang Yuanda Enterprise.

The National Swimming Center, which is also called "water cube" and located inside Beijing Olympic Park, is one of symbolic building for 2008 Beijing Olympic Games – the 27th Games. The individual and distinctive design concept made the water cube the shining point of historical cultural city.

The Swimming Center is located at the Beijing Olympic Park. Its length and width both are 177 metres, with a height of 31 metres, covering a construction area of 62,950 square metres, and building area of 87,283 square metres. The main structure adopts tensible space polyhedron steel frame structure, whole structure possesses about 22,000 steel bar component and 12,000 joint points.

The project is co-designed by China State Construction and Engineering Corporation, PTW Architects and ARUP from Australia, which show the Chinese traditional culture and modern technology perfect combination. Shenyang Yuanda Aluminum Industry, core subsidiary of the Yuanda Enterprise Group, was awarded the ETFE Roof & Wall Cladding System of the National Swimming Center. Shenyang Yuanda is a professional company engaging the research and development of products for the decoration of the external facade of buildings, project design, processing and manufacturing, installation engineering and after sales service. Vector Foiltec Ltd, an international design and building company specialising in lightweight roofing/cladding structures, was awarded the project to install the ETFE membrane material on the "Water Cube".



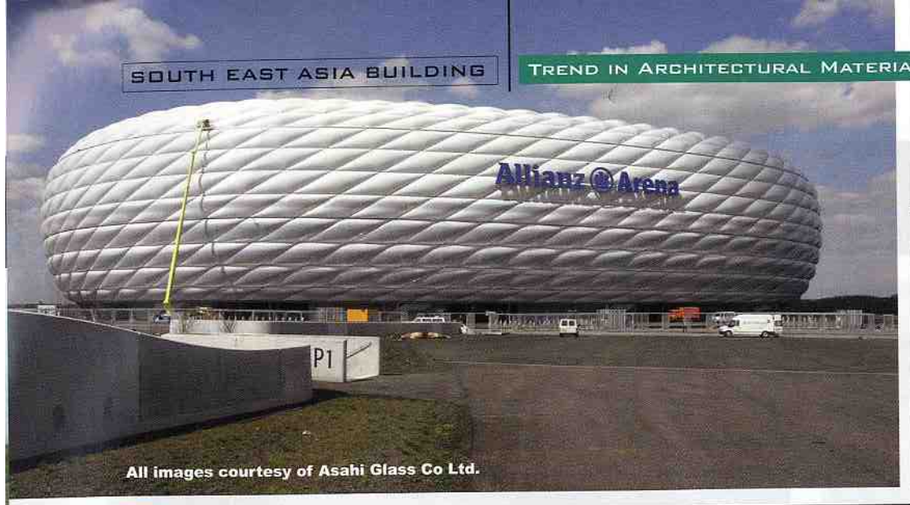


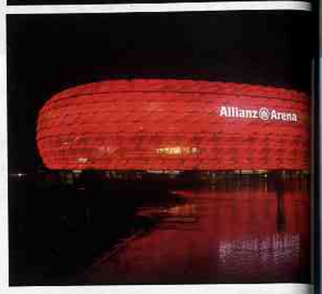
Water, is an active element, which is expressive. The light blue ETFE is aired into different bubble, arranged in the wall and roofing. In the far view and sunlight, it is just like shining "water drops" on the surface, bringing activeness, fresh and power. In the near sight, under the white cloud and blue sky, it is a beautiful and pretty painting. At night, the light on the wall and the river show the effect of waving water and the quiet atmosphere.

The perfect "Water Cube" design concept realisation thanks to the reasonable adaptation of external wall and roofing material - ETFE membrane material. Meanwhile, ETFE aired membrane structure system satisfies the demand of building physical property and function.

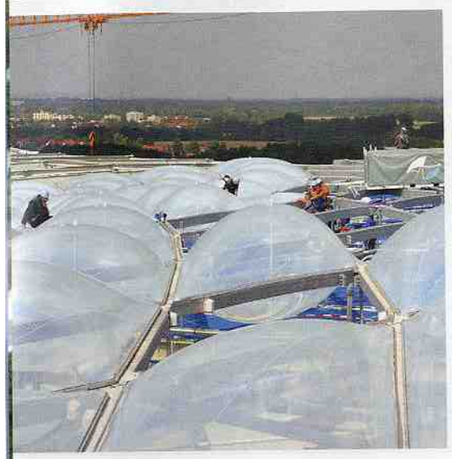
Since the structure demand of "Water Cube", the roofing steel structure thickness is 7 metres, wall steel structure thickness is 3.4 metres. In and outside the steel structure are air pillows, namely roofing and wall are both double-aired membrane structure system. Air pillow shape is different with steel structure shape, which regularly arranged in the roofing and wall surface arranged in irregular manner. In total more than 3,000 air pillows with a total area of 100,000 square metres, the biggest air pillow area is 70 square metres, the largest span is 8.5 metres.

ETFE aired membrane structure system is a new external wall and roofing material with high performance and price ratio. Because it is lightweight, it is usually used in maintenance system with excellent advantages, and has a large market application. It is especially used in large span space structure such as palestra and may lead to a cost effective building structure. "Water Cube" is currently a project with the most difficult technology, and the most complicated for the ETFE membrane structure in the world.





All images courtesy of Asahi Glass Co Ltd.



ALLIANZ ARENA, GERMANY

The Allianz Arena is a football stadium in the north of Munich, Germany. The stadium is constructed from panels containing ETFE foil, which was developed and manufactured by Asahi Glass Co Ltd. The panels form the stadium's walls and roof. The arena façade is constructed of 2,874 ETFE-foil air panels that are kept inflated with dry air to a differential pressure of 0.038 hPa.

A major advantage of Asahi Glass's foil is that it allows light to pass through it. The foil has a thickness of 0.2 mm. Each panel can be independently lit with white, red, or blue light. The intention is to light the panels at each game with the colours of the respective home team, or white if the home team is the German national football team.

The other advantage is the foil's lightness and flexibility, making it easy to install in the smoothly curved panels.

KHAN SHATYRY ENTERTAINMENT CENTRE, ASTANA, KAZAKHSTAN

Designed by Foster + Partners, the Khan Shatyry entertainment centre in Astana is set to become a dramatic civic focal point for the capital of Kazakhstan. The soaring structure, at the northern end of the new city axis, rises from a 200-metre elliptical base to form the highest peak on the skyline of Astana. The 100,000-square-metre-centre's unique concept to provide a sheltered environment embracing an urban-scale internal park, shopping and entertainment venue, was developed in response to the harsh climate of extreme weather in both winter and summer.

Held by a mast, the vast tent-like cable net structure is clad in ETFE, a material that allows light to wash the interior spaces while sheltering them from extreme weather conditions. The ETFE is to be supplied and installed by Vector Foiltec. A park steps up the height of the building in undulating terraces providing public space and green oases for the visitors. A tropical water park, weaves its way through the landscape and its wave pools, river and waterfall are lit by roof lights that are seamlessly integrated into the design. The highest terrace is a viewing deck, which will offer dramatic views over the park. At the core of the building is a large flexible space that will form the cultural hub of the centre, accommodating a varied programme of events and exhibitions.

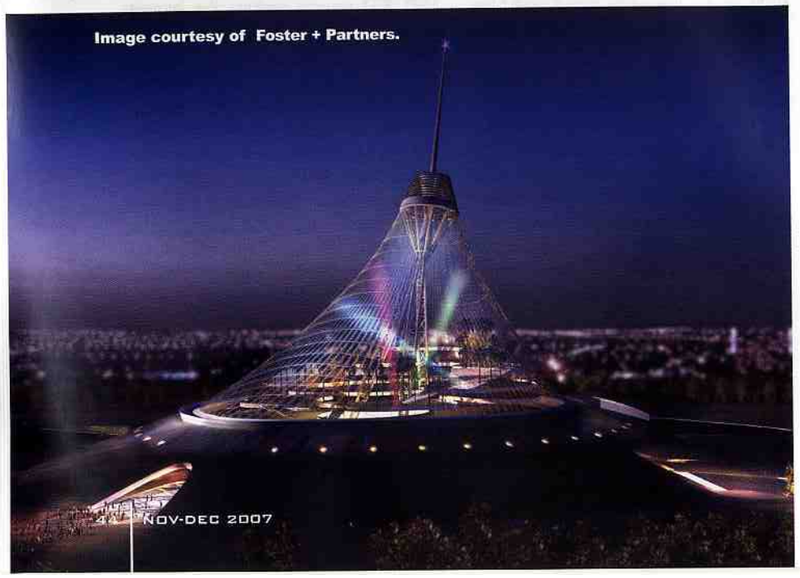


Image courtesy of Foster + Partners.

Eden Project, Cornwall, UK

Architect Sir Nicholas Grimshaw sought to create an innovative enclosure for a tropical rain forest and Mediterrannean biomes more than 80 metres deep into a clay pit.

The Eden Project is the world's largest self-supported transparent envelope, with individual panels up to 80 square metres in area. The biomes themselves are made up of 625 hexagons, 16 pentagons and 190 triangles. They contain 667 tonnes of steelwork and enclose 536 tonnes of air. The largest biome could enclose the Tower of London. Over 230 panels are intelligently controlled and operable for ventilation.

The Eden project requires maximum light penetration to ensure optimum plant growth around the year. The Texlon cladding system achieves this objective on three fronts.

Vector Foiltec has pioneered the use of Texlon ETFE, the climatic envelope, successfully developing and promoting the use of this innovative technology worldwide.

Texlon ETFE offers many advantages. Firstly, Texlon ETFE is much more light transparent than glass – particularly in the UV spectrum that plants require. Secondly, Texlon ETFE self cleanses under the action of rain. Thirdly, the Texlon cladding system can be manufactured in much greater panel sizes therefore minimising structural shading.

Image courtesy of Apex (Photographer: Simon Burt).

Southern Cross Railway Station, Melbourne, Australia

Formerly known as Spencer Street Station, the new Southern Cross Railway Station in Melbourne has immediately become an icon in a city for its architecture.

The distinctive undulating roof of the station serves both as a practical and an emotive solution. Any smoke exhausted from the various train types that frequent the station is channeled to the roof high points where it can be transferred outside the building envelope. At the same time, the shape of the roof reminds us of steam engines and the trail of smoke that they would leave when passing.

Set within the roof are long lines of Texlon ETFE cushions. The Vector Foiltec team worked closely with the architects, structural engineers, wind engineers and the builder (Leighton Contractors) to create a cost effective, semi-transparent system that allowed enough light into the building envelope for natural illumination but not enough so that the resulting glare from the highly reflective roof structure caused discomfort to the public inside.

Each Texlon cushion measures approximately 20 metres x 6 metres. The large size of the cushions meant that costly secondary framing that would be required for a glazed solution could be eliminated. In addition, Vector Foiltec's innovative installation methods – used for the first time in Australia – allowed construction to occur over the top of public access platforms without the need for traditional style hoardings, barricades or even traffic management personnel.

Image courtesy of Gollings Pidgeon Photography (Photographer: John Gollings).

Duisburg Meiderich Theater, Duisberg, Germany

Architects: planinghaus architekten bda/ Germany
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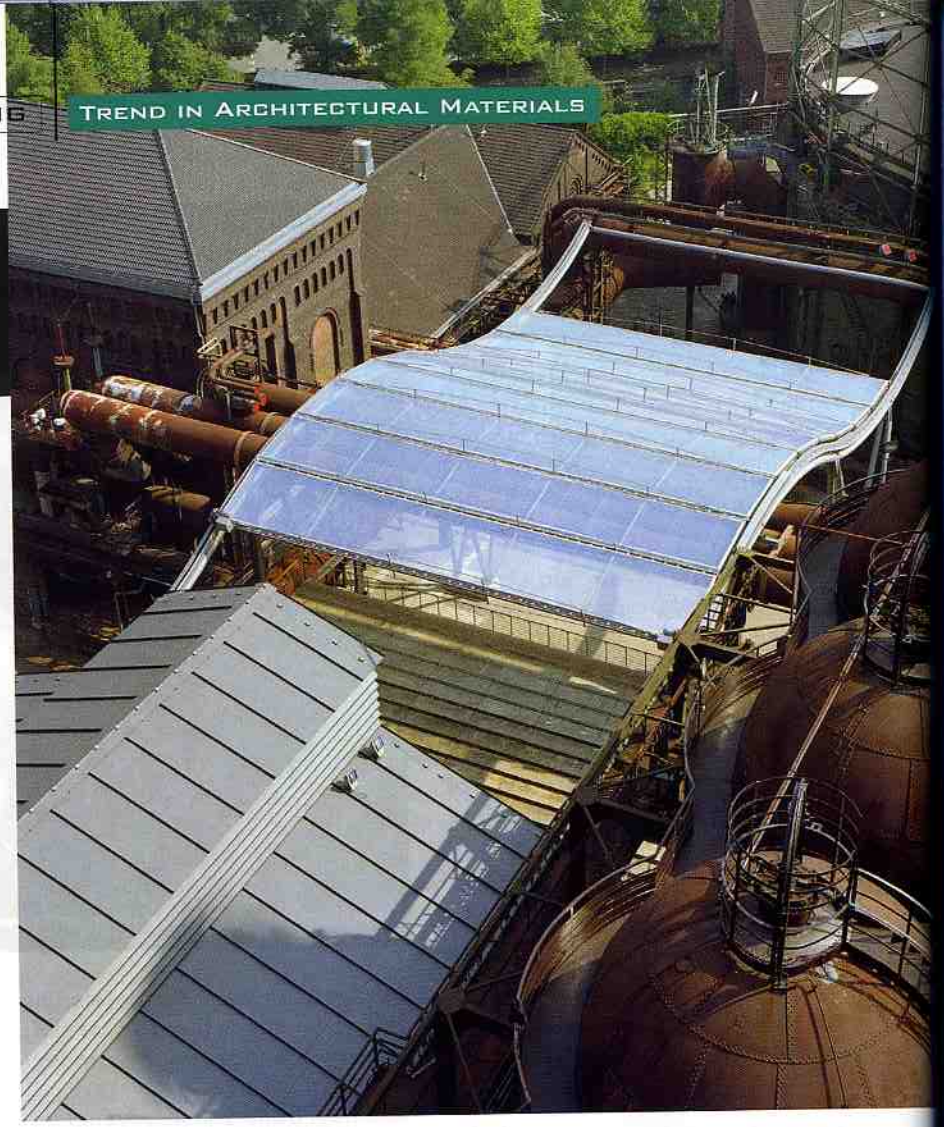

Duisburg Meiderich Theater is an outdoor theatre built at a former blast furnace in Duisburg, Germany.

The theatre required a transparent and completely convertible pneumatic cushioned roof of 600 square metres to serve the purpose of offering temporary shelter during performances in the cast house of furnace no. 1 of the former blast furnace plant.

The convertible roof is constructed of transparent pneumatic cushions consisting of ETFE-foils and is kept in shape by inner excess-pressure. The cushions are hung up in a steel-construction, arranged on two S-shaped rails for transport. These rail carriers swing freely above the pipelines from the cast house to the "Open-Air Foyer". Here the loads are being carried into two of the existing foundations of the old traveling crane via V-shaped double-supports. Loads are being led into the under construction of the pipelines and into the main entry-frames of the cast house as well. Because of the high degree of transparency of the pneumatic cushions and the "withdrawn" steel-construction the view of the blast furnace side-scene and into the cast house is guaranteed even through the roof. The membrane cushions, that swing up above the platform give an airy space impression.

During the course of planning an important stipulation materialised, namely the view of the impressive blast furnace scene should be impaired as little as possible, and the new roof along with the manifold component of old constructions should maintain its independent character. Thus, a unique construction was created.

Primarily designed to shelter the open-air area in case of bad weather in as short time as possible, the convertible construction was developed with the aim of covering the area between cast house and the immediately adjoining area for performances inside the steam blast engine house, thus creating an open-air foyer.

Vector Foiltec Ltd was awarded the project to install the ETFE foils on the Duisburg Meiderich Theater.

Darmstadt Jens Daube of p l a n i n g h a u s architekten bda served as architect for the project. The planning of the structural framework was done by Schlaich Bergermann from Stuttgart, Germany, well known engineers for their work in textile and convertible constructions.