PROJECTS WITH MEMBRANE ENVELOPES AT PRAGUE EXHIBITION GROUNDS IN HOLEŠOVICE

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Abstrakt

The Prague Exhibition Grounds in Prague district Holešovice currently holds major urban potential for the development of the Prague 7 district. The City of Prague is preparing a new development plan for the fairgrounds, in which a significant part will be formed by so-called sports zone which will contain mainly sports facilities lacking in this district; in this case water and wellness activities. The climbing tower has a movable pneumatic facade allowing for the use of climbing walls all year round. The Pavilion of the 1990 Pyramid Jubilee Exhibition will be converted into aqua-wellness purpose.

The 20 m high climbing wall can be used in outdoor conditions in the summer, while in the winter it is enclosed and heated. The moving facade also provides daylight to the boulder climbing walls in the basement. In the winter, the tower becomes a giant skylight.

Concerning the pavilion, the original architectural form of the pyramid is preserved. The indoor wet operations are enclosed in a single-layer envelope made of transparent ETFE foil reinforced with a wire mesh. In the space between the outer envelope of the Pyramid bearing structure and the inner foil, a negative pressure is permanently maintained to disengage the inner wrapper. In the peak of the Pyramid, there is a viewing café, which is accessible by a panoramic elevator.

Keywords

Public outdoor sports area, movable pneumatic foil façade, giant ETFE skylight, original storage area on the top of the tower, wet microclimate enclosed in foil, negative pressure between two envelopes

HISTORY OF THE EXHIBITION GROUNDS IN HOLEŠOVICE, DEVELOPMENT OF THE AREA IN INTEGRATED ZONES AND THE PLAN OF THE SPORT ZONE

At the time of the foundation of the exhibition area, Prague, the contemporary capital of the Czech Republic was part of the Austro-Hungarian dual monarchy. The exhibition area was set up in Prague in the eastern part of the Královská obora park for the occasion of the General Land Centennial Exhibition World Fair in Prague 1891. Following the example of Paris, the exhibition area in Prague planned the exhibition exposition in pavilions; near the centre of the area an Art Nouveau Industrial Palace; realization of the new Křižík Light fountain; and featuring the exhibition area with electric lighting with arc lamps. At the same time, the city of Prague built a tower on Petřín hill in the likeness of the Eiffel Tower, and introduced the first electric tram and a cableway to the lookout tower. Later a number of exhibitions and events took place on the premises in connection with the emancipation efforts of the Czech nation. In addition to exhibitions, cultural events, and events related to sports program were held. In 1896 for example, here was held the third so-called “sokolský slet.” On the premises pavilions were erected on the premises by significant architects of their time. The original function of exhibition area gradually turned into an amusement park. After 1948, the totalitarian regime built a

sports hall with audiences and a swimming pool, later a winter stadium, and there were fairgrounds and theaters in the complex.

After the totalitarian regime was overthrown in 1989, attention was again paid to the Exhibition Grounds in connection with the plan for the General Czechoslovak Exhibition in Prague, 1991, to mark the 100th anniversary of the opening of the Exhibition Grounds. At that time, three new buildings were built in the area: the Křížík pavilions around the modified fountain, the Spiral Theater and the Pyramid Pavilion. The City of Prague is currently preparing the development of the site, taking into account the multifunctional nature of the features traditionally generated in the area, namely exhibitions, culture, free areas of entertainment, and sports. For the function of sport, the eastern part of the area is to be developed, where there is a sports hall with a great sporting tradition, but also in the middle of the sports zone the Pyramid Pavilion needs to get a sports function, which now has temporary use as a musical theater. Along with the Industrial Palace, the Pyramid Pavillion has become the second spatial dominant building of the Exhibition Area in the last 25 years.

The multifunctional strategy of the grounds divides the territory into five zones, each with a predominant character of use. The strategy, however, does not stipulate how the functional regulation of the Exhibition Area as a whole, follows from the spatial concepts of development in functional zones. Consequently, it is not possible to define architectural competitions for the individual parts, that would support a concept for the whole area. This became clear when a local competition was held for the entrance gate with the surroundings, which failed because it was unclear how the assignment should be judged in the absence of a spatial conception of the Exhibition Area as a whole. It turned out that relying solely political decision-making in complex development issues, which perpetually changes every four years through changing leadership of the city, does not bring long-term strategy to the development of the territory. A similar negative influence on strategic development is the strict implementation of the Public Procurement Act. Architectural concepts, that take into consideration multidisciplinary aspects through artistic creation, is not done by applying the rules of economy of public funds nor majority opinion through referendums. Nearly 30 years of such approach have resulted in the dilapidated state of the Exhibition Area in Prague Holešovice. With our team of architects and students we tried to guide the development of the sports zone at the Exhibition Grounds, by taking advantage of the physical-technical properties of membranes and foils. This unconventional approach to design is reflected in the architectural expression of the buildings. In the work, the Team of Membrane Architecture Studies at ČVUT Praha relies on its expertise and knowledge gained through several years of research into membrane structures.

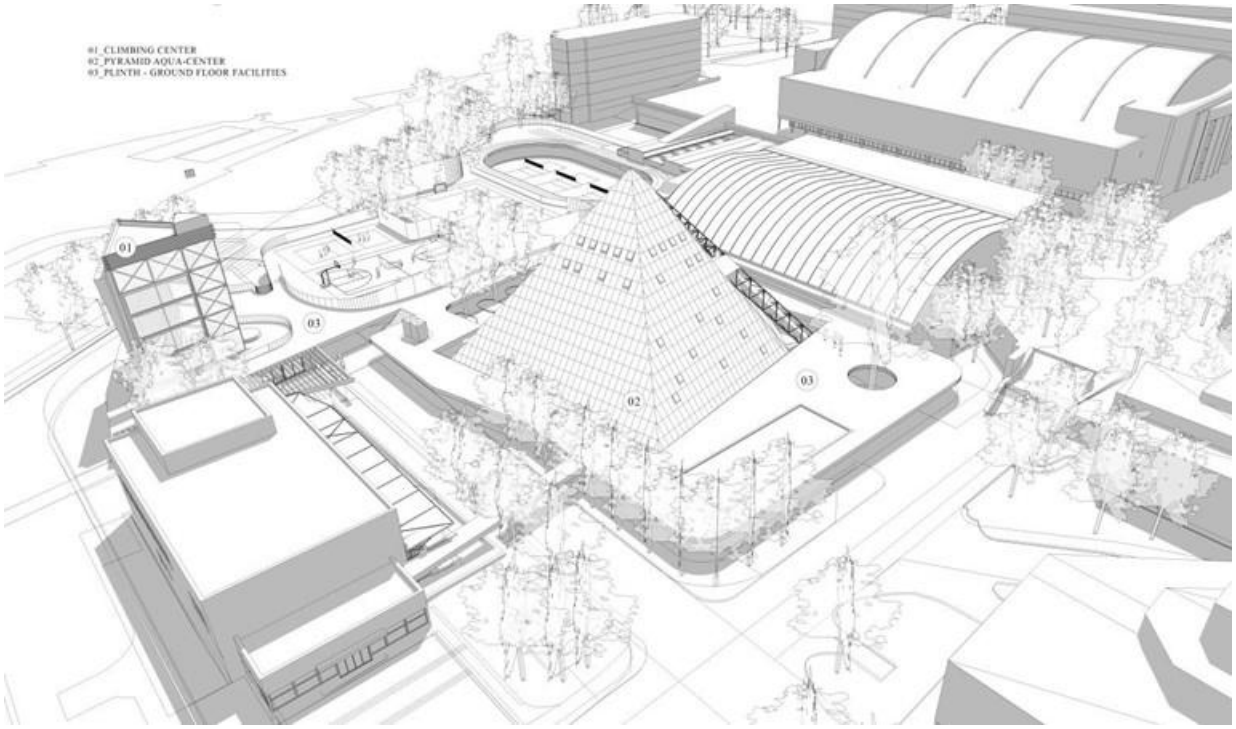
According to the opinion of the architect in charge of the development, in the future the sports zone should be in the form of a fully equipped integrated sports center. It should offer the inhabitants of Prague physical activities, wellness functions, and retain some of the traditional sports features with spectators. In contrast to the current situation, it should also offer outdoor sports grounds with popular youth sports (climbing walls, squash, bowling), including as well water recreation. The Pyramid Pavillion, located alongside the northern area of the zone, will be converted to a modern climbing

center. Part of the climbing center's façade will be dynamic, made possible through application of membrane materials, specifically the ETFE film. Likewise, the swimming pool section inside the Pyramid Pavillion, will be accommodated in an experimental ETFE foil pneumatic hall. We apply the house-in-house principle to separate the existing building envelope from the high-humidity environment of swimming pools. This corresponds to our general economical vision of new constructions in the Exhibition Area, that prioritizes free space between objects rather than filling the grounds with buildings. Further stages of area development is realised through smaller sports buildings with similar functional character. For sustainable development, buildings with continuing function will be conversed.

The first prepared building with an unconventional concept of operation will be the gradual construction of a climbing center with the dominant climbing tower adjacent to existing swimming pool. The urban composition of the sporting area includes gradual removal from the area several objects that have lost their original functions. These are for example warehouses, production and administrative operations that will be replaced in favour of outdoor sports areas. Logistic connections between the functional parts are placed under the new level of outdoor playgrounds of + 3,9 m. This improves not only the overall height of the terrain, but also the flood parameters of the nearby riverbed. The existing system of orthogonal paths at the exhibition grounds is deliberately disrupted by the slight rotation of the main axis of the composition parallel to the Pyramid position. This makes it possible to direct visitors to the new southern square. The main compositional axis is accentuated by parallel walls and the solitary masses of the climbing tower and the Pyramid along the sides of the axis. Through these new spatial relationships, the sports zone becomes much more pronounced against the formerly dominating functional complexes, exhibitions and cultural buildings in the area. The outdoor sports areas are accessible for school's physical education and the general public. The elevated surface at 3,9 m height will have openings of various size for lighting the underground terrain. For example, the school's oval running track line skirts the edge of the elevated surface. In the summer season, there will be three areas for beach volleyball, which in the winter after the clearing of sand will turn into ice rinks for public skating. Putting this area under the oval is beneficial in winter by keeping the volume of cold air above the ice surface, which has a positive impact on ice cooling technology and lowers energy demands.

The complex of the climbing center, in its final form, has three independent uses. These are the outdoor boulder walls limited to summer use, the all-year round climbing tower, and a future multipurpose gymnastics hall added to the swimming pool. The future climbing center should fulfil all requirements for hosting international events, including bouldering, high wall climbing, and speed climbing. However, it's main purpose is for the public and youth. Because of gradual realisation of the entire zone, it is important for the architectural quality that each realised object by its own acts as a harmonic mass composition even without adjacent objects. Because of its large footprint on the green field, the climbing center requires the maximum length of future connections. This then results in optimal proportions between the relationship of horizontal and vertical parts of the whole. The tower breaking through the roof plane allows daylight to the footprint level. The lowest floor offers bouldering climbing walls, as well as cloakrooms for the climbers. The ground floor has reception and snack area.

Fig. 1 Situation of the sports zone with the location of new objects



CLIMBING CENTER, A SIGNIFICANT ELEMENT OF THE SPORTS ZONE OF THE EXHIBITION AREA

The requirement that the boulder area and climbing hall should be in continuous operation, regardless of weather conditions, is essential for the concept of the climbing tower. The vertical tower with 16 m equilateral triangular ground plan penetrates into the base. In the ground plan's centre of gravity is the climbing wall with securing ropes of 21 m length. Two side walls are openable, each consisting of 4 movable facade panels made of two-layer ETFE foil. Each moving element measures 10 x 4 m. The opening part of the facade measures 2 x 10 x 16 m. During summer, with opened facade, the climbing wall will be used as outdoor environment. The boulder wall in the basement is illuminated by a triangular opening of 56 m2 in the ground floor area. The internal walls and boulders are made of plywood boards. In summer, they are outdoors, in the winter when the facade is closed, they will be inside the temperature-regulated part of the building. The transparent tower acts as a vertical skylight with two movable walls. The more detailed description of the moveable parts follows later in the text. The roof and part of the facade covering will be green, with grass and covered with climbing plants. The summer use of the terrace on the base floor allows views of the outdoor boulder area and into the interior of the tower. The three-legged staircase connects the ground floor with the basement, the technical floor with the facade panels and ends on the tower's roof. On the northern facade of the tower there will be a speed climbing wall of 20 m high.

Fig. 2a), b), c), and d) View of the climbing tower in summer, dominant part of the climbing center

a) b)

c) d)

Fig. 3 Section of the tower with moving facade panels

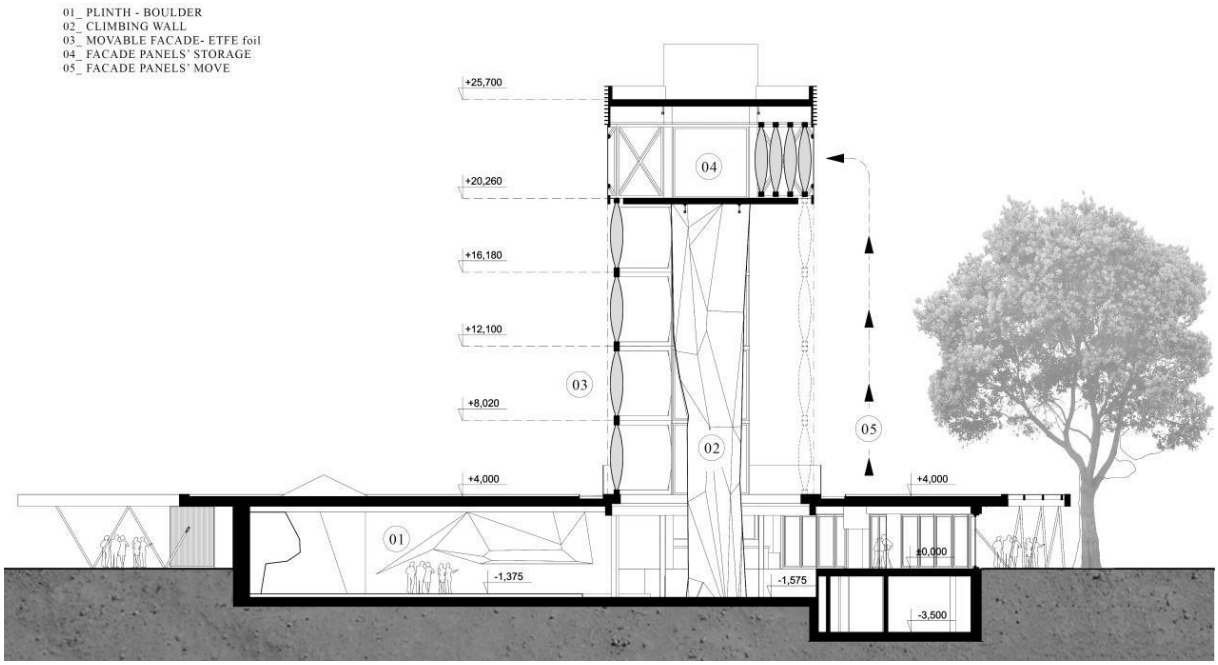
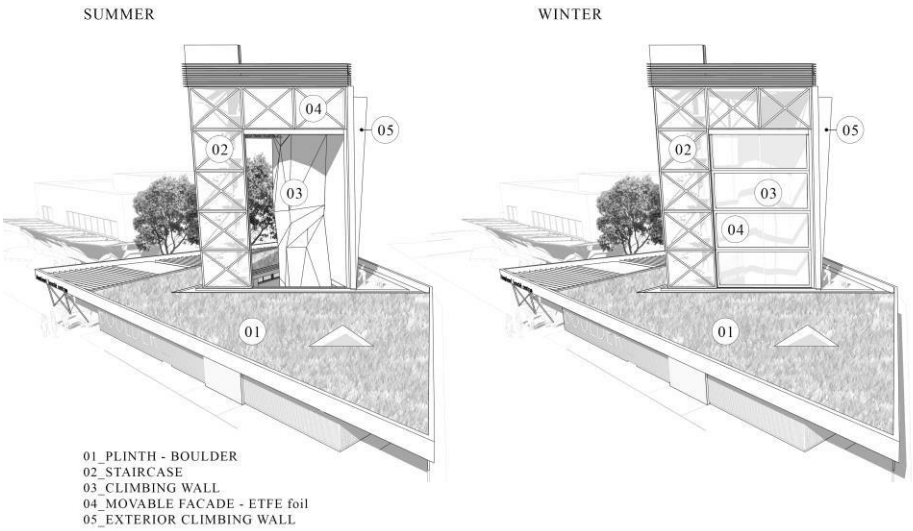


Fig. 4 The scheme of the tower in summer and winter



MOVABLE FAÇADE-SYSTEM

The concept of the movable foil facade system was designed by PJ Jurčík and M. Kopřiva in 2014 at the Faculty of Civil Engineering of the Czech Technical University in Prague. The concept was elaborated extensively in a larger team with the participation of ing.arch. Miroslav Němec for the joint-stock company Výstaviště Praha. Technical development was done by Dirk Temme (AG konstrukt) and machine engineers from Est Stage Brno. The sport design of the climbing walls was developed by ing. Tomáš Sládek from Wall-tech s.r.o.

Movable structures with membranes or foils solve the problem of appearance of the stored materials. The larger the moveable areas, the bigger the problem of the storage layout. There are quite a number of examples, especially the moving roofs of the stadiums, where the stored structures do not look good. Since the first sketches of the tower, a closed storage floor has been proposed for transparent movable façade panels. The stored individual panels are not visible inside the storage. The 10 x 4 m vertically sliding fields have a rigid steel construction inside the foil package. The ETFE-pillows, strengthened with cable network, are pressurised with compressed air. The outer foils are designed from ETFE that deflects up to 70% solar thermal energy. During the spring and summer, the facade panels are moved up to the technical floor. Legislatively it is difficult to qualify the volume around the high climbing tower, which will be around 7 months outdoors and 5 months indoors. From the point of view of the heat gains of solar energy, the risk of greenhouse effect in the interior only occurs during the winter when the foil facade is closed. By means of technical measures, the chimney effect within a high space can be supported by the air flow within the VZT. The opening of the facade is done through gradual vertical sliding of each panel up to the level of the technical floor to the manipulator, which horizontally stacks the panels side by side into the storage space. The guides of the vertical movement of the panels are located in the notches in the tower construction. The facade opens with a vertical lift of counterweight panels. The

rope lift will be anchored to the bottom panel, which will gradually lift the panels above each other. Then each panel removes the manipulator on the technical floor from the lead and places it in a fixed rack. During the action, panels are still filled with compressed air. The side pockets are covered with a sliding rubber bar that prevents the rainwater from entering the interior of the tower. Closure of the tower facade takes place in reversed order from the top downwards.

PYRAMID IN THE URBAN CONCEPT OF THE NEW SPORTS ZONE

Base idea of concept for the sports zone is the increase of areas for outdoor sports grounds and playgrounds. The principle of placing the missing outdoor area on the raised ground floor roof supports also the main conversion concept of the existing Pyramid Pavilion. The clear architectural shape of the pyramid grows from the large area of sports grounds and all the necessary water-related operations will be carried out under the board of the raised outdoor sports grounds. The unifying design of the raised slab is essential for integrating the whole year operation of the zone into a single unit. Water recreation facilities and the wet wellness areas can take more than 2,000 square meters, directly connected to the main pool area above them. The steel structure of the original of entire Pyramid was dimensioned only on the weight of sandwich panels with sheet metal cover. In order not to interfere with the tectonics and the purity of the Pyramid steel structure, glass panes are used only in the ground floor and lower parts of the pyramid. The three-layered transparent ETFE foil strips are located only on the southwest corner of the Pyramid. Most of the casing remains the original full of sheet metal. The sheet metal casing, will partly be replaced by transparent squares in an irregular grid, which in the top section will turn into glass, giving views of the luxury café in the Pyramid's canopy. The operational layout of the ground floor corresponds with the clear pyramid penetration into the hole in the roof plane of the sports grounds. The microclimate of the swimming pool is strictly separated from the structure and the Pyramid facade. The pneumatic cover of the wet operations inside the Pyramid Hall will be seen through the transparent facade as a house in the house. Within the envelope there will be no compressed air, as the structure is closed from the outside by a vacuum between the shell of the Pyramid and the enclosed envelope. Therefore, it is possible to make passages to the outdoor swimming pool on the roof of the base. The large foil surface of the envelope is further reinforced by a wire mesh placed on the outer sheet of the foil.

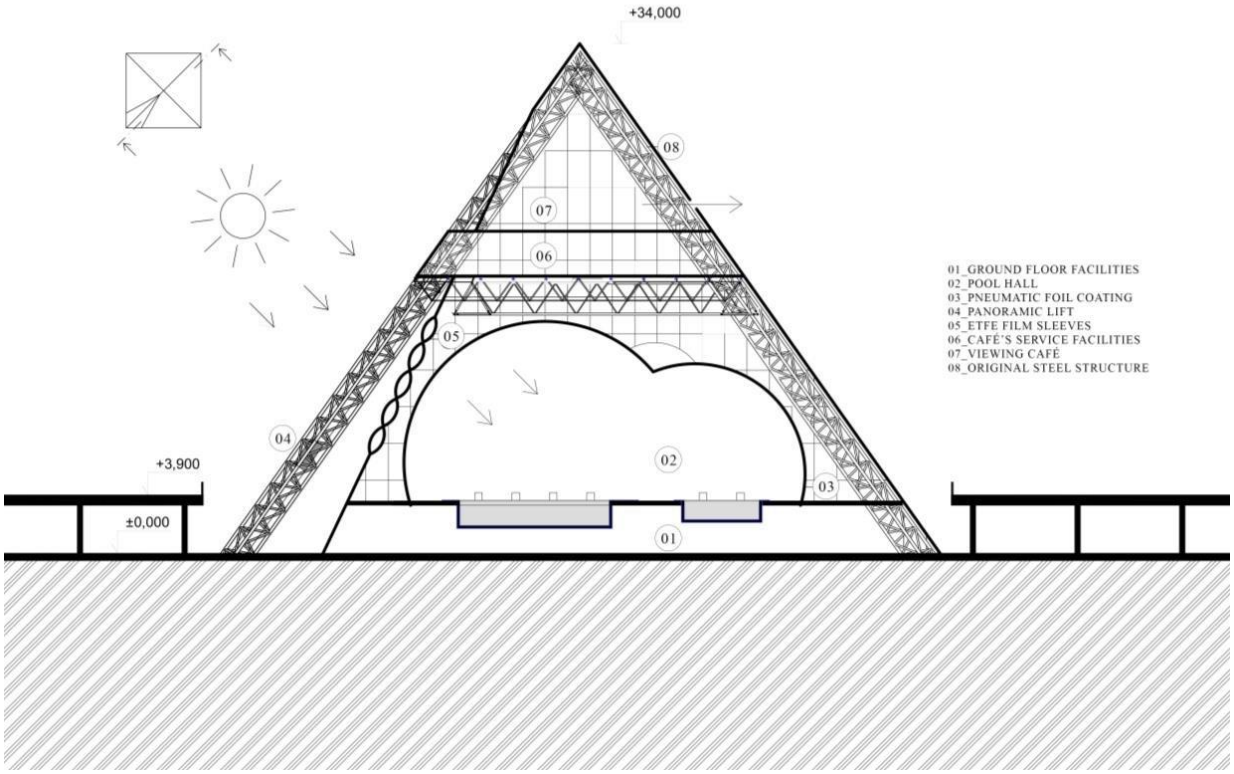
NEW ENVELOPE OF THE PYRAMID AQUA-CENTER

The technical thermal design of the envelope is conceived in a non-traditional experimental solution. The bottom part of the pool hall will be closed to a height of approx. 3 m by a glazed casing. The hall is enclosed by a transparent ETFE foil that closes the wet microclimate of the pool environment. The atmospheric pressure inside is the same as in the outside environment. In the southwest corner of the pyramid, the facade is obliquely recessed under the truss frame system. The original load-bearing structure comes outward and will be a load-bearing structure for panoramic lifts running from the ground floor to the pyramid canopy with a viewing café. The area of the large window under the southwest corner is closed with three-layer ETFE film sleeves. It allows sun to the pool area of the hall, but it also provides views of the interior of the pool hall from panoramic lifts and from the hall to the historic buildings of the Exhibition Grounds. In the sloping window, the thermal passage through the casing will be secured through 3 air-tight

cavities. Similarly, an airtight vacuum air layer will be used between the entire perimeter shell of the building and the foil wrapping of the pool hall.

The conversion design of the Pyramid Pavilion was the winner in an invited student competition at CTU in April 2018. The author is Bc. Oleksandra Tsesko. After discussing the proposal in the Committee of Experts for the Development of the Exhibition Center, composed by L. Burgerová, P. Durdík, E. Jiřičná, M. Kopřiva, J. Kotalík and J. Smetana, it was recommended to limit the winning proposal to the range of the foil cladding in the corner. The principle of inserting the pneumatic hall inside the Pyramid will be elaborated from the competition proposal by CTU Studio of Membrane Architecture s.r.o. (SMA). The author of the winning design is a member of SMA s.r.o. under guidance of Engineer Jan Vecko. Experimental components and investigations of design assumptions of the Pyramid conversion design will be verified at CTU's research laboratories.

Fig. 5 Section of the pyramid at the foil facade



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