PROJECT FOR COVERING A LARGE-SPAN FOOTBALL STADIUM USING A STEEL FRAME

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В данной статье предложено конструктивное решение проекта полного покрытия большого пролетного футбольного стадиона стальным каркасом.
Ключевые слова: Мембранное покрытие, полимерный материал ETFE, стальная конструкция, подвижная стальная арка, консольная ферма.
This article presents a structural solution for fully covering a large-span football stadium using a steel frame.
Keywords: Membrane covering, polymer material ETFE, steel frame, movable steel arch, cantilever truss.

Introduction. The construction of indoor sports arenas in large cities is essential for hosting sporting events with large spectator numbers, in any weather and at any time of year. Indoor stadiums are one of the types of buildings that play an important role in urban planning and serve as architectural and artistic landmarks in the development and design of cities. The significance of such structures is primarily defined as part of large sports complexes, the creation of which requires the development or reconstruction of major urban areas, the resolution of various transportation issues, and extensive efforts to improve urban infrastructure. [1]. The main architectural feature of indoor stadiums is the interconnection between their exterior and interior appearance and the adopted structural system and construction methods. Many sports facilities, such as indoor stadiums, ice arenas, multipurpose arenas, volleyball and basketball courts, and indoor tennis courts, occupy large areas, and it can be observed that there are no load-bearing columns inside the buildings.

Large-span architecture has always held a distinct place in world history and continues to do so. Designing and constructing such large-scale facilities follows a specific technical approach, which has retained professional interest to this day. For this reason, large-scale projects have become a distinctive feature of modern major cities. These are primarily public buildings, and the unique characteristics of such structural systems—both functional and aesthetic—must be clearly expressed.

Large-span structures are made from a variety of materials, including steel, reinforced concrete, wood, special fabrics, cables, carbon fiber, and others, which can be used in individual elements. Large-span facilities are designed as single-span structures. Due to the different requirements imposed on them, architectural solutions can vary widely. Buildings may have a rectangular plan, which is typical for industrial and specialized-purpose buildings. Public buildings, on the other hand, can be designed with circular, polygonal, or oval plans

Main Part. The world's first indoor stadium was built in 1899 in Montreal, Canada [2] (Figure 1). This stadium was designed for ice hockey. It had a capacity of 10,000 people, including 4,300 seats. Artificial ice was used for the first time in this stadium in 1915. In 1918, the stadium was destroyed by a severe fire and no longer exists today.

The construction of large-span indoor sports facilities began in the 1920s in the United States, where various technical solutions were implemented much earlier than in other countries. Some time later, in the 1930s, sports facilities began to be built in Europe. In Russia, this type of construction started later, in the 1950s, and was carried out without fully utilizing the variety of approaches, despite taking into account the experience accumulated in constructing such facilities [2].

Figure 1. The world's first indoor stadium in Montreal, Canada

In many sports facilities, the roof structure is closely connected with the planning scheme, particularly the arrangement of spectator seating. This can be illustrated by facilities such as the indoor sports arena in New Haven. The same approach was applied in the Yoyogi Swimming Pool. The indoor sports arena in Raleigh and the municipal sports hall in Ludwigsfelde serve as examples of how well the selected structural solutions can align with functional requirements (Figure 2).

Figure 2. Yoyogi Sports Complex

The small sports hall in Rome, with a permanent seating capacity of 4,000, is covered with a prefabricated reinforced concrete dome. The supports extending beyond the building's contours bear the loads transmitted from the dome (Figure 3). The structural design of the building is an excellent example of resolving architectural requirements.

Figure 3. Small Sports Hall in Rome

Figure 4. Sports Palace in Mexico

The Sports Palace in Mexico accommodates 15,500 spectators in permanent stands and 7,000 spectators in retractable stands. The building is covered with a spatial grid dome composed of triangular elements in the form of bars, with their vertices connected by bars. The structural grid is filled with thin wooden laminated panels with external cladding, made of necessary insulating materials and copper sheets (Figure 4).

Thus, in the practice of constructing sports facilities, there are spatially covered structures with clearly load-bearing elements such as trusses, beams, and frames, made from various materials, including panels, shells, domes, and suspended constructions. The universal use of indoor stadiums requires a wide range of equipment, and spacious, conveniently arranged auxiliary rooms must be designed to store it.

In Uzbekistan, there are no large-span indoor stadiums. Stadiums in Uzbekistan are not completely enclosed; only the spectator seating sections are built in a partially covered form.

Indoor stadiums are of significant importance in urban planning and are one of the types of buildings that serve in the development of cities. For this reason, the idea of covering the "Dinamo" stadium in Samarkand was proposed. Given that Samarkand is a large tourist city, constructing indoor sports facilities to host sports competitions with a large number of spectators in any weather and at any time of year has become highly important today.

Figure 5. View of Samarkand "Dinamo" Stadium

Figure 6. Polymer material "ETFE" membrane

One of the stadiums located in the center of Samarkand, intended for hosting various events, is the "Dinamo" Stadium (Figure 5). The Dinamo Stadium was built in 1963, with a playing field 72 m wide and 112 m long, covering an area of 8,064 m², and a spectator capacity of 13,800. The exterior dimensions of the stadium are 120 m in width and 220 m in length.

Considering the possibility of hosting sports competitions with a large number of spectators in any weather and at any time of year, and the stadium's central location in the city, it would be appropriate to reconstruct it as an indoor stadium. The proposal to cover the "Dinamo" Stadium in Samarkand is based on studying international experience, with the use of modern lightweight materials planned. One such material is the ETFE (Ethylene Tetrafluoroethylene) membrane, made from polymer material (Figure 6).

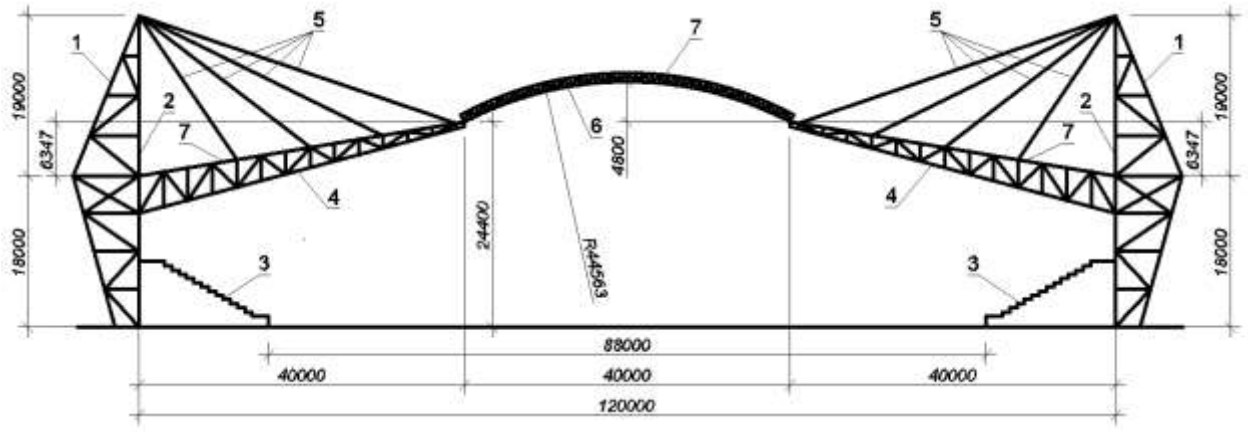

Figure 7. Proposed structural scheme for covering the Dinamo Stadium . *1-Main load-bearing steel column , 2-Vertical bracing to increase the rigidity of the steel column , 3-Spectator stands , 4-Cantilever truss , 5-Steel cables , 6-Movable steel arch cover , 7-Polymer ETFE membrane.*

The ETFE membrane can be used to cover the entire stadium.

E The ETFE polymer material has the following advantages:

1. Very lightweight
2. Extremely strong
3. Fire-resistant
4. Resistant to hot and cold climate temperatures
5. Long service life
6. Chemically resistant to corrosion
7. Resistant to wind and snow loads

Currently, this ETFE polymer material is widely used in covering the roofs of leading stadiums around the world. Based on global experience, it is proposed to cover the “Dinamo” Stadium with the ETFE polymer material. Figure 7 shows the proposed cross-sectional structural scheme for covering the “Dinamo” Stadium. The main load-bearing steel column (1) is installed on two pile-like foundations. Given that the base of the steel column will experience a very large moment of force, the use of pile foundations is considered appropriate. To increase the rigidity of the steel column, a vertical counter-bracing (2) is attached. The steel columns are positioned outside the spectator stands (3). A cantilever truss (4) is installed on the steel column. To support the cantilever truss, steel cables (5) are used. At the end of the cantilever truss, a movable steel arch (6) is installed. This steel arch can be opened or closed depending on weather conditions, using special electronic carts. The electronic carts are remotely controlled from the ground. The movable arch and the cantilever trusses are covered with a polymer ETFE membrane (7) to protect them from precipitation and solar radiation.

Conclusion

1. The main load-bearing structures for covering the “Dinamo” Stadium can be made from local steel materials, and there will be no difficulties in the construction process. The ETFE polymer membrane material, with its lightweight properties, will not add excess weight to the structure.

2. Unlike other stadiums, the “Dinamo” Stadium can have its roof opened or fully closed depending on weather conditions. Currently, many stadiums only have the spectator stands covered, while the main field area is unprotected from the weather.

3. The proposed structural scheme for covering the “Dinamo” Stadium differs from the structural schemes used in other global arenas. A vertical truss steel column is used to support the cantilever truss and the movable arch, which makes the design stand out for its efficiency in material use, ease of construction, and installation.

Currently, the economic and cost-effective variants of the steel column for covering the “Dinamo” Stadium are being explored by the researcher.

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