DOI: 10.46299/ISG.2023.MONO.TECH.2.1.6

1.6 Overview of steel space truss structures

Large-span structures provide long spans without supports with minimal use of steel, making them highly efficient and aesthetically pleasing. These structures use in the construction of airports, exhibition centers, gyms, warehouses and other large buildings. Structures in architecture have become increasingly popular in recent years. They allow you to create large and impressive structures that can become real symbols of the city. However, the development of such buildings requires extensive knowledge and experience in architecture and engineering.

Structural steel constructions use in construction with the greatest efficiency and endurance compared to other structures. Steel structures are usually made of sheet metal or various profile elements, such as beams, columns, slings and others. These structures provide high strength and stiffness, which makes them ideal for the construction of large industrial and commercial buildings.

These technologies use to create large span structures and include innovative materials and welding methods, metal components, and various construction technologies. An important step in the development of such structures is to take into account various factors, such as weight, thermal effects, dynamic loads and other factors.

Structural engineers are often faced with the challenges of ensuring safety and reliability. These structures are usually large in size and have high loads, so they have to be constructed in a way that ensures stability and strength.

Benefits of using large-span steel structures:

- The use of large-span steel structures is due to their high strength and resistance to loads. These structures can provide sufficient strength to withstand heavy loads such as wind, snow, rain, as well as any static loads that occur during the operation of the building;
- Flexibility and assemblability. Due to their large size and spatial structure, such structures can provide flexibility in design, allowing for more options in terms of

layout and space organization. In addition, large-span steel structures can be quickly assembled, which reduces construction time and costs;

- Steel structures have a long service life and minimal maintenance requirements, which reduces the cost of maintaining buildings. In addition, steel structures can be reused or recycled at the end of their life cycle, which ensures that steel structures meet environmental protection requirements and increase their resistance to destruction due to dangerous conditions;
- Low construction height, which is approximately half that of classical steel structures;
- The possibility of laying communications in the height of the structure;
- Ability to be reconstructed and modified. If the size or shape of the building needs to be changed, large-span steel structures can be easily modified, which reduces the cost of constructing new buildings and saves time.

Disadvantages of large-span steel structures:

- Construction cost. It can be quite high, depending on the size and complexity of the structure. In addition, very high quality and safety standards must be met in the design and construction of such structures;
- The need for specialized equipment and skilled labor for the assembly and installation of structures, which can be quite expensive and complicated.

For demonstration purposes of the capabilities of the space truss structures, a unique existing building was considered, specifically Beijing Airport, built for the 2008 Olympics by Foster + Partners, is located 20 km northeast of the center of Beijing. It was designed to represent popular in traditional Chinese culture dragon. Despite taking inspiration from the recognizable folk tradition architecture is combined with high-tech geometry - intersections of straight lines, symmetry of light and reflection. In order to create such shape steel space structure was used. The Applied R+D department used specialized software to generate the geometry for the spaceframe's roof and facade.

Information, photos and construction schemes obtained via an open link [141,142].

Figure 1. Bird flight view of the building

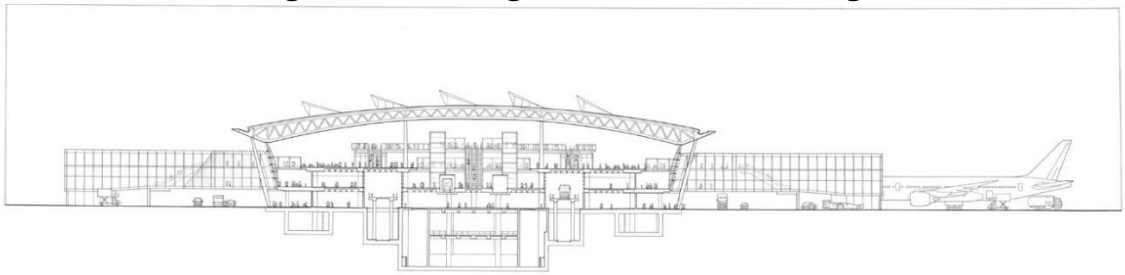

Figure 2. Main sections of the airport

The rigidity of the structure in both directions is provided by a steel space frame made of beams, joints and braces and supporting steel trusses. (Figure 3).

The building incorporates a number of passive environmental design principles, such as south-east facing skylights that maximize heat gain from the morning sun and an integrated environment-control system that reduces energy consumption.

Figure 3. General view of structures and interior

Steel space frames with triangular lights and painted metal decking make up the roof. As people approach toward the gates and airplane berths, it curves, rising in the center to create an elevated central space and tapers towards the outside of the structure to create sections.

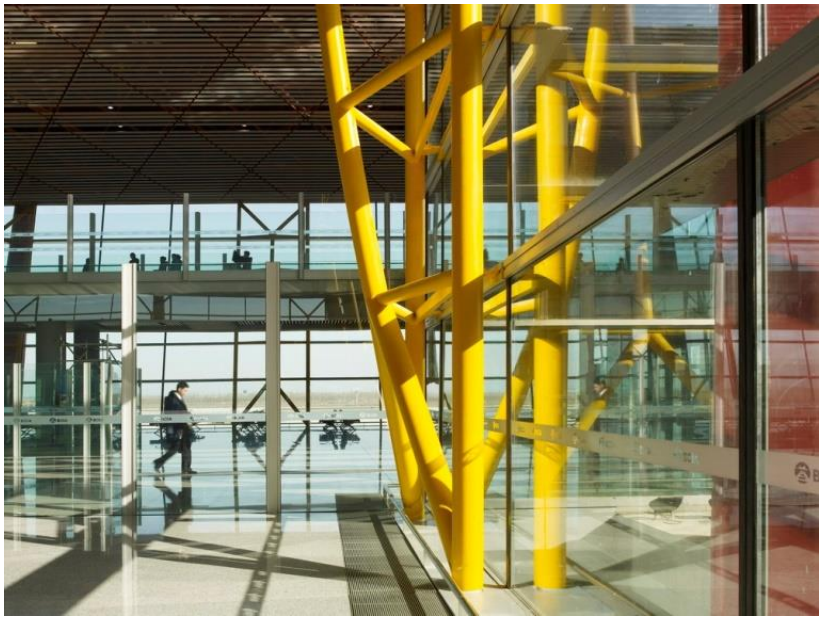

Figure 4. Supporting steel trusses

Figure 5. Construction photos

The review of the structure of Beijing Airport shows the possibilities of using such structures, which certainly deserves research and further improvement.

In previous years, research on large-span structures was aimed at improving their efficiency, reliability and reducing construction costs. Links to some of these studies are provided in the literature references.

One of the most important aspects concerns the materials used in the structure. Studies show that the use of high-quality steel reduces the weight of the structure and ensures its high strength and stability. In addition, studies have shown that the use of reinforced concrete as a material for structural elements takes longer and is more expensive to produce than steel.

Also important to note are studies related to the development of new methods for designing and optimizing large-span structures. The use of computer modeling and analysis makes it possible to determine the optimal parameters for each structure with millimeter accuracy. This helps to reduce construction costs and shorten project development time.

Research into the safety and stability of large-span structures is also important. Because these structures are large and heavy, they can be destroyed during earthquakes, fires, and other disasters. Researchers are actively working to develop new technologies and methods to improve the stability and safety of steel space truss structures.

The design of large-span structures is a complex process that requires consideration of many factors, such as loads, materials, geometry, and other technical characteristics.

For a visual demonstration of the work of the steel structural construction, a model of the structure with the size of 48 x 48 m, height of 2.4 m, cell size of 4.8 x 4.8 m was made.

Figure 6 shows a plan of the structural design under consideration, and figure 7 – 3D model.

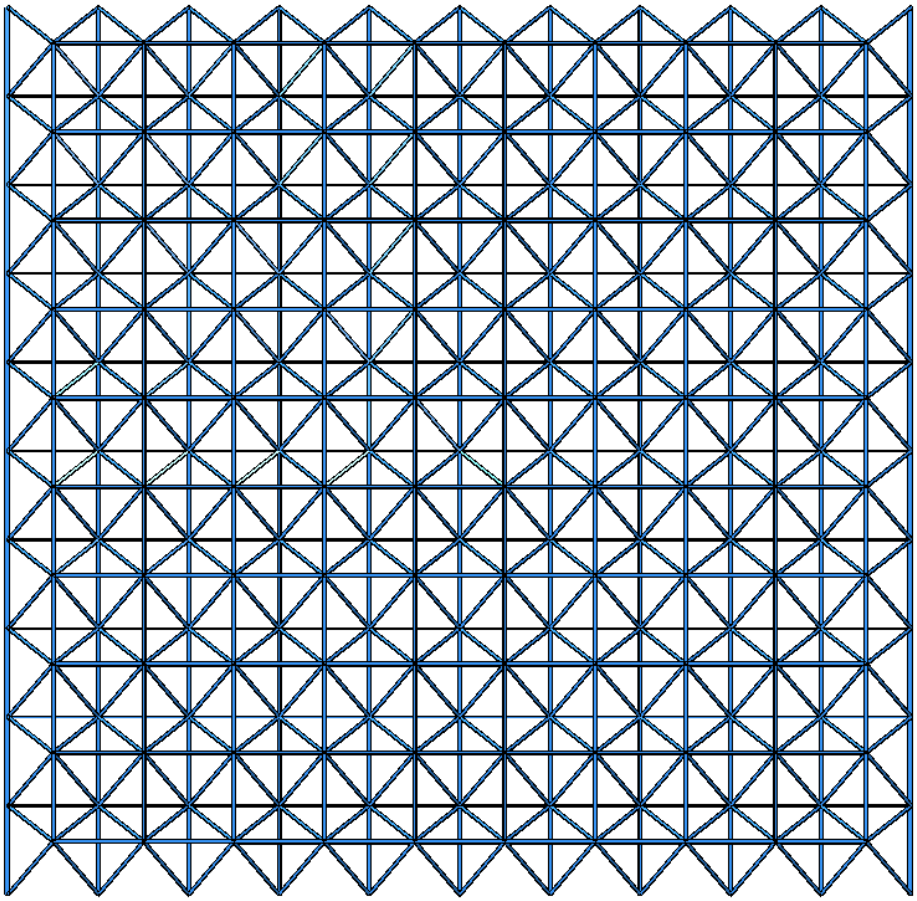

Figure 6. Plan of the structural construction.

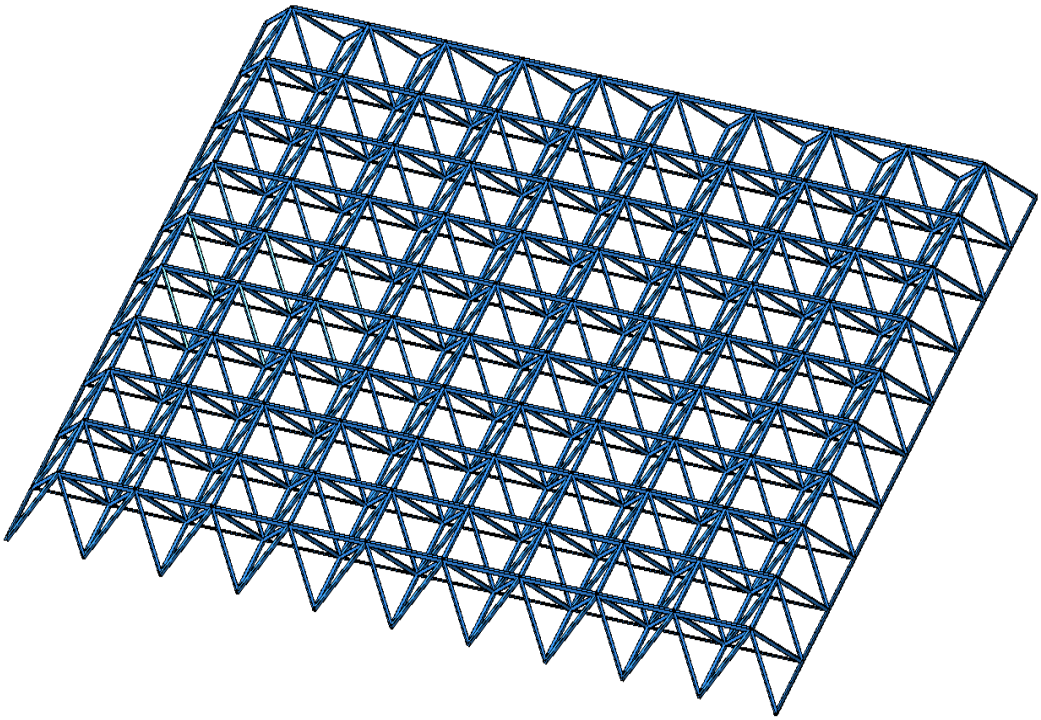

Figure 7. 3D model of the structural construction.

The load applied to the upper belts of the structure was collected taking into account that the uniformly distributed load was assumed to be 3 kN/m2.

In Figure 8, you can see the nature of the system's vertical movements.

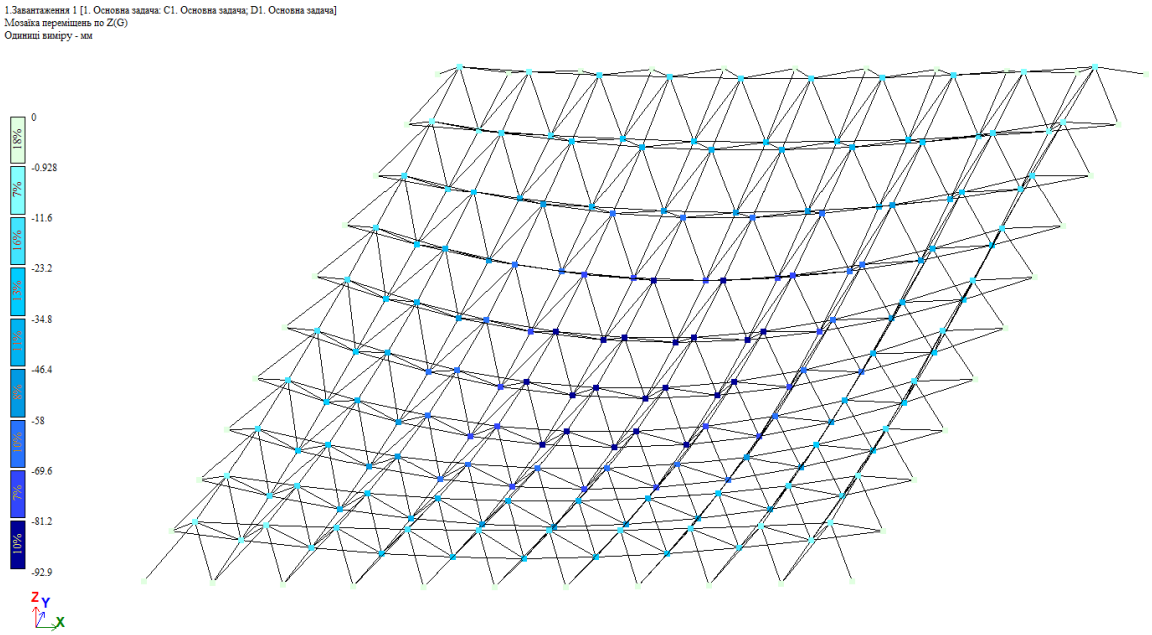

Figure 8. 3D model of the structural construction.

The maximum displacement was 93 mm, which, with a distance of 48 m between the supports, complies with current regulatory documents.

Figure 9 shows the distribution of longitudinal forces in the rods of the structure.

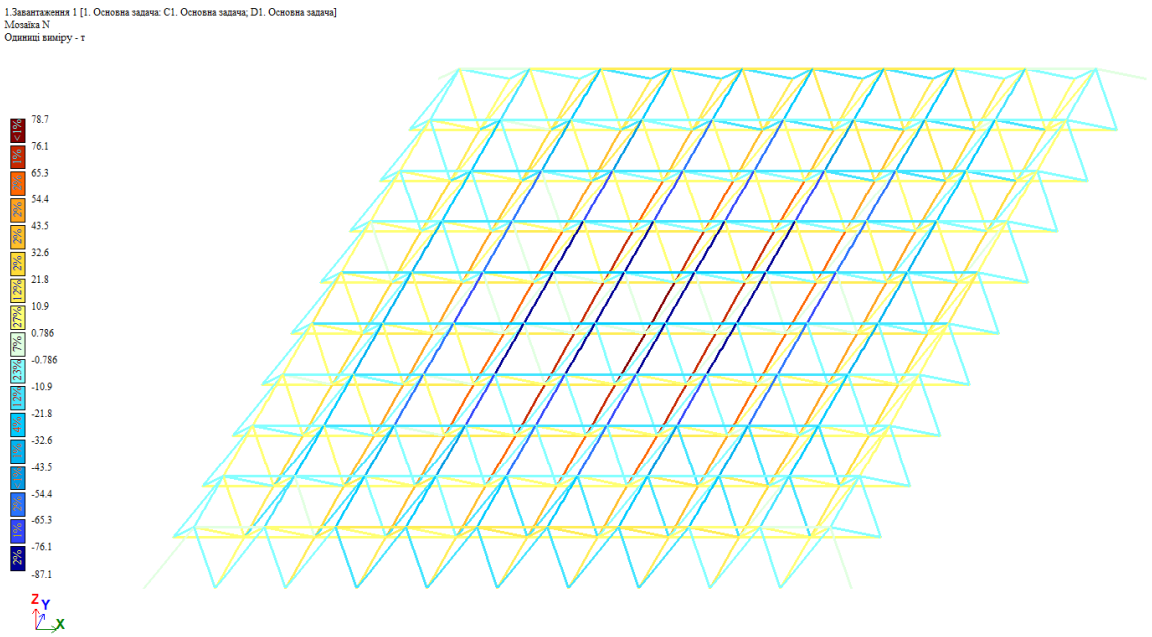

Figure 9. Distribution of longitudinal forces in the rods of the structure.

Figure 10 shows the density of the distribution of deformation potential energy in the scheme, which is being considered.

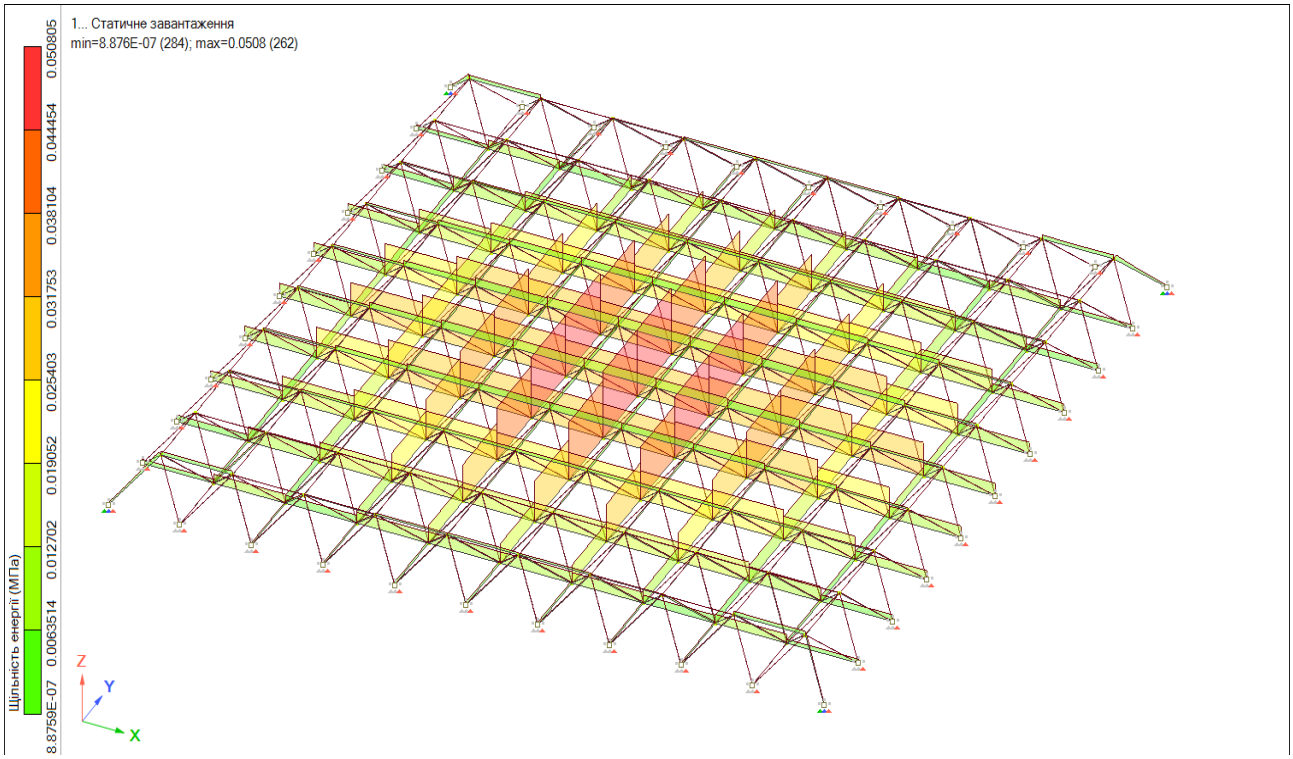

Figure 10. The density of the distribution of deformation potential energy in the scheme.

As can be seen from Figure 10, in the places of the highest tensions, the density of the distribution of deformation potential energy is close to uniform, which indicates the efficiency of the use of structural structures.

The study of structural steel structures is carried out using numerous methods and tools, such as computer modeling and stress analysis. An important part of the study is the analysis of the life cycle of structures, which includes the process of manufacturing, transportation, installation and operation of structures.

Steel structures have a long service life and minimal maintenance requirements, which reduces the cost of maintaining buildings. In addition, steel structures can be reused or recycled at the end of their life cycle, which ensures that steel structures meet environmental protection requirements and increase their resistance to destruction due to hazardous conditions.

In general, research into structural steel structures is an important process that helps improve the quality and efficiency of building structures. New manufacturing and modeling technologies allow for improved design and provide more accurate and efficient solutions. In the future, researchers can continue to investigate structural steel structures to improve their strength, resistance to hazardous conditions, and efficiency.