Engineering challenges and solutions in the concert hall Mitava – open-air building with 57m timber span

Pēteris Supe [1]

[1] SIA Rodentia, Latvia

Summary

Concert hall *Mitava* is an open-air concert hall with glued laminated timber (glulam) beams and steel columns. The clear span of up to 57 meters, open space and spherical geometry challenged the structural system and connections with varying loads and individual geometry. By using large number of custom made components and adopting technologies from other engineering disciplines, the building was completed in 2019.

Key words: Timber structures; Connections; Timber construction; Architecture.

1. Introduction

Located on a small island between two rivers in Jelgava, Latvia, concert hall Mitava is an open-air concert hall with capacity of up to 1200 seats. The Pasta island is created as a recreational zone for the residents of the city with playgrounds, a beach and a timber open-air ice skating rink. The structure of the roof was built over an existing amphitheatre to shelter visitors from wind gusts, rain and also hot summer sun.

The architecture is inspired by a shell washed upon the shore of the river, as explained by the architect of the building – Vents Grietēns (*Projektu birojs Grietēns un Kagainis*). We had a close collaboration on all the technical details to achieve the desired aesthetics of elements and connections.

The total dimensions of the structure are 60.7 meters by 60.6 meters with the height of 15 meters. The load bearing structures of the building consists of approximately 510 m^3 of timber, 77 tons of steel and 11 600 connectors.

Figure 1 Concert hall Mitava

2. Structural system and design

The asymmetrical roof structure consists of curved glulam beams with 4 round steel ties for each beam and span up to 57 meters. The curved beams are supported by elliptical glulam ring beams that are continuous on both sides of building and connect at ground level.

Glulam purlins and steel tension rods are used to provide the stability of roof structure. The whole building stability is provided by the ring beam and steel columns that support the ring beam.

The structure is covered by a tensile membrane. After the design of tensile membrane (*Canobbio Textile Engineering*), the top glulam purlins had to be moved downwards as the membrane can have considerable deflections from snow load. The horizontal forces from tensile membrane also had to be taken into account for the design of glulam beams.

Combination of light materials and the open location of the building results in significant uplift forces from the wind load. Thus, most of the elements and connections have varying direction internal forces. This is also the reason why the ring beam could not be hanged in the cables coming from the steel pylons and additional columns were necessary. Therefore, the cables from pylon are architectural.

3. Connections

Connections are made with custom steel parts, steel dowels, bolts and fully threaded timber screws. Most of the steel parts for connections were verified individually in FEM software.

The bending moment resisting connections of glulam members are made with fully threaded timber screws at 45 degree angle for a higher stiffness of the connection. During the construction phase, a special electric screwdriver was used for the fully threaded timber screws. This screwdriver is usually used in machine industry and controls the torque by a computer thus preventing of overtightening of screws against a steel plate.

The connection between the ring beam and steel columns were designed as semi-rigid. But due to the geometry of the building, the forces in the shortest columns and pylons were too large to maintain the desired profiles and dimensions of members and connections. A hinged connection was necessary to allow the rotation along all axis of the connection which couldn’t be solved by usual means. The idea of custom made spherical bearings was inspired by bridge industry in which this solution is seen more often.

4. Building systems

The structural design of this building included the design of acoustic shields, acoustic panels, wind mesh and rainwater collection system.

The rain gutter is mounted on the ring beam and made of open profile bent form structural steel. The gutter ends and downspouts are made of closed steel profile. To reduce the wind inside the concert hall, special wind mesh is used between the steel columns

The placement, size and materials of the acoustic panels and shields were designed according to the acoustics project. This included triangular plywood shields on three sides of the building to reflect and disperse the sound and panels between curved beams made from perforated plywood and mineral wool to absorb the sound. Additionally, rounded elements were added to the interior edges of the curved beams and ring beam. As a result, the building has excellent acoustics already praised by people from the industry.

5. Acknowledgements

We thank the following companies for taking part in the design of this building: *Projektu birojs Grietēns un Kagainis (architecture), IKTK (production of glulam and acoustic system), Canobbio Textile Engineering (design and production of roof membrane), Mitau Steel (production of steel structures), Igate Būve (general contractor).*