Investigations and Testing of Full-Scale Glass Roofs for Individual Approval

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Summary

The TU Dresden is decisively involved in the development of a sustainable and transparent glazed roof structure. The designed transparent space grid structure is based on a conventional steel space grid, in which all steel members of the compression layer are replaced by glass panes. The glazing transfers large in-plane forces and serves as roof covering.Two full-scale mock-ups of a double layer space grid structure in the structure geometries half-octahedron plus tetrahedron and half-Vierendeel demonstrated the feasibility to build such new structures. To achieve an individual approval comprehensive testing was conducted. This included small sized testing of block elements for the local load application into the glass edge, in-plane stability tests, walk-on and post breakage behaviour tests and load bearing tests at roof strips of about 15 m length. In the structural tests the glazing had to resist a load with the safety factor of 3.0.

Keywords: Experiments, Testing, Glass, Roof, Space Structure, mock-up, individual approval, Long Span, Grid, Module

1. Introduction and spatial geometry of transparent space grid structures

At the Technische Universität Dresden the development of transparent space grid structures was accelerated by testing of different full-scale mock-ups for research purposes and for individual approval.The concept of transparent space grid structures made of steel glass modules pursues the use of glass as part of the primary load-bearing system. At the example of a double layer grid the use of the glazing as compression layer, roof stabilization and roof covering is proven. The structure is material-efficient as the glazing fulfils a double function: it serves for the primary load transfer and as roof covering. Two different structural systems of transparent space grid structures were tested: the hinged half-octahedron + tetrahedron system and the moment stiff half-Vierendeel.

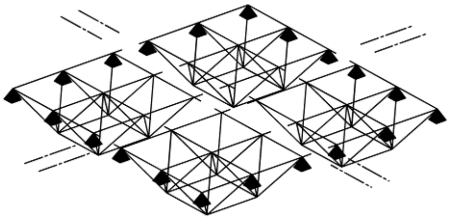

Figure 1: Half-octahedron plus tetrahedron

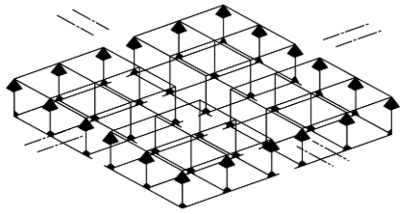

Figure 2: Half-Vierendeel

Starting with the huge amount of spatial geometries of traditional steel double layer grids the replacement of all bar members in the compression layer by glass panes limits the number of economically feasible geometries. The grid definition of the compression and tension layers defines the whole structures. For the compression layer especially pane size and homogeneity of the central knot define an economic grid.

https://doi.org/10.2749/222137809796088800
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2. Structure half-octahedron plus tetrahedron

One of the most efficient structures is the space structure half-octahedron plus tetrahedron geometry that was used for the prototype realization. At this structure the upper and the lower layer have the geometry of square grids and are dually situated to each other. The connection of upper and lower grid is achieved by diagonal bars that link the nodes in the two layers. Each module is a stable, statically determined structure in the shape of a half-octahedron. The dimensions of the glass panes are 1.25 m square. The panes consist of laminated glass made of two layers of 10 mm heat-strengthened glass with 0.76 mm PVB-Interlayer.

Figure 3: Module half-octahedron plus tetrahedron

Figure 4: Erection of pre-assembled 10 m roof strip

Figure 5: Load bearing test at a 15 m spanning mock-up

At the mock-up different load bearing tests were executed. The main task of the tests was the verification of the FE-calculations. The applied load was factored with the safety factor of 3.0 to comply with the regulation of the building authorities at structural glass tests. The conducted testing ensures that the maximum applicable load can be safely transferred to the supports. To ensure the walk-on access as part of usual cleaning and maintenance strategies standardized testing has to be done. The simulation of hard body impact and soft body impact was executed at single panes.

3. Structure half-Vierendeel

Another structure geometry is the half-Vierendeel. At this structure no diagonal bars exist, because the stability is achieved by moment fixed bar connection in the tension layer. The structure possesses a complete modularity, consisting of vault strips. The mock-up strip (13.5 m x 1.8 m) with the knots and sensitive connections glass edge and steel knot can be pre-assembled in the production hall. Each strip is a stable and statically determined structure. Before starting with tests at the full-scale mock-up small sized test for the load application of pressure into the glass pane were conducted. In stability tests the buckling behaviour was investigated.

Figure 6: Load bearing test at a 13.5 m spanning mock-up

Figure 7: Buckling test

Figure 8: Pane supported by tension rods

4. Conclusion and acknowledgments

Two full-scale mock-ups of a double layer space grid structure (geometry half-octahedron plus tetrahedron and half-Vierendeel) demonstrated the feasibility to build such new structures. All tests necessary for an individual approval were done. This research project is funded by the Federal Ministry of Economics in Germany and the following companies: Glaswerkstätten Frank Ahne, MBM Metallbau Dresden, Pauli + Sohn, Saint-Gobain Flachglaswerk Radeburg, Thiele Glas.