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The Mansueto Library – Notes on a glazed steel grid shell from design to construction

Werner Sobek, Lucio Blandini
Werner Sobek Stuttgart, Germany, lucio.blandini@wernersobek.com

The highlight of the Joe and Rika Mansueto Library in Chicago is an almost dematerialized glazed steel grid shell spanning over the reading room. The geometrically constructed translational shell is 36.5 m wide, 73 m long and features a mesh size of 2 by 2 m. The building, currently under construction, includes further special structures as a 20 m long, glazed steel bridge connecting the new library with the existing building and a row of glass study rooms, which reach a total transparency by exploiting the structural properties of glass. The present article gives an overview of the design, calculation and construction phases of the grid shell and the other special structures.

Keywords: Glazed grid shell, Glass special structures

1. Introduction

The Joe and Rika Mansueto Library, designed by Murphy/Jahn Chicago, is an extension to the main library of the University of Chicago. The two buildings are located next to each other; above ground they are connected by means of an enclosed bridge. They constitute an ensemble that will, upon completion, be one of the largest on-campus university libraries in the world. It was in this area that in December 1942 scientists conducted the world's first controlled , self-sustaining, nuclear chain reaction.

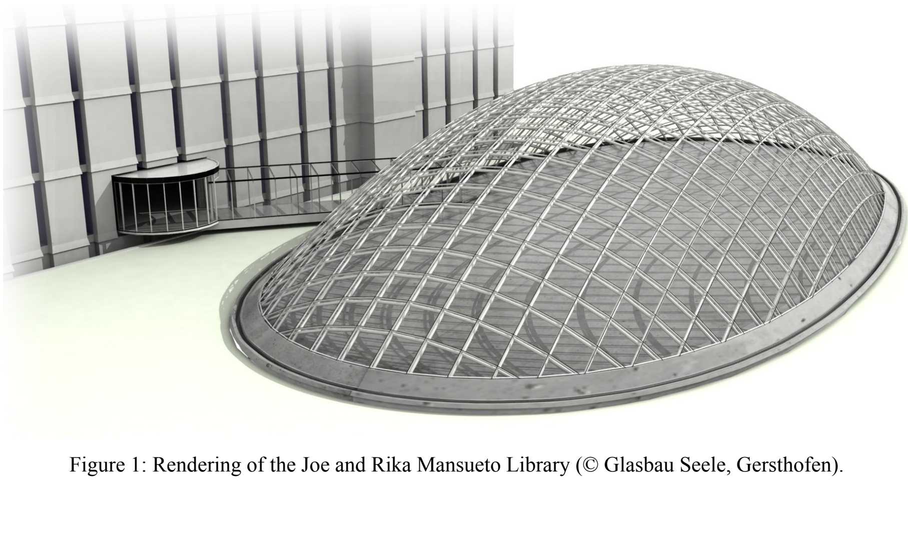

Figure 1: Rendering of the Joe and Rika Mansueto Library (© Glasbau Seele, Gersthofen).

An underground storage using a high density automated shelving and retrieval system will hold more than 3 million books, so to assure storage room for the next 20 years.

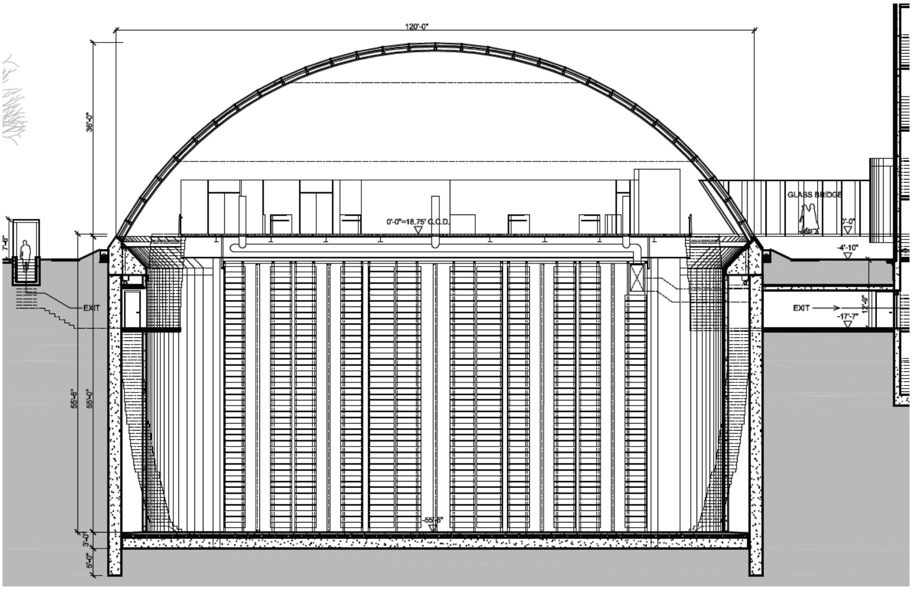

Figure 2: Vertical section (© Murphy/Jahn Architects, Chicago).

2. Design

The library is characterized above ground by a highly transparent glazed steel grid shell spanning over the reading room and the areas dedicated, among others, to the preparation and conservation of books. The shell has been constructed geometrically as a translational grid shell [1], generated by a sequence of arches with constant curvature translated over a guideline. This way, flat insulated glass units could be adopted.

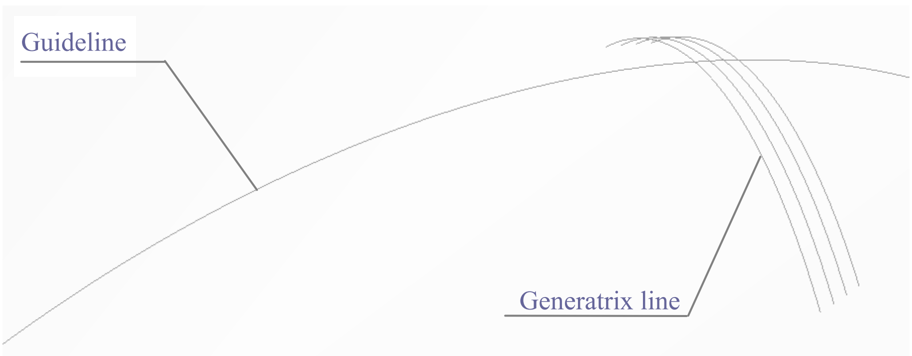

Figure 3: Grid shell geometry (© Werner Sobek Stuttgart).

The glass units are laid on compact hollow extrusions made of aluminum. The glass shell reaches an optimal balance between transparency and comfort by means of frit patterns with different densities. The customized aluminum profiles are supported at the nodes by means of 300 mm high stainless steel rods, which are welded to the pipe nodes. Such steel nodes are welded in shop, thus allowing for different angles with a high rate of precision. In order to avoid any optical interruption in the grid continuity, the bolted connection between each pipe and the node, executed on site, is not visible after erection. Just a hairline joint remains as connection trace.

Figure 4: Rendering of the glazing connection details (© Glasbau Seele, Gersthofen).

The steel pipes transmit the resulting forces to a 1.65 m wide concrete ring. This is supported vertically by 17 m deep slurry walls and braced horizontally by a radial set of I-beams connected to the ground floor slab. The shell forces are transmitted into the ring by means of a bolted steel base plate and a shear lock. In some cases, according to the geometry, two pipes converge into the same node, thus leading to special base details.

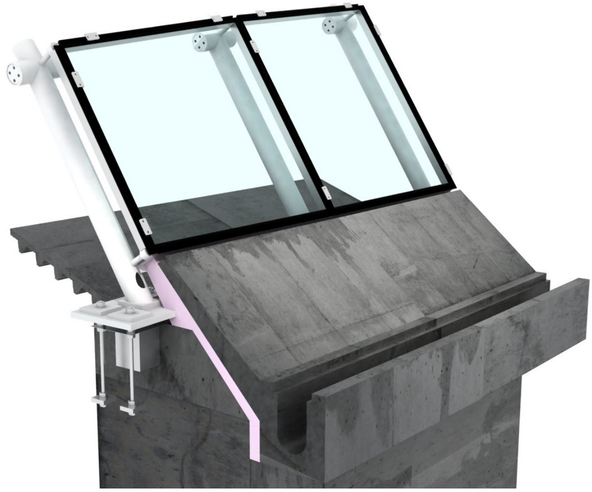

Figure 5: Rendering of the grid support details (© Glasbau Seele, Gersthofen).

The new building is linked to the existing building by means of a glazed steel bridge. The bridge is 20 m long and 3.3 m high. On the side of the existing building it terminates in a half round area called “the knuckle”. The bridge is carried by two welded sharp-edged hollow steel sections. These are braced together and supported on both sides so as to avoid thermal constraints. The insulated glass units which clad the bridge are supported by tapered steel frames. These are made of sharp-edged welded T-profiles and linked together by 50 mm square steel profiles at the upper corners. A joint between the bridge envelope and the shell glass unit allows for relative movements.

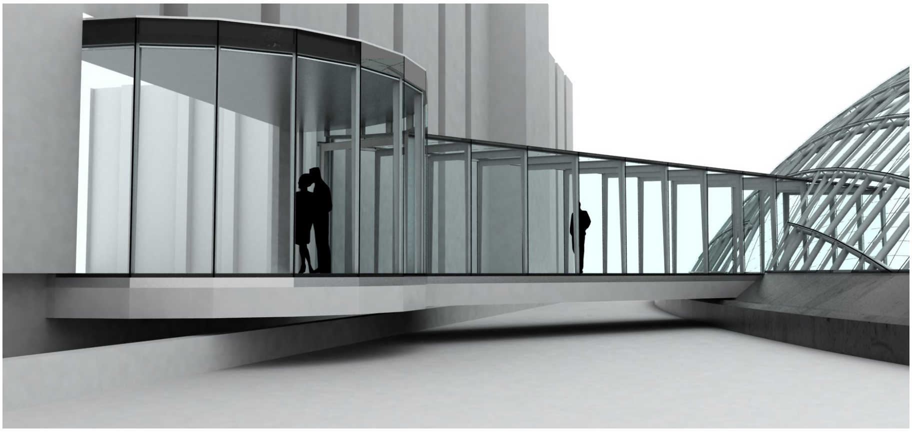

Figure 6: View of the bridge and the “knuckle” (© Glasbau Seele, Gersthofen).

A row of glazed cubicles inside the reading room demonstrates the nearly total transparency that can be achieved by fully exploiting the structural properties of glass. The laminated panes are connected by means of glued stainless steel angles. The size of these angles is kept to an absolute minimum so as to minimize optical interferences.

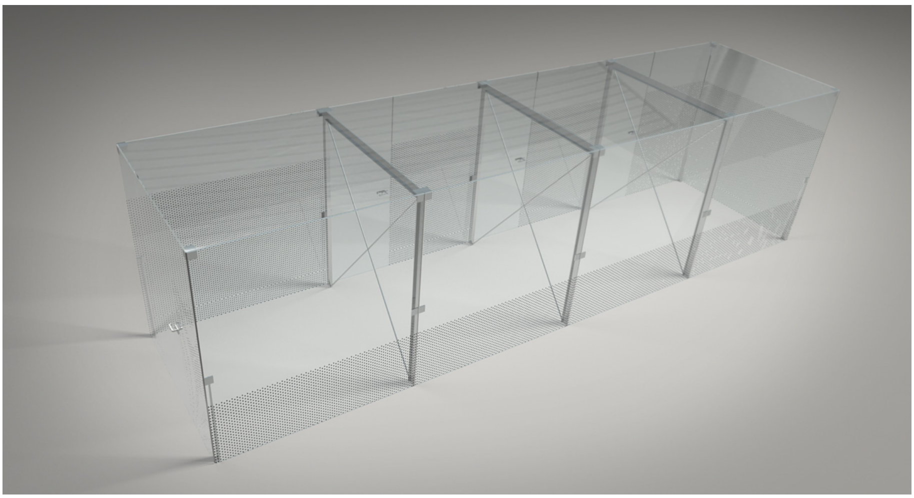

Figure 7: Rendering of the cubicles located inside the reading hall (© Werner Sobek Stuttgart).

3. Structural analysis

The glazed roof acts mostly as a shell under snow, wind, dead load and temperature. Asymmetric load distributions as well as ring movements and local settlements lead to some local bending moments whose effects on the structure have been considered. The steel pipes all have the same diameter but different wall thicknesses, depending on the intensity of the internal loadings. The pipes with the maximum wall thicknesses are located at the cut-outs (the firemen door on one side, the bridge penetration on the other one), since there the regular flow of forces in the shell is locally interrupted.

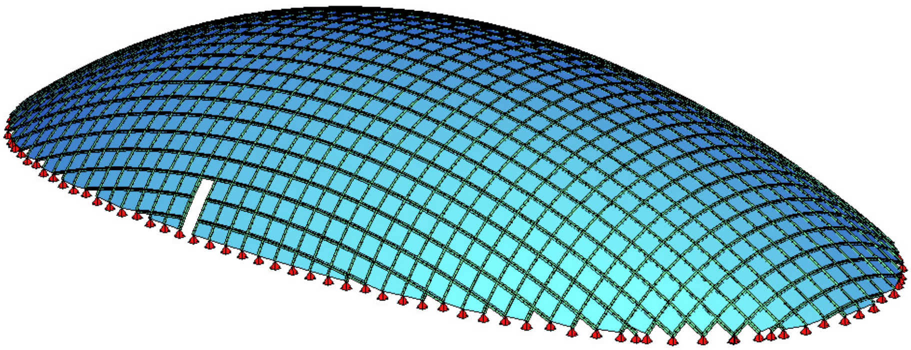

Figure 8: Grid shell structural model (© Werner Sobek Stuttgart)..

In order to check the structural global stability of the grid structure, the geometry of the grid structure was modified according to certain imperfection shapes. The imperfection shapes were selected according to the structure's natural modes of vibration and according to certain load combinations.

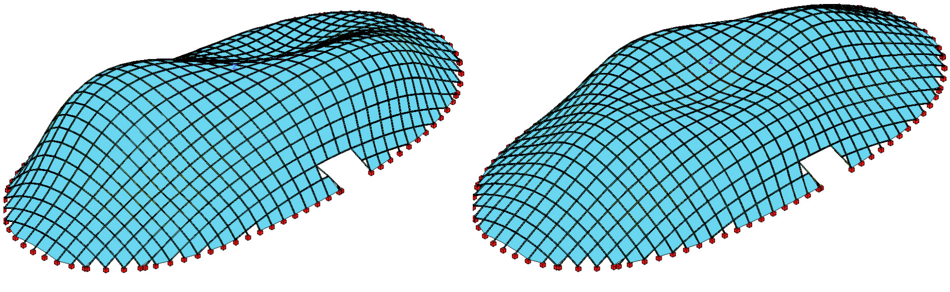

Figure 9: Shell imperfection forms (© Werner Sobek Stuttgart).

4. Construction

Construction of the Mansueto Library started at the end of 2008 and the opening is scheduled for 2011. The first part of the building to be executed was the concrete ring beam supporting the shell. In this phase a special care was necessary during the installation of the embeds to guarantee a precise positioning.

Figure 10: The site in spring 2009 – construction of the ring beam (© Werner Sobek Stuttgart).

Once the ring beam had been completed, the underground area dedicated to the book storage inside the ring beam could be excavated over the summer. At the same time were executed the slurry walls that vertically support the ring beam and withstand the lateral earth pressure.

Figure 11: The site in summer 2009 - excavation of underground levels (© Halvorson and Partners).

In winter 2010 parts of the grid shell have been preassembled by the manufacturer in Germany. At the same time the assembling of the underground steelwork has been carried out on site. The erection of the grid shell has started in March 2010 with the installation of the dome pipe setting plates, which will allow for a correct positioning of the pipes.

Figure 12: The site in March 2010 – Installation of dome pipe setting plates (© Halvorson and Partners).

5. Conclusions

Given the innovative character of the project and the complex interaction between the several teams involved in all the design phases, a tight coordination between the architects Murphy/Jahn, the engineers, the consultants, as well as the manufacturing companies has been the key to guarantee the high quality of execution requested by the University of Chicago.

6. References

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