Sony Center, Berlin – Potsdamer Platz: Forum Roof

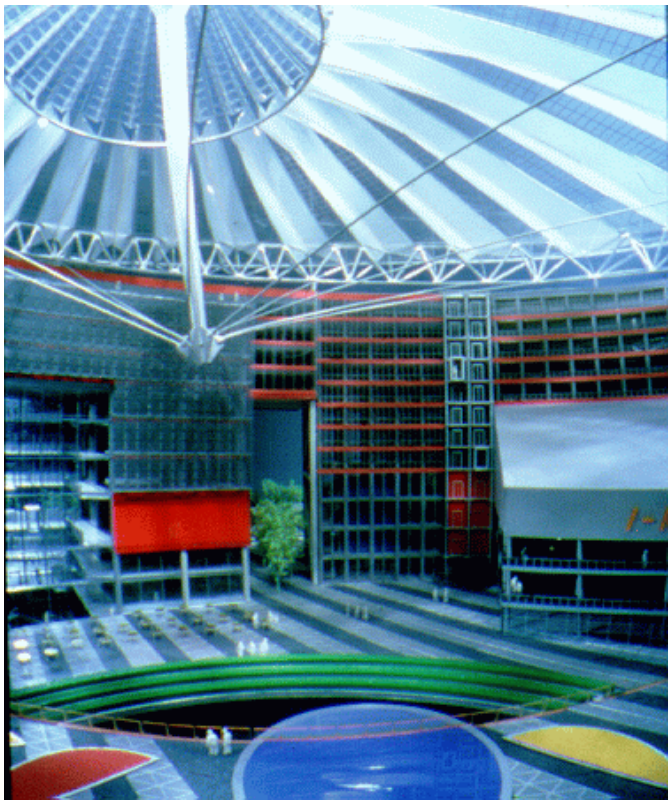
Ross C. Clarke, Markus R. Schulte

Introduction

In 1992 the German-American architect Helmut Jahn, assisted by Ove Arup & Partners in New York, won the architectural competition for the Sony European Headquarter in Berlin, located on the western edge of the Potsdamer Platz. The southern boundary of the triangular site is the ‘Neue Potsdamer Straße’, the western edge is the ‘Kulturforum’ and the northern and eastern boundary will be ‘Bellevuestraße’. Figure 1.): Project OverviewThe whole building complex consists of seven buildings with a gross floor area of 212.000 m^2. The average height of the buildings is around 40m; one office building exceeds 100m. The use of the buildings differs, with offices and apartments in the upper floors, retail and restaurants at ground floor levels, movie theatres in the basement. The ‘Deutsche Mediathek’ with a

permanent ‘Marlene Dietrich Museum’ and the ‘Filmhaus’ will be in one building. The only remaining building after World War II is the former ‘Grandhotel Esplanade’, which will be integrated into the new building complex. Excavation for the project started in November 1995, completion is anticipated for the end of the year 1999.The focus of the project is an internal elliptical plaza, the Forum, which will be accessible through portals in the surrounding buildings. It will be used for events and will create a space for social gatherings. The Forum will be covered with a roof to extend its use: the Forum Roof.

Figure 2.): Sony Forum, Internal View



Description of the geometrical and structural concept

The concept for the form and structure of the forum roof was conceived during the competition submission in February 1992 and has remain unchanged. The dominant features of the proposed internal forum are its elliptical plan with principle axes of 102m and 78m and the offset circular pool, marking a skylight to the cinema complex below.The surface of the roof can be described mathematically by a hyperbolic cone. The geometry of this hyperbolic cone has a spatial relation to the elliptical forum below. Sections through the cone perpendicular to the axis of symmetry are circular in plan while sections through a cone at an angle are elliptical in plan. The elliptical forum of the Sony Center reflects an elliptical section through a special tilted hyperbolic cone, which reflects the roof surface. The circular opening in the center of the roof reflects a perpendicular section through the hyperbolic cone and is marking the circular pool in plan.This mathematical concept provided an axissymmetric surface and a geometrical discipline needed for the analysis and the erection of the roof.

The structure for the roof is similar to that of a bicycle wheel. Two layers of cables span radially from an inner axis to an outer ringbeam. The top layer of cables, the ridge and the valley cables (Ø 45 mm), create the folded surface of the roof where strips of glass (5 degrees) and fabric (10 degrees) alternate. The bottom layer of cables, the kingpost cables (Ø 91 mm), suspend the kingpost over the forum. The ringbeam of the roof is a triangular space frame and it is supported on top of the buildings. This arrangment is horizontally determinate to allow for independent movements of the buildings under the roof. The ringbeam varies in height from 4.00 to 7.50 m, it has a constant width of 6 m and weighs ~ 500 t. A computer orientated form-finding process determined the shape of one 10-degree fabric segment. One fabric segment has two ridge cables and one valley cable. These cables have anti clastic curvature and the fabric spans uni-axial between them. In a second step to create the overall geometry of the roof, this segment is rotated around a central axis creating the previously described axissymmetric hyperbolic cone. The gaps

between the fabric are filled with glass panels. The cone is now tilted by an angle of 8 degrees. Similar to a ‘cookie cutter’ the final shape of the roof is chopped out of the cone. The ringbeam of the roof is placed along the chopping line of the cone while the kingpost is placed in the axis of symmetry of the cone. Radial cables connect ringbeam and kingpost and create structurally a closed system resembling a bicycle wheel.

Figure 3.): Axissymmetric hyperbolic cone with ‘Cookie Cutter’

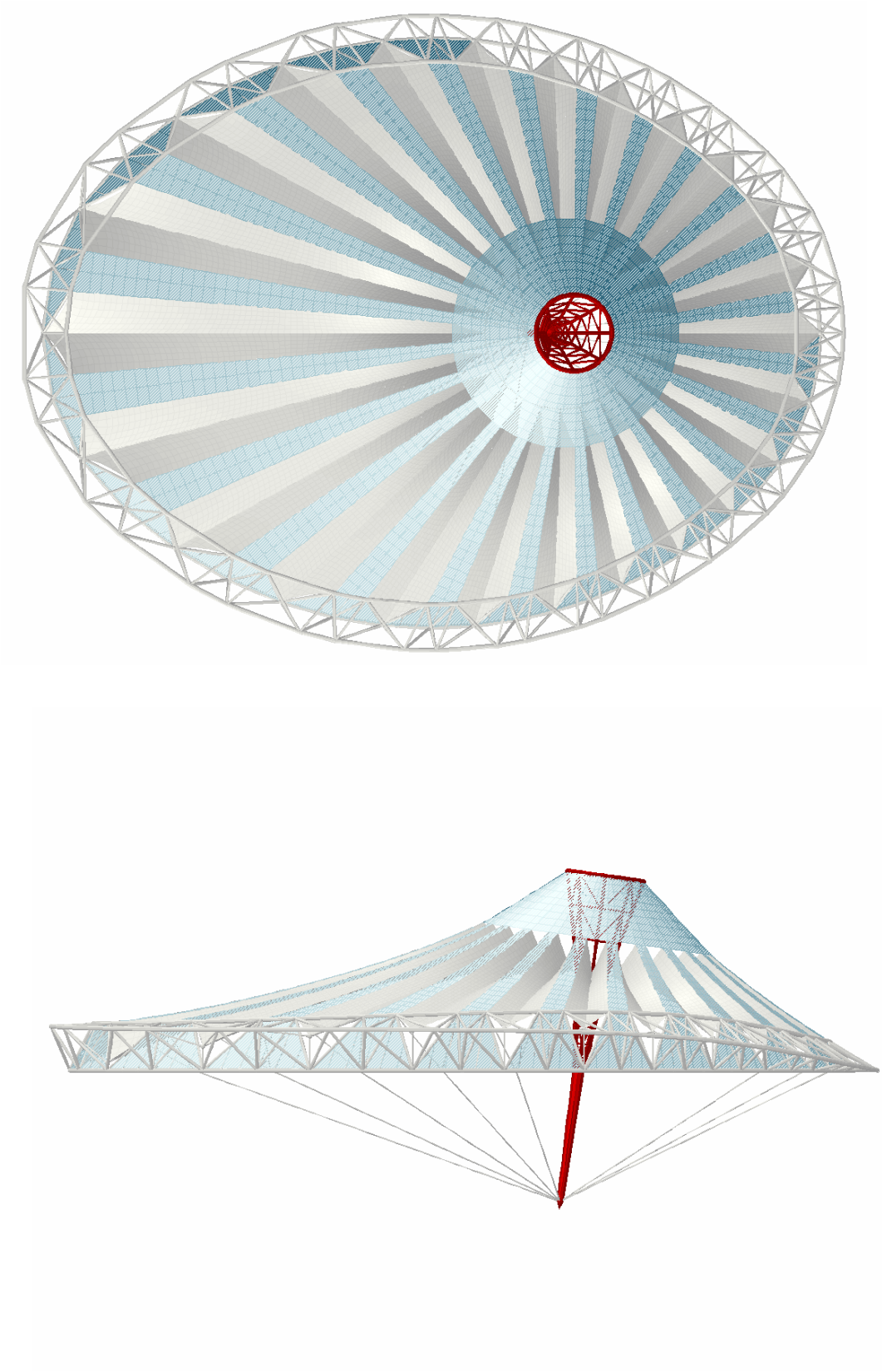


Figure 4.): Sony Center, Forum Roof: Plan view and elevation (Main span 102m, 5250m^2 PTFE, 3250m^2 of laminated glass (2x8mm), height of king post 42.50m)

Analysis of the structure

Ultimately three different complete computer models of the roof were built with three different computer programs to evaluate the integrity of the structure:-

Fablon, a program internally developed by Ove Arup & Partners, was used for formfinding and investigation of strength and serviceability-

SAP2000Plus, developed by CSI in California, was used to calculate the natural frequency of the roof (~ 1.1 Hz)-

GSA, internally developed by Ove Arup & Partner, was used to calculate the lowest buckling eigenvalues for the ringbeam and the kingpostAll programs could handle geometrically non linear calculations. Each of the models contained tens of thousands of elements. The basic prestressed configuration of the roof was used to crosscheck results between programs. RWDI in Canada were appointed to conduct wind tunnel testing to assess snow and wind loading for the roof.The major concern for serviceability of the roof was the distortion of the glass panels. A computer program was written to calculate the warping and the rotation of each glass panel based on the results for the overall displacements of the structure. The maximum global displacement of the structure is of the order of 1 metre , the maximum warping of the glass panels is L/83. The maximum rotation of the panels is 0.87 degrees or 23 mm, assuming a constant width of 1.50 m for the panels.

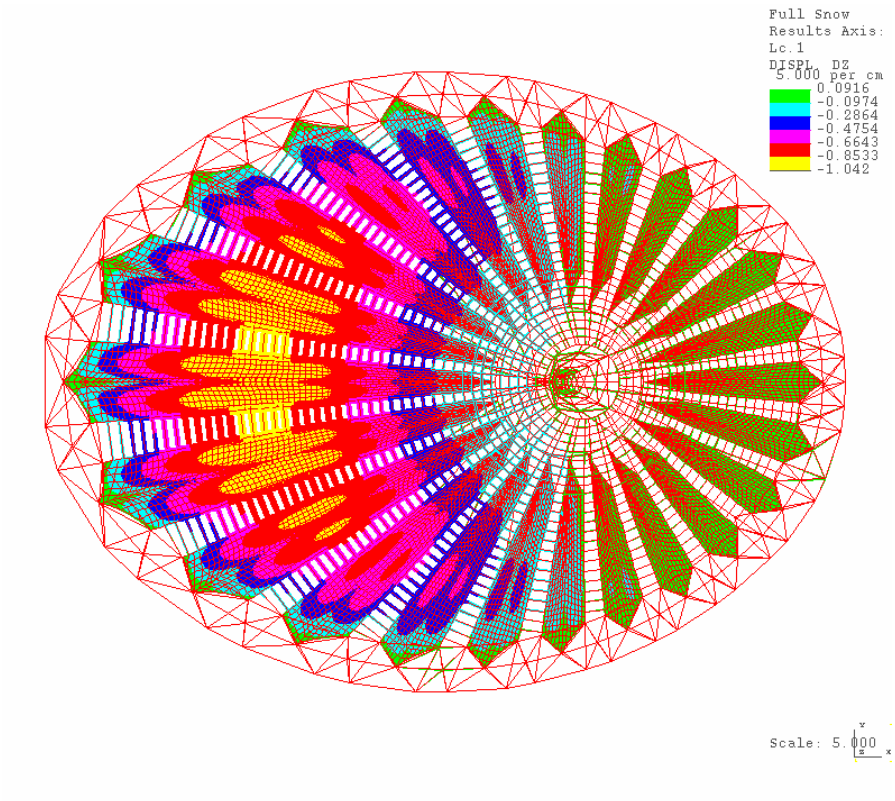


Figure 5.): Displacements under maximum snow-loading, $d_{z,max}$ = 1.04 m

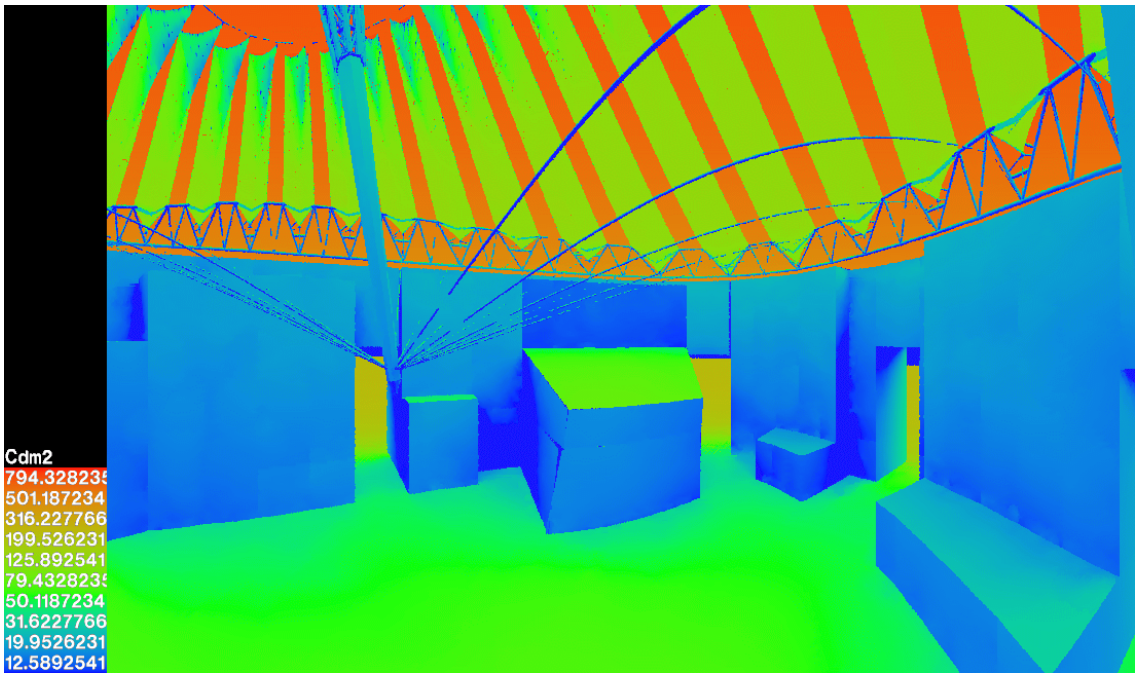
The initial concept for the glass was to have a shingled surface with sliding bearings. In discussion with the contractor these bearings were replaced with elastomeric buffers.

Environmental investigations

Several studies were conducted by OAP to evaluate the quality of the space below the roof in regard to light, temperature, smoke and fire. For example, a daylight study had to prove that the rooms adjacent to the forum would receive sufficient daylight according to the German code requirements.Figure 6.) shows a 3D-simulation of the Forum. On that basis partial daylight factors were calculated in the rooms of the buildings.Figure 6.): Daylight study of the forum

Conclusion

The erection of the roof started in July 1998 and is programmed to finish at the end of the year 1999. Ove Arup & Partners were appointed as engineers for all design phases including site supervision and consultation to the client and to the architects for the various special permissions required in Germany.



Intensive testing of materials (glass and fabric) was conducted and consulting services were provided to the contractor.The whole process of designing and erecting this roof was a result not only by the often mentioned integration of architectural and engineering aspects, but through an awareness, that modern roof structures do not only have to fulfill esthetical and structural criteria but also have a strong relation and interaction regarding the quality of the spaces they create.

Key personnel Client:
represented by
Tishman Speyer Properties
New York, NY 10022
Murphy/Jahn Architects
35 East Wacker Drive
USAEngineers:
Ross Clarke, Markus Schulte
New York, NY 10013
department to review calculations:
Strauss Str. 27
GermanyGeneral Contractor:
Eberhard Pannhorst, Dr. Rützel
10779 Berlin
Waagner-Biro AG with Birdair
Stadlauer Str. 54
Austria
Sony with Tishman Speyer & Kajima
Charles DeBenedittis, Shem Krey
520 Madison Avenue
USAArchitect:
Helmut Jahn
Chicago, Illinois 60601
Ove Arup & Partners USA
155 Avenue of the Americas
USARepresentative of building
Prof. Joachim Lindner
14193 Berlin
Hochtief AG, Berlin
Bayerischer Platz 1
GermanySubcontractor Roof:
Johann Sischka
1221 Vienna
Richard