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9. Roy Thomson Hall, Toronto (Ontario)

Owner: *Roy Thomson Hall*
Architects: *Arthur Erickson/Mathers and Haldenby Associated Architects*
Structural Engineers: *Carruthers & Wallace Limited*
Construction Managers: *Eastern Construction Co. Ltd.*
Structural Steel Supplier and Erector: *Dominion Bridge, Ontario*

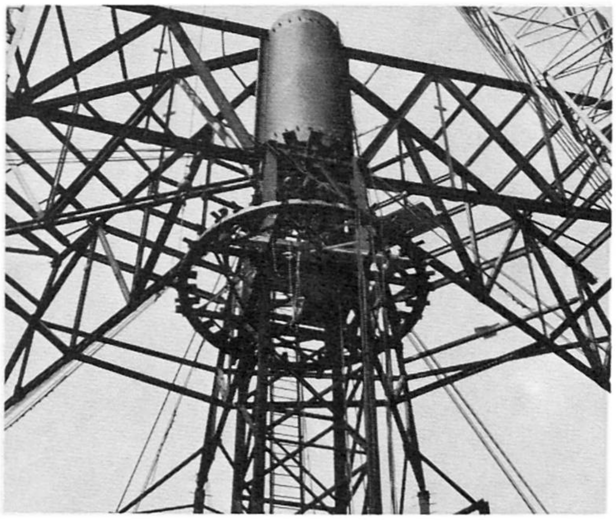

Fig. 2 Roof structure

Roy Thomson Hall is the new permanent home of the Toronto Symphony Orchestra and the Toronto Mendelssohn Choir. The main auditorium, with a seating capacity of 2800, is encircled by a spectacular, sloping glass canopy which rises to a height of 23 m from a podium structure which contains the lobbies and access galleries for the Hall's (suspended seating) levels. The latter, cantilevered from the curved inside perimeter of the Hall, form a pair of horseshoe shaped rings as they ascend in a series of graceful steps towards the rear of the auditorium. The musicians' level, containing rehearsal rooms, instrument storage facilities, recording, radio and TV rooms, is located in the first basement directly below the lobby areas. Parking for 400 cars occupies the second and third basement floors.

Acoustics requirements dictated that all interior surfaces must be facetted sufficiently to scatter sound so that all seats will experience music of equal clarity and quality. A further requirement was that the auditorium be isolated from penetration of any noise from the outside. These requirements were met by designing the Main Hall as a structure, within a structure and completely divorced from the surrounding lobby and parking levels (Fig. 1). The few contact points between the central auditorium structure and the surrounding lobby consisted of vibration-isolation pads designed to eliminate sound transmission between the two structures.

The requirement for uniform quality and clarity of sound throughout the auditorium was satisfied by the use of exposed concrete for all the interior surfaces enclosing the auditorium. The enclosing walls take the form of twenty-six overlapping, convex leaves, each offset from its neighbour. The hard, convex surfaces provide the

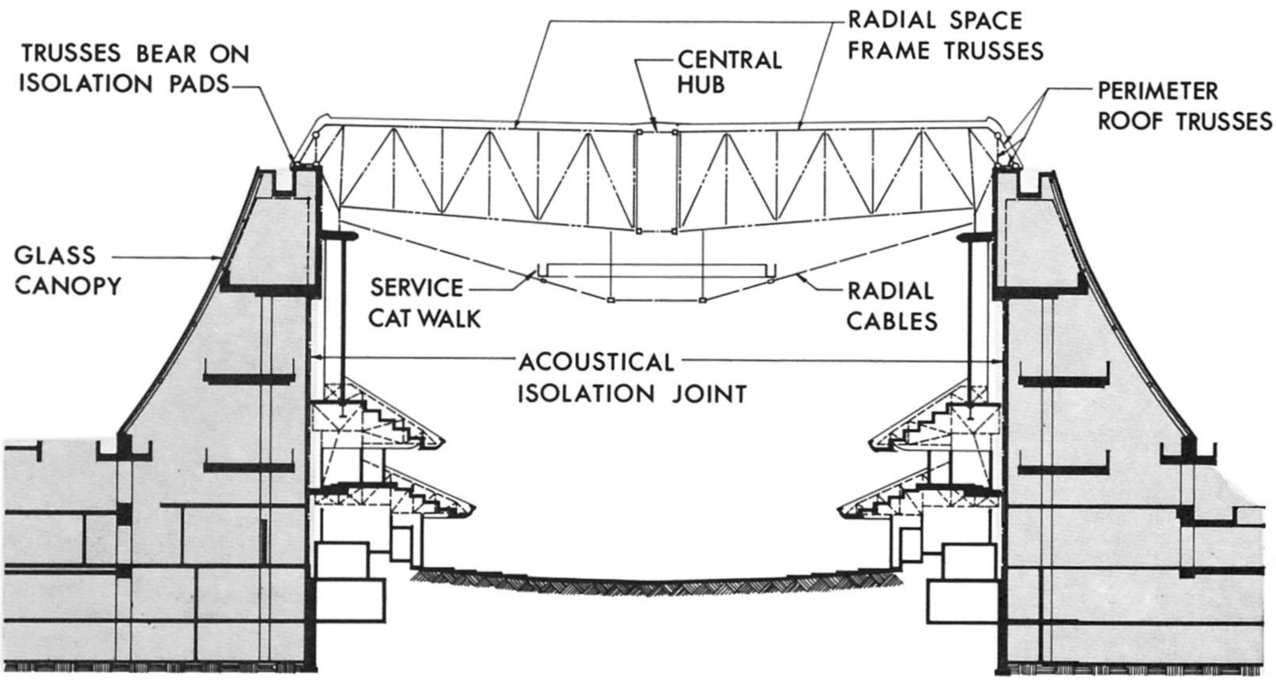

Fig. 1 Cross section through hall facing stage

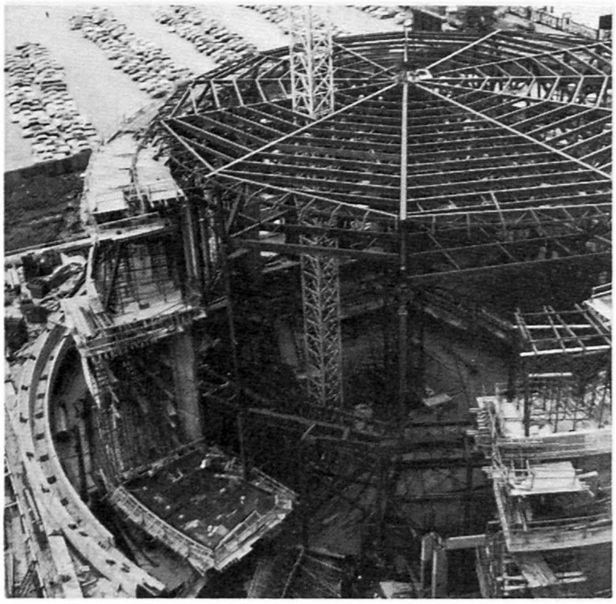

Fig. 3 Roof structure

optimum scatter of sound reflections throughout the Hall and the offsets provide the space for the sound locks necessary at the audience access doors.

Precast concrete panels, each set at a slightly different angle, ensure the uniform reflection of sound from the ceiling surfaces. This scattered reflection is provided again by the curved surfaces of the cast-in-place concrete which encloses the structural framing of the cantilevered mezzanine and upper balconies.

The roof structure is a 7.3 m deep space frame resembling a wheel, with twelve interconnected truss spokes radiating from an eccentric hub (Fig. 2). The top chords of the spoke trusses support steel roof purlins and decking. The roof deck is a sandwich consisting of two, 75 mm thick lightweight slabs separated by a roofing membrane and insulation. This construction acts to prevent exterior airborne noise entering the roof space. The precast concrete ceiling slabs are supported on framing connected at the bottom chord of the spoke trusses. The latter are slotted to allow sound absorptive banners to be lowered into the Hall, allowing adjustment of resonant response.

The entire roof structure was analyzed as a space frame consisting of two parallel plates connected by radial stiffeners (Fig. 3). This approach mobilizes the axial strength of the roof and ceiling purlins without significantly altering their flexural effectiveness, and allows savings in the weight of the trusses.

At the eave, the roof structure is enclosed by a ring consisting of threedimensional triangular trusses supported by the end panel of the main roof trusses. These triangular, space trusses are fabricated from Hollow Structural Section rounds to simplify panel point connections.

The outer, lobby structure, is framed in concrete with two concentric rows of columns supporting ring slabs at three levels. The topmost ring forms the floor of the mechanical room and supports the window washing machine track. The two, lower ring slabs provide the access ramps, platforms and stairs to the balcony and mezzanine seating areas.

The glass canopy over the balcony is supported on a space frame constructed of intersecting 250 mm diameter steel tubes, welded into a diamond shaped pattern (Fig. 4). Due to the rigidity of its joints the frame is self-supporting, allowing an articulated joint at the roof level to compensate for elongation of the tubes under load. The glazing is supported on chairs connected to the space frame. By varying the chair heights, each pane of reflective glass is mounted on a slightly different plane from its neighbour to produce a multi-facetted reflective surface. To avoid wastage and to achieve the economy of repetition, two basic pane shapes were chosen, a square and a 90° triangle, obtained by cutting the square on its diagonal. Out of the two squares and two triangles, flat diamond shaped units were formed and out of these units, a curved surface was generated. Another set of 90° triangles, dimensioned to fit the areas left after joining the corners of the diamonds, completes the glass surface.

The design of the supporting space frame was controlled by the stringent deflection requirements recommended by the glazing consultant. Various load combinations due to wind, snow and temperature were considered and a total of eight load cases were used in the final design analysis. On the advice of the Wind Consultant, the National Building Code recommendations for wind profile on circular structures and snow drifting on inclinded surfaces were followed. Temperature load was applied to one side of the structure to simulate the sun's effect. The space frame analysis provided an accurate determination of the deflection movement of the individual member intersection points, under every load condition. Using this information a full size prototype section of the canopy was constructed and tested for air and water leakage while under critical deformation conditions.

(L. Alejski)

Fig. 4 Inside view