Daplex Pysical Education Complex, Halifax, Nova Scotia (Canada)

17. Daplex Physical Education Complex, Halifax, Nova Scotia (Canada)

Owner: Dalhousie University
Architect: Leslie R. Fairn and Associates, Halifax
Engineers:
Roof concept and fabrication technique: Sinoski Engineering, Toronto
Structural design of membrane roof: Carruthers & Wallace Limited, Toronto
Contractor for membrane: Blankhorn & Sawle Ltd., St. Catharines, Ontario
Contractor for concrete structure: Fraser Brace Ltd., Halifax
Works' Duration:
Membrane fabrication and erection – 6 months
Entire building – 24 months
Service Date: 1979.

The air supported stainless steel membrane roof is shown in Fig. 1. In the lower level of this building, which is 92 m by 73 m, are located an Olympic Pool with 5 m diving board and observation gallery, squash and handball courts, medical science laboratories and classrooms and mechanical equipment rooms, (Fig. 2). The main floor provides an unobstructed area 82 m by 64 m for gymnastics, basketball, tennis and university assemblies. Above this level is provided a perimeter running track.

Zoning restrictions limited the maximum height of the building to 10.7 m above mean exterior ground level. Any conventional steel roof structure would have required 5 m construction depth, forcing the building farther down into the rock foundation by this same distance. Thus, the low profile membrane roof (Fig. 2) suited this building eminently.

The exposed roof membrane is AISI Type 304 annealed stainless steel, 1.5 mm thick. From this, suspended 300 mm below, is a glass fibre accoustic insulation barrier. The internal air pressure is maintained 38 mm water gauge (0.374 kN/m^2) above atmospheric pressure, by conventional ventilation fans. To limit condensation, tempered outside air is passed slowly through the space between the membrane and the insulation. Normal entrance and exit is by revolving doors but leaf type emergency exit doors are provided also.

To avoid internal air pressure in excess of that under which normal door operation is possible, roof snow accumulation is prevented by passing heated air under the membrane, through the ceiling space. However, in the event of failure of the internal air pressure system, the membrane and the perimeter reinforced concrete compression ring were designed to support a snow load of 1.3 kN/m^2, with the membrane in a suspended configuration. All other design conditions produce minimal stresses in the membrane. Maximum membrane stress under design snow load, predicted using a non-linear finite element analysis, is 186 MN/m^2.

To ensure that instability or undesirable response would not be caused by wind, an aeroelastic model of the roof was tested in the Boundary Layer Wind Tunnel at the University of Western Ontario.

The most interesting aspect of the membrane roof, to the structural engineer, is its fabrication. The key to the fabrication is the contraction joint, patented by D.A. Sinoski, which permits the membrane to be fabricated in a flat plane, then to be inflated (or suspended) to the desired curved shape, (a minimum surface for the perimeter shape and height). The contraction

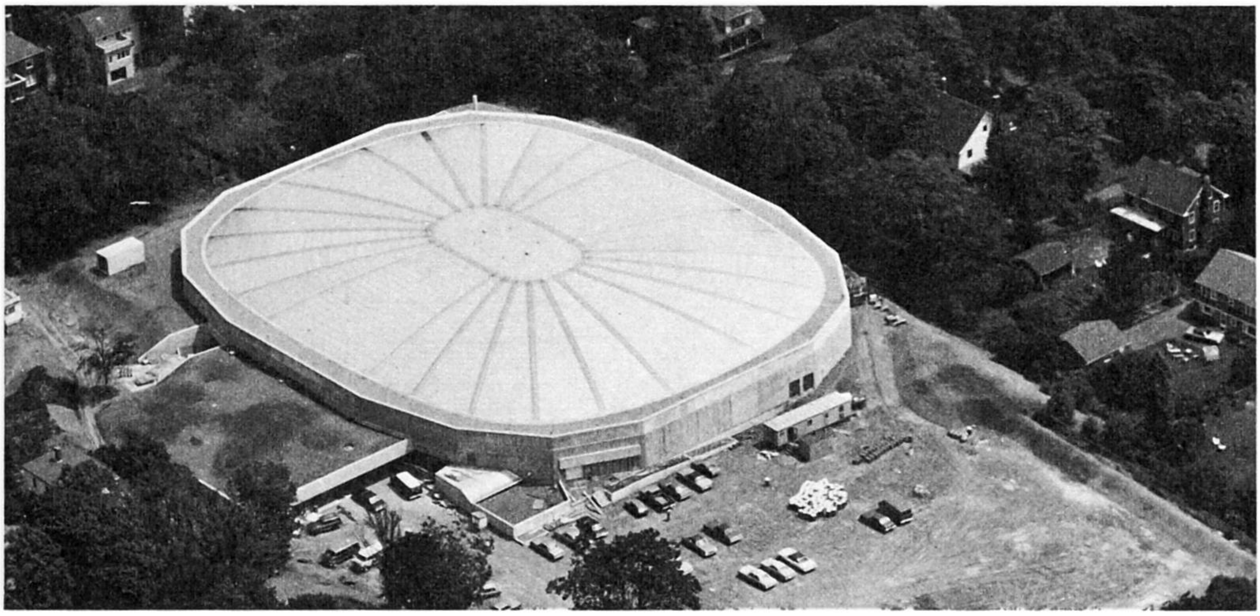

Fig. 1

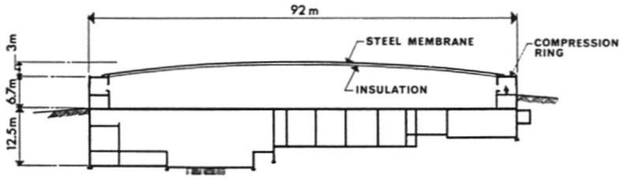

Fig. 2

Fig. 3

joint layout can be seen in Fig. 1, close up in Fig. 3. These are of ¾ hard Type 304 stainless steel, formed to an Ω shape. On inflation, the membrane tension stretches the joints almost flat. The membrane shape is controlled by partially prestretching the joints and holding them with jigs, so that the remaining elongation will provide the necessary geometric difference between the flat and the curved shape.

The flat segments of stainless steel were fabricated by lap welding 1.22 m wide coil sheet, parallel to the perimeter. The completed segments, up to 13 m wide and 30 m long, were reeled onto 2.5 m diameter disks, to form cylinders. With several segments on one cylinder, they were transported by road 2400 km from Ontario to Halifax. At the site, the segments were unreeled onto horizontal falsework, as shown in Fig. 4 and welded to the contraction joints. After inflation, the contraction joint jigs were removed and the insulation installed prior to removal of the falsework.

Welding of lap joints was made with an automatic gas metal arc welding torch and feeder mounted on a crawler, using 0.89 mm diameter weld wire: shielding gas was an argon mixture.

The membrane roof has been inflated for one year. Deflation has been tested under a light snow load. The contraction joints retained their pretension so that, in passing through the horizontal position, the roof remained flat and unbuckled. The insulation barrier and suspended lighting performed as designed and were undamaged by the deflation and re-inflation procedure.

It is believed that this new form of roof construction offers an economic solution to long span roof construction.

(J. Springfield)

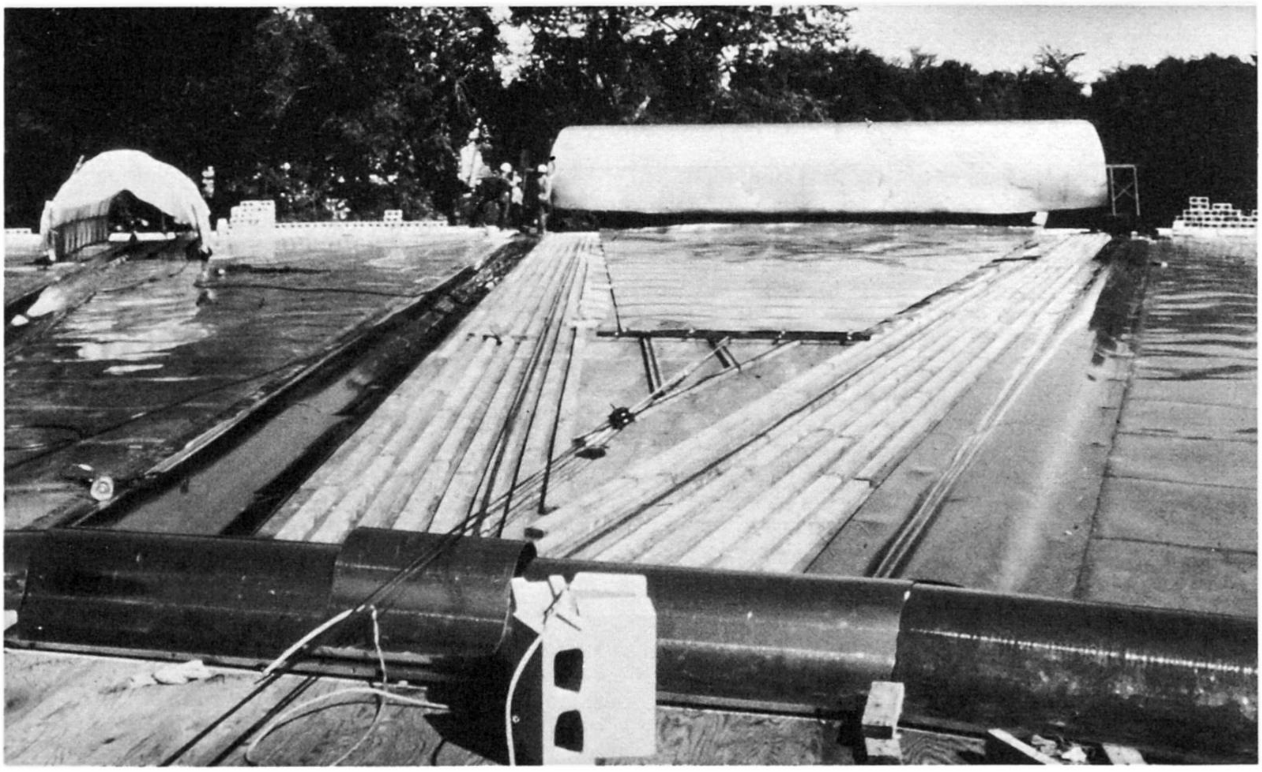

Fig. 4