The roof of the stadium in Riyadh, Saudi Arabia

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La toiture du stade de Riyadh, Arabie Séoudite

Überdachung des Stadions in Riad, Saudi-Arabien

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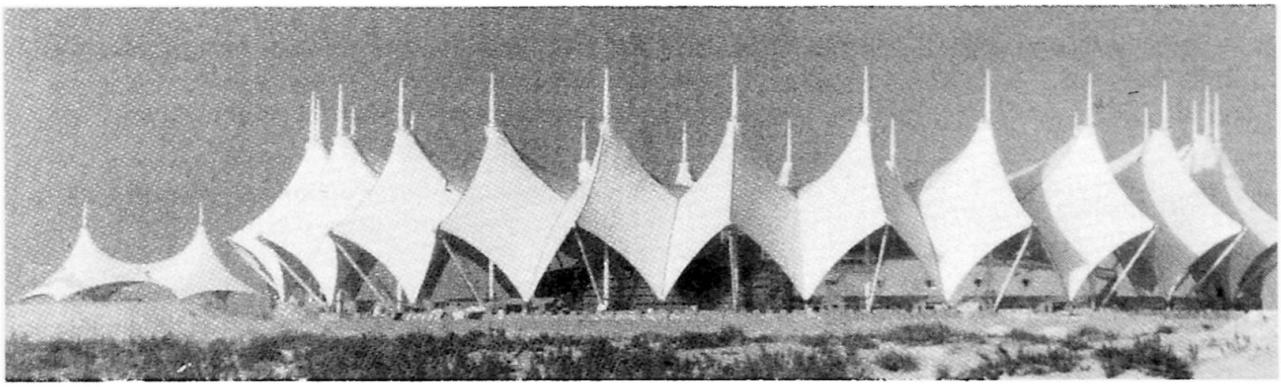

Fig. 1: Riyadh Stadium Roof

Following a design of J. Fraser, J. Roberts and Partners, London, with Geiger and Berger, New York, for the Ministry of Youth and Welfare, Riyadh, as clients, the grandstands of the new stadium in Riyadh are covered by a 50,000 m^2 membrane roof to protect visitors against sun and rain. Each of the 24 units, arranged in an annular shape of 134 m inner and 270 m outer diameter, consists of:
- a vertical main mast
- a pair of suspension and stabilizing cables, which are put under prestress by the center ring cable,
- the staying system, comprising an upper stay and two triangulated lower stay cables, deviated by a 45° inclined edge mast.

These three elements form a stabilized primary system. The membrane units, edged by ridge, valley and catenary cables, are attached to the main mast top ring, the top of the edge mast, the center ring knots and directly to foundations as secondary elements and stressed in between those anchor points.

The masts, cylindrical steel pipes of plates up to 30 mm thickness and with conical end parts center their loads on hinge bearings which are provided mainly to cater for rotational movements during construction. To ease transport, the main masts got 2 HSFG-bolt splices.

All cables are of a locked coil type with up to 3 layers of Z-shaped wires. The diameter variation between 26 and 74 mm yields ultimate cable loads of 650 to 5,100 kN. All wires are hot dip galvanized. The outside corrosion protection of cables and sockets is guaranteed by a 2 mm polyurethane coating, which shows a good bond on galvanized surfaces, high ductility up to 400 %, high tensile strength and an excellent durability against sand abrasion and aging due to UV-radiation.

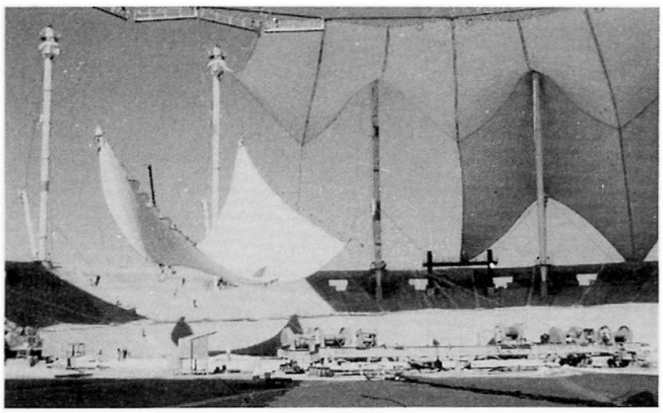

Fig. 2: The membranes are lifted

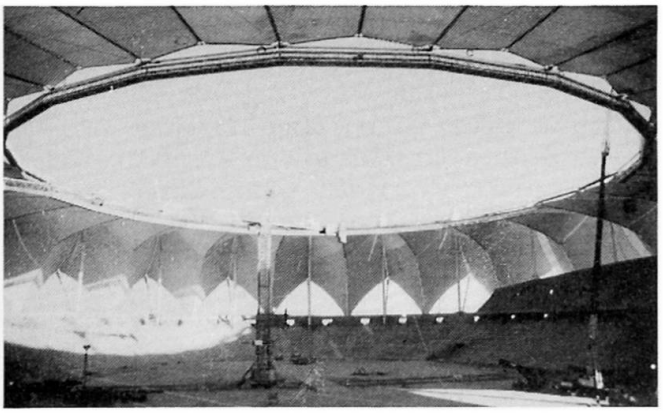

Fig. 3: The roof seen from inside

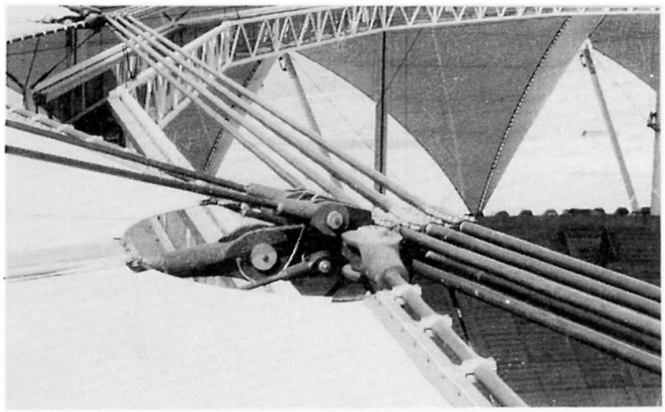

Fig. 4: Center ring detail

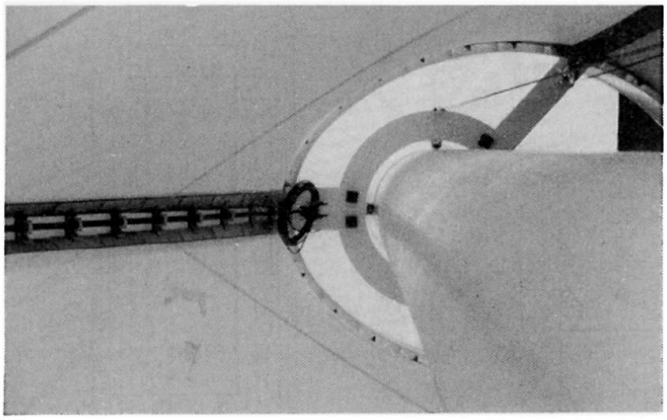

Fig. 5: View of mast top from inside

The membrane is a PTFE-coated glassfibre fabric; its ultimate strength is specified as 150 kN/m in both directions in order to assure a safety factor of >10 for permanent loads like prestress and >5 for short time loads like wind. Each roof unit consists of 4 individual membrane parts, resulting in a maximum size of 850 m^2 per piece; these were manufactured in the shops out of 4 m wide strips, according to a predetermined pattern and folded into a crate for transport to site.

The construction started with the erection of the primary system; the center ring cable, laid out and assembled on ground, was pulled straight up into position by the suspension cables and jacks on the 24 mast tops; the rear stay cable system was lifted piece by piece by a mobile crane. After addition of temporary guy cables from the center ring down to the ground the primary system was slightly prestressed for stabilization.

The membrane units were preassembled on the ground including catenaries and their attachment knots. Then they were trolleyed by a system of guide and pulling ropes into their final position, anchored to the primary system and stabilized by ~ 20 % prestress. The final prestress was applied after installation of all fabric elements by jacking the main mast rings up. The specified membrane prestress of 40 pli was reached with a tolerance of a few centimeters only for the ring levels.

General contractors for the stadium were Holzmann AG, Frankfurt, with Chemfab, Birdair Structures Group, Buffalo, N.Y., as subcontractors for the roof. The detailed design of the membrane, cable and steel structure including the technical site supervision was, in close cooperation with Birdair, Buffalo, entrusted to Schlaich und Partner, Stuttgart.