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5. Kingswood Music Theatre, Vaughan (Ontario)

Owner: *Canada's Wonderland*
Engineer: *Proctor & Redfern Group*
Contractors: *Helios Inc., Canron Inc.*
The D. Pike Co., Franki Pile
Buttcon Construction
Construction Period: *1 Year*
Service Date: *June 1983*

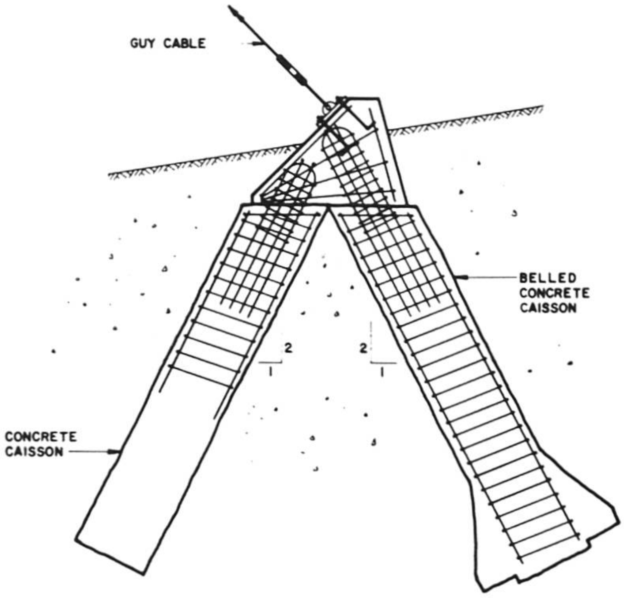

Fig. 2 Tension anchor

Introduction

The Kingswood Music Theatre is the latest edition to the Canada's Wonderland theme park, located just north of Metropolitan Toronto in the Town of Vaughan.

Kingswood is an open air concert facility with reserved seating for 5000 patrons and further space for 7000 on a sloping grassed berm. The stage and reserved seating areas are covered by a 6000 m^2 fabric tension structure which is the architectural highlight of the complex. The tension structure consists of 8 interconnected cones supported on tubular steel columns with the lowest point being 10 m above grade. The combined effect is that of an elegant, light, airy and unconfining space (Fig. 1).

Foundations

The traditional method of resisting guy cable tension has been the use of mass concrete anchor blocks. At Kingswood the large number of anchors and the high magnitude of the forces would have made the use of mass concrete footings very expensive. The dense glacial till, which underlies the site, provided an excellent opportunity to use battered belled caissons to mobilize soil weight and resist tension forces. This system used approximately 1/6 of the concrete volume that would have been used for mass footings at 1/3 the cost (Fig. 2). A total of approximately 200 m^3 of concrete was used for the tent foundations.

Fig. 1 View of performance area

Tension strucutre

The stressed fabric tension structure consists of a performance area structure (2 cones) which is surrounded on three sides by the seating area structure, 6 cones (Fig. 3). The structural concept is a series of pre-stressed, interconnected, anticlastic, warped, parabolic cones.

The membrane is supported by 8 major steel columns, 600 mm in diameter, and 23 perimeter sub-poles, 200 mm to 250 mm in diameter. The major poles are 24 m high in the performance area, 22 m high in the seating area and the sub poles range in height from 10 m fo 13 m. Spiral welded pipe, A139-B, was used for the major columns while A53-B pipe was used for the sub-poles. A total of 65 tonnes of steel was used.

The membrane is pre-stressed, to achieve its design shape and to maintain that shape under loading. Wind loads are transmitted through the fabric to the major poles and to tensioned catenary cables, in the edges of the membrane. Loads are resisted by fabric tension with downward loads being resisted by radial tension; uplift loads by circumferential tension. Successive layers of fabric are used to increase the strength of the membrane in the regions of greatest stress, which occurs at the top of each cone. Pre-stressing in the fabric is achieved by adjusting the length of the guy and catenary cables with turnbuckles.

The membrane has not been designed for snow loads and therefore must be lowered in the autumn and raised in the spring. The poles remain up year-round and are held in position by a system of security cables connecting the tops of the poles.

To facilitate raising and lowering and to maintain the shape of the cone at its apex, the membrane is connected to circular steel rings suspended concentricly about each major pole.

While several days are required for preparation, the critical operation of raising and initial tensioning takes approximately 24 hours. The centres of each cone are simultaneously winched into position; the catenary cables are connected to the tops of the sub-poles and the turnbuckles are adjusted to remove slack from the fabric (Fig. 4). The greatest danger during this operation is unforeseen high winds as the structure is highly dependent upon its final tensioned shape to resist wind forces. Once erected, several more days are required to adjust pre-stress, plumb poles and remove wrinkles.

(R.T. Richardson)

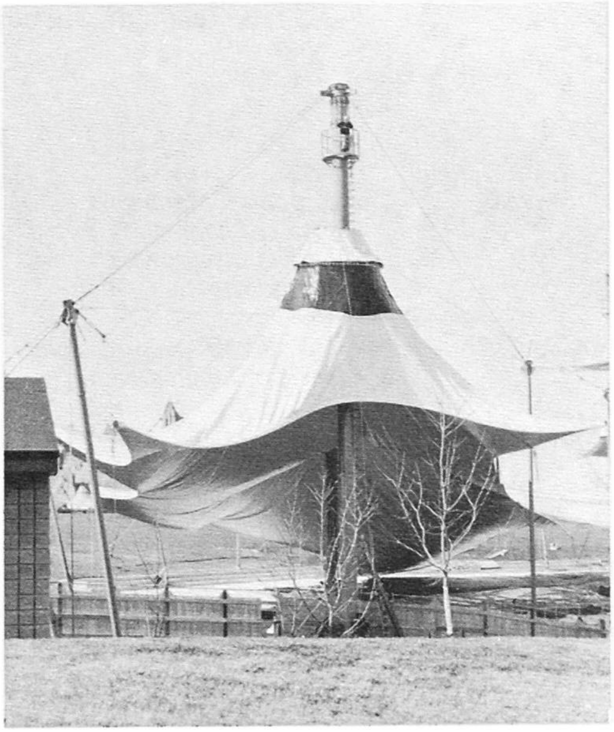

Fig. 4 Raising membrane

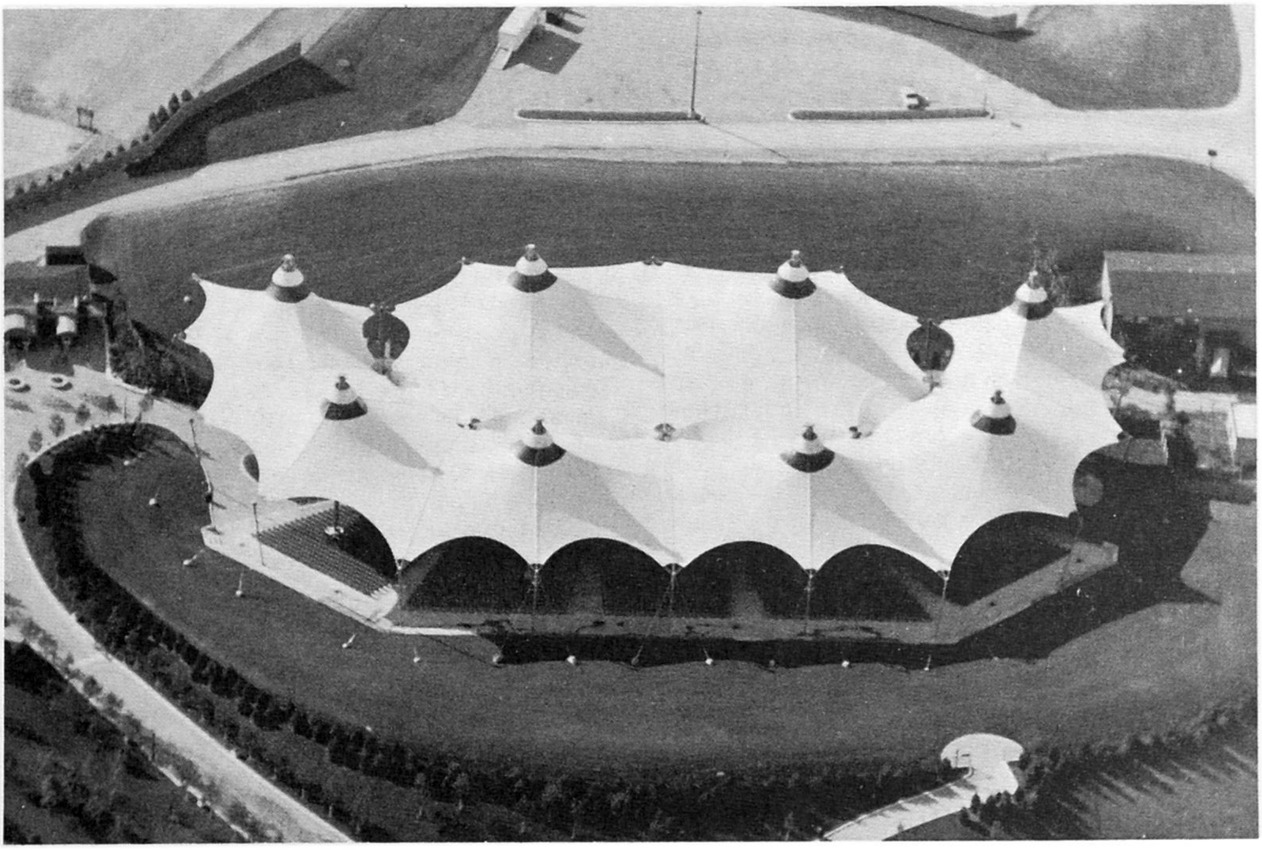

Fig. 3 Areal view