

# A Fascinating Impression

Jalan Besar Stadium is a multi-use stadium located at Jalan Besar, in the Kallang area of Singapore. It is currently used mostly for football matches, and is the home stadium of Young Lions S-League soccer team. The stadium, put up in 1932, is considered the birthplace of Singapore football. Malaysia Cup soccer matches were played here between 1932 and 1966, and 1967 and 1973, among other games. The first Youth Festival (1955) and first Armed Forces Day (1969) were held here too. The original stadium was torn down, and the present one opened officially in 2003.

## Jalan Besar Stadium, Singapore

**W**ITH a spectacular two-way curved Kalzip roof of more than 7000 m<sup>2</sup> crowning the 6,000 seating capacity, the Jalan Besar Stadium is located alongside King George's Avenue and Tyrwhitt Road. This distinctive local landmark has witnessed countless S-League soccer matches and other sporting events. The work began in September 2001. The complexity of the roof design required absolute accuracy in the setting out of the substructure and fixings. The roof is divided into a series of segments or 'bays' between the steel superstructure with a total of 15 bays, all set at various altitudes although mirrored on the centre. The distinctive roof structure was designed to give a fascinating

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Front view of Jalan Besar Stadium, Singapore



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impression of a 'floating' roof. Thereon, Jalan Besar Stadium was renovated in 2002 at a cost of approximately US\$ 20 million.

#### Jalan Besar Stadium's Steel Roof Structure

The main grandstand roof of the Jalan Besar Stadium is a unique steel structure, which is a combination of cable suspension, compression arch, and portal frame structure. A revolutionary new structural development is the use of pre-stressed cables tying the column bases together to reduce the horizontal loads on the foundations. The result is an elegant lightweight structure, which floats above the grandstand, and requires the minimum footprint to suit a narrow site. For a sports stadium, the primary design objective is to achieve an aesthetically pleasing roof form.

#### Site Constraints

The site for the stadium is extremely restricted, and therefore, space for the structure supports was limited. To achieve a clear line of vision, the enclosed area had to be column free. Given the site constraints, the architect envisaged a massive steel truss spanning the length of the grandstand between two staircase blocks on either end of the structure. In order to reduce the weight of the structure, the structural engineers have proposed a cable suspended roof, which would be curved in both plan and elevation. A curved bottom cable was added to carry the roof as well as to give rigidity to the structure. However, the soil condition at the site is poor, with about 10 metres of marine clay and soft soil under the surface. That made it unsuitable for the foundations to carry huge horizontal loads, which would have been imposed by the cable roof. The foundations for the tiebacks would have protruded outside the site boundary. Therefore, a radical new solution had to be found.

#### A Radical Solution for Structure Design

The horizontal loads due to the cable suspension of the roof had to be somehow carried within the structure instead of into the foundations. To do this, the lower cable was made into an arch to carry compression instead of tension. A tie was added connecting the base of the columns at ground level. Thus, all the forces in the structure are self-contained, and only the vertical weight of the structure is carried into the foundations. This radical solution allowed a savings of 85% in the foundations. Although the structure may look like a suspension bridge, the actual behaviour is completely different. For a suspension bridge, large foundations were required to resist the pull of the suspension cables, whereas in the Jalan Besar stadium's roof, all the pull of the suspension cables is balanced within the structure and only the self weight and external forces such as live load and wind load are transmitted to the foundations. This resulted in a dramatic savings in foundation costs over a pure suspension structure, which usually relies on the foundations to carry the suspension cable tension making



An aerial view of Jalan Besar Stadium

the cables carry the vertical load of the structure. Whereas in the Jalan Besar roof structure, the arch and suspension cables shared the vertical load, and therefore, the suspension cable and arch both have very shallow (flat) profiles.

This contributes greatly to the graceful appearance of the structure. Another major difference is that a suspension bridge behaves as a flexible structure which deforms under uneven loads, whereas the Jalan Besar stadium's roof structure behaves as a rigid unit with much less deflection under different loading conditions. **RnF**

#### PROJECT CREDITS:

*Main Contractor: Sanchoon Builder*

*Architect: SAA Partnership*

*Client: Singapore Sports Council*

*Installer: Sentral PL*

*Structural Engineer: Albert LP Loh Consultants*

*Reference: <http://albertlohconsultants.com>*