Partial Prestressing of Long Span Steel Truss Girder

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Summary

The large roof steel structural system with area of 99.00 x 84.30 metre composed mainly of two long span steel space trusses and twelve arched roof steel trusses have been previously analysed and designed accompany with partial pre-stressing system. Span arrangement has been prior introduced to architect with span to depth ratio and appropriate sections of reversed triangular. The final design have found that partial pre-stressing system could not effective and appropriate for steel trusses especially with overhang part because of less eccentric of pre-stressing tendon profiles than its kerning points.

Keywords: Steel Truss Girder; Roof Truss; Partial Prestressing.

1. Introduction

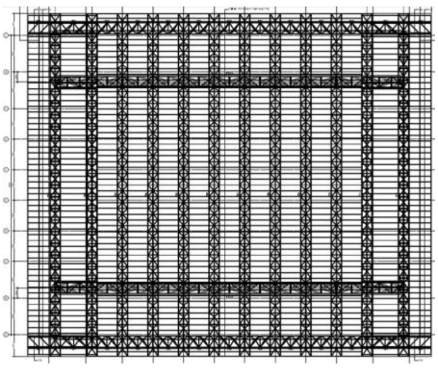

Fig. 1: Roof Steel Structural System

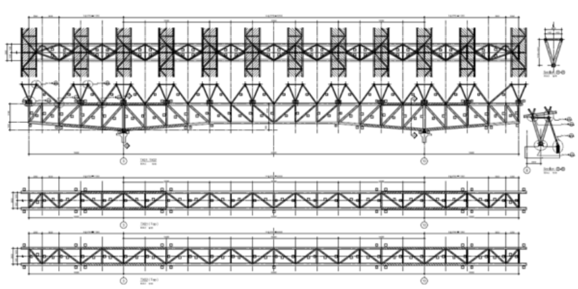

Fig. 2: Main Roof Space Truss Profile and Section

Roof steel structures system of 5000 seats indoor stadium with roof area of 99.00 x 84.30 m., composed of two main steel space trusses, span 52.50 m. and 16.50 m. overhang on both sides, and 12 steel space arched trusses, span 50.70 m. and 16.70 m. overhang on both sides, perpendicular to main trusses with typically spacing of 7.50 m. and 9.00 m. at the first and last span to balance the overhang 6.75 m. of purlin span, as shown in Fig. 1.

Each main roof reversed triangular tubular steel truss, with centre depth of 4.50 m. and 3.30 m. at support and mid span respectively, and 2.80 m. in centre spacing of top chord, has been supported by 2 reinforced concrete stair cores. Main space truss profiles and sections are shown in Fig.2.

2. Design Approach

In conceptual stage, span arrangement of main and secondary roof trusses, by the concepts of inner forces balancing at support and mid span while balancing deflection at end of overhang and mid span, have been introduced to architect. The ratio of overhang to inner span about 0.33 to 0.35 has been suggested. And then, depth to span ratios about 15 to 16 and reversed triangular sections, to provide more lateral and torsional rigidity, and to reduce the span of secondary truss and purlin, in

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main and secondary trusses respectively, have been primary informed to architect to arrange and develop the building layouts and sections both in main and secondary trusses.

Preliminary stage , architectural layouts have been finally arranged for typical span of 7.50 m. and 9.00 m. at the first two spans and the last two spans of building in each direction. Four reinforced concrete stair cores as main roof truss supports and main lateral supporting system, instead of large columns, have been provided. The overhang to inner span ratios are finally of 0.33 and 0.43 for secondary and main roof truss, respectively. And due to the more ratio of overhang to inner span of main roof truss, then more internal forces and deflections have been controlled by overhang part, truss depth has been finally extended with slope of 1:12.5, at 15.00 m. from both sides of support from 3.30 m. to 4.50 m. to reduce internal forces of main roof truss. Partial pre-stressing system has been previously introduced in main roof steel truss designs accompany with structural steel. The main objectives are to less weight of total steel and to reduce dead load deflection and lifting load during construction. Trapezoid tendon profiles along main roof trusses in bounded of top and bottom chords have been modelled and analysed, but analysis have shown that internal forces in structural steels could be only reduced at tension sides while they add more internal forces on the compression sides.

Final Design, the overhang and inner span of main roof trusses are finally 16.50 m. plus 6.75 m. overhang of purlin and 52.50 m. respectively supported by four reinforced concrete stair cores. Centre depth is 3.30 m. at inner span and extended from 3.30 m. to 4.50 m. at 15.00 m. from both sides of each support. Reversed triangular sections of 2.80 m. apart in top chords have been provided with composite steel plate sections in top and bottom chords, and steel pipe sections in diagonal chords, and finally without pre-stressing system due to ineffective internal forces on compression sides. Total weight of each main steel truss is 83 metric ton.

Live load deflections are just only 11 mm. downward and 29 mm. upward at the end cantilever and mid span, respectively, but the maximum deflection combined with wind is 143 mm. upward at the mid span.

3. Discussion

Although span arrangement is the most importance and major factors effecting on cost and performance of long span structure design and construction but there are some limitation in architectural views that cannot arrange the span following to structural views. Close coordination with another designer and architect are more importance to design the whole building.

Ineffective of partial pre-stressing system in steel truss structures caused from the profile of pre-stressing tendons that have to keep in bound of top and bottom chords while their kerning points of trusses, with rigidity mainly depended on top and bottom sections and distance between them only, are outside top and bottom chord bound, then the less eccentric of pre-stressing tendons than kerning point induced the more internal forces on compression sides. So the effective pre-stressing tendon profiles should be assigned farther than centre of section on the compression sides that might not be possible especially of top chord when there are overhang part.

Arch roof with large radius induce wind in upward direction, and due to more overhang to inner span ratio, when it combined with live load deflection, that in upward direction too, then more deflection occur at mid span.

4. Conclusions

Span arrangement is prior the most importance and major factors effecting on cost and performance of long span structure design and construction. Balancing of internal forces and deflections of overhang and inner span are mainly objectives to arrange the overhang to inner span ratio. Space trusses can reduce the secondary structural span while there have been more torsional and lateral rigidity than plane truss. Partial pre-stressing system could not effective and appropriate for steel trusses especially with overhang part because of less eccentric of pre-stressing tendon profiles than its kerning points.