Design of Long Span Exhibition Hall of Steel Structure

Amit A. Gudadhe

[1]Asst. Professor, Datta Meghe Institute of Engineering, Technology & Research, Salod (H), Wardha, Maharashtra, India

ABSTRACT

The current demand from Society/Industry is large clear span structures. A variety of pre-engineered options are available today. For exhibition hall of permanent nature, an attempt has been made to choose a different geometry than that offered by pre-engineered suppliers. The arch shape long span steel structure has been analyzed and designed using the software applications. The trusses designed here are of circular hollow sections since they are of special interest from aesthetic viewpoint. For getting a view of open spaces only three numbers of columns are placed in the interior side of the structure. The span of 25m is kept open on front side of structure for the purpose of entrance and exit, and can be closed with the help of shutters. The roof sheeting over the truss is of galvalume sheet of 0.55mm thickness and in the central strip translucent sheet is provided for natural skylight. Initially the forces are calculated and are applied on the structure modeled in Staad-Pro, then the structure is analyzed and designed. Finally the results are discussed & compared the trusses of different spacing.
Keywords: -Long span structure, steel structure, trusses, hollow sections

1. INTRODUCTION

During the last 50 years our country has continued to lag behind in infrastructure development and consequently poor consumption of iron and steel. Published studies by the Steel Construction Institute (U.K) have established that countries which have a higher rate of growth in Gross Domestic Product (GDP), have proportionately higher consumption of iron and steel. Soon after independence, our country had to gear itself to meet the demands for development and industrial growth and in the first few Five Year plans made reasonable strides in the area of production and usage of iron and steel. Due to various reasons, steel consumption in our country has been stagnating during the past 2-3 years. Further, steel industry is facing stiff global competition through imports. There is also considerable under utilization of installed capacity for steel production. For sustenance of steel industry, extensive usage of structural steel in the construction sector is an important requirement. Our country has to live up to the global competition as we have done in Information Technology!

The design of steel structures involves the planning of the structure for specific purposes, proportioning of members to carry loads in the most economical manner, and considerations for erection at site. First, the structure should serve the purpose for which it is intended and this is achieved by proper functional planning. Secondly, it should have adequate strength to withstand direct and induced forces to which it may be subjected during its life span. An inadequate assessment of forces and their effects on the structure may lead to excessive deformation and its failure. Therefore, the design of structures includes functional planning, acknowledge of the various forces, strength of materials and the design methods. In addition the structure should be economical and easy to erect.

Steel structures are composed of elements which are rolled to a basic cross-section in a mill, and worked to the desired size and form in a fabricating shop or site. A significant difference between steel and concrete constructions is that the designer is normally compelled to use standard rolled sections. Fortunately, the variety of steel sections available is so great that any desired structural effect can be achieved in steel.

2. ANALYSIS OF TRUSSES

Generally truss members are assumed to be joined together so as to transfer only the axial forces and not moments and shears from one member to the adjacent members (they are regarded as being pinned joints). The loads are assumed to be acting only at the nodes of the trusses. The trusses may be provided over a single span, simply supported over the two end supports, in which case they are usually statically determinate. Such trusses can be analyzed manually by the method of joints or by the method of sections. But in the case of multi-span indeterminate trusses, as well as in the case of trusses in which the joint rigidity has to be considered the available computer programs are very useful.

3. DESIGN OF TRUSSES

While trusses are stiff in their plane they are very weak out of plane. In order to stabilize the trusses against out- of-plane buckling and to carry any accidental out of plane load, as well as lateral loads such as wind/earthquake loads, the

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trusses are to be properly braced out -of -plane. The instability of compression members, such as compression chord, which have a long unsupported length out- of-plane of the truss, may also require lateral bracing.

In the case of roof trusses, a member normally under tension due to gravity loads (dead and live loads) may experience stress reversal into compression due to dead load and wind load combination. Such stress reversals and the instability due to the stress reversal should be considered in design. The design standard (IS: 800) imposes restrictions on the maximum slenderness ratio i.e. (ℓ/r).
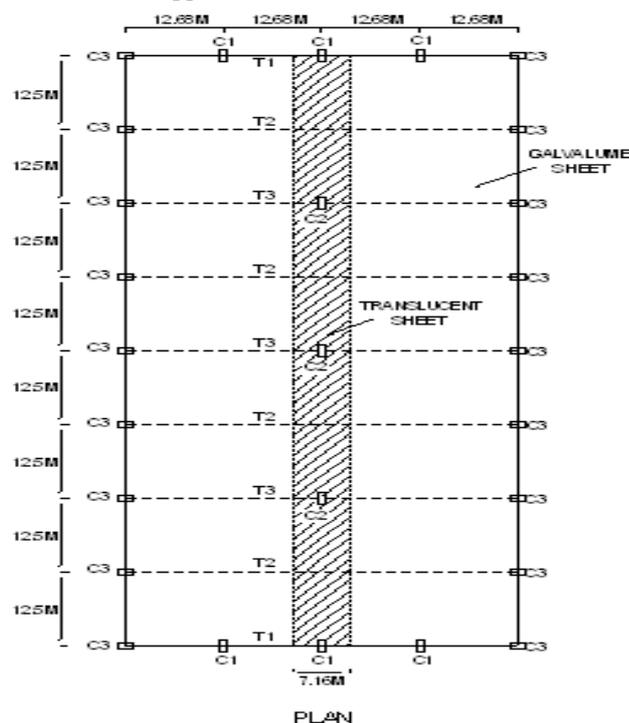
4. TUBULAR SECTIONS

Tubular sections are the most efficient sections. The tubular sections have lot of advantages compared to the other sections. The advantages are:

1. The load carrying capacity increases because of increase in moment of inertia.
2. Circular section may have as much as 30 to 40% less surface area than that of an equivalent rolled shape and thus reduces the cost of maintenance, cost of painting.
3. There is no better section than the tabular one for torsional resistance.
4. Tubes are of special interest to architect from an aesthetics viewpoint.
5. The external surface of the tube does not permit the collection of moisture and dust thus reducing the possibility of corrosion.
6. Under dynamic loading the tube has a higher frequency of vibration than any other cross section including a solid round bar.

5. PLANNING OF EXHIBITION HALL

In this project a long-span exhibition hall of steel structure of size 50.72m x 100m is designed by using Staad-Pro. After the manual calculation of forces i.e. dead load, live load and wind load, the structure has been analyzed and designed in Staad-Pro. The plan area of the hall is 50.72m x 100m. The arch shape truss is used with top chord, bottom chord and web members which are rested on the built-up column sections. The trusses are spaced at 12.5m c/c. The trusses at gable end i.e. truss T1 is supported on 5 columns, 2 external and 3 intermediate columns, whereas truss T2 is supported on 2 external columns and truss T3 is supported on 2 external and 1 intermediate column. The height of all exterior columns is 5.43m and the height of all intermediate columns is 6m. Truss T2 and T3 are alternately placed as shown in the plan. The triangular shape beam is placed perpendicular to the truss in the plane of bottom chord at centre of truss, throughout in the longitudinal direction. The bracings in the form of cross member are provided on all three faces of triangular beam. The truss T2 having no intermediate column gets supported on this beam.
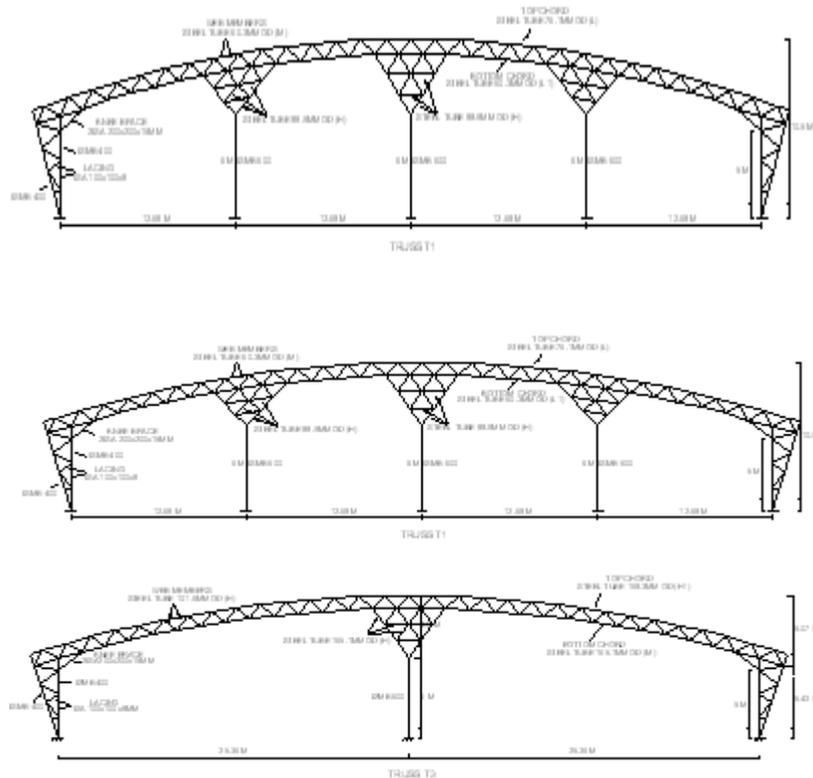
For the structure to be stable and to resist the wind load, the horizontal cross bracing is provided in first and last plane of the structure while the vertical bracings are provided on all sides of the structure. Only on the front side central two panels are kept open for entrance and exit. On top of the truss galvalume sheet is provided while in the central strip translucent sheet is provided for skylight in longitudinal direction which is supported on purlins. On all sides of the structure side sheeting are provided which is supported on side rails.

PLAN

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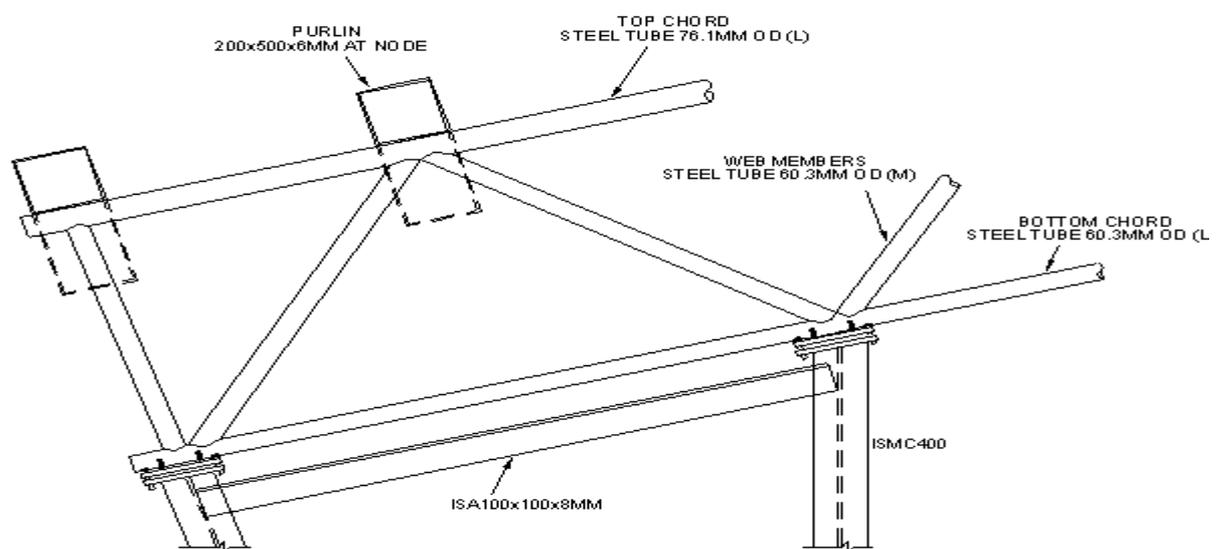Volume 4, Issue 10, October 2015   ISSN 2319 - 4847

6. STAAD-PRO RESULTS

After calculating the forces, the modal has been prepared in Staad-Pro as shown in the figure. Dead load and live load are applied on nodes in downward direction, whereas the wind load is applied in upward direction perpendicular to the member. Initially individual load is applied and afterward the combination of loads is applied on the structure.

After applying the loads the modal has been analyzed and designed. The sections applied to truss are of tubular hollow section and the I – Section is provided to the columns. The properties applied to different trusses are shown in the figure. The overall weight of the structure is coming as 4258 kN.

7. DETAILS OF CONNECTIONS

DETAILS OF CONNECTION OF TRUSS T1

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8. RESULTS

Thus the overall weight per meter square of the structure is coming as 85.58 Kg/m². The following are the total length and weight of different structural members-

STEEL TAKE-OFF

Profile	Length (mm)	Weight (Newton)
ST PIP761.0L	111112.70	6350.504
ST PIP603.0M	160988.88	6307.211
ST PIP603.0L1	110001.34	3498.403
ST PIP889.0H	145130.27	14270.511
LD ISA100X100X8	140571.09	33238.082
LD ISA200X200X15	39830.91	35371.184
ST ISMB400	208928.86	125991.055
ST ISMB600	54000.00	64795.699
ST PIP1683.0H2	222225.34	54798.691
ST PIP1270.0L	1133380.00	150623.594
ST PIP1937.0L	742219.12	168770.156
ST PIP1683.0H1	166669.02	35337.480
ST PIP1016.0H	241483.11	27269.396
ST PIP1651.0M	165001.95	30927.904
ST PIP1651.0H	120134.36	25009.672
ST TUB E	3299994.25	2092930.375
ST PIP2445.0H	1615576.25	522369.594
ST TUB E	1000000.2	204647.156
ST ISA150X150X10	620480.88	138371.594
ST TUB E	720125.19	516906.906
	TOTAL =	4257785.000

Comparison between spacing of trusses and overall weight of structure

The spacing of trusses is mostly determined by the functional requirements of column free space in the building. Where there are no functional limitations, the spacing should be such that the cost of the roof is a minimum. Larger is the spacing, smaller is the cost of trusses but larger is the cost of purlins and vice-versa. The economic range of spacing of roof trusses is 1/5 to 1/3 of span. Larger is the span, smaller is kept the ratio of spacing to the span. For lighter load, say carrying no snow or superimposed load excepting wind, the larger spacing is more economical.

Here the comparison has been made between the two structures where the trusses are spaced at 10m and 12.5m and their overall weight of structure. The weight of structure for 10m spacing of trusses is coming as 83.64 kg/m² and for 12.5m its 85.58 kg/m². The comparison is shown in graphical representation.
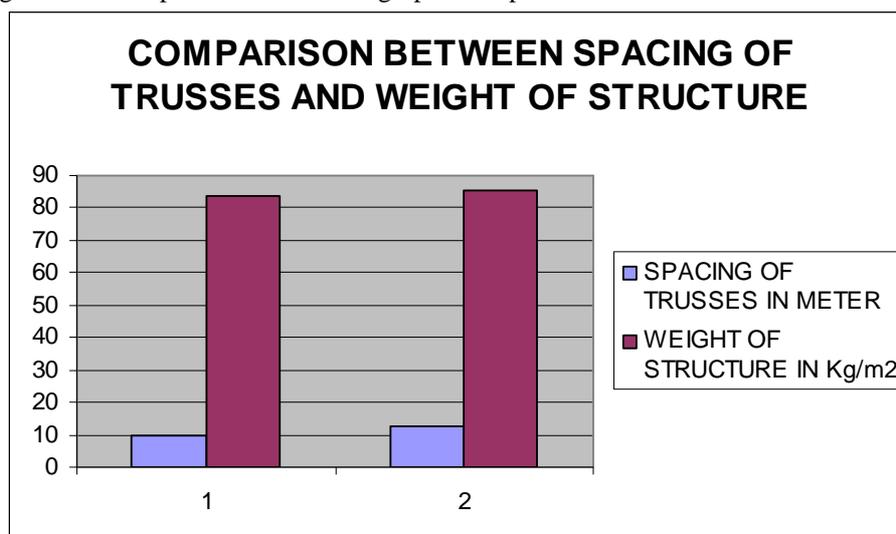
9.Conclusion

The overall weight of the structure though slightly higher than that for pre-engineered structure, the aesthetic appeal of this structure surpasses any pre-engineered building and offers clear column free spaces which is the requirement of exhibition hall displaying variety of merchandise/goods these days.

References

[1]. W.F.Chen , Handbook of Structural Engineering
[2]. Bvick Davison & Graham W. Owens , Steel Designers Manual (SCI)

[3]. A.S.Arya & J.L.Ajmani , Design of Steel Structures

[4]. L.S.Negi , Design of Steel Structures

[5]. IS: 800 – 1984 (Second Revision) – Code of practice for general construction in steel.

[6]. IS: 875 – 1987 (Parts 1 to 5) – Code of practice for design loads (other than earthquake) for buildings and structures.

[7]. S. K. Duggal , Design of Steel Structures

[8]. Teaching Resource on "Structural Steel Design" INSDAG documents.

[9]. Jeffrey Smith, "Creating Models of Truss Structures with Optimization" Carnegie Mellon University.

[10].Dr. Kourosh Kayvani, "Advances in Long Span Steel Roof Structures" Connell Mott MacDonald's Advance Analysis Group.