International Journal For Technological Research In Engineering
Volume 6, Issue 11, July-2019 ISSN (Online): 2347 - 4718

# STEEL ROOF TRUSS AND OPTIMIZATION DESIGN AND COST ESTIMATION OVER AUDITORIUM HALL

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***ABSTRACT: Usually the auditorium roof is covered with dome structure. it is tough to extended after years when further extension is needed inside the auditorium. Hence the dome structure is replaced by truss structure in this paper. The truss contains three rafters and supported by bracings. Span length is taken as 30m.A prototype model is made in STAAD. Pro and using I Section and Channel section as sections available as per IS code. Whole Truss section is checked for its self weight and loads of roof covering material over it. After design analysis, cost analysis is done manually and best section is suggested. Again optimization is done and sections are reduced and design is checked again and it is again checked for its cost and finally best section is suggested for the suggested Auditorium hall of size 30m × 68m.***
***KEYWORDS: Auditorium, Dome, Truss, Rafter, Purlins***

## I. INTRODUCTION

From ancient times large gatherings are done for any special events but due to lack of equipments in olden days such gatherings are done in open space with only sitting arrangements. Slowly this was overcome by dome structures and such buildings are constructed with dome shaped structure are called auditoriums. As it is known fact that population is increasing day by day and so gathering areas are also to be extended accordingly. Auditoriums also need much space and closed areas with safe roofs which can be modified with time. As auditoriums roofs are RCC structures hence they cannot be easily modified. Hence in this paper a truss structured is replaced by this RCC structure with which roof can be extended when ever required. A Rectangular Auditorium hall is considered with dimensions 30m × 68m × 9m. The roof is covered by truss structures with spacing's 5.35m.Purlins are also given between the trusses with spacing 2.36m.So that the covering material which will completely cover auditorium hall. For design of truss structure I Section and Channel sections available in the Indian standards are used. Analysis is performed in STAAD. Pro and best section is suggested for the design.

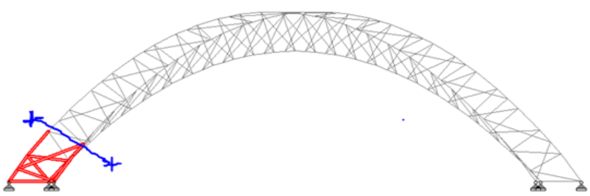


Fig1. a)Section x-x selected of truss for dimension details

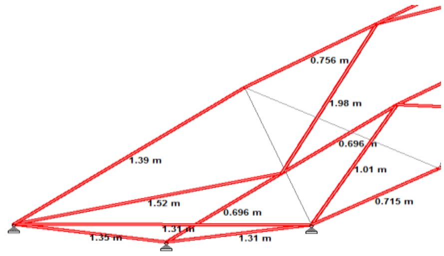



Fig2.b)Details Dimensions of Truss at section x-x

## II. METHODOLOGY

Initially the auditorium hall is planned and a prototype is made as shown in fig. In truss each rafter is connected by small spans having nodes on either sides and they are supported by the bracings in a triangular form at a distance of about 1.348m and central height of about 1.127. The Purlins are designed in the same procedure as the that of the rafters of the truss and with bracings and they are supporting the truss structure in horizontal direction so that the truss members will not sway as well as the loads of sheets from the top is equally distributed over the purlins which further transferred to the truss which further transferred to the column section. The desing is kept easy and simple. Loading on CGI sheet over all=1.6KN/m2,Live Load=500N/m2, Dead Load=300 N/m2, The height of the hall is taken as 9m hence wind loads are not considered on the truss section. Load combination (Dead Load + Live Load)= 800N/m2

Truss configurations

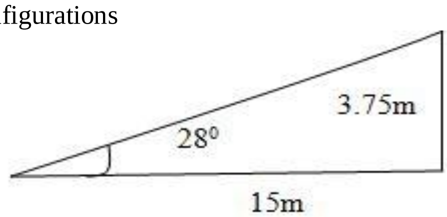



Fig No.2 Truss configurations

Let θ be the inclination of the roof with the horizontal and central height of the rafter be 3.75m.Then,By using formula, Central height we get from formula, Span/ height = 8. Hence, 30/8 = 3.75m Again, Angle = Arch/Radius Sin θ = 15/3.75 or θ = 28°4'

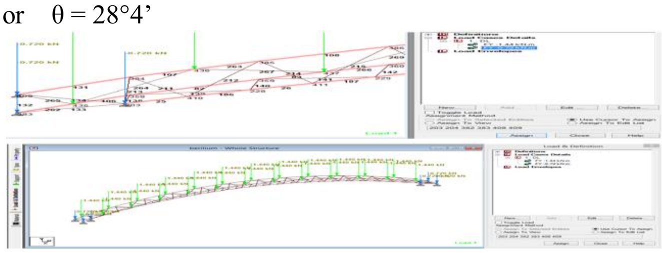


Fig.No.3. Nodal Loads on Truss form Purlins

Initially two methods are considered for analysis of truss for design check and cost Analysis.

Hit and trial method: - In this method again two sections are used randomly for analysis. In this method the complete truss is assigned first with channel section and analyzed. Now in second case complete structure is assigned with I sections randomly available in Indian standard and analyzed for design and cost analysis.

Case-I: - Truss sections bracings and purlins are of channel section
In this case the whole structure of truss is designed using channel section are designed and they are selected as below:-

Table no.1 Details of channel sections combination selected for analysis

| S. No | Location of section | Section details for channel section | Section details for I-section |
|---|---|---|---|
| 1 | Used in Bracings | ISLC400 | I160016C55040 |
| | Used in Rafters | ISLC125 | I80016B50012 |
| 2 | Used in Bracings | ISJC175 | I160016C55040 |
| | Used in Rafters | ISJC100 | I80016B50012 |
| 3 | Used in Bracings | ISMC100 | I160016C55040 |
| | Used in Rafters | ISMC75 | I80016B50012 |

Note: - For simplification and after trials the maximum section available in STAAD. Pro software Sections are selected for I-Section.

Optimization method: After hit and trial method it is seen that sections assigned are to the mark or it can be said that some places the sections are larger than required and some placed small sections are assigned. Hence to overcome such problems and exact sections to be placed at perfect place optimization technique is used. First channel section is optimized and analyzed for its design and cost analysis. Similarly it is done for I section.
Following table gives optimization done in truss no.1 similarly optimization is done for whole structure.

Table no. 2 Optimization of Channel sections by STAAD PRO. for truss no. 1

| Beams | Analysis Property | Design Property | Actual Ratio | Allowable Ratio | Normalized ratio Actual/allowable |
|---|---|---|---|---|---|
| 25 | ISLC400 | ISJC175 | 0.25 | 1 | 0.25 |
| 26 | ISLC400 | ISJC175 | 0.189 | 1 | 0.189 |
| 27 | ISLC400 | ISJC175 | 0.183 | 1 | 0.183 |
| 28 | ISLC400 | ISJC175 | 0.155 | 1 | 0.155 |
| 29 | ISLC400 | ISLC75 | 0.835 | 1 | 0.835 |
| 30 | ISLC400 | ISLC100 | 0.812 | 1 | 0.812 |

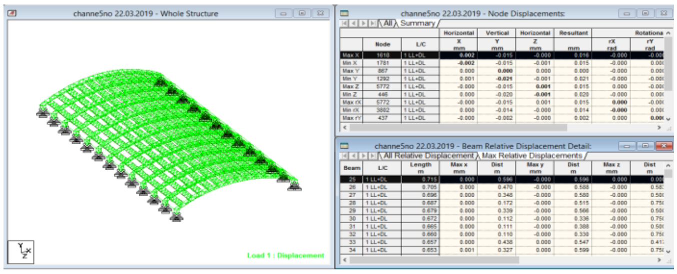


Fig.no 4 Nodal Displacement and beam relative displacement details resulted from STAAD. Pro Analysis for Channel section

Table 3 Optimization of I- sections by STAAD Pro. For truss no. 1

| Beams | Analysis Property | Design Property | Actual Ratio | Allowable Ratio | Normalized ratio Actual/allowable |
|---|---|---|---|---|---|
| 25 | I160016C55040 | I80016B50012 | 0.017 | 1 | 0.017 |
| 26 | I160016C55040 | I80016B50012 | 0.015 | 1 | 0.015 |
| 27 | I160016C55040 | I80016B50012 | 0.031 | 1 | 0.031 |
| 28 | I160016C55040 | I80016B50012 | 0.043 | 1 | 0.043 |
| 29 | I160016C55040 | I80016B50012 | 0.029 | 1 | 0.029 |
| 30 | I160016C55040 | I80016B50012 | 0.063 | 1 | 0.063 |

Design of Columns, connections and foundation
For the above truss discussed above an inclined RCC beam are desinged on both the ends of the truss so that all the trusses rest on it.After which the RCC beam is directly rested on the RCC columns.The details are shown in the figure below. The association between the main rafters and RCC beam section on the base support is considered as hinged support. The loads are transferred from the roof sheets to truss than to inclined RCC beam than directly to the RCC columns below. Foundation is considered is similar to general design as for other building structures.

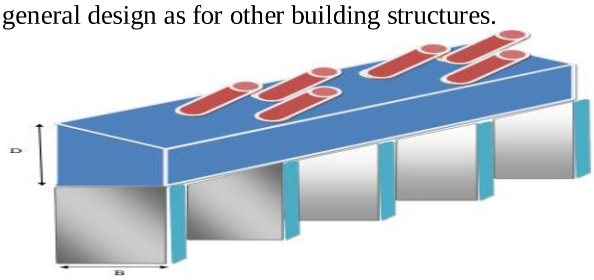
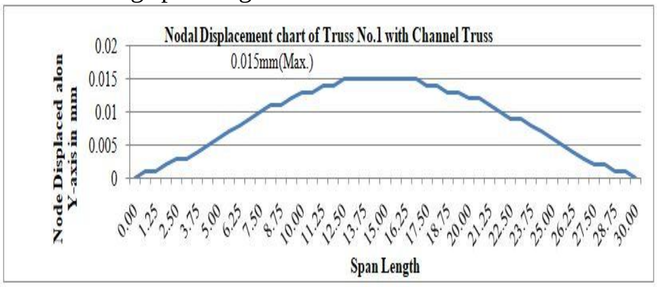


Fig No. 5. Inclined RCC beam for supporting three rafter ends

Graphical comparison of nodal displacements of truss section no.1 for all the sections

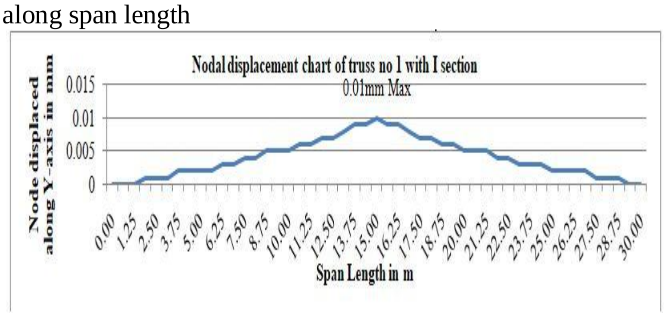
Max. Nodal disp. of Channel Section Truss at different interval along span length




Graph1 Nodal displacement along Y-axis in channel section for truss no.1

The above graph shows the nodal y-axis displacement of the truss no.1 at every 0.67m length along the span the truss members is assigned with channel section. In the above graph X-axis is showing the distance in meter of span length which is starting from zero meter and ends at 30m and Y-axis is showing nodal displacements in mm. The maximum value of the displacement is seen at 0.015mm at 15m of the span that is in the center of the truss.

Max. Nodal displacement of I- Truss at different interval along span length



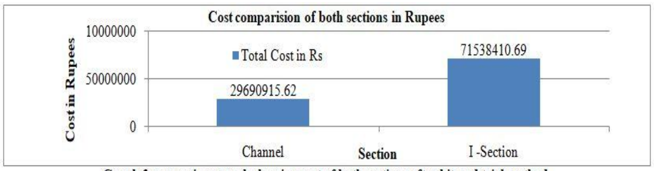

Graph2 Nodal displacement along Y-axis in I section for truss no.1

The above graph shows the nodal y-axis displacement of the truss no. 1 at every 0.67m length along the span .When the truss members are assigned with I- section. In the above graph X-axis is showing the distance in meter of span length which is starting from zero meter and ends at 30m and Y-axis is showing nodal displacements in mm. The maximum value of the displacement is seen at 0.01mm at 15m of the span that is in the center of the truss.

Cost estimation of auditorium roof with selected sections

Table no.4 Estimation of total quantity of steel for both sections

| S. no | Section | Total wt. in Kg | Cost of sections per Kg(as per market rates) | Total Cost in Rs |
|---|---|---|---|---|
| 1 | Channel | 618560.742 | Rs 48.00 | 2,96,90,915.62 |
| 2 | I - Section | 1402713.935 | Rs 51.00 | 7,15,38,410.69 |

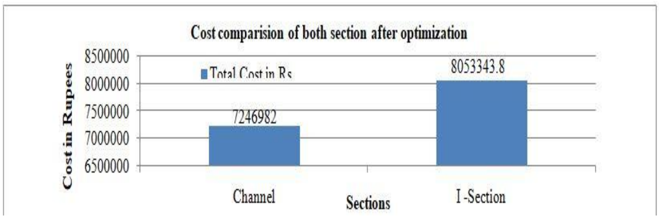



Graph 3 comparison graph showing cost of both sections after hit and trial method

Cost Comparison of sections after optimization

Table no.5 Total cost of steel for complete roof with optimized sections

| S. no | Section | Total Cost in Rs |
|---|---|---|
| 1 | Channel | 72,46,982 |
| 2 | I -Section | 80,53,343.8 |




Graph 4 comparison graph showing cost of both sections in case of optimization method

In the above graph a comparative graph is plotted between two sections used for the truss model after optimization and it is seen that I section is very uneconomical

After optimization it is found that channel section is more economical section for design than I sections Hence more economical section is channel section which is also stable and can resist the load on it.

## III. RESULT

The Arch truss is worked out for two different configurations for minimum dead load of material used with minimum cost of steel for considered area. Hence following conclusion are made.

After analysis of all two sections that is channel section, I section in STAAD. Pro the truss sections are analyzed considering the loads and the quantity; cost is evaluated with which it is found that channel section is more economical with safe bearing.

Secondly optimization technique is used in STAAD. Pro again and adequacy checked.. Hence we can conclude that after comparison of tables in result Channel section is best section for the required area 30m×68m×10m to make Arch roof truss

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