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Truss bridge structure analysis by using Finite Element Method

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Abstract— The Purpose of this investigation is focused on alerting structural engineers to the possible distortions, associated to the steel and composite bridge service life, when subjected to vehicles dynamic actions. In this study, effort has been made to analyse two types of bridge structure i.e. Pratt truss & lattice truss with two different sections ('I' Section & 'C' Sections) by applying various loads at the nodes of the frame of two trusses. This work focuses on the analysis of truss bridge structure which is most widely used in steel bridge as railway and pedestrian crossings. The basic emphasis has been given to check the total deformation and direct stresses between two types of bridge structure with 'I' Section and 'C' section. Eight node solid element is selected and meshing is done individually for each modal. The material property of each material is selected as per literature database in Ansys software. The modal analysis in Ansys is completed to atta.in the total deformation and mode shapes of bridge structure to stay away from the failure of the bridge. As per study, we found out that, the major variations in truss structures. Pratt truss have less deformation and stresses as comparison to lattice truss. And minor variations have found in 'c' section with less deformation and stress, in both Pratt bridge truss structure and Lattice bridge truss structure

Keywords — Steel Truss, Bridge analysis, Finite Element Method, Modal analysis, Deformation, Stresses, ANSYS14.0, Static Analysis.

I. Introduction

The bridges are the structures, which provide means of communication over a gap and they provide passage for the highway and railway traffic over these gaps. There are several classifications of bridges based on different considerations. Some of the major classifications are based on: material used, makeup of main load carrying elements, the structural layout of the principal load carrying members, floor location, type of connections, the level of crossing of highway and railway track and the nature of connections, the level of crossing of highway and railway track and the nature of movement of the bridge. The present analytical study is limited to only steel truss bridges, in particular truss portion. A bridge is a structure that crosses over a gorge, street, river, railway, or other obstructions, permitting smooth and secure passage of cars, trains and pedestrians. A pedestrian railway bridge is a connection planned for pedestrians and in a few instances' cyclists, animal site visitors and horse riders, instead of vehicular passage. Pedestrian bridges set off the scenery and may be used decoratively to visually hyperlink wonderful areas or to indication a transaction. In many evolved nations, pedestrian bridges are each functional and can be stunning works of art and sculpture. For poor rural groups within the growing global, a footbridge can be a community's most effective get entry to medical clinics, faculties, and markets, which might if not be inaccessible while canals are too elevated to move. Plain suspension bridge modelling had been superior to be sustainable and naturally constructible in such rural areas the use of most efficient nearby material and hard work. Truss systems are composed of individuals that are connected to shape an inflexible body of metallic. This extensive application can be used in many areas, along with pedestrian crossing bridge, Rail Street and other transportation bridges. The person individuals of a truss bridge are the burden wearing components of the structure, they are arranged in a triangular way ensuing in the hundreds carried to grow to be both in tension or compression. Today bridge is used for many purposes, due to the fact that they're easy to collect and low in cost

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II. Steel Truss

Steel is broadly used around the world for the development of bridges of various sizes. It is a flexible and powerful material that offers green and sustainable answers. Steel has long been known as the financial option for a variety of bridges. It dominates the markets for long-span bridge structure, railway bridges, footbridges, and medium span dual carriageway bridges. It is now increasingly more the selection for shorter span dual carriageway systems as properly. Society receives in many ways from the profits brought with the aid of metal bridge answers.

Landmark metal bridges embody right design, they're rapid to construct and have inspired the regeneration of many former commercial, dock and canal facet regions. The connected elements (usually directly) can be pressured from tension, compression, or now and again each in response to dynamic loads. These trusses can be made from wooden, steel or can be composite shape. In this thesis, metal trusses used for constructing bridges are considered. Steel has higher strength, ductility and durability than many different structural materials inclusive of concrete or wooden.

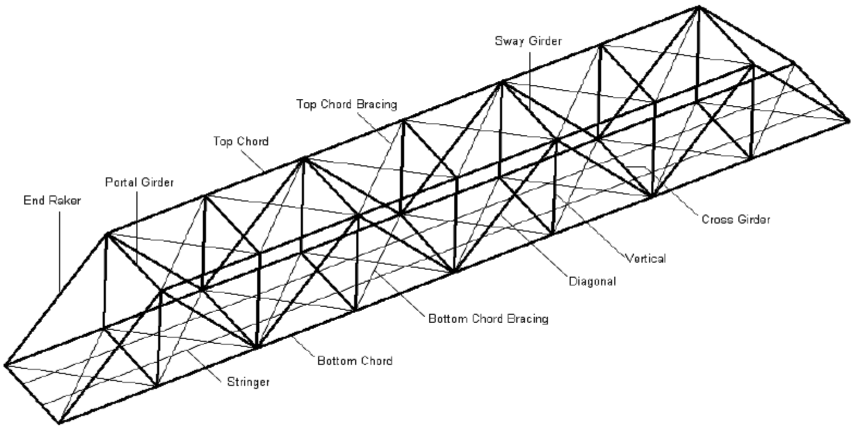


Figure 1: Skeleton of a typical steel truss bridge (Lattice truss)

III. FINITE ELEMENT ANALYSIS

The finite element method is a useful asset to obtain the numerical arrangement of extensive variety of building problem. The technique is general enough to deal with any complex shape or geometry, for any material under various limit and stacking conditions. The all-inclusive statement of the limited component strategy fits the examination prerequisite of the present complex building frameworks and structures where closed shape arrangements of administering balance conditions are normally not accessible. What's more, it is an effective plan apparatus by which fashioners can perform parametric structure thinks about by considering different structure cases, (diverse shapes, materials, loads, and so on.) and studied them to pick the ideal structure.

The technique originated in the aerospace industry as a method to study about stress in an intricate airframe structure. It becomes out of what was known as the matrix examination strategy utilized in aircraft machine structure. The technique has increased expanded prominence among the two specialists and professionals. The essential idea of limited component strategy is that a body or structure might be isolated into little components of limited measurements called "finite components". The first body or the structure is then considered, as a gathering of these components associated at a limited number of joints called hubs or nodal focuses.

IV. MODELLING OF BRIDGE STRUCTURE

Modeling of the designs of bridge truss structure using ANSYS Workbench has been explained in detail. The intention of finite element investigation is to reconstruct the mathematical behaviour of an actual engineering structure. The model comprises all the nodes, elements, material properties, real constants, boundary conditions and additional features that are used to characterize the physical system. First model be generated then specific boundary conditions will be applied on the specific nodes then final analysis will be conducted.

- **Geometry of sections**

Two types of bridge structure Pratt bridge truss structure and lattice bridge truss structure are designed here, and sections used for bridge i.e. 'I' section and 'C' section used to designed bridge. Firstly, bridge designed by using 'I' section beam and then second bridge designed by using 'C' section of beam. Geometry of 'I' section and 'C' section are described below. Structural steel used as material for designing of bridge structure.

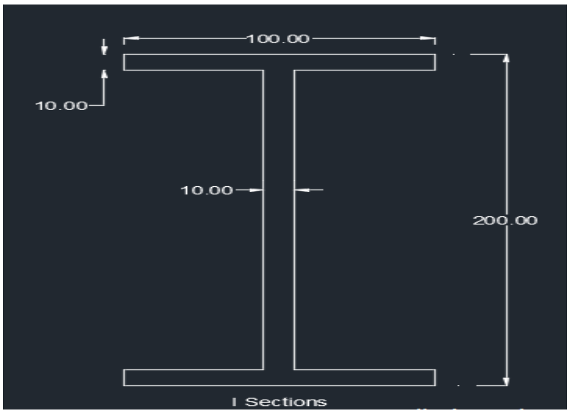


Figure 2: Dimension of 'I' Section

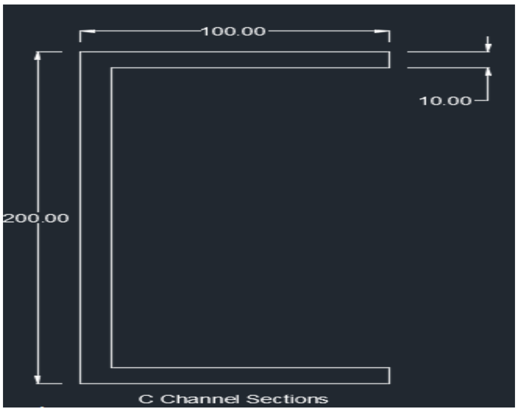


Figure 3: Dimension of 'C' section

'I' section beam analyse in two different designs, Truss Pratt and Lattice type. 'C' Section Bridge analysed in two different designs, Truss Pratt and Lattice type also

- **Dimensions of bridge truss:** dimensions of bridge structure are described below.

Table 1: Dimensions of bridge truss structure

Bridge Type	Length (mm)	Height (mm)	Bridge (mm)
Type 'A'	10000	1250	3200
Type 'B'	10000	1250	3200

'I' Section Bridge :- Bridge truss designed using 'I' section of two types, Truss Pratt Type and Truss Lattice Type. Figure shows the design of 'I' Section Bridge

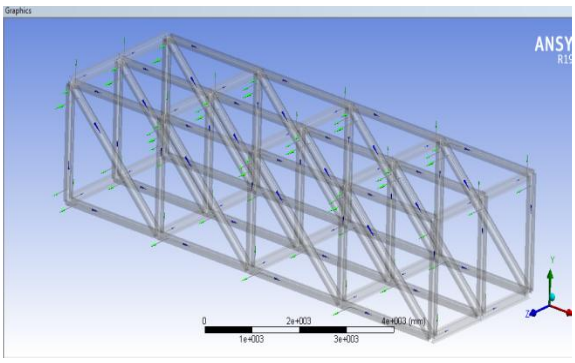


Figure 4 : 'I' Section Bridge of Pratt Type

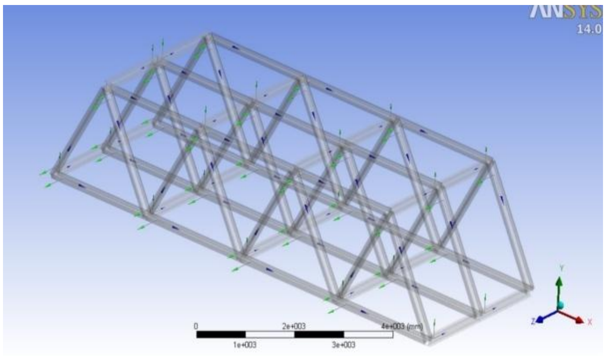


Figure 5 : 'I' Section Bridge of Lattice Type

'C' Section Bridge:- Bridge truss designed using 'C' section of two types, Truss Pratt Type and Truss Lattice Type. Figure 6, 7 shows the design of 'C' Section.

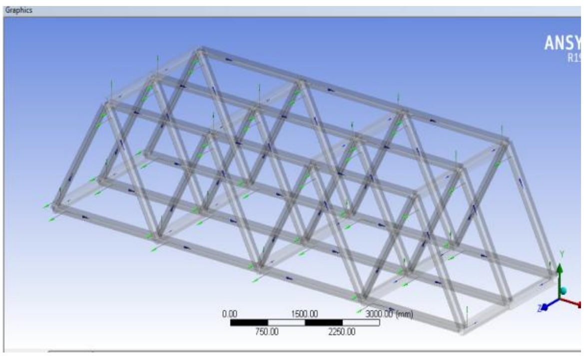


Figure 6 : 'C' Section Bridge of Pratt Type

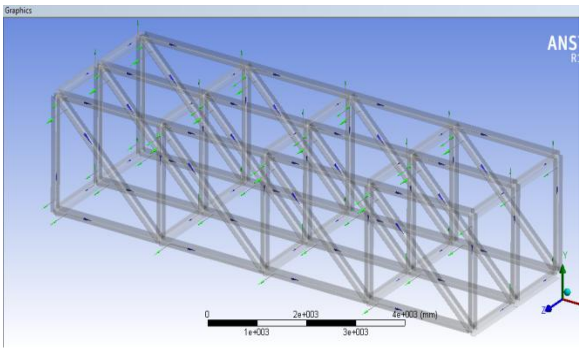


Figure 7 : 'C' Section Bridge of Lattice Type

- **Applying Boundary Conditions**

Applying boundary conditions on bridge, one end of bridge kept fixed support and, on another end, applying 100 KN, 200 KN, 300 KN, 400 KN, 500 KN load. In Type 'Pratt'' and Type 'Lattice'' bridge structure. Figures shows the applying boundary conditions on the bridge structure Type 'Pratt' and Type 'Lattice'.

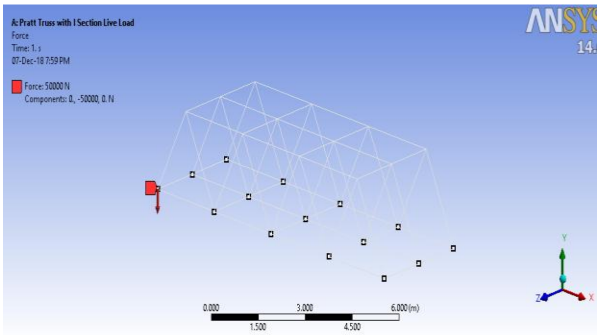


Figure 8: Boundary conditions on Bridge truss Structure.

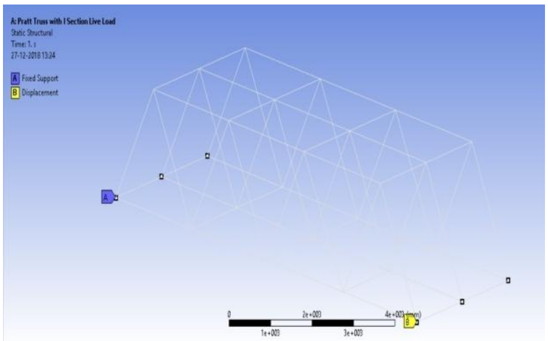


Figure 9: Displacement on Bridge Truss structure.

V. TEST RESULTS AND DISCUSSIONS

The deflection occurred in bridge structure model is optimized and compared. Two types of section used in bridge element designing i.e. 'I' section and 'C' section. In 'I' section two type of bridge structure used for study i.e. Type 'Pratt' and Type 'Lattice' also in 'C' section two type of bridge structure used for investigation i.e. type 'Pratt'' and Type 'Lattice'. Figures shows the deflection.

- ***Deflections of bridge structure due to load***

Deflections of bridge structure at variable load from 100 to 500 KN

- **Pratt Truss Deflections of 'I' Section**

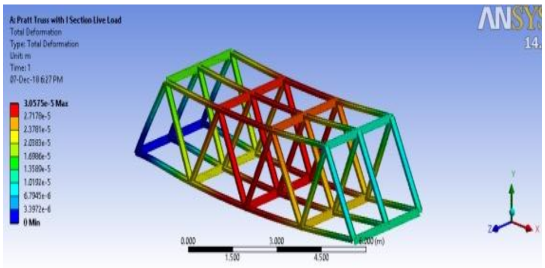


Figure 10: 'I' Section Pratt Bridge deformation at 100 KN

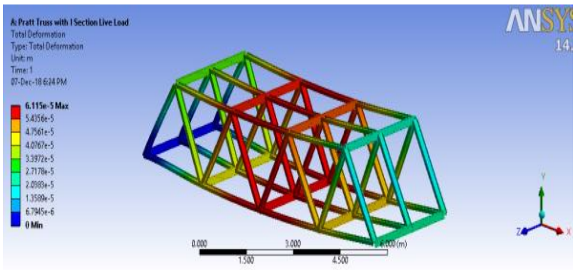


Figure 11: 'I' Section Pratt Bridge deformation at 200 KN

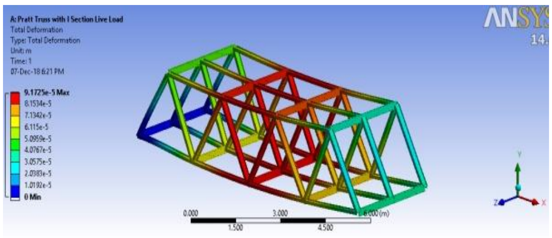


Figure 12: 'I' Section Pratt Bridge deformation at 300 KN

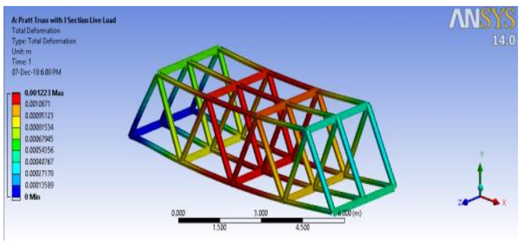


Figure 13: 'I' Section Pratt Bridge deformation at 400 KN

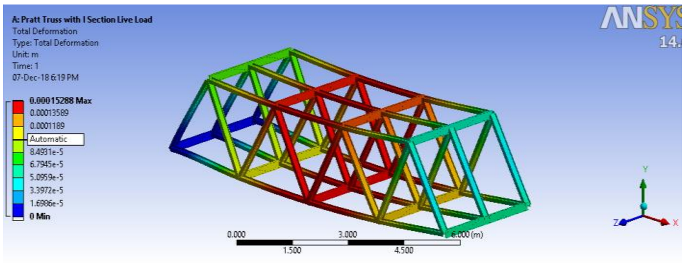
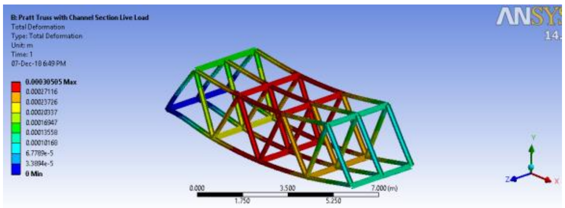


Figure 14: ‘I’ Section Pratt Bridge Truss deformation at 500 KN load

- **Pratt Truss Deflections of ‘C’ Section**



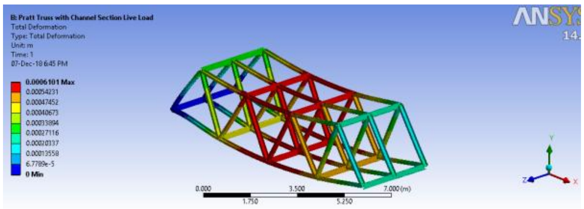
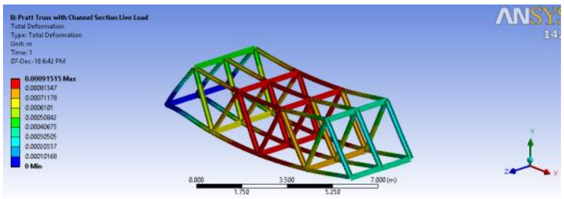


Figure 15: ‘C’ Section Pratt Bridge deformation at 100 KN Figure 16: ‘C’ Section Pratt Bridge deformation at 200 KN



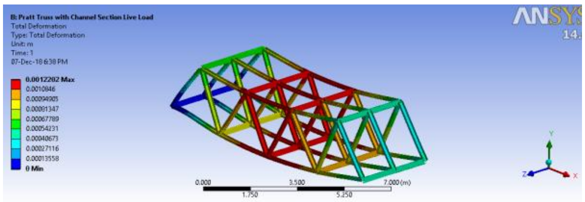


Figure 17: ‘C’ Section Pratt Bridge deformation at 300 KN Figure 18: ‘C’ Section Pratt Bridge deformation at 400 KN

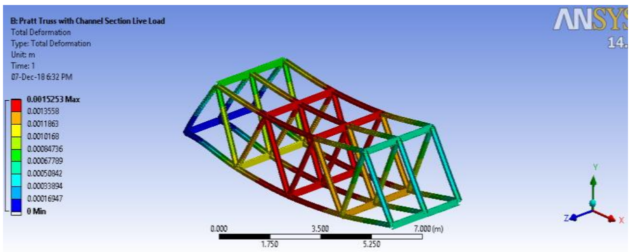
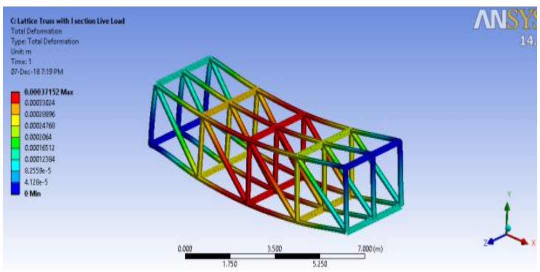


Figure 19: ‘C’ Section Pratt Bridge Truss deformation at 500 KN load

- **Lattice Truss Deflections of ‘I’ Section**



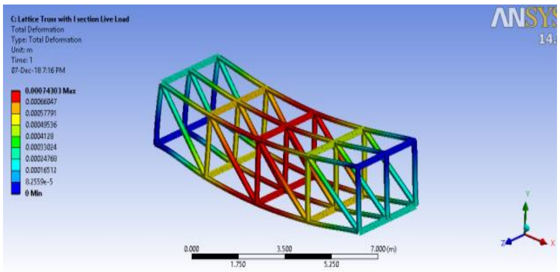


Figure 20: ‘I’ Section Lattice Bridge Deformation at 100 KN Figure 21: ‘I’ Section Lattice Bridge Deformation at 200 KN

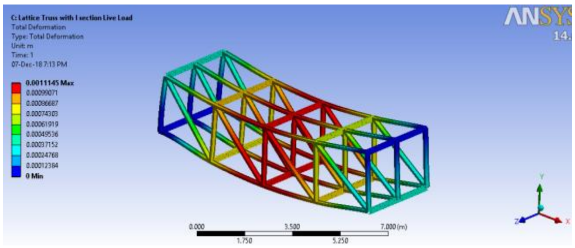


Figure 22: 'I' Section Lattice Truss Deformation at 300 KN load

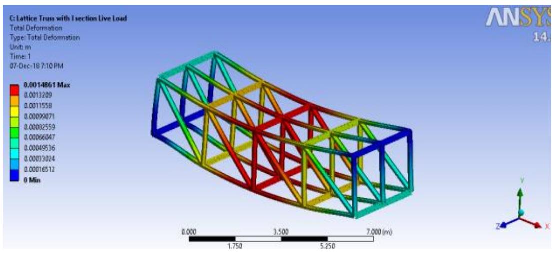


Figure 23: 'I' Section Lattice Truss Deformation at 400 KN load

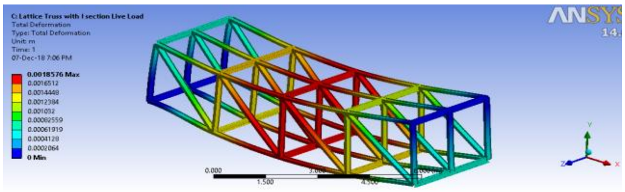


Figure 24: 'I' Section Lattice Bridge Truss Deformation at 500 KN load

- **Lattice Truss Deflections of 'C' Section**

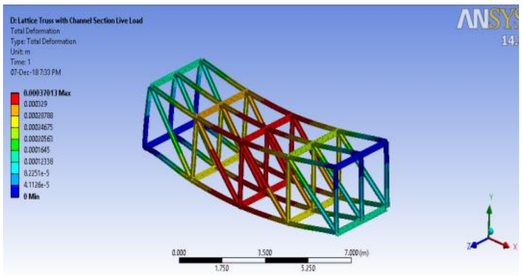


Figure 25: Truss Deformation at 100 KN load

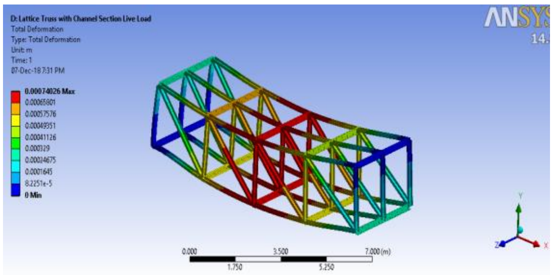


Figure 26: Truss Deformation at 200 KN load

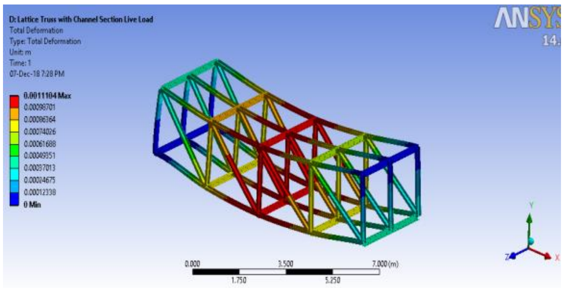


Figure 27: Truss Deformation at 300 KN load

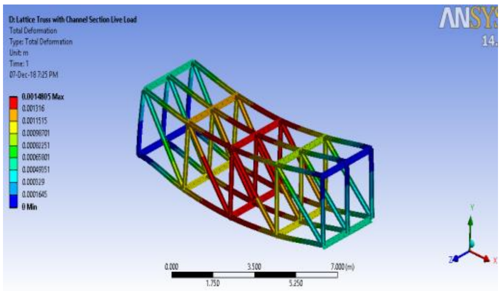


Figure 28: Truss Deformation at 400 KN load

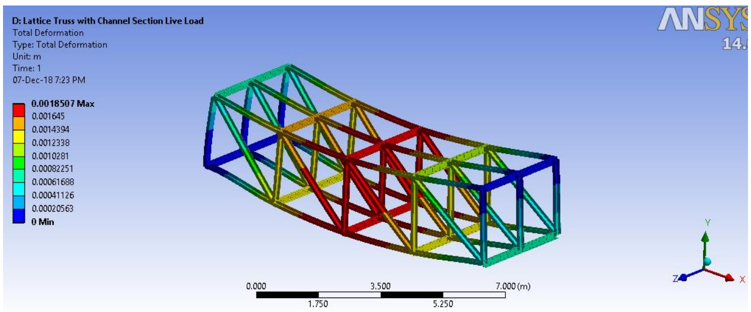


Figure 29: 'C' Section Lattice Bridge Truss Deformation at 500 KN load

Table 2, 3 shows the values of deformation developed in bridge truss structure due to load, and Table 5.3, 5.4 shows direct stresses generate in bridge structure.

Table 2: 'I' Section Bridge truss Structure deformation variations due to load

Load (N)	Pratt 'I' Section Deformation (mm)	Lattice 'I' Section Deformation (mm)
100000	0.306	0.37152
200000	0.612	0.74303
300000	0.917	1.1145
400000	1.223	1.4861
500000	1.529	1.8576

Table 3: 'C' Section Bridge truss Structure deformation variations due to load

Load (N)	Pratt C Section Deformation (mm)	Lattice C Section Deformation (mm)
100000	0.305	0.37013
200000	0.61	0.74026
300000	0.915	1.1104
400000	1.22	1.4805
500000	1.525	1.8507

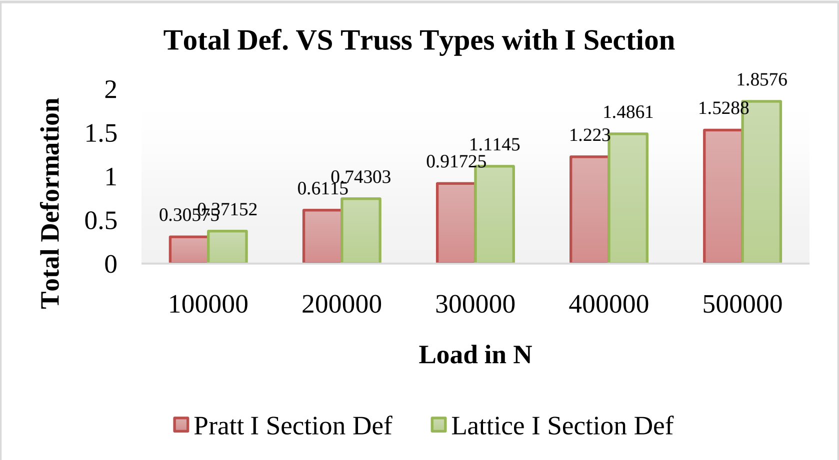


Figure 30: Comparison Deformations of Pratt and Lattice Type Bridge truss structure

Table 4: 'I' Section Bridge truss Structure Stress variations due to load

Load (N)	Pratt 'I' Section stress (N/mm^2)	Lattice 'I' Section stress (N/mm^2)
100000	3.4635	3.9777
200000	6.927	7.9555
300000	10.39	11.933
400000	13.854	15.911
500000	17.317	19.889

Table 5: 'C' Section Bridge truss Structure stress variations due to load

Load (N)	Pratt C Section stress (N/mm^2)	Lattice C Section Stress (N/mm^2)
100000	3.4549	3.9671
200000	6.9099	7.9341
300000	10.365	11.901
400000	13.819	15.868
500000	17.274	19.835

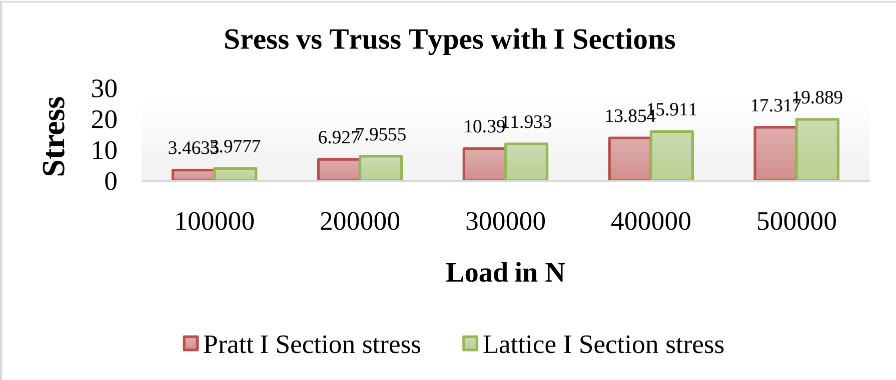


Figure 31: Comparison Stresses of Pratt and Lattice Type Bridge truss structure

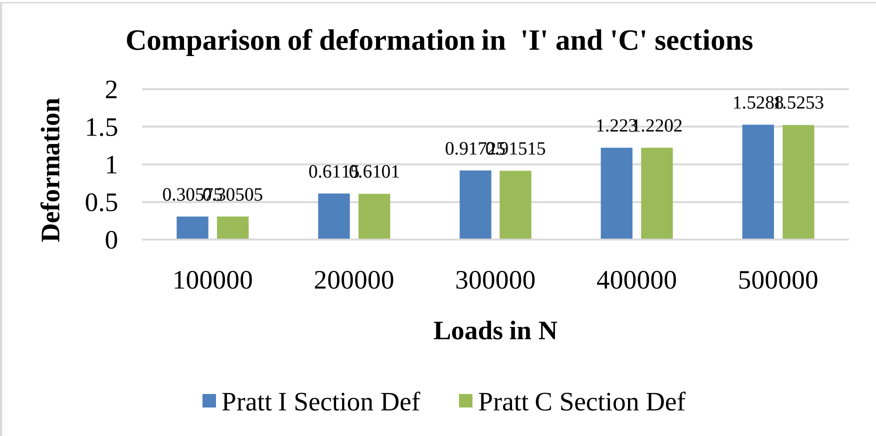


Figure 32: Comparison of Pratt truss Deformations in 'I' and 'C' Sections

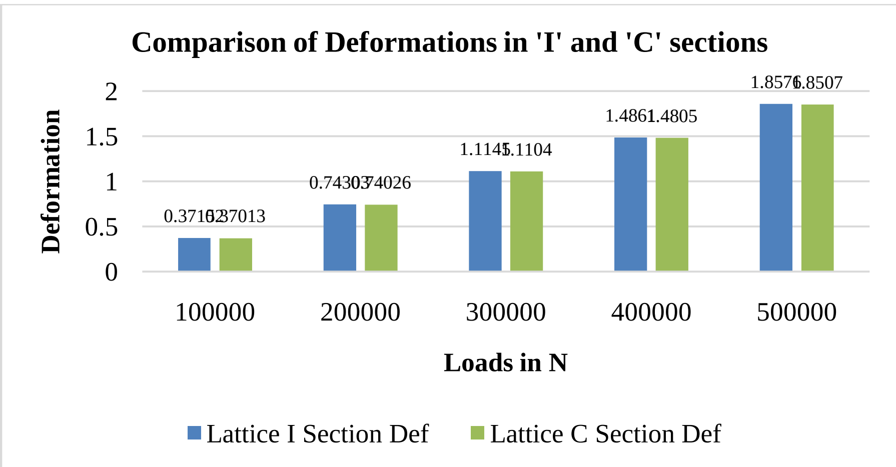


Figure 33: Comparison of Lattice truss Deformations in 'I' and 'C' Sections

As per above study it is shows that Pratt bridge truss structure having lower deflection due to applied load.

From this we can conclude the ANSYS analysis for this truss is very insightful. The study has addressed the possibility of analysis and design of steel bridges with locally available steel profiles. Based on the analysis and design made so far, the study has proved that, construction of steel bridge with locally available steel profiles is an option worth, even though the cost of local production is closer to importing it is still a good option since it helps in the capacity building of local design, fabrication and construction firms, creates job opportunities for many people.

In Pratt truss structure deformation results nearly similar in 'I' section and 'C' section. Same in lattice Truss structure but maximum Variations found in between Pratt truss structure and lattice truss structure. Maximum stresses found in Lattice truss structure in comparison of Pratt structure.

V. CONCLUSIONS

The ANSYS analysis for this steel truss is done based on the standard loading system, and the results are within the limited preconditions sated by the standard value. From this study we can conclude the ANSYS analysis for this truss is very insightful. The study has addressed the possibility of analysis and design of Truss bridges structure with locally available steel profiles. Even though the cost of local production is closer to importing it is still a good option since it helps in the capacity building of local design, fabrication and construction firms, creates job opportunities for many people and is a saving in foreign currency. The following conclusions can be stated based on the evaluation of the analyses.

- When we compare Pratt truss structure with I and C section at maximum applied load (500 KN), Pratt truss with 'I' section deformation and stresses are 1.529mm and 17.317 N/mm2.
- As per Analysis in Pratt truss with 'C' section deformation and stresses are 1.525 mm and 17.274 N/mm2. After analyzing both section results, we find out, Pratt truss structure with 'C' section having minimum deformation and stresses as per study, Pratt truss with 'C' Section is good for designing purpose.
- When we compare the results of Lattice truss structure with 'I' and 'C' section at maximum. Applied load at 500KN, Lattice truss with 'I' section deformation and stresses are 1.8576 mm, and 19.889 N/mm2, after that as per analysis for both section results, the difference between both sections found at the third digit after decimal, as a civil engineer or professionally we do not neglect these types of minor variations. As per study 'C' Section have low deformation either we use Pratt bridge truss structure or lattice bridge truss structure.
- The comparison between Pratt truss with 'I' section and Lattice truss with 'I' section, found results of Pratt truss with 'I' section deformation and stresses at 500 KN load are 1.529 mm and 17.317 N/mm2. Also, for Lattice truss with 'I' section deformation and stresses at 500 KN load are 1.8576mm & 19.889 N/mm2.
- Here, Pratt truss with 'I' section having above study Pratt truss with 'I' section is good for designing Purpose. When we done comparison between Pratt with 'C' section to Lattice 'C' the results at 500 KN are Pratt truss with 'C' section deformation and stresses at 500 KN load are 1.525 mm and 17.3274 N/mm2. Also, for Lattice truss with 'C' section deformation and stresses at 500 KN load are 1.85707 mm & 19.835 N/mm2. Here, results show that Pratt with 'C' section having minimum deformation and stresses as per above study Pratt truss with 'C section is good for designing purpose.

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