iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** XII **Month of publication:** December 2018

DOI:

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

Comparative Study of TRUSS Bridges under Static Conditions

Sachin Saj T K[1], Shruthy Aravind Menon[2]
[1, 2]*Amrita Vishwa Vidyapeetham, Coimbatore, India*

Abstract: Truss Bridge, main element is truss, which is very rigid and it is been connected in the form of smaller triangular units which can transfer load from a single point to much wider area. But, Truss bridge structure is very heavy, since it is mainly constructed using iron and structural steel. which ultimately reduce the endurance of the bridge. In this paper, focuses on using much lighter material such as aluminium for the Static analysis and the results is been compared.

I. INTRODUCTION

Truss bridges were first came into existence around 1820s at that time they were made up of woods and it were used to transport carts to one place to another. When railway became popular for transportation during 1880s and 1890s, truss bridges also attained its popularity and was made with iron and other strong materials. Truss bridge, the main element is trusses and it is been connected in the form of smaller triangular units. Truss is a very rigid and it can be used to transfer load from a single point to much wider area, thus reducing the stress imposed on the structure, reducing the failure chances. One more positive point in Truss bridge is that, it is very economical to construct because truss bridges uses each and every materials efficiently. Some of the most common truss bridge include

A. Pratt
B. Howe
C. K truss
D. Bailey
E. Warren
F. Bowstring

Each and every piece of materials used is efficiently utilized for the construction of the truss bridge to its full potential and this materials plays a vital role.

This bridge is able to withstand extreme weather conditions compared to other bridges, this bridges is been used in precarious locations such as deep ravines between mountains tops, and widely used in mountain areas. Roadways can be built on this type of structure, unlike other designs of bridges.

This bridge is able to carry its roadway on structure. So, this are some advantages of Truss bridges, there are some disadvantages to this type of bridges such as it requires lots of space, high maintenance cost and the most important think, structure is heavy, thus it requires heavy foundations ,spanning in length will be difficult. Since, the structure is very heavy. In this paper we took care of this problem on truss bridges.

Thus, we are proposing a material change from Structural steel to aluminium, which is less in density compared to structural steel. Aluminium is approximately 2.5 times less denser than structural steel. Actually, In case of any bridge it is subject to dynamic loading, loading with respect to time.

But, in this paper we are analysing the behaviour of the truss bridge, when it subjected to static loading as an initial step for finding the differences that can conclude by switching the materials .Thus it will be able to lower the weight of the structure, creating more endurance.

II. METHODOLOGY

For constructing a truss bridge, Ansys software is been used. The Material used is Structural Steel and aluminium for the truss member .For slab, which is assumed to be a road is made up of concrete, so the analysis is carried out for (Aluminium + concrete) and (Structural Steel + Concrete).

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The specification for Material used in this experiment:

Aluminum	Structural Steel	Concrete
Youngs modulus :70GPa	Youngs modulus :200GPa	Youngs modulus :41GPa
Poisson ratio :0.3	Poisson ratio :0.26	Poisson ratio :0.21
Yield Strength :240MPa	Yield Strength :250MPa	Yield Strength :30MPa
Ultimate Strength:290MPa	Ultimate Strength:400MPa	Ultimate Strength:5MPa
Density : 2700 Kg/m^3	Density : 7800 Kg/m^3	Density : 2400 Kg/m^3

Table 1: Material Specification

Specification	
Length (slab)	4 m
Breadth (Slab)	2 m
Thickness(Slab)	0.1 m
Truss (Length)	0.05 m
Truss (Breadth)	0.05 m

Table 2: Model Specification

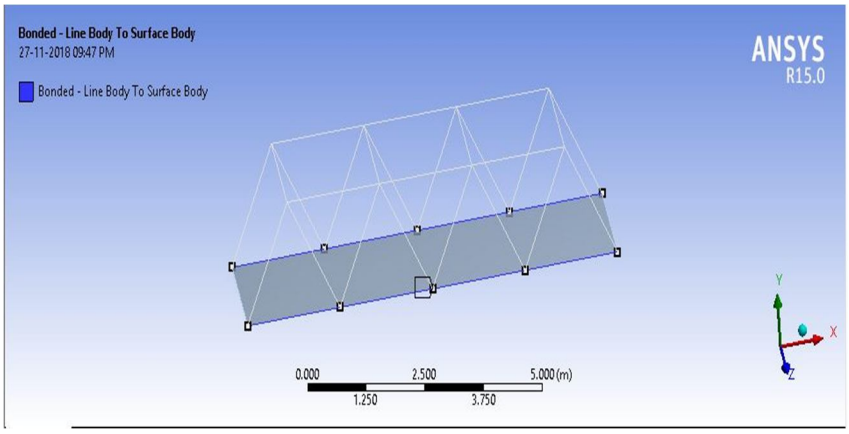


Figure 1 : Truss Bridge Model

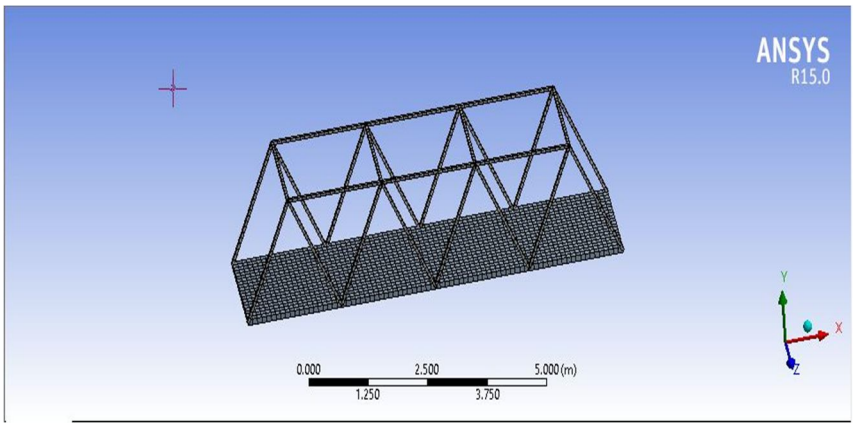


Figure 2 :Truss Bridge model Meshing

Then Static analysis is been carried out on the bridge by keeping one end fixed (Left) and other end is subjected to movement in X and Z direction, But constrained in Y direction. A uniform pressure of 0.1 MPa is subjected on the Slab for the analysis ,the slab material is same in both case/analysis, the truss material is changed from Structural steel to aluminium .

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III. RESULTS AND DISCUSSION

The analysis were carried out in Structural steel + concrete and Aluminium + concrete and lots of parameter were extracted for understanding the behaviour of the truss bridge when it is subjected to static loading. Such as Axial force (Truss), Direct stress on beam (Truss member), equivalent stress, Total bending moment, Total deformation.

A. Axial force on Beam (Truss)

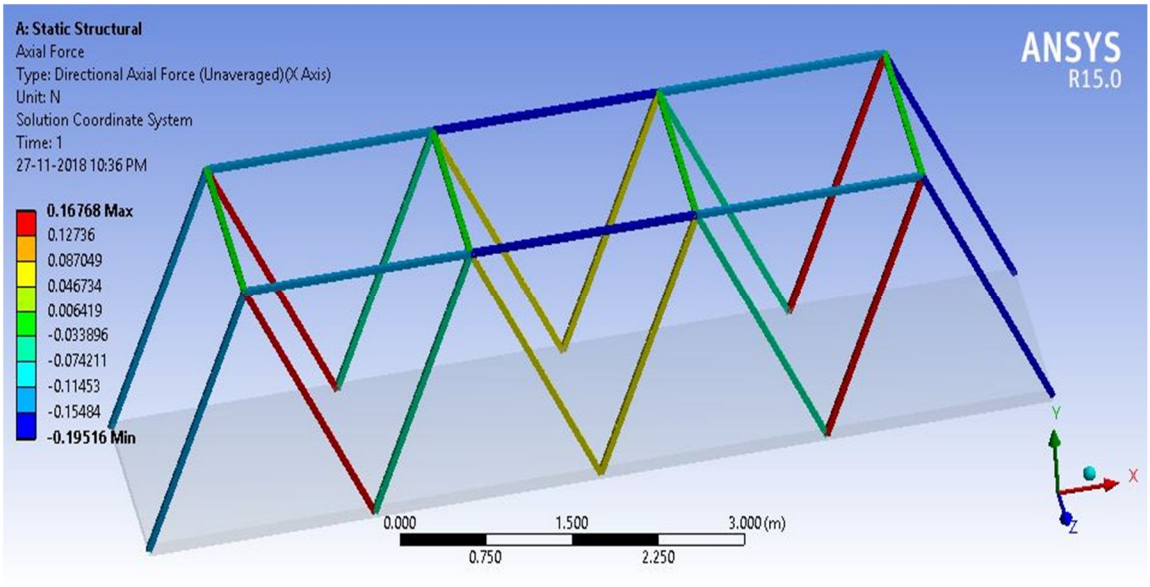


Figure 3 : Axial force (Truss) ; Material : Aluminium

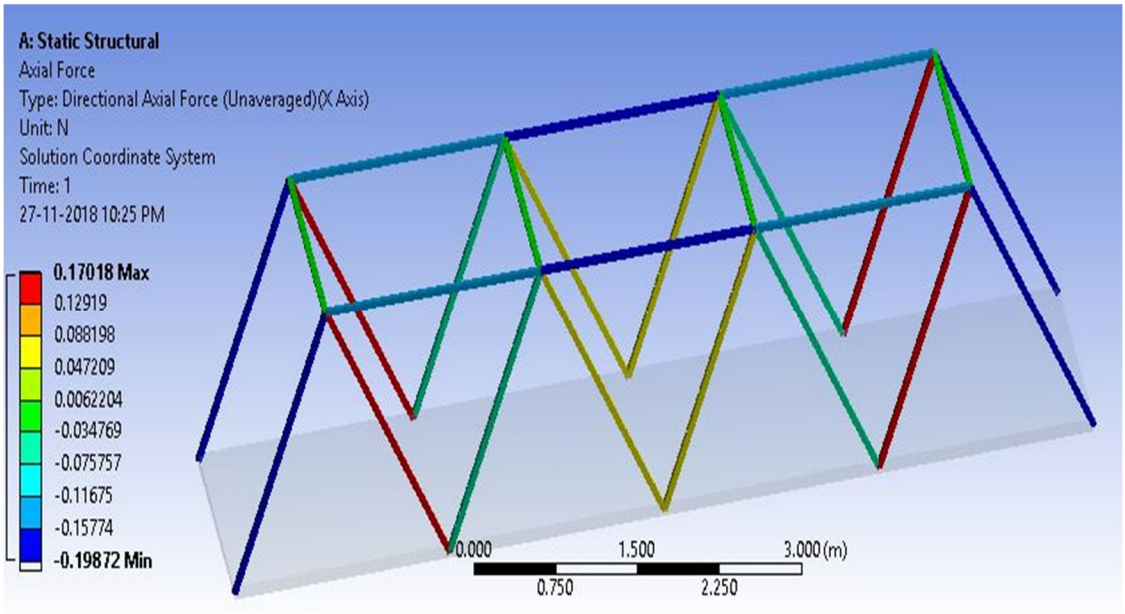


Figure 4 : Axial force (Truss) ; Material : Structural Steel

1) *Discussion:* Axial force is the tension or compression force experienced by the structure, positive sign denotes tension and negative sign denotes compression. From the figure it is clear that red and yellow coloured truss member experience tension as its value is positive and blue as well as green experiences compression, which is denoted by negative sign. From this Analysis, we can find the axial force(tension) on truss. For aluminium it is 0.16768 N , Compression is -0.19516 N and for Structural Steel tension it is 0.17018 N , compression is -0.19872 N Thus, Aluminium experience least tension and compression force compared to structural steel by 1.4 times.

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B. Direct Stress on Beam (Truss)

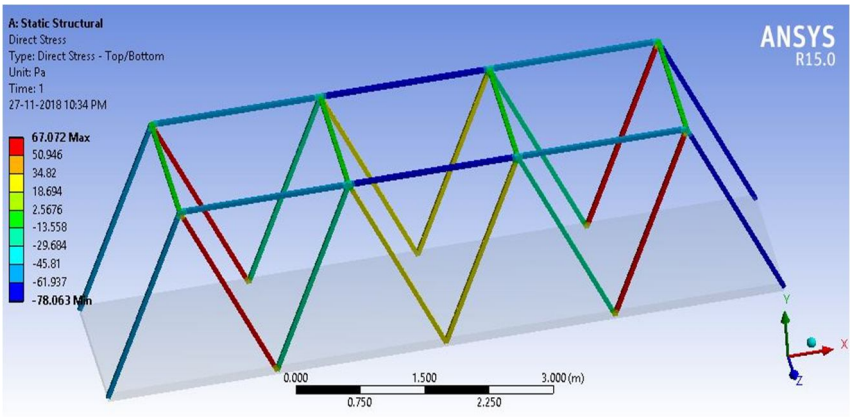


Figure 5 : Direct Stress on Beam (Truss) ; Material : Aluminium

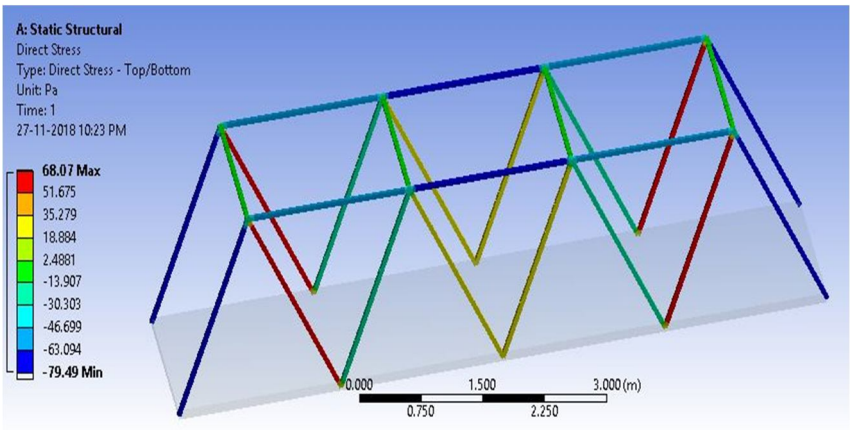


Figure 6 : Direct Stress on Beam (Truss) ; Material : Structural Steel

1) Discussion: When ever there is introduction/ subjected to axial tension or compression, direct stress comes into play. Thus from both the figures the maximum stress caused by tension in aluminium and Structural steel is 67.072 N/m^2 and 68.07 N/m^2respectively .The maximum stress caused by Compression in aluminium and structural steel is -78.063 N/m^2 and -79.49 N/m^2 respectively.
Thus the Direct stress experienced is less in aluminium compared to Structural steel, even though it is small difference by 1.4 times.

C. Equivalent Stress

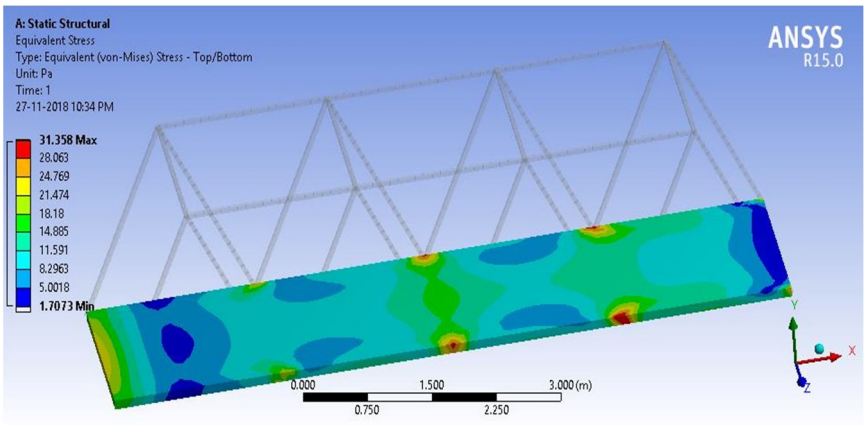


Figure 7: Equivalent Stress ; Material : Aluminium

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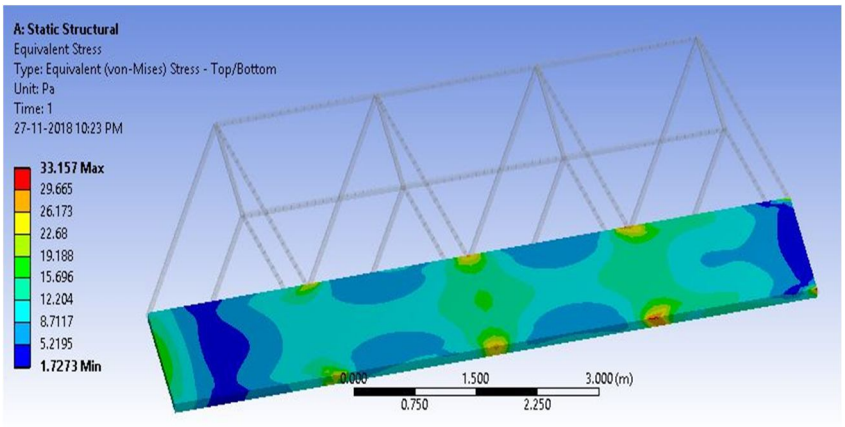


Figure 8 : Equivalent Stress ; Material : Structural Steel

1) *Discussion:* Equivalent stress is often been used for analysis because it allows any 3-dimensional arbitrary stress state to be represented as a single positive stress value. Equivalent stress can be used in predicting yielding of a material, a point where material is converted from elastic behaviours to non-elastic behaviours. From the figure, aluminium structure produced an equivalent stress of 31.358 N/m^2 and Structural steel produced 33.157 N/m^2. Aluminium was able to produce less equivalent stress, that means aluminium is more resistant compared to structural steel by 0.5 times.

D. Total Bending Moment

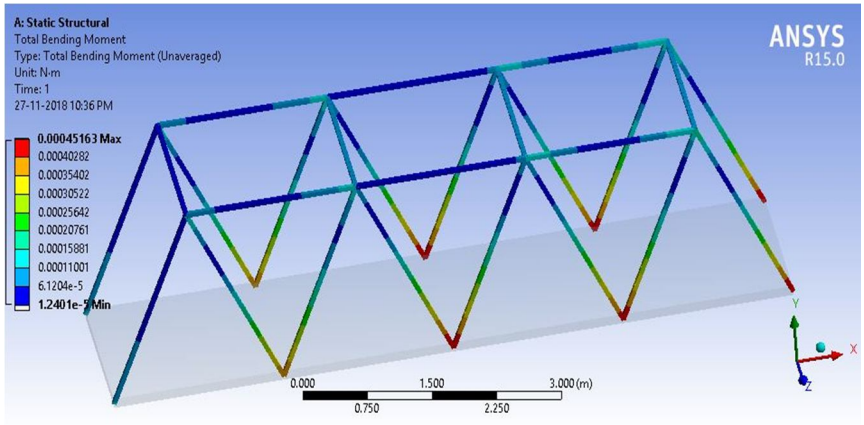


Figure 9 : Total Bending Moment ; Material : Aluminium

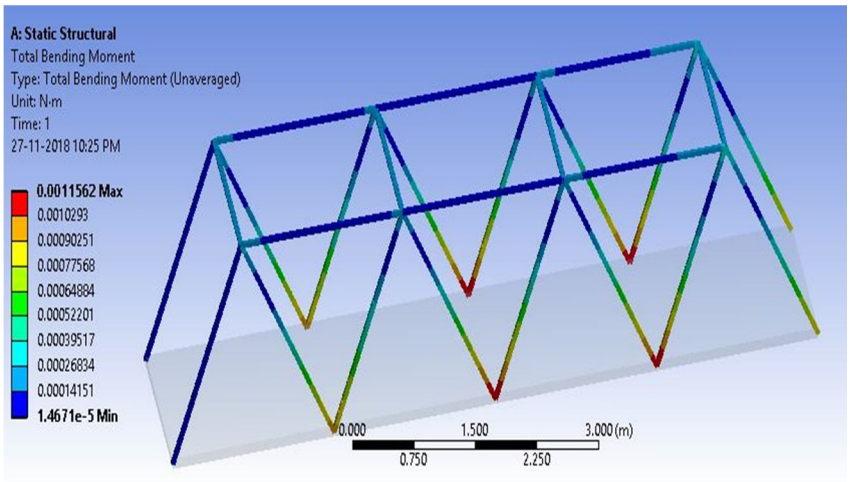


Figure 10: Total Bending Moment ; Material : Structural Steel

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1) *Discussion:* Bending moment is a type of reaction which is induced on the structure, when an external force or moment is applied, causing the structure to bend. The red colour indicates bending moment been more and blue denotes the least. The maximum bending moment experienced on aluminium structure is 0.0004516 N.m and 0.0011562 N.m experienced by structural steel. From this, it is clear that structural steel is more prone to bending moment than aluminium. It is one the most important constraints in truss bridge, as we know the truss member is in form of triangular and bending moment says lot about the structure. So, when we compare structural steel with aluminium, aluminium out performs it by 0.6 times.

E. Total Deformation

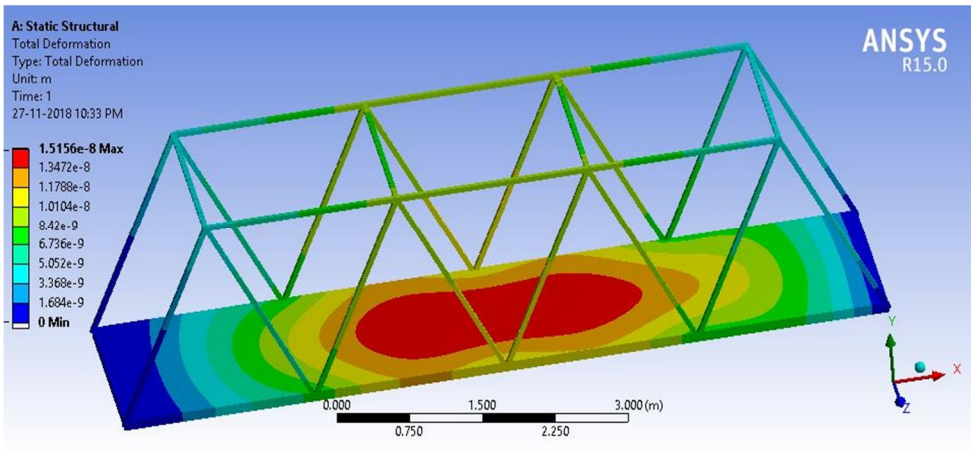


Figure 11 : Total Deformation ; Material : Aluminium

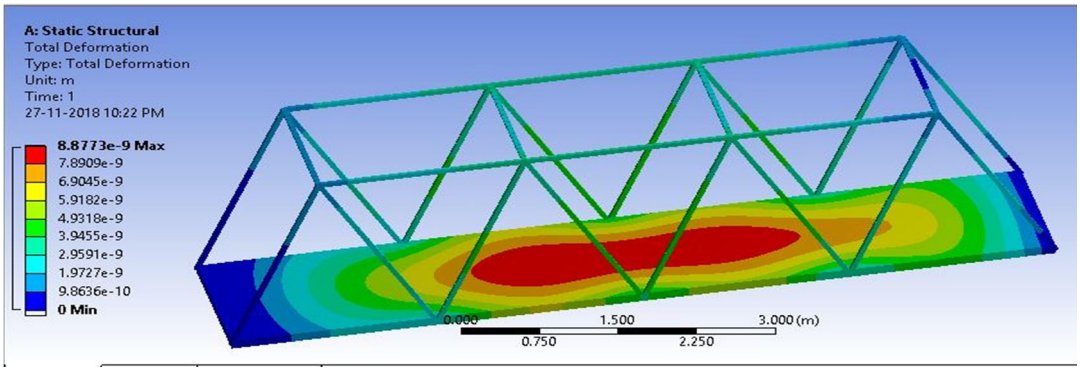


Figure 12 : Total Deformation ; Material : Structural Steel

1) *Discussion:* In total deformation, aluminium out performs structural steel. Deformation experienced by aluminium was 1.515e-8 m and 8.8773e-9 in structural steel.

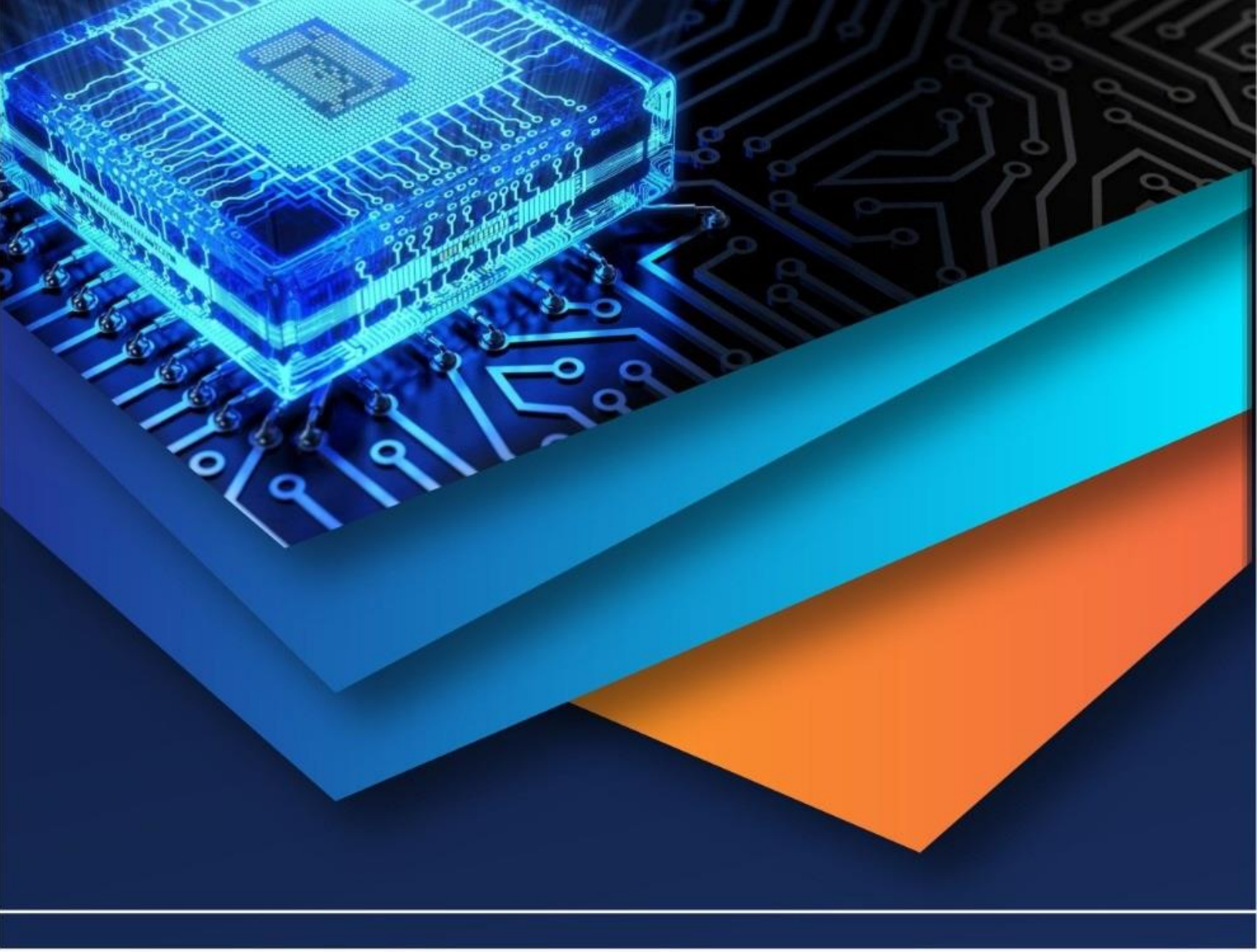
IV. CONCLUSION

Thus, from the Static analysis conducted by Ansys on Truss Bridge with two different materials, aluminium and Structural steel were able to produce results and compared, showing that aluminium material can outperform structural steel with same conditions by (0.5-1.5) times. Thus, through this one of most important problem with truss bridges, Structure heaviness can be solved by using aluminium, without comprising on the strength and durability of the Structures.

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