STRUCTUAL DEFORMATION – FEA on PATRAN

Introduction:

A truss structure which is made of 5 members and 4 nodes that are labeled according to Figure 1. The vertical member has a cross-sectional area of 1.75 in^2, while all other members have cross-sectional areas of 2.0 in^2. Node 1 is a pin while node 4 is a roller. There is a force of 5000 lbf coming down in the negative y-direction on node 3.

Method:

The load is tested on this truss structure twice with different materials: the first being a **steel truss** structure, while the latter being a **titanium alloy** truss structure. The material properties needed for these two tests are shown in the Table 1 below:

Material	Elastic Modulus (Nm^2)	Poisson's Ratio
Steel	2E11	0.30
Titanium Alloy	1.1E11	0.34

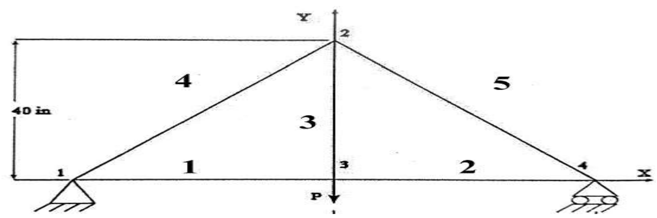

Table 1: *Material Properties of the Truss Structure*

Figure 1: *Truss Structure*

The creation of a truss structure begins its basic geometry where the 4 nodes are added to the x-y coordinate plane on PATRAN in an orderly fashion:

Node	Coordinate
1	<-1.524, 0, 0>
2	<0, 1.016, 0>
3	<0, 0, 0>
4	<1.524, 0, 0>

Then the members (also known as 'curves' in PATRAN) are added by connecting these nodes together. These members are created with a cross-sectional areas of **0.00129032 m^2** with the exception of the vertical member in the middle, which is set to a cross-sectional area of **0.00112903 m^2**. The material needed for the analysis also get added along the corresponding properties according to Table 1 to these members. Restraints are also set in such a way that it resembles the properties of a fixed pin and a roller pin. On node 1, it is restricted to any translation, so it has a restraint of **<0, 0, 0>,** which prevents node 1 from moving in any direction. On node 4, a restraint is set to **< , 0, 0>,** which demonstrates the property of a roller that can only move in the x-direction. The load then is added node 3 with input **<0, 22241, 0>** as the force going downward in the y-direction.

Result:

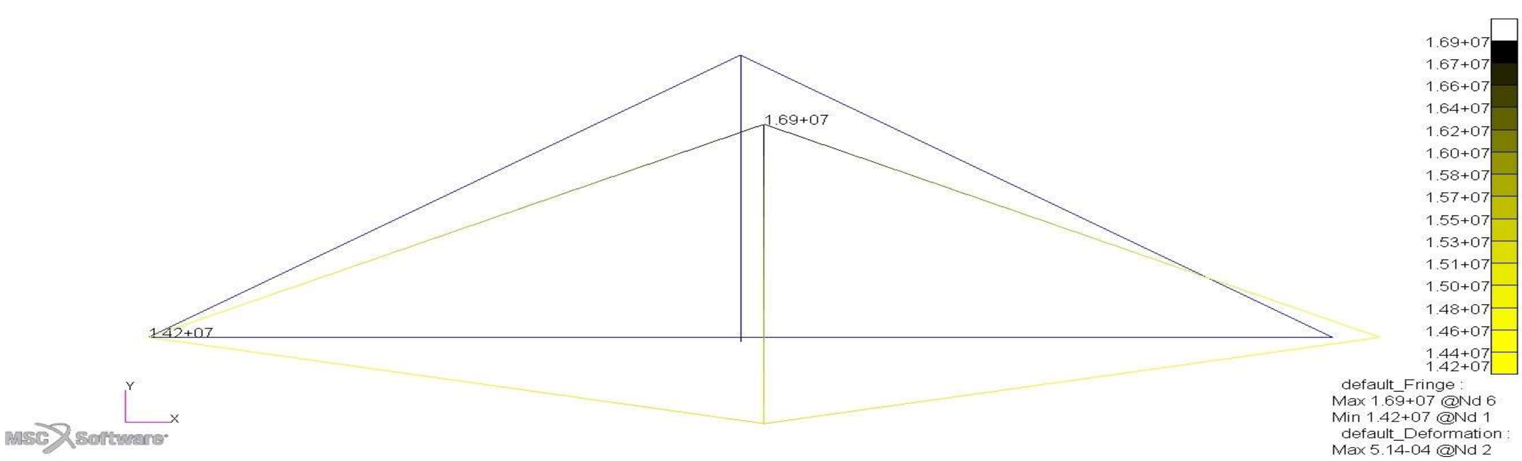

Figure 2: *Undeformed and Deformed Structure of Steel Truss*

Node	△X (m)	△Y (m)	△Z (m)
1	0.0	0.0	0.0
2	9.850837E-05	-4.042793E-04	0.0
3	9.850837E-05	-5.043513E-04	0.0
4	1.970167E-04	0.0	0.0

Table 2: *Displacements of Nodes for Steel Truss Structure*

Member	Axial Stress (N/m^2)
1	1.292761E+07
2	1.292761E+07
3	1.969921E+07
4	-1.553705E+07
5	-1.553705E+07

Table 3: *Stresses of Members for Steel Truss Structure*

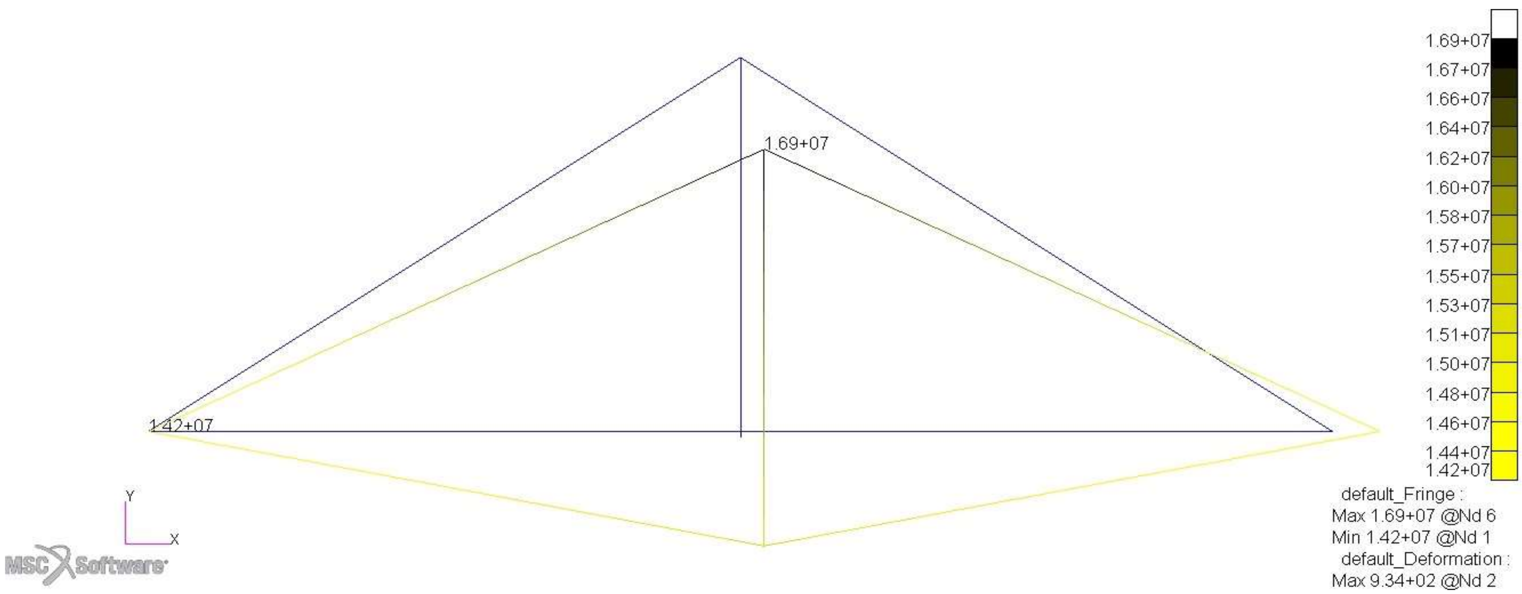

Figure 3: *Undeformed and Deformed Structure of Titanium Alloy Truss*

Node	△X (m)	△Y (m)	△Z (m)
1	0.0	0.0	0.0
2	1.791061E+02	-7.350532E+02	0.0
3	1.791061E+02	-9.170023E+02	0.0
4	3.582123E+02	0.0	0.0

Table 4: *Displacements of Nodes for Titanium Alloy Truss Structure*

Member	Axial Stress (N/m^2)
1	1.292761E+07
2	1.292761E+07
3	1.969921E+07
4	-1.553705E+07
5	-1.553705E+07

Table 5: *Stresses of Members for Titanium Alloy Truss Structure*

Conclusion:

As Table 3 and Table 5 above have shown from the two truss structures, member 3 tends to have the highest stress which are **19.7 MPa** for Steel and **19.7 MPa** for Titanium Alloy. They have the same value of stress because the axial stress is a product of force over the cross-sectional area. So, the variety of material does not affect this value as long as the external force and the cross-sectional area of the truss structure remain the same in both cases. The axial stress is highest on member 3 because of the downward force located on node 3, which putting additional stress on the member. Moreover, node 2 and node 3 are evidences of this scenario due to the fact that they both have high values for displacement because they are located at each end of the member. It makes more sense for them to behave in such a way since they are not bound to any restriction from displacements like node 1 and node 4.

The material of the truss is an important factor that gives off different increments as shown on Table 2 and Table 4. Due to different values in the elastic modulus and Poisson's ratio between Steel and Titanium Alloy, the displacements when a force is applied vary differently among them. Knowing that Titanium Alloy has a lower elastic modulus, it is expected to have a higher displacement value, such that the displacement on y-direction on node 3: **5.043513E-04 (Steel)** is smaller than **-9.170023E+02 (Titanium Alloy).** Therefore, material with a higher elastic modulus will generally produce less displacement compared to a lower elastic modulus from a different material.