Aircraft Tail Section Stress Analysis - Axial Finite Elements

Introduction:

A tail section of an aircraft with is shown in Figure 1 below. The tail section is modeled as a 2-Dimensional truss structure with all the members having the same cross-sectional area of 1.0 in^2 along with a given material data. Moreover, there are 3 different loads (**80 lbs, 275 lbs, and 100 lbs**) being applied concurrently on node 1 and node 3 as shown below. Node 4 and Node 5 are displayed as pin joints, therefore, the truss structure is expected to deform in a certain way in the analysis. The goal is to analyze the deformation of a truss structure when multiple loads are applied with a given condition of 2 pin joints.

Method:

The exact coordinates of all the nodes (1 through 5) must be re-calculated since the structure is shifted by an angle of 15°. The Table 1 shows the calculated values that are used as input data for the coordinates of these nodes.

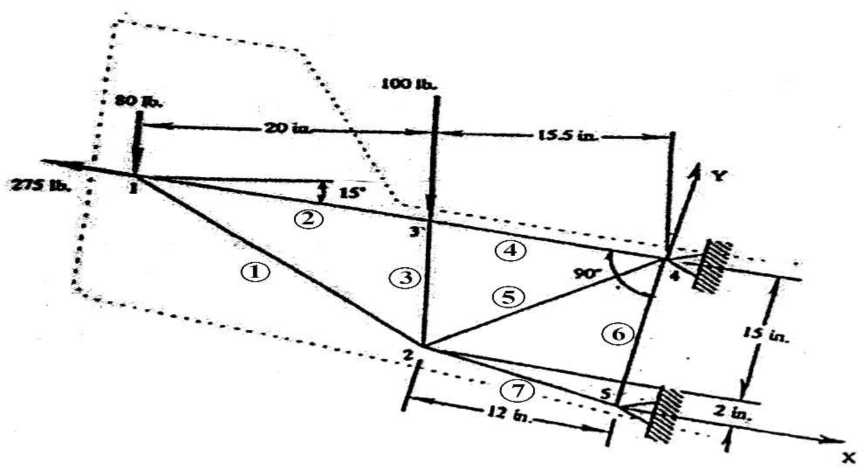

***Figure 1:** 2D Aircraft Tail Section*

Node	Coordinates <x, y, z>
1	<-36.75, 17, 0>
2	<-12, 2, 0>
3	<-16.04, 17, 0>
4	<0, 17, 0>
5	<0, 0, 0>

***Table 1:** Calculate Nodal Coordinate for the tail*

Once these nodes are created in PATRAN, the members can now be added by connecting these nodes together in an orderly fashion. Each of these members will be set to have a cross-sectional area of **1.0 in^2** and have the property of an unknown material with **Elastic Modulus = 29.5E6 psi**, and Poisson's Ratio, ***ν* = 0.29**, while having its Yield Strength = 3.4E4 psi. Restraint is set on node 4 and node 5 to have these nodes function like pin joints. On node 4, it is restricted to any translation, so it has a restraint of <0, 0, 0>, which prevents itself from moving in any direction. Similar action is done on node 5 to create the second of the two pin joints.

After the truss model is set up, the loads are added onto node 1 on node 3. Since the structure is shifted by 15°, the load as shown on Figure 1 are broken into 2 components to fit with the given x-y coordinate. Thus, "100 lbs" load on node 3 becomes 25.88 lbs on the x-direction and -96.59 lbs on the y-direction. The "80 lbs" load on node 1 becomes 20.71 lbs on the x-direction and -77.27 lbs on the y-direction. The "275 lbs" load remains as -275 lbs on the x-direction because it is perfectly aligned with the given x coordinate of this system.

Result:

Node	△X (in)	△Y (in)	△Z (in)
1	-4.639421E-04	-1.337980E-03	0
2	7.390101E-05	-1.997729E-04	0
3	-1.979217E-04	-3.169914E-04	0
4	0	0	0
5	0	0	0

***Table 2:** Displacement Information of Nodes*

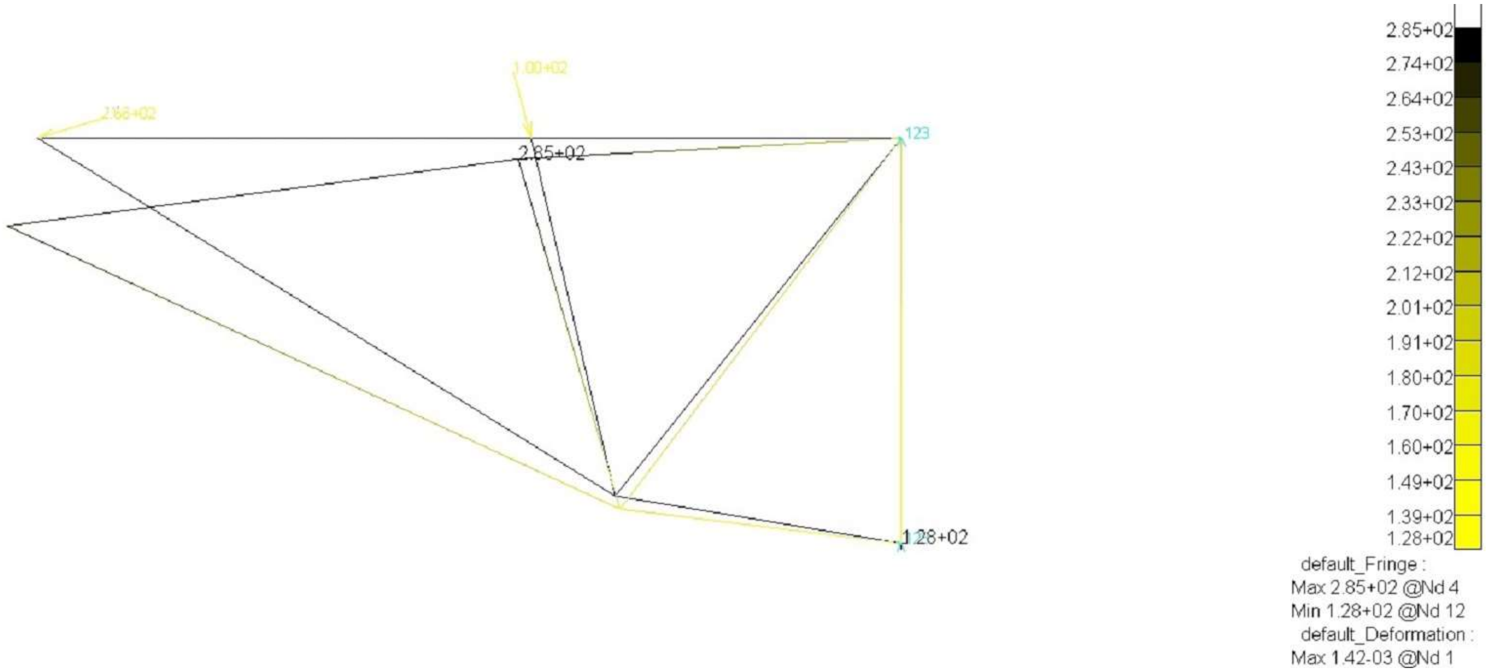

Figure 3: *Undeformed and Deformed model of the tail section*

Member	Axial Stress (psi)
1	-1.467988E+02
2	3.791112E+02
3	-9.922862E+01
4	3.759621E+02
5	1.686681E+02
6	0
7	-2.564024E+02

Table 4: *Axial Stress Information of Members*

Conclusion:

From the analyzed data shown on Table 2, the result shows that node 1 has the greatest displacement out of all the nodes due to two loads simultaneously pushing onto one location. The second node that has a wide range of displacement is node 3, which is directly under the "100 lbs" load and caused it to move in some degree. From the position of the force on node 3, one may assume that its location would move toward a positive x-direction. However, this is not the case because node 3 and node 1 are connected by member 2 (shown on Figure 1); therefore, the loads on node 1 indirectly affected node 3 and caused it to have a negative displacement in the x-direction instead. This similar case can also be seen in node 2. With the connection of member 1 and member 3, node 2 moved slightly downward in the negative y-direction and x-direction which was caused by the loads affecting on node 1 and node 3. Because node 4 and node 5 are pin joints, it makes sense for them to not have any displacement.

A negative axial stress value represents compression while a positive value indicates stretch. From deformation of the truss model in Figure 2, it can be seen that member 2 is being stretched by the positive x-direction: forces coming loads "100 lbs" and "80 lbs," and the negative x-direction: force coming from the load of "275 lbs." Member 2 also has the highest stress because of all these loads pushing onto its two nodes (node 1 and node 3). Since these members and nodes are all connected as a single entity, all these members are expected to have a variety of stresses upon loaded with these three forces except for member 6. Member 6 has no stress value because it is fixed by two pin joints. Since two pin joints have no displacement, there is no stress generated to deform the member. From this we can see a correlation between displacement vs. stress when impacted by a load.